NOVOTEST

Combined Hardness Tester
NOVOTEST T-UD3

Operating Manual

2019

CONTENT

Caution!
Please read this manual carefully before using the NOVOTEST T-UD3 hardness tester.

This operating manual (hereinafter O.M.) includes general information in order to give the operating personnel understanding of functioning and operating rules of the NOVOTEST T-UD3 hardness tester (hereinafter referred to as the device or hardness tester). The document contains technical characteristics, description of the design and principle of operation, as well as information necessary for the correct use of the device. Before starting work, it is necessary to read this manual, as the device operation must be carried out by persons who are familiar with the operation principle and the device design.

Correct and effective use of the hardness tester requires obligatory availability:

- Testing methods;
- Conditions for testing, according to testing methods;
- Trained, and familiar with this O.M. user.

The enterprise-manufacturer reserves the right to make non-critical changes, without making worse technical characteristics of the device. These changes may not be mentioned in the text of current document.

The standard delivery kit of the device includes the operational documentation as a part of this O.M. and the SERVICE AND MAINTENANCE RECORDS.

The present O.M. applies to all modifications of the device: T-UD3, T-U3, T-D3.

Terms used in this manual:

Hardness testers for metals – are used for material hardness testing, without destroying its structure.

Hardness – property of a material to resist the elastic and plastic deformation, or destruction when another material that is more solid is incorporated into the surface layer and takes no deformation of its body - an indenter.

Indenter – an element of the device pressed into the testing material for measuring its hardness. Diamonds, hard alloys, hardened steel are used for manufacturing indenters.

Young's modulus (modulus of longitudinal elasticity) – physical value characterizes the properties of the material to resist tension, compression under elastic deformation.

Leeb method – to measure the hardness of the material, the rebound method is used (the ratio of the speed of the impact body before and after the impact).

Ultrasonic Contact Impedance (UCI) – measuring the degree of change (damping) of the vibration frequency of the rod with the indenter at the end when penetrating into the surface of the testing sample. The softer is metal the dipper indenter penetrates into it, and the bigger is square of the contact and higher degree of damping of the vibration frequency (in the ultrasonic range).

Kalman filter – an effective recursive filter that estimates the vector of a dynamic system state using a series of incomplete and noisy measurements.

Median filter – one of the digital filter types, widely used in digital signal processing to reduce noise. The median filter is non-linear FIR filter. Median filtering is an efficient procedure for processing signals influenced by impulse noise.

1 DESCRIPTION AND OPERATION OF THE DEVICE AND ITS COMPONENTS

1.1 The purpose of the device

The device is designed to measure hardness of:

- metals and alloys on the Rockwell (HRC), Brinell (HB), Vickers (HV), Leeb (HL), Shore (HS) hardness scales and others;
- surface layer of metal subjected to fusing, spraying, mechanical, thermal and other types of metal surface treatment;
- cast iron, stainless steels and non-ferrous alloys, using the calibration mode on non-standard hardness test blocks;
- measuring of the tensile strength (σv) for stretching products from carbonaceous steels of the pearlite class by automatic recalculation from the Brinell hardness scale (HB).

The Hardness Tester allows instant analysis of the hardness of the product directly at the site of operation or production of the product in workshop, laboratory and field conditions, for example, in machine building, metallurgy, power engineering, shipbuilding and railway transport, aerospace and oil and gas industry, repair and installation and service organizations etc.

The objects of measurement can be: pressure vessels for various purposes (reactors, steam generators, collectors, boiler drums, gas holders, etc.), rotors of turbines and generators, pipelines, rolls, crankshafts, gears, parts of various vehicles, industrial semi-finished products (castings, forgings, sheets), etc. Also, the hardness tester can be used for:

- assessing the stability of technological processes (product processing, welding, etc.);
- diagnostics of equipment, in order to evaluate its residual safe resource (control of hardness of pipelines, boilers, etc.);
- assessing the quality of performed repairs;
- heat treatment quality evaluation.

1.2 Technical characteristics of the device

The NOVOTEST T-UD3 hardness tester is a portable device made in an impact-resistant housing (with a special protective silicone bumper-case for complicated operating conditions) inside which a board with electronic components and accumulators are placed. The main characteristics of the device are presented in Table 1.1, Table 1.2 shows the ranges of measurements, and characteristics of probes are in Table 1.3.

Table 1.1 - The main characteristics of the device

Overall dimensions, mm	180x80x35
Powered by three NiMH batteries or AA batteries	each 1,2 V
Power supply current, not more than, mA	100
Time of continuous operation, not less than, h	10
Weight of electronic unit with batteries, not more than, g	250
Operating temperature range, ° C	from -20 to +40
Humidity, not more, %	from 30 to 80

Table 1.2 - Measurement range and limits of the basic permissible error

Hardness scale	Measurement range	Measurement error	
		U1	Leeb
Rockwell, HRC	From 20 to 70	±2	±2
Brinell, HB	from 90 to 150	±10	±10
Brinell, HB	from 150 to 650		±15
Vickers, HV	from 240 to 500	±15	±15
Vickers, HV	from 500 to 940		±20
Leeb, HL	from 300 to 800	–	±4
Shore, HS	from 30 to 100	Is determined when markup	
Strength limit σv (reference), MPa	from 370 to 1500	Is determined when markup	

Table 1.3 - Characteristics of probes

Probe Type	U1 (98 N)	U1 (50 N)	U1 (10 N)	Leeb
Overall dimensions, mm	Ø30x140	Ø30x140	Ø30x140	Ø20x145
Weight, g, not more than	250	250	250	130
Roughness of the measured surface, Ra	3,2	2,5	1,5	3,2
Radius of curvature of the measured surface, mm	5	5	5	10
Weight of the controlled product, not less than, kg	0,1	0,1	0,1	5
Thickness of the controlled product, not less than, mm	1,5	1	0,8	12
Load, kgf	10	5	1	-

The device corresponds to: ASTM A956 “Standard Test Method for Leeb Hardness Testing of Steel Products”; ASTM A1038 “Standard Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method”.

Device body protection.

Level of the device body protection from penetration of solids and water is according to required standard.

MTBF

Mean time between failures (MTBF) of the device without taking into account the reliability factor of the probes is not less than 6000 h.

Service time

The total average service life of the device is not less than 10 years.

The criteria of decommissioning of the device - economic inexpediency of restoring the operable state of the components of the instrument by repairing.

1.3 Standard delivery set

- Electronic Unit ..... 1 pc.
- Rebound Leeb Probe ..... Availability - according to the order
- Ultrasonic Contact Impedance Probe U1 (98 N) ..... Availability - according to the order
- Ultrasonic Contact Impedance Probe U1 (50 N) ..... Availability - according to the order
- Ultrasonic Contact Impedance Probe U1 (10 N) ..... Availability - according to the order
- Rechargeable battery ..... 3 pc.
- Charger ..... 1 pc.
- USB cable for PC ..... 1 pc.
- Case ..... 1 pc.
- Operating manual NOVOTEST.T-UD3 ..... 1 pc.

Additional equipment:

- Hardness test blocks (HRC, HB, HV, HLD, etc.) ..... If ordered
- Cordless grinder ..... If ordered

* At the request of the customer, the delivery set can be expanded with additional equipment or parts. The exact information about the delivery set is indicated on the separate document.

1.4 Purpose of the probes

The Rebound Leeb Probe (Figure 1.1, Rebound Leeb Probe) – purposed for hardness measurement by dynamic method. It is intended for measuring hardness of large-sized objects, and also coarse-grained materials.

The UCI Probe U1 (Figure 1.1, Contact Impedance (UCI) Probe U1) - Measurement of hardness by Ultrasonic Contact Impedance method. The use of a diamond indenter allows the probe to be mounted precisely at any tiny point, and leaves a small-size imprint, making the measurement of the U1 the least destructive.

The probe is perfectly suited for the following tasks: measuring the hardness of complex shapes, fine-grained materials, heat-treated materials, thin layers and coatings, surface hardened parts, thin-walled pipes, small parts, etc.

Table 1.4 shows the characteristics of the UCI U1 type probes.

Rebound Leeb Probe UCI Probe U1

Figure 1.1 - Types of probes

Table 1.4 - Features and applications of UCI U1 probe type

Model	Load	Features	Main applications
UCI U1 (98 N)	98 N (10 kgf)	The main type of probe for solving most problems of hardness measurement. 10 kg load is to be applied for measurement (set automatically by the probe). Low requirements for surface cleanliness.	– Heat-treated and cemented details. – Measuring in grooves, on teeth, on radius surfaces. – Measurement on the blades, on the internal surface of the pipes, openings.
UCI U1 (50 N)	50 N (5 kgf)	The main probe type for the most tasks of hardness measurement. 5 kg load is to be applied for measurement (automatically controled by the probe). Average surface cleannes requirements.	– Heat-treated and cemented parts, for example, shafts, turbines, gears, teeth, welds, heat affected zones. – Measuring in grooves, on teeth, in grooves, on radius surfaces. – Measurement on the blades, on the internal surface of the pipes, openings.
UCI U1 (10 N)	10 N (1 kgf)	The reduced load probe is designed to measure the hardness of material with increased requirements to the imprint size (polished surfaces), to measure the hardness of surface hardened layers. 1 kg load is to be applied for measurement (automatically controled by the probe). More sensible to the surface cleanliness, in comparison with U1 (50 N).	– Nitrided and cemented surface layers of molds, stamps, stamps, thin-walled parts. – Bearings, lateral surfaces of saws teeth. – Measurement of hardness of hardening coatings. – Measurement on the blades, on the inner surface of the pipes, inside the holes.

1.5 Parts

The device consists of an electronic unit made of impact-resistant ABS plastic and placed into a protective silicone bumper, and connected probes. The detachable connection is located on the upper end surface of the housing; there is also a mini USB connector, which is used to connect the device to PC or to charge the batteries. The control keyboard is located on the front panel, which also houses a contrasting color LCD / TFT display. In the lower rear part of the device under the cover, fixed with the threaded connection with the help of two screws, there is a battery compartment in which the batteries are installed (Figure 1.2). In Figure 1.3, it shows the control keyboard of the device.

1– bumper; 2 – LCD/TFT color contrast display; 3 – NiMH battery; 4 – control keyboard; 5 – battery compartment; 6 – electronic unit; 7 – probe socket; 8 – flash light; 9 – photo camera; 10 – mini USB socket; 11 – cover; 12 – threaded connections for cover.

Figure 1.2 - Hardness tester NOVOTEST T-UD3

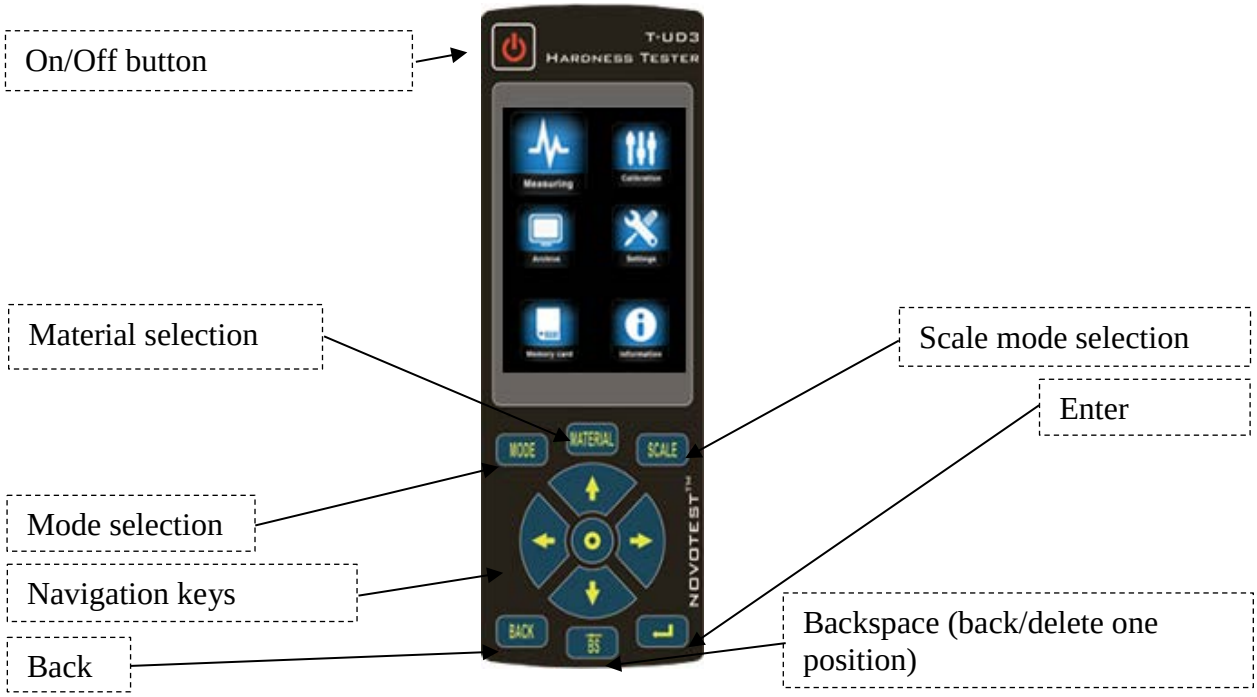
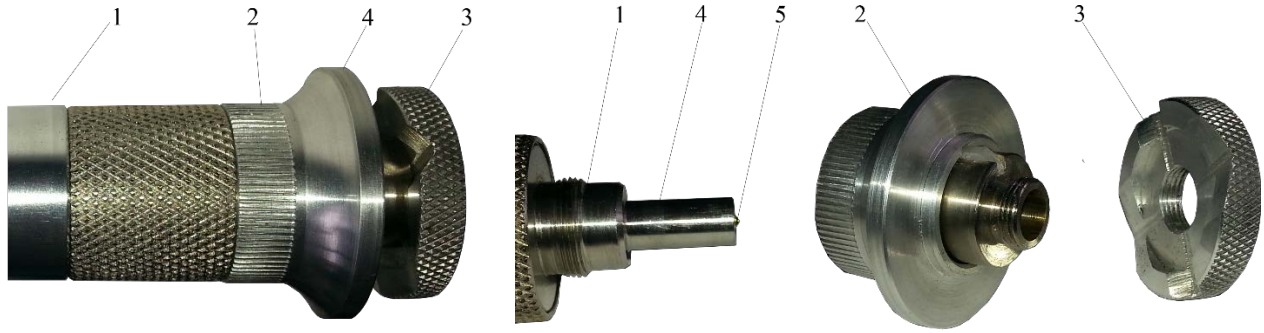


Figure 1.3 - Control buttons and their functional purpose

1.5.1 Ultrasonic Contact Impedance Probe U1 probe

The construction of the probe is shown in Figure 1.4 The probe has a special removable collapsible head with a double-sided thrust washer. The thrust washer provides the convenience of positioning the probe onto the testing product and pressing during the measurement.



1 – housing; 2 – removable collapsible nozzle;
3 – removable double sided thrust washer;
4 – support platform.

1 – housing; 2 – removable collapsible nozzle;
3 – removable double sided thrust washer;
4 – centering pipe; 5 – diamond tip.

Figure 1.4 - Appearance of the Ultrasonic Contact Impedance Probe U1

One side of the washer is flat; the other has prismatic grooves designed for the convenience of measuring hardness on cylindrical products of different diameters. The probe with the removed washer is used for carrying out of measurement of hardness in narrow and hardly accessible places.

To measure hardness on flat surfaces, the washer on the probe head should be installed flat to the surface of the product, and to measure the hardness on the cylindrical surfaces, the washer on the probe head should be installed with a side with prismatic grooves to the product.

Caution!
To ensure a better smoothness of the collapsible detachable nozzles, they are individually grounded to each probe. Replacement of probe tips is not allowed.

1.5.2 Leeb probe

The Leeb probe has a built-in mechanism for charging the spring, which is the most ergonomic and convenient to work with (Figure 1.5). Spring charging is provided by moving the upper part of the probe housing downwards, after which the probe can be installed on the controlled object and measurement can be done.

Caution!
It is forbidden to discharge the trigger of the Leeb probe “in the air”.

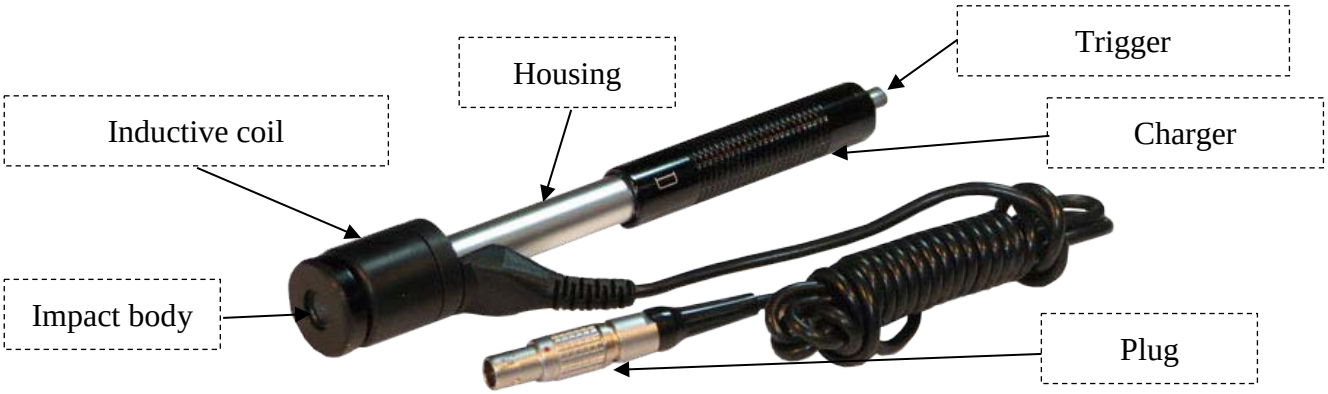


Figure 1.5 - The appearance of the Leeb probe

1.6 Design and functioning

The principle of operation of the hardness tester depends on the type of the connected probe.

When using the Leeb probe, the hardness is measured by the dynamic method of Leeb, and when using the UCI probe - by the ultrasonic contact impedance method.

The dynamic method of measuring hardness is used to control:

- hardness of objects weighing more than 5 kg and wall thickness of more than 10 mm;
- hardness on solid products, products with coarse-grained structure, forged and cast products;
- hardness, if minimal surface preparation is required.

Ultrasonic contact impedance method for measuring hardness is used to measure:

- hardness of objects with low mass (from 0,1 kg) and wall thickness (over 1 mm);
- hardness of products with a glossy surface (if the minimum imprint size is required);
- hardness of the surface hardened layer at the inspection site.

1.6.1 Modes

The hardness tester works in the following modes:

1. <MEASUREMENTS>:
   - Main scales mode (HRC, HRB, HB, HV, HS, HL, MPA);
   - User scales mode (U1, U2, U3);
   - A mode of measurement of hardness of basic materials (steel, alloy steel, stainless steel, gray cast iron, high-strength cast iron, aluminum, brass, bronze, copper);
   - A hardness measurement mode of user materials (<USER 1>, <USER 2>);
   - <GRAPH> mode;
   - <HISTOGRAM> mode;
   - <STATISTIC> mode;
   - <SMART> mode;
   - <SIGNAL> mode.
2. <CALIBRATION>:
   - One or two points;
   - Three points.
3. <ARCHIVE>:
   - Saved measurements view.
4. <SETTINGS>:
   - <DATE>;
   - <TIME>;
   - <LANGUAGE>;

- <PHOTO>;
- <BRIGHTNES>;
- <PALETTE>;
- <SOUND>;
- <RESULT>;
- <VOLUME>;
- <AUTO OFF>;
- <RETRO>;
- <FLASH>;
- <TOLERANCE>;
- <FILTER>;
- <FILTER MODE>.

5. <MEMORY CARD>:
   - <SAVE>;
   - <LOAD>;
   - <CLEAR>.
6. <INFORMATION>:
   - About dealers;
   - About the device.
7. Two-way communication with PC:
   - Data transfer;
   - Transfer of calibration settings;
   - Interface change.

1.6.2 Leeb measurement principle (Leeb)

The dynamic principle probe (rebound method) is a separately executed device connected to the electronic unit by means of a cable.

The principle of measuring hardness is based on the determination of the velocity ratio of impact and rebound of the striker (impact body) inside the probe. Carbide ball is located at the end of the impact body, directly in contacting with the material at the moment of impact. Inside of the impact body is a permanent magnet. The striker, after pressing the trigger button, is ejected onto the testing surface by a pre-charged spring. While this, the striker moves inside the inductor coil and, with its magnetic field, induces an electromotive force (EMF) in it. The signal from the output of the induction coil is fed to the input of the electronic unit, where it is converted into a hardness value of the selected scale and displayed.

This method is particularly suitable for hardness measurements on solid products, coarse-grained products, forged and cast products.

The design of the dynamic probe allows user to make many measurements for a short time, and working with it does not require special skills, such as with an UCI probe.

1.6.3 Ultrasonic Contact Impedance method

Ultrasonic probe (UCI - ultrasonic contact impedance method) is a separate device connected to an electronic unit by means of the cable.

The probe basically uses a steel rod with a diamond pyramid at the end, which is an Acoustic Resonator (Oscillating Rod) of the built-in self-oscillator of ultrasonic frequency. When the diamond pyramid penetrating into the testing object under the fixed force of the calibrated spring, the resonant frequency of the resonator changes in accordance with the material hardness. The relative change in the frequency of the resonator is converted by the electronic unit into the hardness value on the selected scale and displayed.

This method is suitable for hardness measurements on products of various weight and thickness, and especially on finished products with a glossy surface, as it leaves a minimally visible imprint after measurements.

The design of the ultrasonic probe makes it possible to carry out measurements in hard-to-reach places (for example, the surface of gear teeth, etc.), as well as on thin-walled structures (eg. pipelines, etc.) that could not be measured by the Leeb probe.

It should be taken into account that the result of the measurement by the UCI method depends on the Young's modulus of the test sample.

1.7 Means of measurement, tools and accessories

The correct work of the device is checked by the hardness measuring of the reference hardness test blocks (2 category), reference hardness blocks should be grounded through a lubricant layer to the grinding plate weighing not less than 5 kg. Mismatch readings must not exceed the permissible error (Table 1.2). If the permissible error is exceeded, user should calibrate the instrument in accordance with 2.3.7.

In case of device defect the manufacturer is obliged to make adjustment and installation of the device.

1.8 Marking and sealing

There is a label with device type and trademark of the manufacturer on the front panel of the device.

The serial number is printed on the back panel, under the battery compartment cover.

1.9 Packing

The electronic unit and the probe are delivered in a package (case), excluding their damage during transportation.

To avoid mechanical damage to the cable and connectors of the device, it is necessary to disconnect the probe from the device before packing it into the package.

2 INTENDED USE

2.1 Operational limitations

Operation of the device should be carried out under the influence of factors and taking into account the parameters of the monitored objects in accordance with the specified technical characteristics. The device must be used within its technical characteristics.

Only qualified personal, familiar with the operation manual is allowed to use this device.

After transporting the device at temperature below zero to the place of operation and bring it into the room with a positive temperature - it is necessary to keep the device in its package for at least 6 hours in order to avoid failure due to condensation of moisture.

2.2 Preparing the device for use

2.2.1 Visual inspection

Carry out visual external inspection of the device; make sure that there are no mechanical damages to the electronic unit, the probe, the connector and the connecting cable.

2.2.2 Installing the batteries

Install the batteries into the battery compartment by unscrewing the two fixing screws and removing the battery cover. Batteries are to be installed according to the polarity indicated on the device (Figure 2.1). Close the battery compartment cover and screw in the screws.

Figure 2.1 - Installing the batteries

2.2.3 Connecting the Probe

Using the connecting cable connect the required probe to the probe socket on the electronic unit. Connect the connecting cable making sure that the red dot on the plug and socket are in line (Figure 2.2).

Figure 2.2 - Connecting the probe

2.3 Using the device

2.3.1 Preparing the object of testing

Prepare the tested surface area of the material, removing moisture, contamination (oil, dust, etc.), grease, scale, oxide film, and rust from it. Grind it with a grinder or sandpaper and wipe the testing surface.

The roughness and curve radius of the tested surface, as well as the weight and dimensional characteristics of the product, should correspond to the parameters specified in the technical characteristics of the hardness tester (Table 1.3), and consider the type of probe (UCI or dynamic) used for the measurement.

The results of measurements by the UCI method are affected not only by the properties of the metal during plastic deformation, but also by the Young's modulus (modulus of elasticity). It entails the need to adjust the device when working with products that have the Young's modulus different from the Young's modulus of structural and carbon steels.

To determine the additional error presence, user should compare the results of measurements with the measurements carried out according to the static measurement principle. If the difference in the results does not exceed the error of the device, it means that it is possible to carry out measurements according to the characteristic written in the memory of the device with delivery. If the measurement error exceeds the allowed accuracy, a two-point or one-point calibration of the device on the product or sample (see 2.3.7) is necessary.

If the product or hardness value does not respond to the requirements of Table 1.3 (mass and / or thickness), the device will make measurements with additional error. It will be as bigger, as bigger is

deviation from these requirements. The additional error may be, either positive or negative, depending on the specific conditions.

The reason for the additional error is the parasitic vibration at the indenter contact point with the material at the moment of measurement. This is due to the vibration of the whole product, if its weight is low, either because of product deflection if its thickness is small.

To determine the presence of additional error user should compare these measurement results with the measurement results using a bench hardness tester.

There are three methods to delete the additional errors.

The first method – to make the one-point or two-point correction of the current user setting in accordance with clause 2.3.7. It is used if an additional error is not more than 15%, and the results in a series of measurements are constant.

The second method – deleting parasitic vibrations by gripping product in a vise (vise weight should be over indicated in Table 1.3). To prevent damage of the product it is allowed to use the vise with overhead jaws from a softer metal.

The third method (recommended) – deleting parasitic vibrations by grinding the object to a massive polished plate. The plate should have roughness Ra not more than 0.4 microns, obviously greater weight than indicated in Table 1.3, non-flatness not less than 0.005 mm, a Young's modulus of the material from which the plate is made should be close to the Young's modulus of the product. The underside of the product should be plane-polished with a roughness Ra not more than 0.4 microns and flatness should be not more than 0,005 mm. For installation the product on the plate its support surface (underside) should be covered with a thin layer of lubricant. Then the product is to be ground to the plate surface in this way that between the surfaces and plates there are no even small air gaps. Grinding must be tight enough so as the product and the plate are a single monolithic.

Also, imprints of different depths may be the reason of the additional error. Depths values may be different, depending on the measured hardness (Table 2.1). It is recommended to measure the hardness of the layer that is 20 times greater than the depth value. For the reasons mentioned above, the measurement result is under the influence of the surface layer properties. The depth of indenter penetration into the material is substantially smaller in comparison with the measurement by bench machines: Brinell and Rockwell. This can cause the measurement result discrepancy in the case of hardening, decarbonized layer, burn marks, and martensitic spots.

Table 2.1 - The depth of the imprints on the material surface in millimeters

Probe type	100HB	187HB	400HB	60,7HRC
Leeb (D)	0,039	0,028	0,021	0,018
UCI (98 N)	0,098	0,081	0,052	0,036
UCI (50 N)	0,070	0,056	0,038	0,025
UCI (10 N)	0,031	0,025	0,017	0,011

Hardening can be formed in the surface layer after the turning, milling and rough polishing. The softer is metal, the greater is difference between the hardness of the top layer and the inside layer.

Decarbonized layer with low hardness is formed by the high-temperature heat treatment. It may be hardening, normalization, hot rolling, forging, etc. The thickness of this layer is typically less than 0.2 mm.

For heat treated steels with good hardenability when getting the average hardness due to surface overheating martensitic spots with high hardness may occur.

2.3.2 Turning on

Turn on the device by long pressing the button <⏻> on the control panel until the short-time splash screen on the display (Figure 2.3).

Figure 2.3 – Splash screen

After this, the device switches to the main menu (Figure 2.4), or in the <Measuring> mode (if the probe is connected).

Figure 2.4 - Main Menu

From the Main Menu the user can enter:
1. <MEASURING>;
2. <CALIBRATION>;
3. <ARCHIVE>;
4. <SETTINGS>;
5. <MEMORY CARD>;
6. <INFORMATION>.

After entering the selected sections, except the <Information>, the display is divided into two areas: the main area and information area (upper part of the display).

In the main area Workspace section is located, and the information area provides information about the batteries charge, connecting the device to PC, SD card presence and current time.

Before using the device, make sure that the batteries have enough power. Fully stocked LED (green) indicates that the battery is charged to 100%. If there is absence or lack of charge (red), charge the battery by a charger or by connecting the device to PC or Power Bank.

Long press on the button <⏻> makes the device to shut down.

2.3.3 Charging the battery

To charge the battery, plug the power supply (included into the hardness tester standard set) to the power connector located on the upper end of the device housing. During charging the device can be used.

Full battery charging time - 14 hours. Always look after device when charging. Also, the device can be charged by connecting to a PC or Power Bank.

If do not use the device, should charge the batteries at least once per two month to avoid batteries from failure.

2.3.4 Measurements using Ultrasonic Contact Impedance Probe U1

LIMITATION: ***limited use for measuring products with a coarse-grained structure (e.g., cast iron) or a weight of less than 100 grams, or a thick less than 1 mm! Typically, such products must be ground to a massive polished plate.***

1. Before measurements, it is necessary to prepare the surface according to p. 2.3.1.
2. Plug the UCI probe.
3. Turn on the device by long pressing <⏻>.
4. As the probe is already connected, the device immediately goes to the <MEASUREMENTS> section (Figure 2.5).

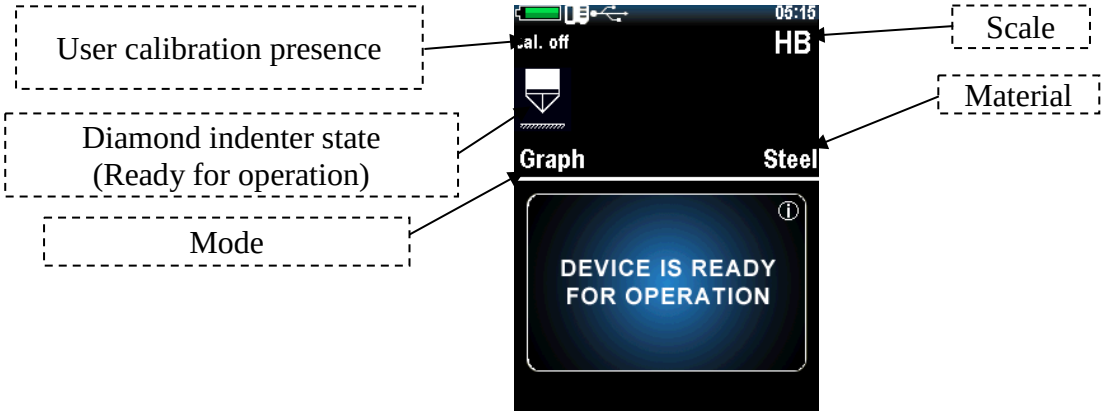


Figure 2.5 – <MEASURING> section

5. Select the required hardness scale, press <SCALE> to assess the selection menu (Figure 2.6), than select the scale with <▲> and <▼> keys (the Rockwell C (HRC), Brinell (HB), Vickers (HV), Rockwell B (HRB), Shore (HS), Leeb (HL), the measurement of tensile strength (σv) for carbon pearlite steel (MPA), user scales (U1, U2, U3)).

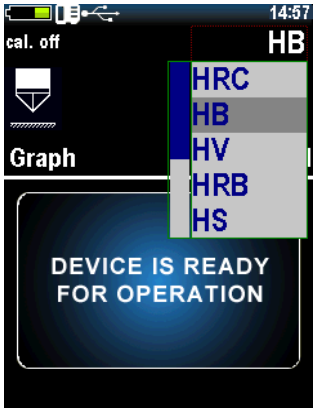


Figure 2.6 - Selecting the hardness scales

6. Select the material that is going to be tested. By pressing <MATERIAL> open the selection menu (Figure 2.7), with the keys < ▲ > and < ▼ > select the required material (steel, alloy steel, stainless steel, gray iron, ductile iron (<Nodular Iron>), aluminum, brass, bronze, copper, user material (<USER. 1>, <USER. 2>).

   Note: If the UCI probe delivering there is steel calibration only. Other materials are to be calibrated by user.

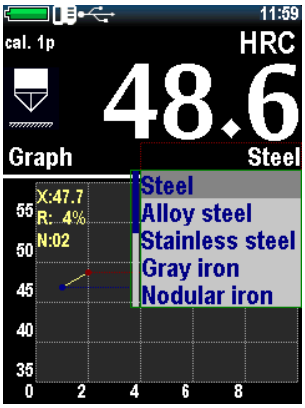


Figure 2.7 – Material selection

7. Select a required measurement mode (see p. 2.3.6), using <MODE> open mode selection menu (Figure 2.8), using keys < ▲ > and < ▼ > select the mode (<GRAPH>, <HISTOGRAM>, <STATISTICS>, <INTELLECTUAL>, <SIGNAL>).

Figure 2.8 – Measurement mode selecting

8. Place the probe thrust washer on the sample surface, holding for support platform as shown in Figure 2.9 A. By pushing on the support platform with two hands move diamond intender of the probe vertically to the sample until it touch the surface (Figure 2.9, B) and then non-stop, gently (approximately while 0.5 seconds), with a pressing force (5 kg if probe UCI (50N) press the diamond intender into the metal surface without any displacement (Figure 2.9 C).

Caution!
Do not press abruptly, because it can cause exceeding of the permissible error value and damage of the diamond indenter.

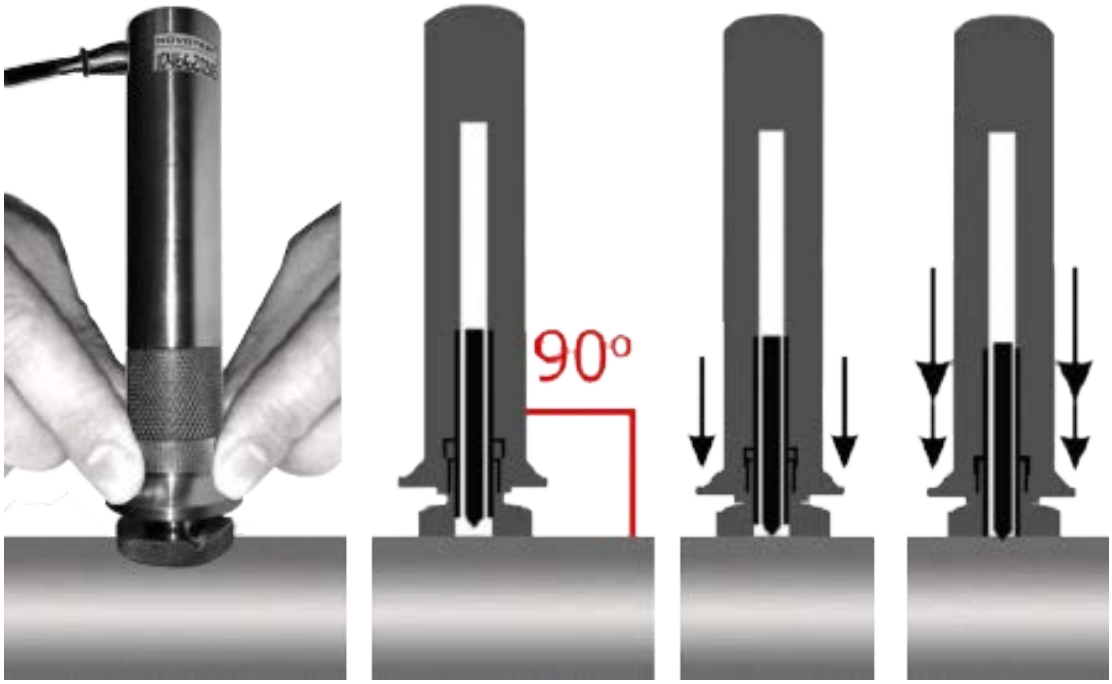


Figure 2.5 – Measuring with UCI U1 probe

Note: The pressing force is set by the probe built-in spring with fixed force.

9. The display shows the value of hardness (Figure 2.10). The measurement result is displayed on the display until the next measurement.

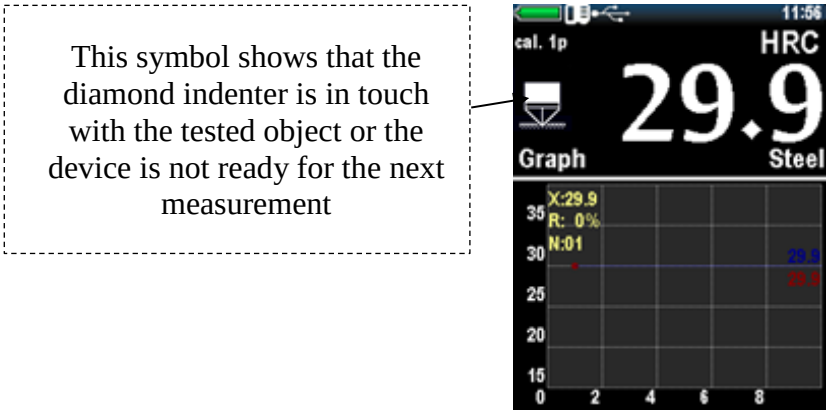


Figure 2.10 – The display after measurement

10. After the measurements the user can save measurement (series of measurements) into archive by pressing <↵> key (ENTER).
11. A keyboard will appear on the display to enter the measurement (series of measurements) name (Figure 2.11).

Figure 2.11 – Entering the name for the saving measurement

12. Select the required symbol and press <●>. After entering the name or saving result press key <↵> to save.
13. If <PHOTO> mode is set on (See 2.3.12 for the details about the <PHOTO> mode), than the device display will offer to <TAKE PICTURE> or <SAVE WITHOUT PHOTO> (Fig. 2.12).

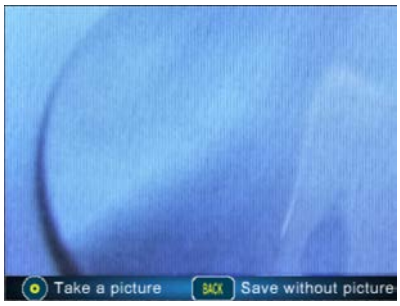


Figure 2.12 – Mode <PHOTO>

14. Press <BACK> key to save the measurements without photo, or <●> to make photo.
15. Then press <↵> key to save photo. Then, using navigation keys <▲>, <▼>, <◄> and <►> put the marker on the point, where the measurement was occurred, press <↵> key to save, or <●> to put another marker on the photo. Confirm saving of the pointed marker by pressing <↵> key – saving photo without possibility to add another measument point (marker).

Note: The distance between the imprint center and the edge of the sample or another close-in imprint should be at least 2.5 imprint diagonal length.

2.3.5 Measurements with the Leeb Probe (dynamic)

RESTRICTION: limited use for measuring objects with weight less than 5 kg or thickness less than 10 mm without additional preparation! Typically, such products must be ground to a massive polished plate.

1. Prepare the tested object before taking measurements as in p. 2.3.1.

2. Connect the Leeb probe to the device.
3. Turn on the device by long press the <⏻> key.
4. As the probe is connected the device opens the <MEASUREMENT> mode at once (Figure 2.13).

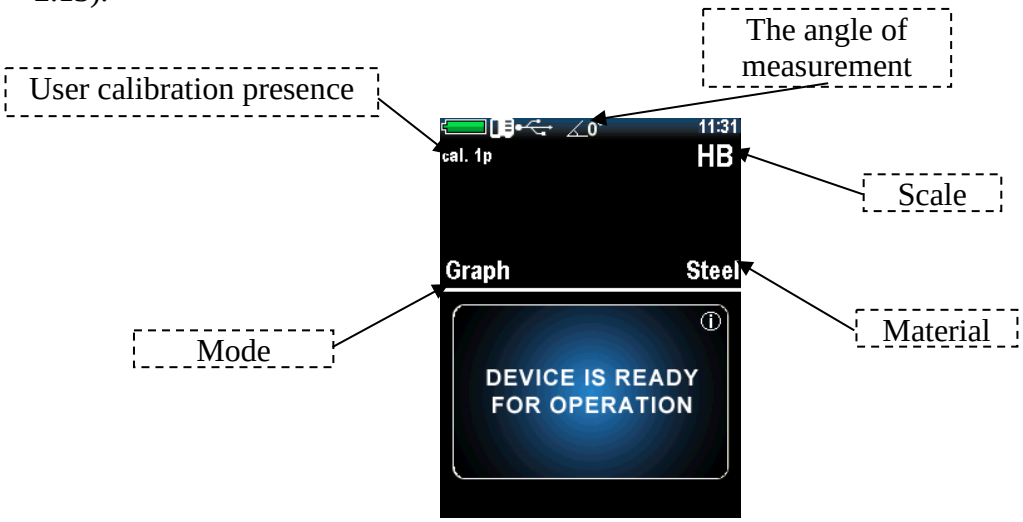


Figure 2.13 – <MEASUREMENT> SECTION

5. Select the required hardness scale, press <SCALE> to enter the selection menu (Figure 2.13), then select the required scale with <▲> and <▼> keys (the Rockwell C (HRC), Brinell (HB), Vickers (HV), Rockwell B (HRB), Shore (HS), Leeb (HL), the measurement of tensile strength (σv) for carbon pearlite steel (MPA), user scales (U1, U2, U3)).
6. Select the required material. By pressing <MATERIAL> open the selection menu (Figure 2.13), with the keys <▲> and <▼> select the required material (steel, alloy steel, stainless steel, gray iron, ductile iron (<NODULAR. IRON>) aluminum, brass, bronze, copper, user material (<USER 1>, <USER. 2>)).
7. Select a required measurement mode, using <MODE> open mode selection menu, using keys <▲> and <▼> select the required mode (<GRAP>, <HISTOGRAM>, <STATISTICS>, <INTELLECTUAL>, <SIGNAL>).
8. Press keys <▲> or <▼>, to set the measurement angle. The angle value is shown at the top of the display (Figure 2.14). Angle 0 degree corresponds to vertical position of the probe, when trigger button is in the up position.

Figure 2.14 – Setting the angle

9. Set the probe onto the tested material surface (Figure 2.15).

Figure 2.15 – Setting the probe

10. Hold the bottom housing part of the probe with one hand, and with other hand charge the spring of the probe by mowing the upper housing part down. (Figure 2.16).

Figure 2.16 – Charging the spring of the probe

11. Smoothly push the trigger button on the top of the probe (Figure 2.17). Make sure that the probe does not move and is securely pressed to the tested surface.

Figure 2.17 – Pushing the trigger button of the probe

12. After pushing the trigger button the impact body hits the tested surface and the value of measured hardness is displayed (Figure 2.18).

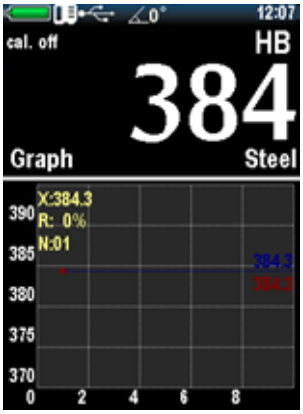


Figure 2.18 – The display after the Leeb probe measuring

Caution!
The minimal distance between the points of measuring (imprints) should be not less than 3 mm. Repeated measurements at the same point are not allowed. They give overestimated values of the product hardness due to cold-worked metal in the imprint zone.

2.3.6 Measurement modes

Enter measurement mode and press <MODE> key to enter the mode selection menu (Figure 2.19). The device will offer user the following measurement modes:

- GRAPH – graph drawing mode;
- HISTOGRAM – histogram building mode;
- STATISTICS – statistics mode;
- SMART – measurement failure filtration mode;
- SIGNAL – signal displaying mode (for the Leeb probe only).

Figure 2.19 – Measurement mode selection

Press <> key to set up the selection.

2.3.6.1 GRAPH

In this mode, the device displays the current measurement value or the average value of the series of measurements in the form of a graph (Figure 2.20), depending on the settings in the menu settings.

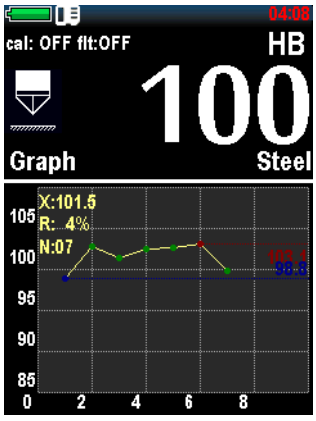


Figure 2.20 – GRAPH mode

2.3.6.2 HISTOGRAM

Histogram of a series of measurements (Figure 2.21).

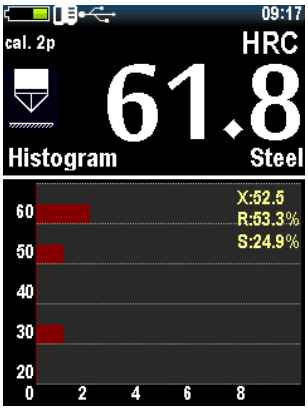


Figure 2.21 - Histogram mode

2.3.6.3 Statistics

Statistics mode allows user to view the following parameters in a series of measurements:

- maximum;
- minimum;
- deviation;
- average;
- coefficient of variation of a random variable;
- number of measurements.

Figure 2.22 shows an example of work in the statistics mode, in which the table shows all the parameters of a series of measurements.

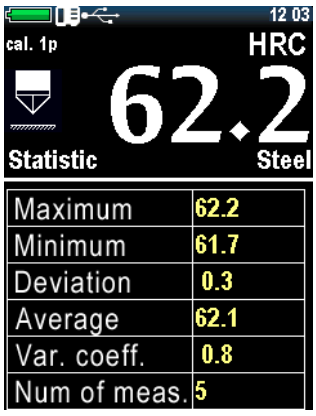


Figure 2.22 - Statistics mode

2.3.6.4 SMART mode

The accuracy of the device is influenced by many external factors, which introduce an additional error in the measurements. Some factors are:

- trembling hand;
- displacement of the tested object;
- probe swing;
- surface cleanliness;
- surface roughness.

For UCI probe additionally:

- the load is too short or too long;
- probe is pressed too lightly or too hard;
- low batteries.

SMART mode allows determining the overall sequence of measurements. The first three series of measurements that do not exceed permissible error are selected. After that, the next measurements, which exceed the permissible error, will be excluded from the series, and will not be taken into account when calculating the average value of the measured hardness from this series (Figure 2.23).

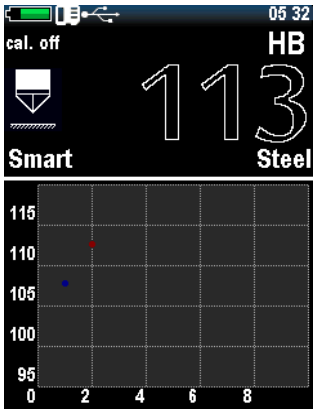


Figure 2.23 - Intelligent mode

A hardness value figures with white color mean that the device has a fixed common sequence and the intelligent mode is active (Figure 2.24).

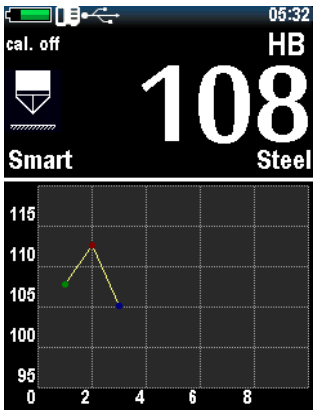


Figure 2.24 - Active Smart mode

To set the permissible error for Smart mode, the user should go to the <Settings> menu, set the permissible error values in percentages from 1 to 10 (Figure 2.25).

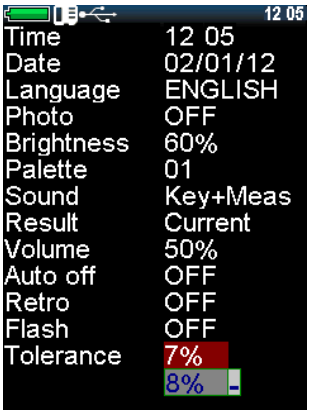


Figure 2.25 - Setting the permissible error for the intelligent mode

Also, in order to reduce the influence of external factors user can switch on the Kalman filter or the Median filter in the device settings.

To make the most accurate device measurements, user has to select the proper filter for the particular case.

Kalman filter

The Kalman filter is a linear filter, which is used to obtain the most correct value. Also, the Kalman filter can be defined as a filter giving the least mean-square error.

The main idea of the filter is to find the coefficient C that will correct the received value so that it would minimum differ from the true (correct) value.

Kalman filter is recommended to be used when measuring heterogeneous structure product, where there are hardness value jumps, which must be taken into account when calculating the common hardness value of the product. Kalman filter can reduce the influence of external factors on the measurements, while not distorting hardness value jumps.

Median Filter

The median filter - is a nonlinear filter that is applied to signals which are under the influence of pulse interference.

The medial filter is recommended for measuring homogeneous products, in which there are no hardness value jumps. In case, when due to external factors, the probe fixes hardness value jumps, the filter will correct it to the normal value.

2.3.6.5 SIGNAL

The mode is active for the dynamic probe only and shows the voltage. M - represents the maximum value that corresponds to the signal (Figure 2.26).

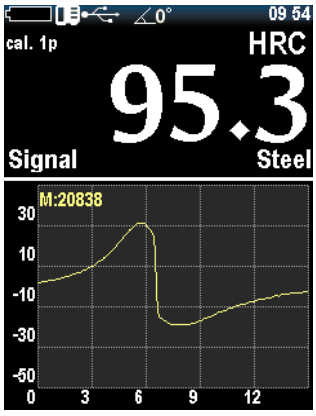


Figure 2.26 - Signal mode

2.3.7 Calibration

2.3.7.1. Calibration of scales

To calibrate the probe, 3 samples of material with known hardness value are required. The hardness range should be wider than the hardness of the material that will be measured in the future (the value should be a maximum or more, a minimum or less, and an average).

1. Select <CALIBRATION> from the main menu. Each table cell corresponds to a specific calibration scale for a particular material (Figure 2.27). All calibrations can be calibrated for any materials and any scales, and are thus separated to systematize calibration sets.

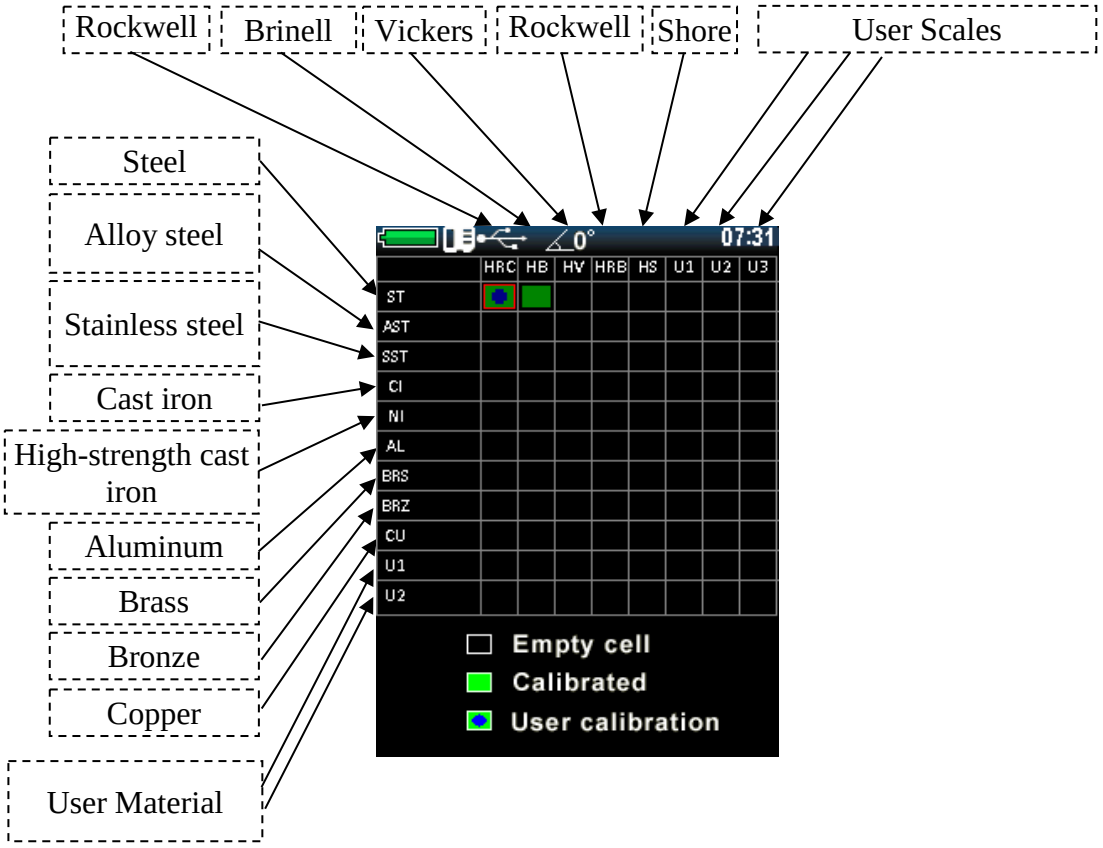


Figure 2.27 - Calibration Mode

2. Use the navigation keys to select a cell for calibration, for example, HRC for steel (Figure 2.28).

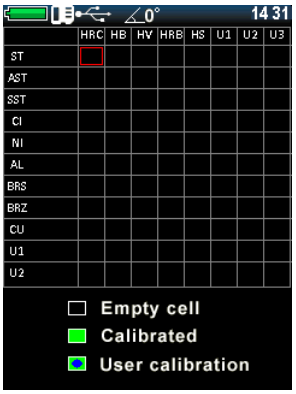


Figure 2.28 - Selecting a cell for calibration

1. Press <> to select, user will see the table as in Figure 2.29. The device, while measuring, receives nominal codes. The purpose of calibration is to find the correlation between the code value and the hardness value (to create the function of dependence).

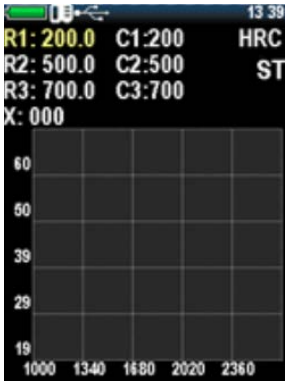


Figure 2.29 - Calibration table

2. To start the calibration, enter the real hardness values of the samples by pressing the key <>. Using navigation keys < > and < > to set up the real hardness values, push < > key to enter the next value (Figure 2.30).

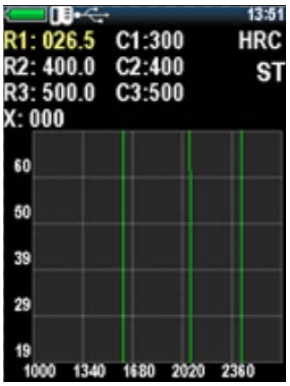


Figure 2.30 - Setting real hardness values

3. Press the key <> one more time to set the first value, than the key < > to edit harrdness value for the next samples.
4. Then move the cursor to the hardness value according to the sample, and make at least five measurements (Figure 2.31). Make sure that the value of X (the current code value) does not deviate more than 3%.

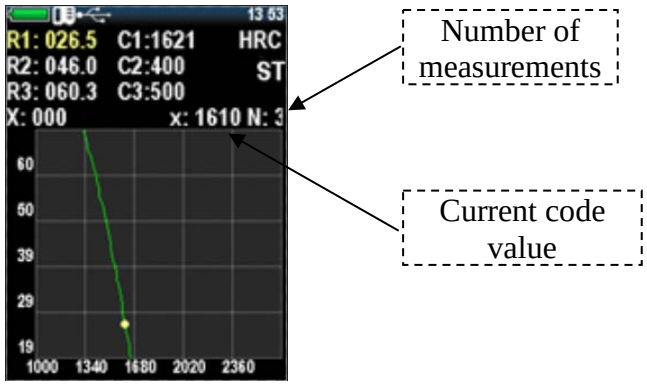


Figure 2.31 - Measuring for calibration

Press <BS> key if there is an obvious error and the last value will be removed from the series.

5. Move to the next nominal <▼>, and complete the same procedure to the other samples (Figure 2.32).

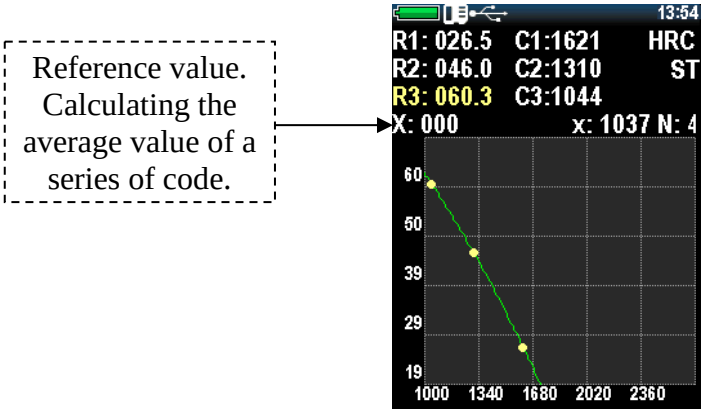


Figure 2.32 - Calibration for one sample

6. To verify that the value is correct, move the cursor to X: 000 and make several measurements on one of the samples.
7. Press <↵> (“YES”), to save, or <BACK> key (“NO”), to exit without saving (Figure 2.33).

Figure 2.33 – Saving

2.3.7.2 User (additional) calibration

Each of the stored calibrations can be corrected.

The user calibration of the hardness tester during the inter-service calibration period is recommended in the following cases:

- while checking the hardness tester with the reference hardness measure, its values are constant, but differ from the value of the reference hardness measure;
- after long-term storage (more than 3 months);
- after intensive use;
- if the operating conditions (temperature, humidity, etc.) change significantly.

For hardness tester calibration ONE (one-point graduation) or TWO (two-point calibration) reference hardness measures with the maximum and minimum values are required at the controlled range of the hardness scale.

For example, there are two samples of steel with a known hardness value of HRC, and the instrument shows a stable deviation when measuring the hardness on it.

1. To calibrate by two points, select <CALIBRATION> in the main menu (Figure 2.34).

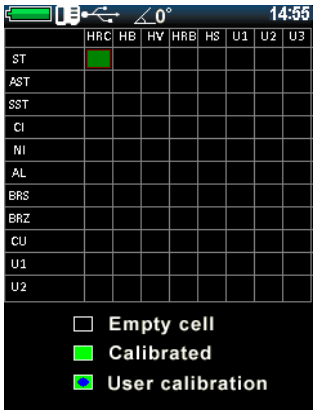


Figure 2.34 – Grading

2. Use the navigation keys to select a cell for calibration, for example, HRC for steel.
3. Press <> , and the calibration window will open on the display (Figure 2.35).

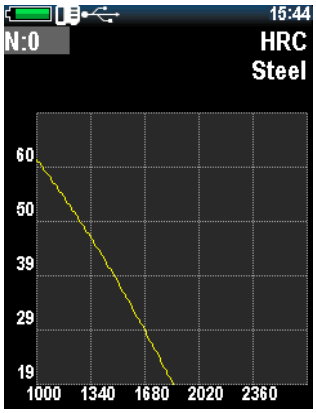


Figure 2.35 – The Graduation window

4. Press <> key to select the number of the calibration points. If there are two samples, user must select 2 using the keys < > and < >, to confirm press <> (Figure 2.36).

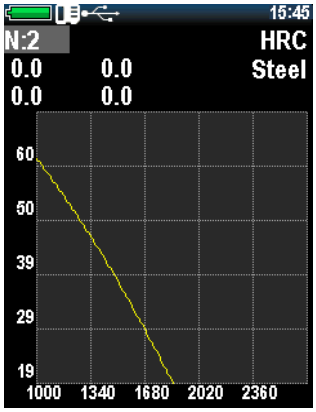


Figure 2.36 – Two points calibration

5. Moving the cursor with <> key, select the first line. Make about five measurements on the first reference sample, the device will show the average value of the series according to the current calibration (Figure 2.37). If get obvious error of measurement press <BS> key, and the last measurement will be deleted from the seriers.

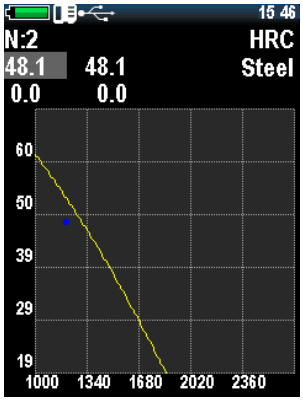


Figure 2.37 – Calibration measurements

Press <>, and using <> and <> set the nominal hardness value of the reference sample.

6. Use <> key to move to the next value, press <> to save the first one. After the correction of the hardness value of the first sample the display will look like on Figure 2.38.

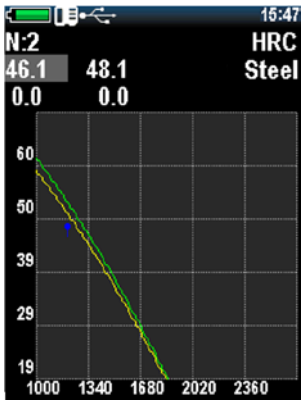


Figure 2.38 - After correcting the first sample

7. Press <>, to set up the second sample value, the procedure will be the same as for the first one. After the end of all the operations, the display will look as on Figure 2.39.

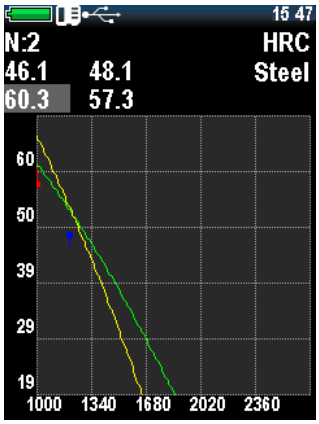


Figure 2.39 - After correction the second sample

8. Press key <BACK> to save. Press <↵> ("YES"), to save, or <BACK> key ("NO"), to exit without saving.
9. The saved user calibration will be marked with a special state of the cell (Figure 2.40).

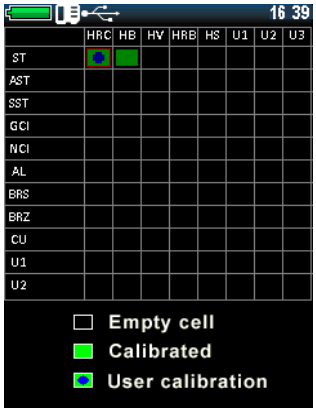


Figure 2.40 - User calibration marking

10. To delete user calibration, go to user calibration mode and set the value "0" for the N parameter (Figure 2.41).

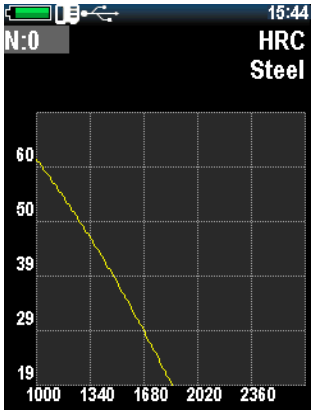


Figure 2.41 - Deleting a user calibration

2.3.8 Settings

When <SETTINGS> menu section is selected, the device enters the setting mode of the following parameters:

- <TIME>: setting the time (24h format);
- <DATE>: setting the date format DAY / MONTH / YEAR;
  <LANGUAGE>: selection of the menu language of the device (available in English, Russian, etc.);
- <PHOTO>: turn on / off the camera (for versions with the camera);
- <BRIGHTNESS>: change the brightness of the display;
  <PALETTE>: section of menu themes (creation of a color palette of the menu is made with special software);
- <SOUND>: there are 4 sound modes (off, keyboard, measurement, keyboard and measurement);
- <RESULT>: measurement results can be current (a current measurement value is displayed) or calculating average value;
- <VOLUME>: adjust the volume of the device;
- <AUTO-OFF>: setting the device to automatically turn off when not in use;
- <RETRO>: allows the user to return to the measurement mode with the last measurements saved after the device is rebooted;
- <FLASH>: enable/disable camera flash (for the version with camera);
- <TOLERANCE>, %: this parameter is used only for intelligent mode. The value in % controls the range of measurement deviations, which will be included in the calculation of average for the series when intelligent mode is set;
- <FILTER>: Kalman or Median, and also turn off the filtering;

To make changes in <SETTINGS> section, all the navigation keys are used: <>, <>, <>, <>, <>. Press key <BACK> to exit.

In Fig. 2.42 <SETTINGS> section is presented.

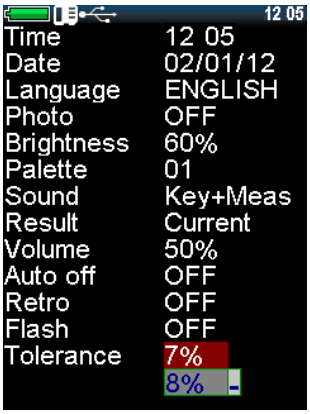


Figure 2.42 – <SETTINGS> section

2.3.9 Archive

When <Archive> is selected, the device enters the list of saved measurements, that displays the name, date and time of the measurement, scale, material and average value (Figure 2.43).

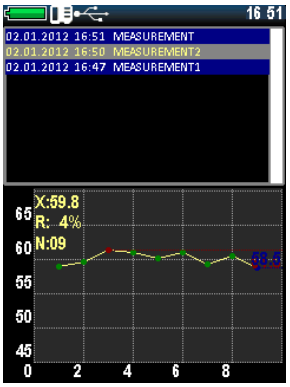


Figure 2.43 - Archive

Use keys < > and < > to navigate.

After selecting the required saved measurement, the user can not only see it, but also print: turn on the printer and press < >.

To delete a record from the archive, select it with the navigation keys and press <BS>, after that the confirmation message <DELETE?> is displayed on the display, press key < > to delete or <BACK>, to cancel.

2.3.10 Memory card

When the menu item <MEMORY CARD> is selected, the device goes to the memory menu (Figure 2.44).

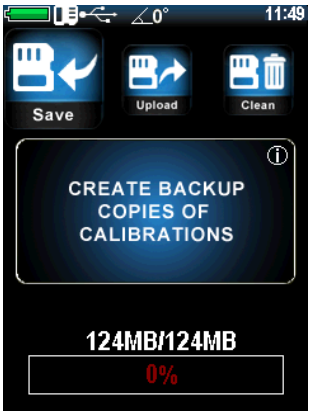


Figure 2.44 - Section <MEMORY CARD>

– Creating backup copies of calibrations.

After the probe calibrating, it is recommended user to create a backup calibration (usually the manufacturer calibrates 1-2 scales to check the probe). This is done in order to be able to restore the proper calibration after incorrect settings in the future.

After initial saving of the calibrations, user can always transfer the settings to the probe. This function is needed to restore proper calibration in case of incorrect probe settings.

– Memory card cleaning.

Deleting of saved records in the archive and backup copies of the calibrations: after cleaning the SD card, the archive will be empty and the backup copies of the calibrations will be saved. At the bottom of the screen of this menu the memory status indicator is displayed.

2.3.11 Information

In this menu item, user can see information about the manufacturer and representative offices around the world (Figure 2.45).

Figure 2.45 - Section <INFORMATION>

Also in this menu item the user can find information about the device and the number of measurements, use the navigation keys < > and < > to open the required table (Figure 2.46).

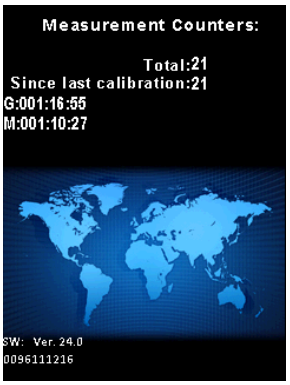


Figure 2.46 – Information about the device and the measurements number

2.3.12 Photo fixation of the measurements

Photo fixation of the measuring point is used in models with a photo camera.

The user can install photo fixation mode in the device settings. For this go to the <SETTINGS> section from the main menu, using the keys < >, < > select <PHOTO> and using keys < >, < > change <OFF> to <ON>. Also in <SETTINGS> turn on the photo flash light. For this, using the keys < >, < > select <FLASH> and by keys < >, < > change <OFF> to <ON>. Then press <BACK> key to exit from <SETTINGS> section. Now the user can start measuring.

After measuring, in order to save the measurement (a series of measurements) to archive with photo fixation of the measurement location, do the following:

1. Press < > key (ENTER). A keypad for entering the measurement name (a series of measurements) appears on the display (Figure 2.47).

Figure 2.47 - Entering the name for the stored measurement

2. Move the cursor to the desired character and press the <> key to select it. When finish typing a name, press <> to save. Further, the image from the camera will be transferred to the display in real time and it will be offered <TAKE A PICTURE> or <SAVE WITHOUT PHOTO> (Figure 2.48).

Figure 2.48 - Picturing the object

3. Press key <BACK> to save the measurement without photos, or point the camera at the measured object so that the measuring point can be seen and press <> to take photo. If the place is poorly visible due to lack of lighting at the time of shooting, the flash will <highlight> it (when it is switched on in <SETTINGS> section).
4. After shooting, the display will look like in Figure 2.49.

Figure 2.49 - After shooting

5. Press <> key to save photo or key <BACK> to take another picture.

6. After saving the photo using the navigation keys <>, <>, <>, <> mark the measurement location on the photo (Figure 2.50). Scale and the value of hardness, as well as the date and time of measurement (creating a snapshot) are indicated automatically. To finish the photo fixation and save the measurement in the archive, press <>.

   Note: To save a picture with one measurement point (marker), press <>. And in order to mark the next measurement point on the same photo, press the key <>. If confirm saving the measurement point (marker) by the key <> – will be saved photo without the ability to add a new measurement point (marker).

Figure 2.50 - Marking of the measuring point

2.3.13 Connecting to PC

2.3.13.1 Software setup

When connecting to PC the data may be sent from the device and to the device as well. <Archive> measurement data are sent from the device. Also the user can save device display pictures on-line. Color display settings could be load into the device memory (may be changed in settings in the <PALETTE> section), as well as the archived data may be controlled.

To connect the device to PC do the following:

1. Copy driver “DRIVER_FT232RL” for “Windows 7” and “Windows 8” or “CP210x_VCP_Windows” for “Windows 10” (x64 or x32 according to your OS) and the “AWP UNIVERSAL” program (.zip type archives) to the PC hard drive or download the updated versions from the official web site.
2. Unpack the files getting two folders (Figure 2.51): driver and program.

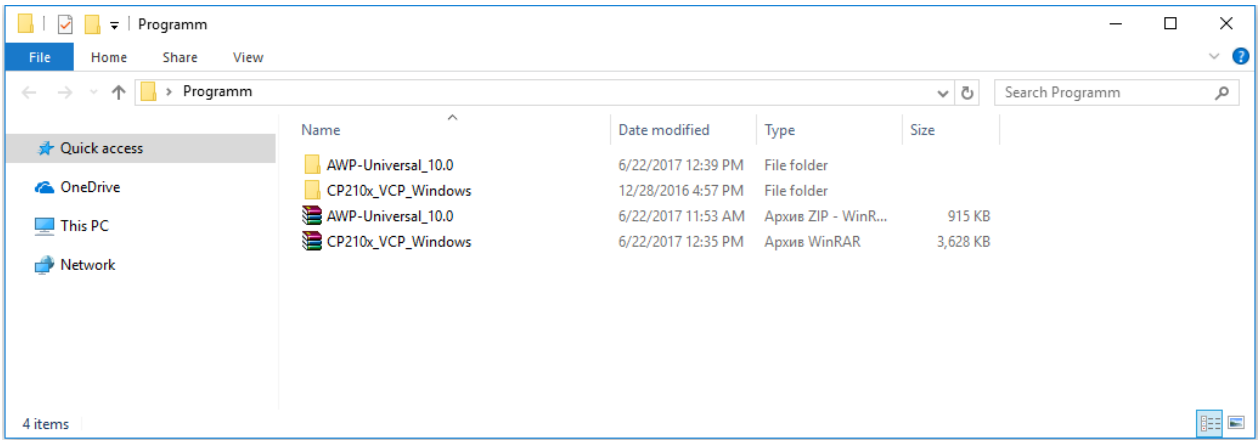


Figure 2.51 – Downloaded software

3. Connect the device to PC using the USB cable supplied. After connection, computer detects a new connected device, but does not find a driver. It must be installed manually.
4. For installation enter <START> CONTROL PANEL> DEVICE MANAGER>, in the <COM and LTP PORTS> section there will be an unidentified device.
5. Open the device properties by double-clicking the left mouse button on it and select the <DRIVER> tab.
6. Click on the button <UPDATE ...>, select <SEARCH DRIVERS ON THIS COMPUTER>.
7. Click on the <SEARCH> button and select the path to the downloaded (copied) folder with the driver and press the <NEXT> button, after which the driver installation process will begin.
8. After successful driver installation. Disconnect the device and restart your PC.
9. Install the program to work with the device. For this, run the setup.exe file of the program installation and click the <INSTALL> button (Figure 2.52).

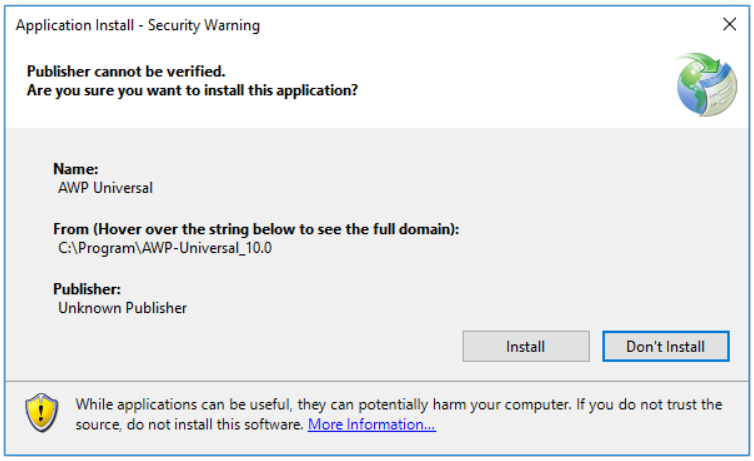


Figure 2.52 – Installing AWP Universal

10. After the installation is completed, the program shortcut <AWP UNIVERSAL> appears on the desktop.

2.3.13.2 Using the software

Connect the device to the PC using USB cable and Run the <AWP UNIVERSAL> program, after selecting the archive location, the program will start.

In the section (Figure 2.53) <WORK WITH ARCHIVE> user can view, print, copy and move data from the archive.

Each record is saved with full measurement information (a series of measurements). There is brief information in the record selection window:

- Name;
- Date and time;
- Probe (converter);
- Probe number (converter);
- Device number.

To copy data from the device to PC, user needs to put on the measurement time, and then press the <COPY> button.

Note: By pressing the <MOVE> button, the data is not simply copied to the PC, but also is deleted from the device memory.

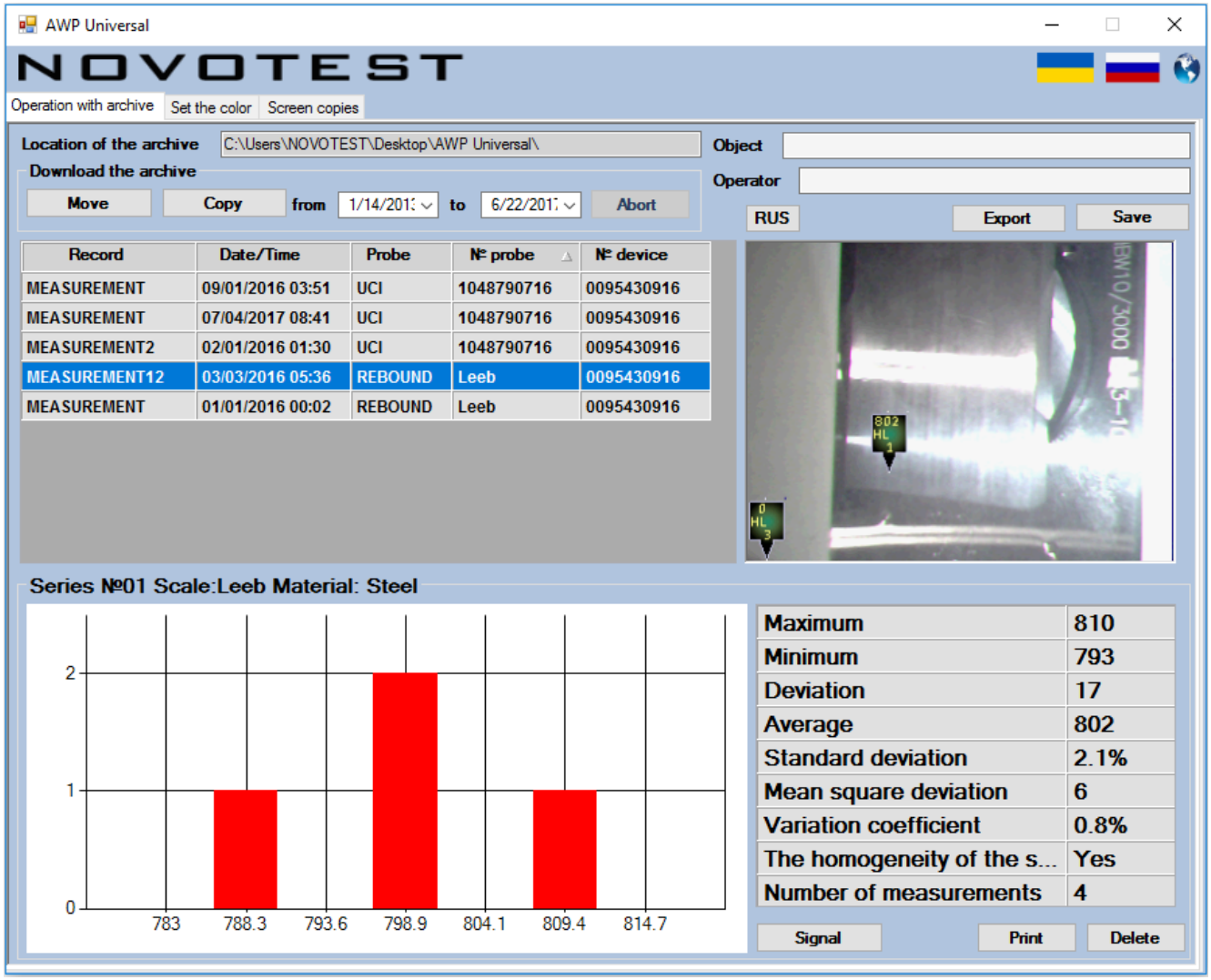


Figure 2.53 – Program <AWP UNIVERSAL> section <WORK WITH ARCHIVE>

After selecting a record, photo of the tested location appears (if it is added to the record) on the right side of the program. Additional information appears in the lower part of the program in the form of a table and a plotted chart or a histogram of a series of measurements (can be selected by the dynamic button <GRAPH / HISTOGRAM>). Above the graph are displayed: the series number, the hardness scale, and also the material of the measurement object.

The table shows following record parameters:

- Maximum;
- Minimum;
- Amplitude;
- Average value;
- Standard deviation;
- Mean-square deviation;
- Variation coefficient;
- Uniformity of the series;
- Number of measurements.

The saved data can be immediately printed, by pressing the <PRINT> button. The user can also delete the record from the device memory using the <DELETE> button.

The data for a certain period (setting by the user) or manually selected from the archive can be moved (deleted from the device memory) or can be copied (remain in the device memory) to the PC.

Also at the <WORK WITH ARCHIVE> tab the user can make settings to the program.

To change the language, press the <ENG / RUS> dynamic key and the program language will change from Russian to English or vice versa.

To change the location of the archive, click on the archive path and select a new archive location.

To go to our site, click on one of the flags or on the planet (international in English), after clicking the site will open in browser by default.

On the <COLOR SETTING> tab, user can create a new one or download and edit the standard color settings of the device (Figure 2.54).

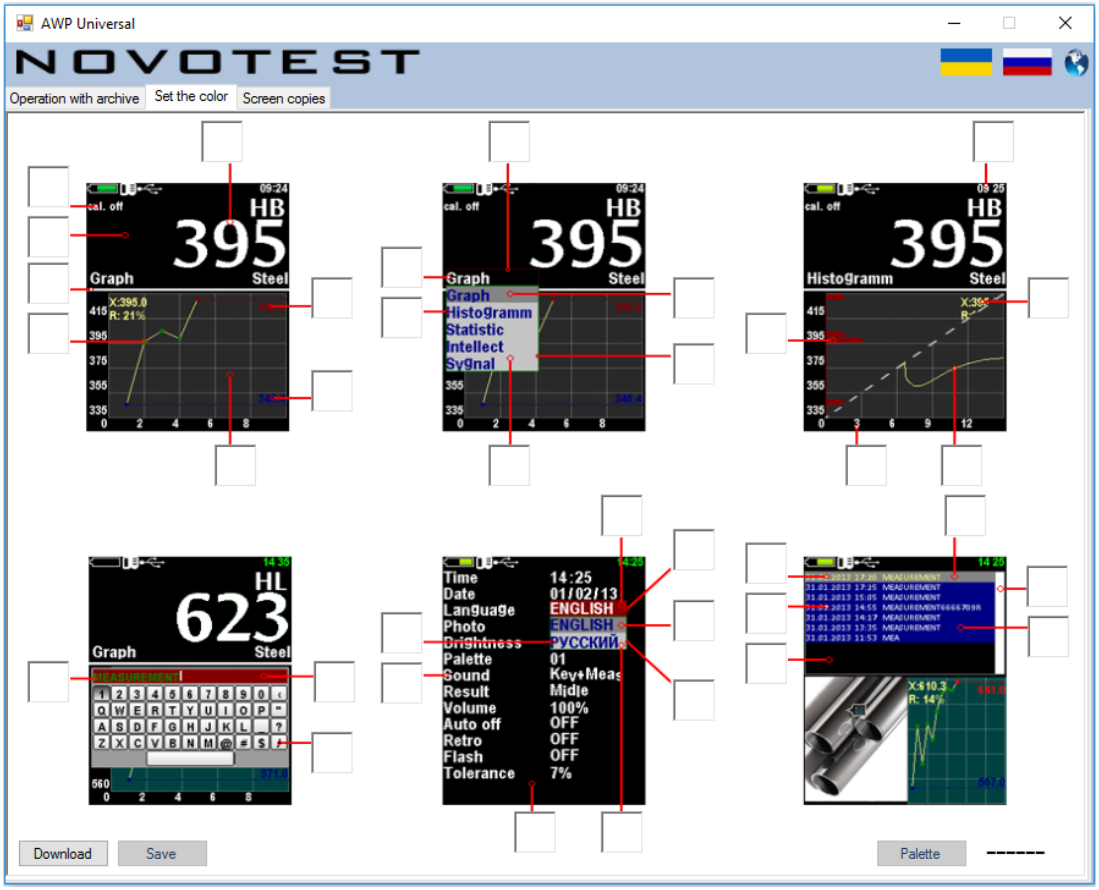


Figure 2.54 – <COLOR SETTING> tab

To load the current color settings, click on the <LOAD> button, and then select the edited color theme with the <PALETTE> button. To edit, click on the color, which would like to change, and select a new one. When all colors are changed, enter the palette name and save it on the device by the <SAVE> key.

On the <SCREEN COPIES> tab, the user can save the screen images on the device in current time (Figure 2.55).

To save the image, press the <CAPTURE> button, after which a message about screen image saving will be displayed on the PC screen. When all the necessary images on the device are <CAPTURED>, the user need to click on the <LOAD> button after which the images will be saved in the program archive.

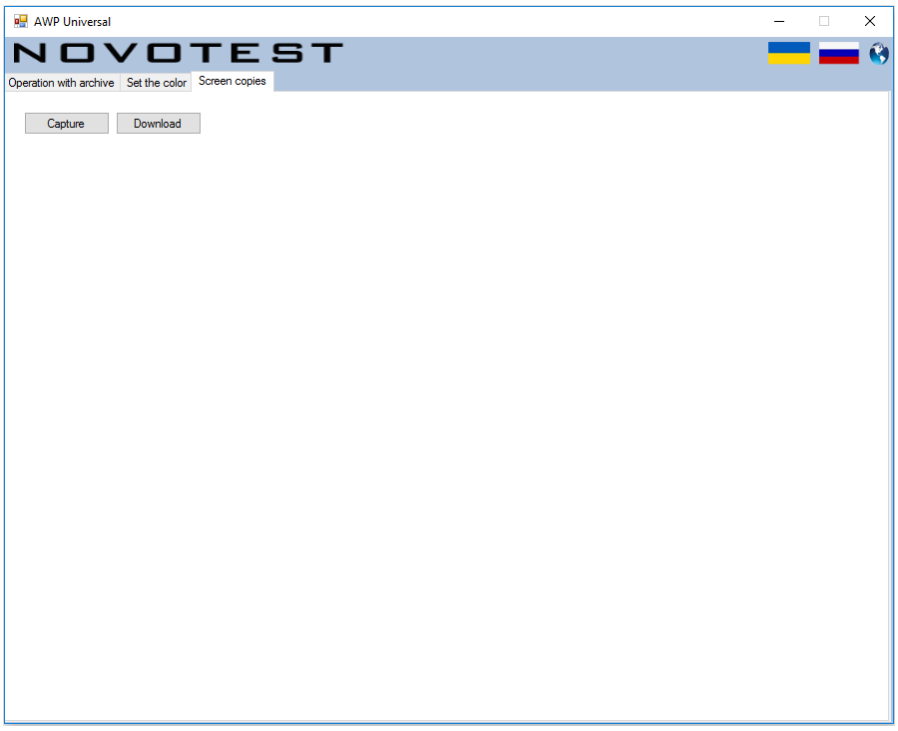


Figure 2.55 - Screen saving tab

3 TECHNICAL MAINTENANCE OF THE PRODUCT AND ITS COMPONENTS

3.1 Security measures

After putting into operation it is recommended to inspect the device periodically in order to control:

- operability;
- compliance with the operating conditions;
- battery charge level;
- absence of external damages to component device parts.

When working with a charger connected to the 220-volt system at 50 Hz, the requirements set out in the “Safety rules for the operation of electrical installations of consumers” are mandatory.

If the device is not used for a long time, the batteries should be turned off or removed. In doing so, the batteries storage rules must be kept.

To work with the device are allowed those who have been instructed and certified for certain qualification group for safety in working with electro-radio measuring devices.

3.2 Verification

The recommended verification interval is at least once a year.

The verification procedure (calibration; hereinafter - verification) applies to hardness testers NOVOTEST T-UD3 and establishes methods and means of their primary and periodic verification.

Verification conditions and preparation for it

Verification of the device is carried out under climatic conditions:

- temperature from 15 to 28^{0}C;
- relative humidity 65 ± 15 %;
- pressure 101 ± 2 kPa.

The power supply must comply with Table 1.1 (It is possible to connect an external power supply if polarity is correct).

Hardness test blocks during verification should be ground to a grinding plate with a mass of not less than 5 kg, through a layer of lubricant.

3.2.1 Operations and verification means

During the verification, it is necessary to carry out operations and to apply means of verification specified in Table 3.1.

Table 3.1 - Operations and verification means

Name of verification operations	Number of items	Name of verification means	Is mandatory after	
			manufacturing and repair	operation and storage
1	2	3	4	5
1. Visual inspection	3.3.2		yes	yes
2. Testing	3.3.3		yes	yes
3. Determination of the basic error of the instrument according to the HRC scale	3.3.4	Reference hardness test blocks	yes	yes

1	2	3	4	5
4. Determination of the basic error of the instrument according to the HB scale	3.3.5	Reference hardness test blocks	yes	yes
5. Determination of the basic error of the instrument according to the HV scale	3.3.6	Reference hardness test blocks	yes	yes

3.2.2 Visual inspection

The device standard set should be in accordance with p.1.3.

No foreign objects should be inside the electronic unit, when tilting the device detected by hearing.

Probes and its parts should not have any corrosion and mechanical damages.

3.2.3 Testing

The device is tested according to p. 1.7, and also:

– NOVOTEST T-U3 testing is carried out with an Ultrasonic Contact Impedance Probe U1;
– NOVOTEST T-D3 testing is carried out with a Rebound Leeb Probe.

3.2.4 Determination of the basic error of the instrument according to the HRC scale

1. Select the HRC hardness measurement.
2. Select the statistics measurement mode.
3. Carry out at least 3 measurements of HRC_i on hardness reference blocks (excluding explicit measurement errors).
4. Determine the basic error of hardness measurement on the HRC scale using the formula:

$$\Delta HRC = HRC(\ ref.\ ) - \frac{1}{n}\sum HRC_i, \quad (1)$$

where *n* – number of measurements.

5. Select the hardness measurement on user scale HRC.
6. Select the statistics measurement mode p. 2.3.5.
7. Make at least 3 measurements of HRC_i on hardness reference blocks (excluding explicit measurement errors).
8. Determine the basic error of hardness measurement on the HRC scale by the formula (1).
9. If the error exceeds the allowable value (Table 1.2), then it is necessary to calibrate the user scale according to p. 2.3.7.
10. Repeat operations 6 through 8.
11. The basic error of hardness measurement for the HRC scale and for the user HRC scale should not exceed ± 2,0 HRC.

3.2.5 Determination of the basic error of the instrument on the scale HB

1. Select the hardness measurement on the HB scale.
2. Select the statistics measurement mode.
3. Carry out at least 3 measurements of HB_i on hardness reference blocks (excluding explicit measurement errors).
4. Determine the basic error of hardness measurement on the HB scale by the formula:

$$\Delta HB = HB(\ ref.\ ) - \frac{1}{n}\sum HB_i, \quad (2)$$

where *n* is the number of measurements.

5. Select the hardness measurement on the user scale HB.
6. Select the statistics measurement mode.
7. Make at least 3 measurements of HB_i on hardness reference blocks (excluding explicit measurement errors).
8. Determine the basic error of hardness measurement on the HB scale by the formula (2).
9. If the error exceeds the allowable value (Table 1.2), then it is necessary to calibrate the user scale according to p. 2.3.7.
10. Repeat operations 6 through 8.
11. The basic error of hardness measurement for the HB scale and for the user HB scale should not exceed ± 10,0 HRB.

3.2.6 Determination of the basic error of the instrument on the scale HV

1. Select the hardness measurement on the HV scale.
2. Select the statistics measurement mode.
3. Carry out at least 3 measurements of HV_i on hardness reference blocks (excluding explicit measurement errors).
4. Determine the basic error of hardness measurement on the HV scale by the formula:

$$\Delta HV = HV(\ ref.\ ) - \frac{1}{n}\sum HV_i, \quad (3)$$

where *n* is the number of measurements.

5. Select the hardness measurement on the user scale HV.
6. Select the statistics measurement mode.
7. Make at least 3 measurements of HV_i on hardness reference blocks (excluding explicit measurement errors).
8. Determine the basic error of hardness measurement on the HV scale by the formula (3).
9. If the error exceeds the allowable value (Table 1.2), then it is necessary to calibrate the user scale according to p. 2.3.7.
10. Repeat operations 6 through 8.
11. The basic error of hardness measurement for the HV scale and for the user HV scale should not exceed ± 15,0 HV.

3.2.7 Registration of verification results

Positive results of the primary verification of the device are to be mentioned in the SERVICE AND MAINTENANCE RECORDS.

The results of periodic verification of a device that is recognized as ready for service are documented by: a protocol of verification in free form, a mark in the device SERVICE AND MAINTENANCE RECORDS and a device marking.

A negative result is documented by a certificate of the inadequacy of the device, indicating the cause, and deletion of the previous verification marking.

3.3 Warranty

The following warranty information is valid for all NOVOTEST products.

The manufacturer guarantees the conformity of the device to the requirements of the technical conditions under the user's compliance with the conditions of transportation, storage and operation, and timely maintenance at the manufacturer's premises at least once a year.

3.3.1 Basic warranty

New NOVOTEST device, purchased from the manufacturer or an authorized dealer, is covered by basic warranty of 1 year. It is also available extended granted warranty period up to 5 years.

If any part of the device fails due to a defect in the material or production process, it will be repaired or replaced free of charge by the manufacturer or by any authorized NOVOTEST dealer, regardless of whether the ownership of the device has passed to another person during the warranty period.

Warranty for batteries and chargers is provided directly by the manufacturers of accumulators, batteries and chargers and therefore they are not covered by the NOVOTEST warranty. However, the authorized NOVOTEST dealer will assist in presenting warranty claims regarding batteries, batteries and chargers.

The warranty for the device begins to operate from the date of purchase of the device, as a rule, on the day of shipment of the device to the customer. In the case that the device is purchased by an intermediary company, the beginning of the warranty period is the time of transfer of the device to the intermediary.

3.3.2 Extended warranty

A special program for extending the basic warranty period from 1 to 2, 3, 4 or 5 years is available. To participate in the program, the user must pay a certificate when purchasing equipment. Extended warranty terms are specified in the certificate.

3.3.3 Warranty for repaired or replaced parts

All NOVOTEST brand spare parts installed during the warranty repair process are covered by the NOVOTEST guarantee (until the end of the warranty period).

Spare parts replaced during warranty service under warranty are not returned to the owner of the device.

3.3.4 Wear parts

Parts that are subject to wear during the operation of the device fall into two main categories. The first includes those parts that require replacement or adjustment at the interval prescribed by the maintenance schedule of the device, and to the second wear elements, the frequency of replacement or adjustment of which depends on the operating conditions of the device.

3.3.4.1 Parts replaced with routine maintenance

The parts listed below have a limited service life and need to be replaced or adjusted at intervals prescribed by the maintenance schedule of the device. The basic warranty extends to these parts until the moment when their first replacement or adjustment is required. The warranty period for each part can’t exceed the restrictions (on the time of operation of the device or operating time) specified in the conditions of the basic guarantee.

- built-in rechargeable batteries;
- gaskets, if they are removed in connection with the concomitant adjustment;
- oil and working fluids.

3.3.4.2 Wear parts

The parts listed below either have a limited service life, or may require replacement (adjustment) because of the damage. However, these parts are covered by the basic NOVOTEST warranty for 12 months or until the first scheduled maintenance of the device (whichever comes first):

- probes and their components;
- connecting cables;
- details and mechanisms exposed to mechanical influences during operation.

Note: Details, which are wearing by friction (such as knives, cutters, movable probe parts, ultrasonic piezoelectric probes, details with support platforms and so on.), are not covered by the basic guarantee NOVOTEST if these parts fail due to normal wear during the device usage. However, if during the warranty period these parts fail due to an initial defect in the material or workmanship, they will be repaired or replaced according to the basic warranty.

3.3.5 Duties of the owner

The "Operation Manual" and "SERVICE AND MAINTENANCE RECORDS" contain information on the proper operation and maintenance of the device.

Proper operation and maintenance of the device will help the user avoid expensive repairs caused by incorrect operation, neglect or improper maintenance. In addition, following our recommendations increases the life of the device. Therefore, the owner of the device should:

- If a defect or fault is detected, send the device as soon as possible to the manufacturer or an authorized NOVOTEST dealer for warranty repairs. This will help to minimize the repair required by the device.
- Carry out maintenance for appliance in accordance with the operating instructions and the SERVICE AND MAINTENANCE RECORDS.

Note: Neglect of timely maintenance of the device in accordance with the prescribed schedule deprives the rights to warranty repair or replacement of defective parts.

- When servicing the appliance, use only original spare parts and NOVOTEST service fluids (which are marked accordingly).
- Make notes in the SERVICE AND MAINTENANCE RECORDS about instrument maintenance, save all invoices and receipts. If necessary, they will serve as proof that the maintenance was carried out in time, using the recommended spare parts and operating fluids. This will helpful with warranty claims for defects that may occur as a result of maintenance schedule neglecting or using of unauthorized parts or materials.
- Regularly clean the instrument housing and probes of the device in accordance with NOVOTEST recommendations.
- Keep operating and storage conditions in accordance with NOVOTEST recommendations.

3.3.6 Warranty limitations

NOVOTEST is not responsible for repair or replacement of parts in case of one of the following factors:

- Damage caused by negligent/improper device operating, natural disaster, water intrusion by an accident into the device, probe, accessories and parts of the device (not a manufacturing defect) or off-label device use;
- Operational wear of parts;
- User does not comply with NOVOTEST recommendations for maintenance of the device within the specified time;
- Violation of the operating conditions of the device, recommended by NOVOTEST;
- Changes in the design of the device or its components, interference with the operation of the instrument systems, etc., without agreement with the manufacturer;
- Usage of batteries and other components of improper quality;
- Voltage drop in the mains;
- When refuse to repair in time any damage identified during routine maintenance;
- Factors beyond NOVOTEST responsibility, for example: air pollution, hurricanes, chipped piece of damage, scratches and use of unsuitable cleaners;
- Application of repair technologies not approved by NOVOTEST;
- Usage of non-original NOVOTEST spare parts and fluids.

Repair operations covered by the NOVOTEST warranty must be made only by an authorized NOVOTEST service center.

3.3.7 Other cases not covered by the warranty

The basic NOVOTEST warranty, the extended NOVOTEST warranty excludes NOVOTEST responsibility for any unforeseen or consequential damage happened in the result of defect covered by the above warranties. Such damages are (but are not limited to a list below):

- compensation for inconvenience, phone calls, storage and shipment of the device, loss of profits or material damage;
- all warranties become invalid if the device is officially recognized as not subject to repair.

3.3.8 Guarantees and consumer legislation

The basic NOVOTEST warranty, the extended NOVOTEST warranty do not infringe user legal rights granted by the sales contract, which is drafted for purchasing of the device from the manufacturer or an authorized NOVOTEST dealer; as well as applicable local legislation that defines the rules for the sale and servicing of consumer goods.

3.4 Maintenance of the device

This maintenance information is valid for all NOVOTEST products.

Maintenance of the device is performed during the entire service life and is divided into:

- preventive;
- planned.

Preventive maintenance is carried out not less than once per three months and includes external inspection, clearing and greasing.

Planned maintenance is carried out by the manufacturer at least once a year and is a mandatory requirement for maintaining the guarantee from the manufacturer.

It is very important to carry out its maintenance in a timely manner throughout the life of the device. At the same time, it is necessary to follow the schedule presented in Table 3.2 (focusing on the development of the device or the months of its operation, whichever comes first).

The specific list of operations performed during each maintenance depends on the model of the device, as well as on the year of its production and the amount of operating time. An authorized NOVOTEST service center will provide the user with information on the work to be performed when servicing the device.

Records on the routine maintenance of the device are made in the SERVICE AND MAINTENANCE RECORDS of the device. Information about maintenance is very important, it may be needed to implement user rights to warranty repair of the device. Therefore, always check that at the end of the maintenance period, authorized NOVOTEST service center has stamped SERVICE AND MAINTENANCE RECORDS in the appropriate place under the record of the procedures performed.

Table 3.2 - Maintenance schedule for NOVOTEST

Device	Maintenance schedule NOVOTEST
All models except those listed below	Annual maintenance is performed after one year or 2,000 operating hours (whichever occurs first)
Portable hardness testers (Leeb, UCI, Combined)	Annual maintenance is performed after one year or 2,000 operating hours (whichever occurs first)

In case of instrument fault detection, the device must be shipped to the manufacturer for maintenance. In Table 3.3. Faults that can be fixed by yourself.

Table 3.3 - Possible malfunctions and methods of their elimination

Name of malfunction, external manifestation and additional signs	Probable cause	Method of elimination
The device does not turn on	No power	Check the presence and status of self-contained power
No measurements	Break in the probe circuit	Check and eliminate the break
The instrument displays false readings	The device is not calibrated or is influenced by the influencing factors	Repeat calibration of the device and eliminate the influence of external factors

4 MAINTENANCE

The device by type of performance and taking into account operating conditions refers to products that are repaired at special enterprises or at the manufacturer.

To set the device for warranty service in the service center (SC), it is necessary to present correctly completed SERVICE AND MAINTENANCE RECORDS for the device. SC makes a mark in the SERVICE AND MAINTENANCE RECORDS about setting the device for warranty service and sends a photocopy to the manufacturer.

Sending the device for warranty (post-warranty) repair or verification should be done with the O.M. or SERVICE AND MAINTENANCE RECORDS of the device. In the accompanying documents it is necessary to indicate the mailing details, telephone and fax of the sender, as well as the way and the address of the return delivery.

Warranty repair is carried out in the presence of a completed SERVICE AND MAINTENANCE RECORDS.

5 STORAGE

Store the device at an ambient temperature of +5 ° C to +40 ° C and relative humidity up to 80% at a temperature of 25 ° C.

Storage of the batteries of accumulators (BA) should be carried out in a charged state separately from the device in a dry premise. Duration of storage of the fully charged BA in the detached state:

- at a temperature from -20 ° C to +35 ° C - no more than 1 year;
- at a temperature from -20 ° C to +45 ° C - no more than 3 months.

Recommended temperature for long-term storage 10 ° C - 30 ° C.

At the end of the shelf life, the batteries should be recycled.

In the case of short-term storage and during interruptions between applications, the device must be stored in a suitable packaging container. In the storage place there should be no vapors of corrosive substances (acids, alkalis) and direct sunlight. The device must not be subjected to sudden shocks, falls or strong vibrations. Devices should be stacked on shelves or stacked in transport packaging.

For long-term storage, the device must be preserved, for which the electronic unit, probe, power unit and thickness measures, cleaned of dirt and oil, are placed in separate plastic bags and placed in separate pockets of the transportation bag of the device.

6 TRANSPORTATION

Packed instruments can be transported by any mode of transport provided the following conditions are met:

- transportation is carried out in factory packaging;
- there is no direct exposure to moisture;
- the temperature does not exceed -50 ° C to +50 ° C;
- humidity does not exceed 95% at temperatures up to 35 ° C;
- vibration in the range from 10 to 500 Hz with amplitude up to 0.35 mm and acceleration up to 49 m/s^2;
- impacts with a peak acceleration value of up to 98 m/s^2;
- the devices placed in the transport are fixed to avoid falling and collision.

To prevent moisture condensation inside the hardness tester when transporting it from frost to a warm room, it is necessary to hold the device for 6 hours at room temperature.

7 RESYCLING

The product does not contain in its design any dangerous or poisonous substances that can harm human health or the environment and do not pose a threat to life, health of people and the environment at the end of their service life. In this regard, the recycling of the product can be made according to the rules for the disposal of general industrial waste. Recycling is carried out separately by groups of materials: plastic elements, metal fasteners. The content of precious metals in the components of the product (electronic cards, connectors, etc.) is extremely small, so it is not appropriate to produce their secondary processing.

SERVICE AND MAINTENANCE RECORDS

№	Description	Date

NOTES