



**NPP Mashproject LLC**  
**Saint-Petersburg, Russia**

# **PORTABLE LEEB HARDNESS TESTER TKM-359CE**

**Operation manual**  
**TKM-359CE OM**



**TABLE OF CONTENTS:**

<b>1 DESCRIPTION OF THE HARDNESS TESTER .....</b>	<b>4</b>
1.1 INTENDED USE AND FUNCTIONS .....	4
1.2 OPERATING PRINCIPLE .....	6
1.3 TECHNICAL CHARACTERISTICS .....	6
1.3.1 <i>Basic technical characteristics</i> .....	6
1.3.2 <i>Hardness tester probes</i> .....	11
1.3.3 <i>Additional devices and accessories</i> .....	14
1.3.4 <i>Requirements for articles under inspection</i> .....	14
1.3.5 <i>Working with non-carbon structural steel articles</i>	16
1.3.6 <i>Measurements on light and thin-walled articles</i> ..	18
1.3.7 <i>Measuring of hardened surface layers, galvanic coatings, and surface deposits hardness</i> .....	20
1.3.8 <i>Working with articles with excessive roughness</i> .	20
1.3.9 <i>Influence of article surface layer properties</i> .....	21
1.4 COMPLETENESS OF THE HARDNESS TESTER .....	21
1.5 DESIGN OF THE HARDNESS TESTER .....	23
1.5.1 <i>Construction</i> .....	23
1.5.2 <i>Menu navigation</i> .....	24
1.6 MARKING AND SEALING .....	27
1.7 PACKING OF THE HARDNESS TESTER .....	27
<b>2 OPERATION .....</b>	<b>27</b>
2.1 GENERAL INFORMATION .....	27
2.2 HARDNESS MEASUREMENT PROCEDURE .....	28
2.3 POWERING ON AND PREPARATION FOR WORK .....	28
2.4 SERVICEABILITY CHECK .....	29
2.5 PROCEDURE FOR HARDNESS MEASUREMENT ON INSPECTED ARTICLES .....	31
2.6 MEASUREMENTS MODE .....	32
2.7 PROBE TYPE SELECTION .....	33
2.8 SELECTION OF CONTROLLED MATERIAL .....	34

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2.9	HARDNESS SCALE SELECTION .....	34
2.10	SETTING AVERAGING PARAMETERS .....	34
2.11	DISPLAYING DATA ON THE SCREEN .....	35
2.12	SETTING CONTROL THRESHOLDS .....	36
2.13	SETTING DIAGRAM THRESHOLDS .....	37
2.14	SCALES CALIBRATION .....	37
2.14.1	<i>General information</i> .....	37
2.14.2	<i>Scale calibration</i> .....	38
2.14.3	<i>Additional calibration setup</i> .....	40
2.14.4	<i>Calibration deletion</i> .....	41
2.14.5	<i>Additional calibration name setup</i> .....	41
2.15	POWER SAVING MODE SETTINGS .....	42
2.16	MEMORY MANAGEMENT .....	42
2.16.1	General information .....	42
2.16.2	Creating a new block .....	42
2.16.3	Selection of a block for recording .....	43
2.16.4	Deletion of a block .....	43
2.16.5	Viewing block data .....	44
2.16.6	Diagram display .....	44
2.16.7	Clearing the block .....	45
2.16.8	Block name change .....	45
2.16.9	Data transfer to a computer .....	45
2.17	BATTERY CHARGE MONITORING .....	45
2.18	HARDNESS TESTER SHUTDOWN .....	46
<b>3</b>	<b>TECHNICAL MAINTENANCE</b> .....	<b>46</b>
<b>4</b>	<b>TRANSPORTATION AND STORAGE</b> .....	<b>46</b>
<b>5</b>	<b>SAFETY MEASURES</b> .....	<b>47</b>
<b>6</b>	<b>RECYCLING</b> .....	<b>47</b>
<b>7</b>	<b>MANUFACTURER'S WARRANTY</b> .....	<b>47</b>
<b>8</b>	<b>ACCEPTANCE CERTIFICATE</b> .....	<b>49</b>

The present operation manual, supported by the technical passport, contains data pertaining to the purpose, functional description, technical characteristics, operating principle, internal design and performance of TKM-359CE hardness testers (hereinafter referred to as “hardness tester”) as well as respective operation, transportation, and storage rules. Based on ASTM and DIN norms.

## **1 DESCRIPTION OF THE HARDNESS TESTER**

### **1.1 INTENDED USE AND FUNCTIONS OF THE HARDNESS TESTER**

1.1.1 The hardness tester is designed for on-site measurement of carbon structural steels using the Brinell (HB), Rockwell (HRC), and Vickers (HV) basic hardness scales through the dynamic contact impedance method.

1.1.2 The hardness tester is designed to perform referential hardness checks of carbon structural steels on the Rockwell (HRA), Rockwell (HRB), and Shore (HSD) hardness scales. This is achieved by automatically converting measurement results from the main hardness scale units into the respective hardness units, based on the user’s or manufacturer’s conversion tables.

1.1.3 The hardness tester is designed to perform referential checks using the Leeb (HL) scale.

1.1.4 The hardness tester is intended to be used for reference checks of the tensile strength (MPa) of pearlitic carbon structural steels via automatic recalculation of the Brinell (HB) scale results to corresponding hardness units according to the ASTM E140 table.

1.1.5 The hardness tester is intended to be used for hardness control of metals and alloys that differ in characteristics from carbon structural steels.

The hardness tester can be used for hardness control of:

- Heat-resistant, corrosion-resistant, stainless, tool and other types of steels
- Non-ferrous metals and alloys
- Specialized cast iron
- Strengthening and other layers used in steel articles

- (electrolytic precipitation, nitrogen hardening, HFC hardening, etc.)
- Overlay welding and plated coating (chromium, etc.)
- Articles made of fine-grained materials (for local investigation of material properties)

When the physical and mechanical properties of the material being inspected differ from those of carbon structural steels, measurements should be carried out after setting up an additional calibration (or additional scale). This additional calibration can be programmed either by the user with test blocks made from the respective material or by the manufacturer upon the user's request.

1.1.6 The hardness tester is designed for use in laboratories, workshops, and field environments.

1.1.7 The hardness tester allows the user:

- To perform real-time calculations of the average value of measurement series results, including the option to reject incorrectly performed measurements using a user-selected algorithm.
- To perform real-time additional statistical processing of measurement series results, such as determining the minimum and maximum values, calculating the average value, and computing the mean square deviation from the average.
- To display additional information in real-time, including the results of the previous measurement series.
- To organise data storage in the form of individualised blocks of measurement results, retain them when the device is powered off, and transfer the data to a computer.
- To analyse stored measurement results in various ways and to plot different types of charts directly on the display.
- To select additional information to be displayed during measurements.
- To set up a measurement range and establish an alarm for range exceedance.
- To monitor battery charge and set up a battery discharge alarm.
- To configure automatic shutoff after a period of inactivity to conserve battery power.
- To adjust the display brightness to conserve battery life.
- To select the required display colour and intensity range.

- To select an interface language from those preset by the manufacturer at the user's request.

## 1.2 HARDNESS TESTER OPERATING PRINCIPLE

The hardness tester implements a dynamic Leeb hardness control method. This method determines the ratio of the rebound rate to the rate of incidence of a carbide indenter from the surface of the article under inspection.

## 1.3 TECHNICAL CHARACTERISTICS

### 1.3.1 BASIC TECHNICAL CHARACTERISTICS

Basic technical characteristics of the hardness tester are listed in Table 1.

Table 1

<b>Hardness measurement range by scales:</b>	
Brinell	90 – 450 HB
Rockwell C	20 – 70 HRC
Vickers	240 – 940 HV

<b>Limits of hardness measurement absolute error, main scales:</b>	
Brinell	
Within (90...150) HB	±10 HB
Within (150...300) HB	±15 HB

Within (300...450) HB	±20 HB
Vickers	
Within (240...500)HV	±15 HV
Within (500...800)HV	±20 HV
Within (800...940)HV	±25 HV

**Hardness measurement range, reference scales:**

Ultimate tensile strength $\sigma_B$	350...1500 MPa
Rockwell A	70,5 – 85,5 HRA
Rockwell B	51 – 100 HRB
Shore D	35 – 102 HSD
Leeb (HL)	300 – 900 HL

**Hardness control ranges according to additional scales for various materials (for Leeb probes)**

Alloy, tool steel	80 – 900 HV 20 – 70 HRC
Stainless steel	80 – 850 HV 80 – 655 HB

Stainless steel	20 – 70 HRC 45 – 100 HRB
Gray cast iron (with lamellar graphite)	90 – 335 HB
Ductile cast iron (with compact graphite), high-strength cast iron (with nodular graphite)	130 – 390 HB
Aluminium alloys	30 – 160 HB
Brass (copper-zinc alloys)	40 – 175 HB; 14 – 95 HRB
Bronze (copper-tin, copper-aluminium)	60 – 290 HB
Hardness tester electronic unit overall dimensions, maximum	121 x 69 x 41 mm
Hardness tester electronic unit mass, maximum	0,3 kg
Mass of the probe, maximum	0,3 kg

<b>Hardness tester rated operation conditions</b>	
Air temperature	From -15 to +35 °C
Relative humidity	30 – 80 %

Atmospheric pressure	84 – 106,7 kPa
Calibration period	1 year
Hardness tester service life	5 years
Number of potential additional calibrations for the hardness tester	5 for each scale
Number of additional scales for the hardness tester	3
Duration of one hardness measurement cycle (average)	2 s
Number of measurement cycles required to calculate the average value	1 – 99
Number of algorithms for rejecting incorrectly performed measurement results during average value calculation	3
Parameters of additional statistical processing of measurements series	Maximum, minimum, mean square deviation from the average value, average value.
Additional information displayed (as defined by the user)	Previous results of the measurement series and results of additional statistical processing.
Number of samples required to set up additional calibrations for hardness tester scales	1 or 2

Number of samples required for additional scales setup	2 to 10 (to be defined by the user)
Intermediate interpolation of additional scales	Piecewise linear or piecewise parabolic (to be defined by the user)
Measurement results overrunning alarm	Colour. Check limits to be set up by the user for each individual scale. Types of limits: greater, less, overrun.
Maximum number of measurements stored in the memory	12 400
Maximum number of individualized blocks set up in the memory	100
Displaying	<ul style="list-style-type: none"> <li>• All results in the block</li> <li>• Results in the block which are greater or less than values set up by the user</li> <li>• Results falling outside the specified range set up by the user</li> </ul>
Statistical processing	<ul style="list-style-type: none"> <li>• Maximum, minimum, mean square deviation from average value, average value</li> <li>• Average deviation from the value set up by the user, number of results bigger/less than specified value, maximum deviation from specified value to bigger/less side</li> </ul>

Statistical processing	<ul style="list-style-type: none"> <li>Number of results falling outside the range set up by the user (outside bigger/ less limit), maximum deviation from upper/ lower limit</li> </ul>
Plotting of charts	<ul style="list-style-type: none"> <li>In reference to average value</li> <li>In reference to value set up by the user</li> <li>In reference to measurement range set up by the user</li> </ul>
Computer interface connection	USB
Hardness tester automatic shutdown	Shutdown time to be set up by the user
Monitoring of battery charging	Continuous. Continuous indication during measurement.
Display illumination	Time to be set up by the user
Display colour and intensity	To be selected by the user
Interface language of the hardness tester	According to the request: English, German, French.
Hardness tester power supply	Autonomous, battery. Use of equivalent non-rechargeable batteries allowed.

### 1.3.2 HARDNESS TESTER PROBES

The probes are equipped with a built-in cable for connection to the electronic unit or with a built-in plug-and-socket coupler for cable attachment upon the user's request.

The characteristics of the probes are listed in Table 2.

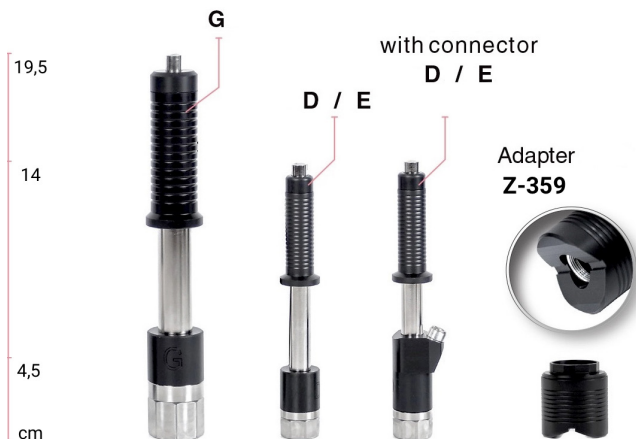
Leeb probes					
Reference designation	Description	Overall dimensions, maximum			
		Length, mm		Diameter, mm	
		usual	With connector	usual	With connector
<b>D</b>	The probe, typically supplied with the Leeb hardness tester, is used for primary measurement tasks.	138	138	21	27
<b>G</b>	The probe has increased overall imensions and impact energy (compared to the probe "D"). It is used to inspect materials with high structural heterogeneity and high surface roughness. <b>Can be used only at the hardness less than 450 HB</b>	200	-	29	-
<b>E</b>	The probe with the indenter made of a polycrystal of cubic boron nitride. For mass control of the materials with the increased hardness ( $\geq 450$ HB)	138	138	21	27

Average nominal diameters of dents (mm) left on the surfaces of articles during hardness measurement are listed in Table 3.

Table 3

Reference designation of the probe	103 HB (103 HV)	209 HB (212 HV)	406 HB (420 HV) (42,5 HRC)	763 HV (63,0 HRC)
D, E	0,80	0,72	0,67	0,57
G	1,29	1,22	0,93	-

At the user's request, specialized probes with characteristics different from those specified in tables can be manufactured and integrated into the hardness tester.



Leeb probes and adapter Z-359

Average nominal depth of dents (mm) left on the surfaces of articles during hardness measurement are listed in Table 4.

Table 4

<b>Reference designation of the probe</b>	<b>103 HB (103 HV)</b>	<b>209 HB (212 HV)</b>	<b>406 HB (420 HV) (42,5 HRC)</b>	<b>763 HV (63,0 HRC)</b>
<b>D, E</b>	0,054	0,043	0,038	0,027
<b>G</b>	0,084	0,075	0,044	-

### 1.3.3 ADDITIONAL DEVICES AND ACCESSORIES

The «Z-359» head facilitates the positioning of Leeb probes D, E on cylindrical surfaces. It replaces the standard support nut by screwing onto the probe.

### 1.3.4 REQUIREMENTS FOR ARTICLES UNDER INSPECTION

The hardness measurement area of the article under inspection should be dry and free from scale, rust, dust, dirt, and grease.

The minimum approximate weight of the article under inspection is according to Table 5.

Table 5

<b>Probe reference designation</b>	<b>Minimum thickness of the article under inspection, mm</b>
<b>D, E</b>	3
<b>G</b>	8

If the weight of the article under inspection is less than specified above, it is necessary to adhere to the requirements listed in section 1.3.6 "Measurements on light and thin-walled articles".

The minimum approximate thickness of the article's area under inspection is according to Table 6.

Table 6

<b>Probe reference designation</b>	<b>Minimum thickness of the article under inspection, mm</b>
<b>D, E</b>	6
<b>G</b>	55

Specified thickness values may vary depending on the geometrical dimensions and hardness of the article.

If the thickness of the article under inspection is less than specified, during measurements it will be necessary to additionally adhere to the requirements of section 1.3.6 "Measurements on light and thin-walled articles".

The maximum recommended roughness of the article (article area) subject to inspection is according to Table 7.

Table 7

<b>Probe reference designation</b>	<b>Surface roughness, maximum</b>
<b>D, E</b>	Ra 3,2
<b>G</b>	Ra 7,6

If the article's surface roughness exceeds the specified value, it is necessary to additionally adhere to the requirements of section 1.3.8 "Working with articles with excessive roughness".

The minimum radius of curvature of article's convex surface under inspection is according to Table 8.

Table 8

<b>Probe reference designation</b>	<b>Radius of curvature, mm</b>	
	<b>Convex</b>	<b>Concave</b>
<b>D, E</b>	18	200 (without washer)

<b>G</b>	50	500 (without washer)
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The minimum diameter of the spot of article's surface under inspection is according to Table 9.

Table 9

<b>Probe reference designation</b>	<b>Spot radius, minimum, mm</b>
<b>D, E</b>	21 (6 without washer)
<b>G</b>	29 (7 without washer)

### 1.3.5 WORKING WITH NON-CARBON STRUCTURAL STEEL ARTICLES

Unlike hardness testers based on the static principle of operation (stationary hardness testers), the measurement results are influenced not only by metal properties revealed during plastic deformation of metal but also by other mechanical and physical properties, primarily the modulus of elasticity of the metal under inspection (Young's modulus).

Additional errors arising in such cases necessitate adjusting the device (additional calibration) to accommodate materials with elasticity modulus differing from carbon structural steels. To determine the presence of additional errors, it is necessary to compare measurement results obtained using the hardness tester with results obtained using a static device.

If the divergence in results does not exceed the maximum error of the hardness tester, it implies that these materials can be inspected without additional calibration.

If the divergence exceeds the maximum error of the hardness tester, additional calibration of the hardness tester (additional calibration) with two hardness samples representing the material under inspection is required (procedure detailed in section 2.15 "Hardness tester scales calibration").

During the use of the hardness tester, there may arise a need to measure the hardness (or other properties) of materials with specific mechanical and physical parameters. In such cases, it is possible that additional calibration may not completely eliminate the resulting error. Therefore, it may be necessary to perform additional calibration of the hardness tester (setting up an additional scale) with one or two hardness samples made of the material under inspection (procedure detailed in section 2.16 “Additional scale setup”).

In cases where the material of the article under inspection exhibits high structural heterogeneity or a coarse-grain structure (such as grey cast iron, etc.), it is likely that the measurement method employed in the given hardness tester may not adequately inspect such articles.

There will be significant dispersion in device readings. To conduct immediate checks on such materials, it is necessary to use Leeb probes (D, E, G) to inspect these objects. These procedures may also not yield accurate results for articles with ultra-high or ultra-low hardness.

### **Requirements for samples used in additional hardness tester calibration**

The number of samples required for additional calibration of hardness testers is 1 or 2 pieces. The recommended ratio of  $H_{\max}$  (maximum sample hardness value) to  $H_{\min}$  (minimum sample hardness value) is 2:1.

For setting up an additional hardness tester scale, 2 or more samples are required.

During sample fabrication, it is recommended to follow the ASTM E140 standards for 2<sup>nd</sup> grade hardness samples concerning roughness and geometric dimensions. This includes additional limitations, specifically a minimum sample thickness (height) of 10 mm. In case of deviation from these standards (which is not recommended), the following conditions must be met:

- Roughness of the sample's working surface: 0.4  $\mu\text{m Ra}$ .
- The sample's supporting surface must be plain ground.

There will be significant dispersion in device readings. To conduct immediate checks on such materials, it is necessary to use Leeb probes (D, E, G) to inspect these objects. These procedures may also not yield accurate results for articles with ultra-high or ultra-low hardness.

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In case of deviation from these standards (which is not recommended), the following conditions must be met:

- Roughness of the sample's working surface: 0.4  $\mu\text{m Ra}$ .
- The sample's supporting surface must be plain ground.

When fabricating samples, ensure compliance with the ASTM E140 standards for 2<sup>nd</sup> grade hardness samples regarding surface hardness variation.

### **1.3.6 MEASUREMENTS ON LIGHT AND THIN-WALLED ARTICLES**

Where an article under inspection, sample, or test block does not meet the requirements of the hardness tester probes regarding article mass and/or thickness, the hardness tester will conduct measurements with additional error. This error will increase with greater deviations from the specified requirements.

For articles with insufficient mass, the error depends on parasitic oscillations occurring when the diamond pyramid penetrates the article during measurement. These oscillations result from the article vibrating due to its insufficient mass.

To determine the occurrence of additional errors, measurements performed by the hardness tester should be compared with those conducted using a static device.

### **Elimination of additional errors on light and thin-walled articles**

If the article thickness is insufficient, it is necessary (to eliminate additional errors) to secure the article to a massive, plain-ground plate. Recommended plate parameters are as follows:

- Mass and thickness should significantly exceed the minimum mass and thickness of the article under inspection as specified in section 1.3.4 “Requirements for articles under inspection”
- Roughness should be kept to a minimum. Optimal roughness should not exceed Ra 0.4  $\mu\text{m}$
- Non-flatness should be maximum 0.005 mm
- The modulus of elasticity of the plate metal (Young’s modulus) should be close to that of the article under inspection
- The bottom part of the article should be plain ground

Before positioning the article, apply a thin layer of grease to the plate’s supporting surface.

Then, secure the article to the plate through the grease layer, ensuring there are no air gaps between the surfaces. This grounding process should be tight enough to create a uniform and monolithic mass.

### **Elimination of additional errors on lightweight articles**

For articles with insufficient mass, it is necessary to secure them in a sturdy metal vice. The vice should have a mass significantly greater than the minimum mass of the article under inspection as specified in section 1.3.4 “Requirements for articles under inspection”. To prevent damage to the article, attachable pads made of softer metal can be used.

Additionally, if there is insufficient mass, the article can be grounded to a massive plate using the method described above.

The grounding method is suitable for thin articles (sheets), articles with a flat shape, and articles with mass comparable to the minimum specified in section 1.3.4 "Requirements for articles under inspection". An example is Rockwell scale test blocks as per ASTM E140.

Vice gripping should be used for small articles with insufficient mass and a volumetric shape.

In cases where articles have small mass and/ or thickness, implementing the above activities may not yield accurate results.

To inspect such articles properly, it is necessary to use static-type hardness testers that apply small or ultra-small loads. The reliability of the inspection should be assessed by comparing readings from the hardness tester and the static device.

### **1.3.7 MEASURING OF HARDENED SURFACE LAYERS, GALVANIC COATINGS, AND SURFACE DEPOSITS HARDNESS**

Depending on the type of probe used and the hardness of the article, the probe pyramid penetrates the article to different depths (refer to section 1.3.2 "Hardness tester probes", Table 4). Plastic deformation of the metal occurs at considerably greater depths.

For Leeb probes, it is recommended to measure the hardness of the layer with a thickness of at least 1.5 mm beyond the pyramid penetration depth. During hardness measurement, it is necessary to consider the requirements of section 1.3.5 "Working with non-carbon structural steel articles".

### **1.3.8 WORKING WITH ARTICLES WITH EXCESSIVE ROUGHNESS**

When measuring an article with a significantly rough surface (exceeding the values specified in section 1.3.4 "Requirements for articles under inspection") the user may observe high additional dispersion in device readings.

Dispersion in the readings can be eliminated by two methods:

- Grinding the surface area (for example, using a grinding machine as per section 1.3.3 “Additional devices and accessories”) to achieve the required roughness specified in section 1.3.4 “Requirements for articles under inspection”;
- Using a higher number of averaging cycles during measurements. This is recommended when it is not possible, for any reason, to properly grind the required surface area.

### 1.3.9 INFLUENCE OF ARTICLE SURFACE LAYERS PROPERTIES

During the fabrication of articles under inspection, thin layers may be deposited on the surface that differ in hardness from the base metal.

For example:

- Decarburized layers with low hardness, resulting from high-temperature thermal treatments (such as hardening, normalisation, hot rolling, forging, etc.)
- Burn marks, caused by faults in the article grinding process, where the surface layer becomes burnt, leading to reduced hardness
- Cold work, occurring in the surface layer after lathe and mill machining and coarse grinding
- Cold hardening
- Martensite spots with excessive hardness, occurring due to surface overheating.

The presence of these layers (detectable with the hardness tester) affects tester readings.

Typically, the thickness of these layers does not exceed 0.2 mm.

To ensure measurement accuracy when such layers are detected, it is necessary to remove them from the measurement areas using a grinding machine, for example.

### 1.4 COMPLETENESS OF THE HARDNESS TESTER

The contents of the hardness tester delivery set are listed in Table 10. Contents of additional sets to be defined together with hardness tester purchase order.

Table 10

Item	Quantity (pcs)	Remark
<b>Basic configuration</b>		
<b>Electronic unit</b>		
<b>D-type probe</b>		№
<b>Rechargeable battery</b>		Li-Po 3,7 B 1100 mA/h (included in electronic unit)
<b>Charger</b>		
<b>PC cable</b>		USB
<b>Soft case</b>		
<b>Strap for securing the device on the arm</b>		
<b>Carrying and storage bag</b>		

<b>Additional set</b>		
<b>D-type probe</b>		
<b>G-type probe</b>		
<b>E-type probe</b>		
<b>Connecting cable for Leeb probes</b>		
<b>Special head "Z-359"</b>		

## 1.5 DESIGN OF THE HARDNESS TESTER

### 1.5.1 CONSTRUCTION

From a functional viewpoint, the hardness tester comprises an electronic unit and a probe (see section 1.3.2 “Hardness tester probes”).

The hardness tester electronic unit receives frequency signals transmitted by the probe, converts them into hardness units, displays measurement results, performs statistical processing, and other functions specific to the hardness tester.

The front panel of the electronic unit features a coloured display and a keyboard.

A schematic image of the electronic unit is provided in Figure 1.

The side wall of the hardness tester houses the probe or cable plug-in connection for the computer.

The rear panel of the hardness tester displays a tag with the manufacturer’s serial number.

The hardness tester control – switching of scales and settings, additional calibrations and scales setup, measurement results, memorisation, and analysis etc. - is performed by means of the device keyboard.



Figure 1

### 1.5.2 HARDNESS TESTER MENU NAVIGATION

The complete setting list (operational parameters etc.) of the hardness tester, except for the selection of work scales, (see «General structure of the menu», Table 11), is accessed through the graphical menu.

The device menu is multilevel, organised to enhance usability by grouping logically connected settings into categories, with sub-menus provided for each respective menu item. An illustration of the menu is shown in Figure 2.

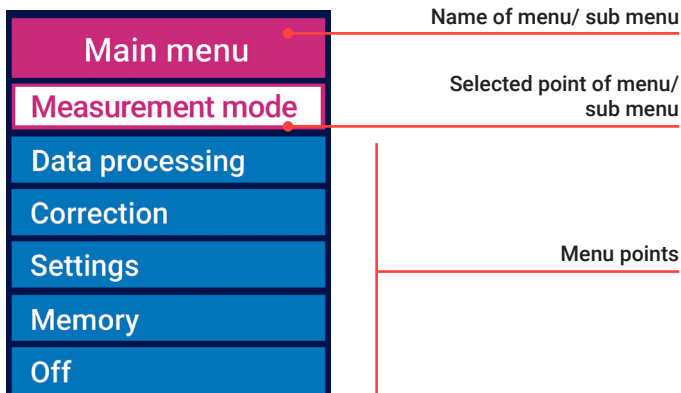






Figure 2

Switching between menu points is performed using of buttons , .

Selection of a menu point (to access parameter settings or sub-menu) is done with the button . The display will show a corresponding parameter entry window (see below) or sub-menu. Exiting from a sub-menu to a higher level is achieved by pressing the button .

The number of menu points displayed during operation may vary depending on the currently selected scale (main, reference, additional) or additional calibration.

The general structure of the menu is detailed in Table 11.

Menu point		Function	Art.
Meas- urement mode	Probe type	Probe type selection	2.7
	Material	Selection of controlled material	2.8
	Scale	Hardness scale selection	2.9

<b>Scale</b>		Hardness scale selection	2.9
<b>Data processing</b>	Average	Setting the averaging parameters (sample size and rejection of extreme values)	2.10
	Output settings	Setting the modes of displaying the results (numeric or diagram) and output statistics	2.11
	Limits	Setting control thresholds	2.12
	Figure	Setting the diagram	2.13
<b>Correction</b>	Correction	Calibration scale. Introduction of an additional calibration to the scale.	2.14.2, 2.14.3
	Clear	Deletion of calibration (return to the original settings)	2.14.4
	Cell name *	Introduction of the name of the additional calibration	2.14.5
<b>Settings</b>	Energy saving	Setting of automatic shutdown of the device, backlight mode	2.15
<b>Memory</b>		Functions for working with the data archive	2.16
<b>Off</b>		Hardness tester shutdown	2.18

\* Visible for additional calibration only

\*\* Visible for additional scale only

## 1.6 MARKING AND SEALING OF THE HARDNESS TESTER

1.6.1 The rear panel of the electronic unit displays a tag indicating:

- Manufacturer's name
- Model type of the hardness tester
- Hardness tester serial number
- Measurement tools approval sign

1.6.2 The probes may bear the hardness tester serial number and a letter representing the probe type.

1.6.3 To prevent unauthorised access and attempts to carry out unqualified hardness tester repairs, the probe casings are sealed accordingly.

## 1.7 PACKING OF THE HARDNESS TESTER

During storage and handling the hardness tester's electronic unit and probes should be kept in a shock-proof casing.

## 2 OPERATION

### 2.1 GENERAL INFORMATION (AS PER ASTM AND DIN)

As described previously, the hardness tester enables the user to perform the following measurements:

- Using main scales
- Using reference scales
- With additional calibrations to scales
- With additional scales
- 

Measurements by the hardness tester are conducted following the hardness measurement procedure outlined below (section 2.2 "Hardness measurement procedure").

The hardness tester operates during measurement in accordance with the scale and settings selected by the user in the menu (see section 1.5 "Design of the hardness tester").

The hardness tester operation cycle should include the following steps:

- Preparation for operation and powering on
- Serviceability check
- Execution of settings (if required)
- Measurement of hardness on articles.

The hardness tester operation cycle should include the following steps:

- Preparation for operation and powering on
- Serviceability check
- Execution of settings (if required)
- Measurement of hardness on articles.

The contents and procedure of each step are described below.

Periodical technical maintenance of the hardness tester is required (see section 3 “Technical maintenance”).

## 2.2 HARDNESS MEASUREMENT PROCEDURE

### Leeb probe

The hardness tester’s construction necessitates the following procedure for hardness measurement:

- Position the probe perpendicularly to the surface of the inspected article
- Press the probe housing (compressing the spring in the probe) to advance the probe into the working state
- Press the release button on the probe
- The hardness measurement results will appear on the tester display in approximately 1 second.

### **ATTENTION!**

- During measurements, it is essential to avoid the indenter entering into the dent left after previous measurements (move the probe along the surface). This can lead to additional **imprecision** in the measurement results.
- When pressing the release button, ensure the probe does not detach from the test surface, deviate from its normal position on the surface, or compress the probe spring sideways. This can also result in additional imprecision in the measurement results.

## 2.3 POWERING ON AND PREPARATION FOR WORK

2.3.1 Visually inspect the hardness tester to ensure there are no mechanical damages to the electronic unit, probe, or connecting cable.

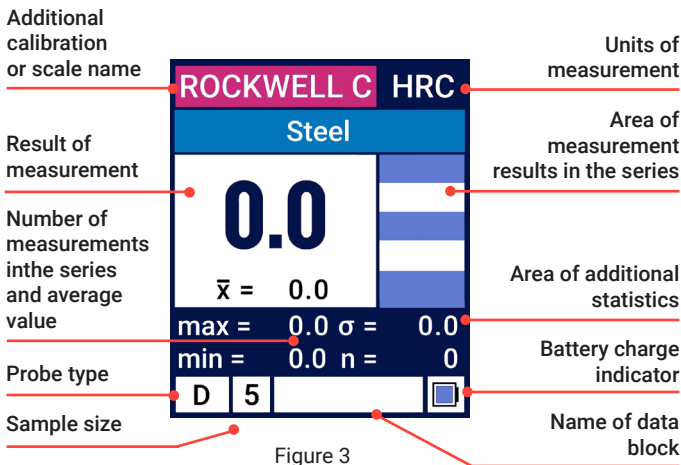
2.3.2 For probes with a built-in connecting cable plug, connect the cable to the plug located on the probe.

2.3.3 Connect the cable to the respective plug on the side wall of the electronic unit.

2.3.4 Switch on the hardness tester instantly by pressing button .

2.3.5 The display will generally appear as shown in Figure 3.

2.3.6 Select the type of probe when using a Leeb probe.



The display image may differ from that shown in Figure 3, depending on the previous settings of the hardness tester.

## 2.4 HARDNESS TESTER SERVICEABILITY CHECK

2.4.1 Prepare a set of 2<sup>nd</sup> grade hardness test blocks (samples) and secure plate as per your local standard according to the requirements of section 1.3.6 "Measurements on light and thin-walled articles".








The test blocks should have valid metrological certification.

Secure the test blocks to the plate following the procedure set forth in section 1.3.6 "Measurements on light and thin-walled articles".

2.4.2 To check serviceability of the hardness tester with reference to additional calibrations of hardness tester scales or to additional scales, it is necessary to prepare the respective hardness test samples.

Handle the samples as required in section 1.3.6 "Measurements on light and thin-walled articles".

2.4.3 Prepare and switch on the hardness tester according to the requirements set forth in section 2.3 "Powering on and preparation for work".

2.4.4 With buttons    ,  ,  select the measurement scale used or additional calibration of the scale ( buttons  ,  ). Control of the hardness tester during measurements is detailed in section 2.6 "Measurements mode".

2.4.5 Perform minimum 5 measurements on each sample (test blocks) in accordance with section 2.2 "Hardness measurement procedure" and calculate the average value.

It is recommended to calculate average value by selecting respective sample size and by using the respective hardness tester functions (see section 2.6 "Measurements mode").

2.4.5 Perform minimum 5 measurements on each sample (test blocks) in accordance with section 2.2 "Hardness measurement procedure" and calculate the average value.

It is recommended to calculate average value by selecting respective sample size and by using the respective hardness tester functions (see section 2.6 "Measurements mode").

2.4.6 Estimate the measurement error and compare the obtained results with certificate data of the test blocks (samples).

2.4.7 If the difference between measurement results and certificate data of samples (test blocks) does not fall outside permissible limits, it is possible to start measuring the articles intended for inspection.

2.4.8 If the difference between measurement results and certificate data of the samples (test blocks) exceeds the permissible error, it is necessary to perform scale calibration using reference hardness samples (additional calibration with hardness samples – i.e. correctly set up an additional scale).

Respective procedures are detailed in section 2.15.2 “Scales calibration”, 2.15.3 “Additional calibration set up”.

## **2.5 PROCEDURE FOR HARDNESS MEASUREMENT ON INSPECTED ARTICLES**

2.5.1 Check conformity of article(s) under inspection with requirements of section 1.3.4 “Requirements for articles under inspection”. If required, ensure conformity to the requirements by performing the necessary actions stated therein.

2.5.2 If necessary, prepare additional accessories as per section 1.3.3 “Additional devices and accessories”.

2.5.3 Additionally, refer to section 1.3.7 “Measuring of hardened surface layers, galvanic coatings, and surface deposits hardness” and section 1.3.9 “Influence of article surface layers properties”.

2.5.4 Check hardness tester serviceability as per section 2.4 “Hardness tester serviceability check”.

2.5.5 If necessary, select measurement scale and additional calibration as per section 2.6 “Measurements mode”.

2.5.6 If necessary, set up averaging parameters (generally, recommended sample size - minimum 5) as per section 2.10 “Setting averaging parameters” and as per section 2.11 “Displaying data on the screen”.

2.5.7 If necessary, set up an alarm of measurement results falling outside the required range as per section 2.12 “Setting control thresholds”.

2.5.8 If necessary, set up or select the memory block to record measurement results as per section 2.16 “Memory management”.

2.5.9 If necessary, set up other service settings of the hardness tester.

2.5.10 Perform hardness measurement of article(s) under check in conformity with measurement and parameter averaging set up procedures as per section 2.2 “Hardness measurement procedure”.

Result of hardness measurement and additional statistical processing to be observed on display as per section 2.6 “Measurements mode”.

If necessary, store hardness measurement results in the memory as per section 2.6 “Measurements mode”.

Repeat such number of cycles as may be required.

2.5.11 If necessary, analyse and/or withdraw the stored data to the computer as per section 2.16 “Memory management”.



2.5.11 If necessary, analyse and/or withdraw the stored data to the computer as per section 2.16 “Memory management”.




2.5.12 Power off the device as per section 2.18 “Hardness tester shutdown”.

## 2.6 MEASUREMENTS MODE



The hardness tester is ready for measurement immediately after switching on.

Measurements are made in accordance with section 2.2. “Hardness measurement procedure”.

**The scales are selected** using the buttons  ,  with their names and units of measurement displayed in the appropriate place on the display.

**Quick selection** of the main scales is also performed using the buttons   .

When switching scales, the hardness tester automatically converts the results into the selected scale. Scale selection can also be made through the hardness tester menu.

**The choice of additional calibrations** to the scales of the hardness tester is made using the buttons  ,  , with their names displayed in the appropriate place on the display.

**The choice of dynamic Leeb probe type** is made through the hardness tester menu. The type of ultrasonic probe does not require selection.

**The choice of the type of controlled material** (only when using dynamic Leeb probes) is made through the hardness tester menu.

**Sample size**, the number of measurements in the series for which the readings are averaged, and additional statistical processing are performed through the hardness tester menu.



**Presentation of data on the display** - the presentation of results

on the display (numeric or chart) and additional statistics displayed during the measurement process are configured through the hardness tester menu.

**To access the menu**, briefly press the  button.



**The thresholds for control** are set through the hardness tester menu. All measurement results beyond these thresholds will be displayed in red.

When making a series of measurements equal to the set sample size, the display shows the average value of the entire series of measurements - **the measurement results**.

The mode for automatic rejection of maximum and minimum readings in a series of more than 5 measurements can be set through the menu. To complete a series of measurements ahead of time press the  button. **The recording of measurement results** into memory is done by long pressing the button . The result will be recorded in the previously created and selected memory block.

## 2.7 PROBE TYPE SELECTION

To set the type of Leeb probe used, select the menu items <MEASUREMENT MODE> - <PROBE TYPE>.

In the list that appears (Fig. 4), select the type of probe and click the  or  button.

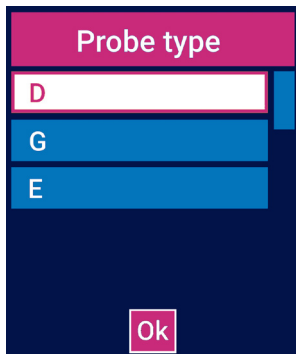




Figure 4

## 2.8 SELECTION OF CONTROLLED MATERIAL

To select the type of material to be inspected (not available for the ultrasonic probe), select the menu items <MEASUREMENT MODE> - <MATERIAL>.

In the list that appears (Fig.5), select material and click the  or  button.

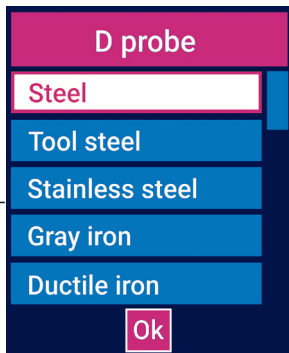




Figure 5

## 2.9 HARDNESS SCALE SELECTION

To select the hardness scale, you select the menu items <MEASUREMENT MODE> - <SCALE>.

In the list that appears (Fig.6), select the scale and click the  or  button.

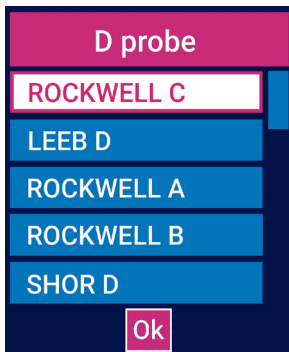









Figure 6


## 2.10 SETTING AVERAGING PARAMETERS

To enter the mode, select the menu items <DATA PROCESSING> - <AVERAGE>.

In the appeared window (Fig. 7), select the desired option using the buttons , . Set the desired value using the buttons , . Press  or .

To return to the menu, click the  button, or select the "Ok" button image and press the  button.

**NOTE:**

You can use the virtual keyboard to enter digits (e.g. the sample size). To do this, select a numeric parameter and press the  button.

Set the value using the keypad (Fig. 8).

To remove the keyboard, press the  button.

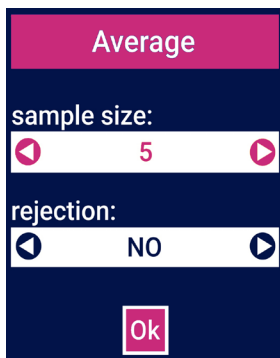


Figure 7

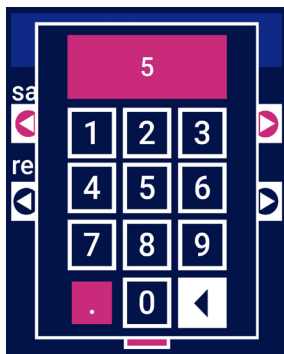






Figure 8

**2.11 DISPLAYING DATA ON THE SCREEN**

To enter the mode, select the menu items **<DATA PROCESSING>** - **<OUTPUT SETTINGS>**.

In the appeared window (Fig. 9), select the desired option using the buttons , .

Then press ,  to set the desired value.

To return to the menu, press the  or  button.

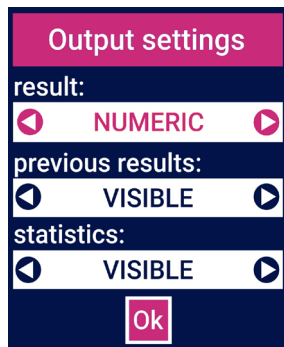








Figure 9

## 2.12 SETTING CONTROL THRESHOLDS

Select the menu items <DATA PROCESSING> - <LIMITS> to enter the mode.

In the appeared window (Fig. 10), choose the alarm type (no alarm, more/ less than the threshold, out of range) and the threshold values themselves using the buttons , , , . You can use the virtual keyboard to set numeric values (see note in section 2.10 "Setting averaging parameters").

Press the  button, or the "Ok" button image and press , to return to the menu.

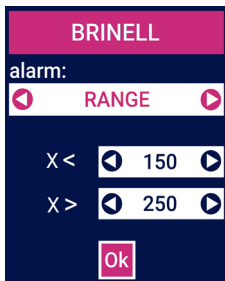
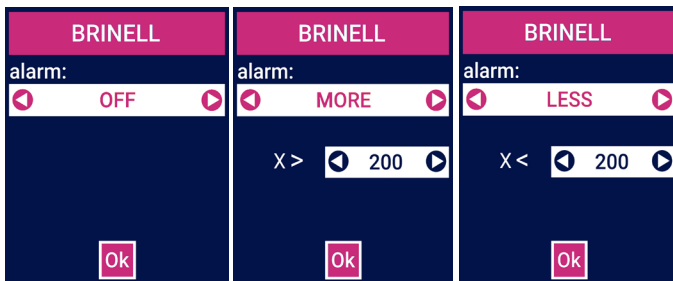


Figure 10

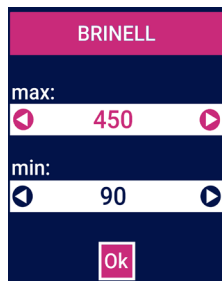








Figure 11

## 2.13 SETTING DIAGRAM THRESHOLDS

To enter the mode, select the menu items <DATA PROCESSING> - <FIGURE>.

In the appeared window (Fig. 11), use the , , ,  buttons to set the limits of the figure.

Use the virtual keyboard to set numeric values. (see the note in section 2.10 "Setting averaging parameters"). To return to the menu, press the button  or select the "Ok" button image and press .

## 2.14 SCALES CALIBRATION

### 2.14.1 GENERAL INFORMATION

The process of calibrating hardness tester scales, including additional scales, involves aligning the **average** readings obtained from hardness test blocks (samples) with the nominal hardness specified in their certification.

The nature of the calibration process involves adjusting the manufacturer's initial settings.

- Calibration of hardness tester scales allows recovering accuracy of readings in case there is an additional error in measurements caused by natural wear of hardness tester mechanical parts.
- Calibration of hardness tester scales should be carried out with the use of minimum 2<sup>nd</sup> grade test blocks as per standard. Test blocks should have valid metrological certification.
- Calibration of hardness tester scales **does not affect** additional calibrations of hardness tester scales.
- Calibration of main hardness tester scales **does not affect** reference hardness tester scales.
- Setting up additional calibrations of hardness tester scales allows checking metal articles which differ in properties from carbon structural steels (ref. section 1.3.5 "Working with non-carbon structural steel articles").

Additional calibrations of hardness tester scales may be set up by the user or at manufacturer's production facilities upon the user's request. Setting up additional hardness tester scales calibrations should be carried out with the use of hardness samples fabricated in compliance with section 1.3.5 "Working with non-carbon structural steel articles".

During the hardness tester supply process, all additional calibrations are equal with calibration of respective hardness tester scale (if not set up in advance upon user's request).

Calibration may be carried out either with two or with one test block (sample).

Calibration with one test block (sample) is possible in cases where such a procedure can provide permissible measurement errors within the required range.

### **ATTENTION!**

- Calibration of hardness tester's main and reference scales should be carried out **ONLY** if unacceptable error in the hardness tester's operation within the respective scales occurs.
- The presence of unacceptable error should be determined using 2<sup>nd</sup> grade test blocks as per standard, which have proper
- metrological certification as per section 2.4 "Hardness tester serviceability check".
- Before starting calibration of the hardness tester's main or
- reference scales, **it is recommended** to ensure that unacceptable error is not caused by improper calibration of the scale carried out earlier. For this purpose, restore hardness tester to factory settings of the said scale as per section 2.14.4 "Calibration deletion". After that, check its serviceability as per section 2.4 "Hardness tester serviceability check".

### **2.14.2 SCALE CALIBRATION**

To calibrate hardness tester scale, prepare the respective 2<sup>nd</sup> grade test blocks as per standard, which have valid metrological certification.

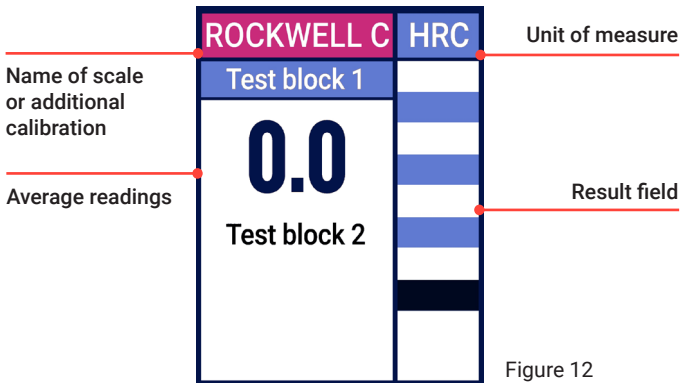
Before calibration it is necessary to secure the test blocks on the support plate as per section 1.3.6 "Measurements performed on light and thin-walled articles".

To enter calibration mode, select the appropriate scale of the hardness tester (see section 2.6 "Control and results submission during the measurement"), then enter the **MENU** and select <CORRECTION> - <CORRECTION>.

**NOTE**







Password is: , , , , .


Then, it is expected that the display of the hardness tester will conform to Figure 12.





Carry out several measurements (at least 5) following section 2.2. “Hardness measurement procedure” on the test block with the lowest hardness value, moving the probe along the surface.

During this process, measurement results will be displayed in the “Results” field, while the “Test block 1” field will show average readings (obtained using a rejection algorithm as per section 2.10 “Setting averaging parameters”).

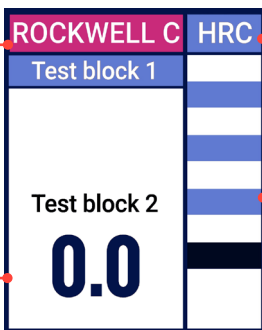
Use buttons ,  to adjust the average reading values to match the certificate (nominal) values of the test block, thereby completing calibration with the first test block by pressing button  (if you press button  without previously pressing buttons ,  readings will be reset to zero, allowing for new measurements). After this, the display will resemble the image below (Figure 13).

If you are performing calibration with one test block, press button . The display will confirm the completion of calibration with one test block, after which the hardness tester will return to the menu.

If calibration with two test blocks is being carried out, perform measurements on the second test block as described above. Set its certificate value and press button . The display will confirm the completion of calibration with two test blocks, after which the hardness tester will return to the menu.

It is possible to cancel calibration with the second test block at any moment by pressing button .

Name of scale or  
additional calibration



Unit of measure

Result field

Average readings

Figure 13

The hardness tester will return to the menu and will provide a message in advance confirming the completion of calibration with one test block. This option is available if, during measurements, it becomes evident that calibrating with one test block is sufficient to correct the error. After calibration, it is necessary to check hardness tester's serviceability as per section 2.4 "Hardness tester serviceability check".

### 2.14.3 ADDITIONAL CALIBRATION SETUP

To set up an additional calibration of the hardness tester scale, it is necessary to prepare hardness samples in accordance with the requirements outlined in section 1.3.5 "Working with non-carbon structural steel articles".

Before calibrating with a hardness sample, it is necessary to follow the procedures outlined in section 1.3.6 “Measurements performed on light and thin-walled articles”.

To enter additional calibration mode, select the necessary hardness tester scale and additional calibration to be defined (see section 2.6 “Measurements mode”). Then, return to the menu and select **<CORRECTION>** - **<CORRECTION>**.

The subsequent procedure is similar to the hardness tester calibration procedure detailed in section 2.14.2 “Scale calibration”.

#### 2.14.4 CALIBRATION DELETION

The function to delete scale (or additional) calibration is used to revert calibration to the manufacturer’s settings.

To select this function, choose the required hardness tester scale (or additional calibration) (see section 2.6 “Measurements mode”).

Then, return to the menu and select **<CORRECTION>** - **<CLEAR>**.

Afterward, the hardness tester will prompt for confirmation of calibration deletion. Upon confirmation, the calibration will be deleted, and the hardness tester will display a confirmation message and return to the menu.

During additional calibration deletion, only the calibration itself will be deleted, while the calibration name (see section 2.14.5 “Additional calibration name setup”) will remain unchanged.

#### 2.14.5 ADDITIONAL CALIBRATION NAME SETUP

To assign a name to the additional calibration, first select the required one. Then, in the menu, navigate to **<CORRECTION>** - **<CELL NAME>**.

Using the virtual keyboard (Fig. 14), enter the name (refer to the note in section 2.10 “Setting averaging parameters”).







Figure 14

## 2.15 POWER-SAVING MODE SETTINGS

To configure energy-saving modes, select the menu items

<SETTINGS> - <ENERGY SAVING>.

Then, in the appeared window (Fig. 15), use the , , ,  buttons to set the automatic shutdown time and the duration for display backlight to turn off.

To return to the menu, press the button  or .

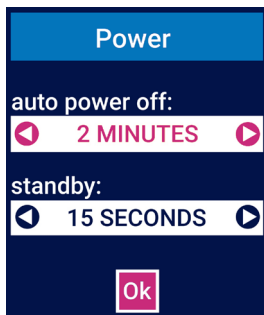


Figure 15

## 2.16 MEMORY MANAGEMENT

### 2.16.1 GENERAL INFORMATION

The hardness tester enables the user to organise versatile measurement data archive in the hardness tester memory and transfer the data to a computer.




The archive is structured into individualised memory blocks. Measurement results are recorded into these memory blocks (see section 2.6 “Measurements mode”).




The user defines the memory blocks (for example, a block containing hardness measurement results obtained from a specific article). Each memory block may contain results of measurements using the same units of measure (by a single scale).

Accessing the data archive is done via the <MEMORY> option in the hardness tester menu. The structure of the corresponding submenu is illustrated below (Fig. 16).

### 2.16.2 CREATING A NEW BLOCK

To create a new block, select the <MEMORY> menu item.

Next, in the «Memory» window (Fig. 16), use the ,  buttons to select the “+” button image and press . Then, in the subsequent window (Fig. 17) enter the block name and select the scale.

To return to the «Memory» window, click the  or “Ok” button image and click .  
To exit the «Memory» window in the menu, press the  button.

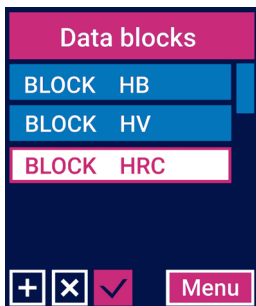


Figure 16

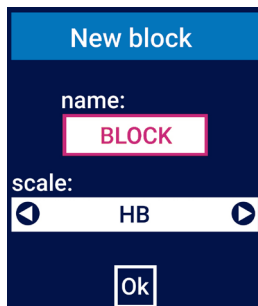








Figure 17

### 2.16.3 SELECTION OF A BLOCK FOR RECORDING




To choose a data block for recording measurement results, navigate to the “Memory” window (see section 2.17.2 “Creating a new block” and Fig. 21), using the buttons  ,  , select the “V” button image and press .

#### **NOTE:**

Alternatively, block selection can also be performed through the block’s menu.




In the «Memory» window, use the  ,  buttons, select “Menu” button image and press . The block menu will appear on the display. Managing actions within the block menu are identical to those in the main menu of the hardness tester.

### 2.16.4 DELETION OF A BLOCK

To delete a data block, navigate to the «Memory» window (see section 2.16.2 “Creating a new block” and Fig. 16), use the buttons  ,  select the “X” button image and press .

**NOTE:**



Alternatively, block selection can also be performed through the block's menu.

In the «Memory» window, use the  ,  buttons, select "Menu" button image and press . The block menu will appear on the display. Managing actions within the block menu are identical to those in the main menu of the hardness tester.



**2.16.5 VIEWING BLOCK DATA**

To view the recorded results within a block, select the <RESULTS> menu item within the block's menu (see note in section 2.16.3 "Selection of a block for recording").

The saved measurement results will appear in the subsequent window.

Scroll through the table, using the  ,  buttons. If thresholds are set for this block, results beyond the threshold will be highlighted in red (Fig. 18).

Threshold values can be set via the block menu item <SETTINGS> <LIMITS>.

Statistics for this unit are displayed below the table. To return to the menu, press the button  or .

BLOCK	HV
1:	1935
2:	1960
3:	1931
4:	1925
5:	1902
$\bar{x}$ =	1931 max = 1960
$\sigma$ =	18 min = 1902

Figure 18

**2.16.6 DIAGRAM DISPLAY**



To plot a chart based on the results recorded in the block, select the <FIGURE> item in the block menu (see note to section 2.16.3 "Selection of a block for recording").

A diagram (Fig. 19) will display based on the saved measurement results. If thresholds are set for this block, columns outside the threshold will be highlighted in red.

Set the threshold values via the block menu item <DATA PROCESSING> <LIMITS>.

Adjust the chart's threshold values through the block menu item <DATA PROCESSING> <FIGURE>.

Below the chart, you will find the statistical results for this block.

To return to the menu, press the button  or .

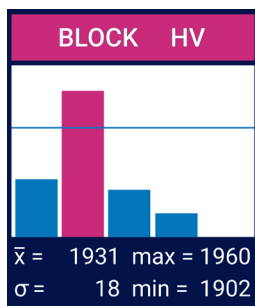


Figure 19

### 2.16.7 CLEARING THE BLOCK

To delete all data from the block, select the menu item <CLEAR> in the block menu.

### 2.16.8 BLOCK NAME CHANGE

To change the name of the block, select the menu item <NAME> in the block menu.

### 2.16.9 DATA TRANSFER TO A COMPUTER

To transfer data to a computer, install and launch the software provided with the hardness tester. Follow these steps:

- Ensure the hardness tester is turned on if it is currently off
- Connect the supplied USB cable to the connector located on the side wall of the electronic unit.
- Connect the other end of the cable to one of the USB ports on your computer.

### 2.17 BATTERY CHARGE MONITORING

Operational monitoring of the battery status is provided. The current battery charge is displayed in the measurement mode.

When the battery charge reaches a critical low level, a flashing battery icon will appear on the display accompanied by an audible beep, after which the hardness tester will automatically turn off.


To recharge the battery, connect the hardness tester to a charger or a USB port on a computer using a USB cable. While charging, the battery icon on the display will periodically fill with colour.

### **ATTENTION!**

Do not leave the device unattended during the charging.

## **2.18 HARDNESS TESTER SHUTDOWN**

The hardness tester can be turned off in the following ways:

- Press and hold button  for 0,5-1 second, then release
- Select < **OFF** > from the men
- Allow the device to automatically turn off after a period of inactivity, as specified in section 2.15 "Power saving mode settings"

## **3. TECHNICAL MAINTENANCE**

Regular technical checks ensure the hardness tester operates reliably throughout its service life. Follow these steps at least once a year:

- Verify the hardness tester's completeness as per section 1.4 "Completeness of the hardness tester".
- Conduct a visual inspection to ensure there are no mechanical damages to the electronic unit, probe, and connecting cable.
- Check the hardness tester's functionality as described in section 2.4 "Hardness tester serviceability check".
- Address any identified defects that cannot be resolved to the manufacturer.

## **4. TRANSPORTATION AND STORAGE**

4.1. The hardness tester may be transported using railway, road, sea, or air transport, ensuring it is securely packaged according to relevant shipping regulations for the chosen method of transport. For air transport, ensure the device is transported in sealed and heated compartments.

4.2. Store the hardness tester inside its case in a closed, heated room with an air temperature of  $25\pm 10^{\circ}\text{C}$ , relative humidity between 45% and 80%, and atmospheric pressure of 630 to 800 mm Hg. The storage area should be free from fungus, acid vapours, reagents, paints, and other chemicals.

Avoid sharp fluctuations in air temperature and relative humidity to prevent dew formation in the storage area.

4.3. If the storage period exceeds two months, the batteries should be removed from the electronic unit.

## **5. SAFETY MEASURES**

5.1 The hardness tester is a technically sophisticated device that requires careful handling. It should be protected from:

- Impacts or loads that could cause mechanical damage
- Exposure to aggressive chemicals
- Ingress of liquids
- Prolonged exposure to sunlight
- Other factors that may compromise its operation

5.2 During measurements, it is crucial not to deviate from the hardness measurement sequence outlined in section 2.2 "Hardness measurement procedure", as this could lead to subsequent breakdown of the hardness tester.

5.3 Using the hardness tester in conditions of sharp fluctuations in ambient air temperature is not permissible. In case of such fluctuations, the hardness tester should remain switched off for at least 1 hour.

5.4 Using batteries that are not authorized by the manufacturer with the hardness tester is prohibited.

5.5 Opening the electronic unit or probe compartments and attempting repairs on the hardness tester without supervision is strictly prohibited.

## **6. RECYCLING**

Upon expiry of its service life, the hardness tester poses no hazard to human life, health, or the environment and does not require specific recycling procedures.

Hardness tester batteries are disposed of in accordance with relevant applicable regulations.

## **7. MANUFACTURER'S WARRANTY**

7.1 The manufacturer hereby guarantees that the hardness tester complies with the requirements, "The Hardness Testers: Portable, Ultrasonic, Model TKM-359CE," for the entire warranty period.

The warranty period for the hardness tester is 24 months from the date of purchase (up to a maximum of 30 months from the date of manufacture), provided that the operation, maintenance, transportation, and storage requirements specified in this Operation Manual and the accompanying technical passport are observed.

7.2. Warranty and post-warranty repairs are carried out at the manufacturer's facilities.

7.3. If defects are detected in the hardness tester during the warranty period, the user must present an Act specifying the need for defect correction. The hardness tester, along with a copy of the Act, should be delivered to the manufacturer or the manufacturer's representative (supplier).

7.4. Hardness testers that have been damaged due to the violation of operating, safety, maintenance, transportation, or storage regulations, mechanical damage (excluding normal mechanical wear), or exposure to liquids or other conditions leading to tester failure are not covered under warranty.

7.5. Hardness testers with broken protective seals (stickers) on the electronic unit or probe casings, or with evidence of tampering or unauthorized repair attempts, are not covered under warranty.

7.6. The manufacturer's warranty does not cover batteries or third-party accessories (such as chargers and grinding machines) included in the same delivery set as the hardness tester.

7.7. The manufacturer's warranty does not cover natural wear of components (such as cables and probes) due to heavy-duty operation.

7.8. Warranty repairs will only be carried out upon presentation of this Operation Manual along with the hardness tester's technical passport.

## 8. ACCEPTANCE CERTIFICATE

The hardness tester TKM-359CE, serial number \_\_\_\_\_,  
complies with the requirements and is certified as fit for operation.

Date of issue:

Person in charge for acceptance:

\_\_\_\_\_ 202\_\_\_\_\_ / \_\_\_\_\_

Stamp

Date of sale \*:

Supplier:

\_\_\_\_\_ 202\_\_\_\_\_ / \_\_\_\_\_

Stamp

The "date of sale" field must be completed by the hardness tester supplier. If this field is left blank, the **release date** of the hardness tester will be considered the date of sale.

**NPP Mashproject LLC**

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