alphaROCK

User Manual

Version 1.0

BAQ

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1 Safety and Liability

1.1 Introduction

This manual contains important information and safety instructions required for trouble-free and safe operation of the alphaROCK. It must be submitted to every user involved with installation, operation, maintenance and repair of the equipment and has to remain permanently accessible in its surroundings. Persons unable to understand or to follow the instructions provided are not allowed to work with the instrument.

In the case of suggestions concerning this document or supplementary questions, do not hesitate and contact our service team (service@baq.de).

1.2 Safety Notes

- Before starting any activity, carefully read this manual.
- Access to the document must always be ensured.
- Messages and warnings displayed on the alphaROCK should not be ignored.
- Operation in electrically hazardous or explosive environment is not admitted.
- Never leave the equipment to persons unable to follow safety instructions.
- Assign qualified supervision for new personnel.
- The alphaROCK is a sensitive device and should not be subjected to mechanical risks like shocks or strong vibrations.
- Before starting to clean the equipment, switch it OFF and disconnect the USB cable.
- Regular maintenance should not be omitted and is reserved to qualified personnel (i.e. tasks concerning electrical components should only be performed by an electrician).
- After completion of maintenance, do not forget to perform functional control.
- Damaged or worn cables should immediately be replaced.
- As soon as a critical damage (e.g. concerning the isolation) becomes obvious, switch OFF the instrument, disconnect the USB cable and consult factory service.
- The instrument must be protected from contact with liquid and humidity.
- Be aware that magnetic components in the vicinity may impair the precision of the measurement.

1.3 Liability

The instrument has been developed and manufactured according to the latest technological standards and current safety directives and has left the site in perfect condition. The client bears the entire responsibility for adequate use and operation by appropriate personnel. Note that warranty and liability claims relating to injuries or material damage, arising from one or several of the following reasons, shall be rejected:

- Applications beyond the scope described in the manual.
- Failure to observe safety information, with respect to operation, maintenance, cleaning and functional control of the instrument itself or connected accessories.
- Arbitrary modification of the instrument or connected accessories. In case of doubt, always consult factory service beforehand!
- Exchange of components by items not released by the manufacturer. Original BAQ spare parts are prescribed.
- Use of accessories not recommended by the manufacturer.
- Damage caused by accidents, improper handling or force majeure.

The information has been compiled by the manufacturer at the best of his knowledge, but no responsibility for correctness, completeness and accuracy can be assumed. In any case of doubt, consult factory service in time.

1.4 Appropriate Use

The instrument, developed exclusively for measurement of hardness for metal objects in solid state, should always be used in conformity with instructions specified in this document. Never leave it to unauthorized personnel, and interrupt all activities whenever a damage is suspected. Any application beyond the specification is considered as improper use.

2 Scope of Delivery

Scope of Delivery:

1 Basic unit alphaROCK
2 Probe cable alphaROCK ↔ UCI-Probe
3 Power supply (100-240 VAC; 50/60 Hz; 1.5 A)
4 USB cable (USB-A ↔ USB-C)
5 USB-Stick with manuals (PDF)
6 Transport case
7 Adjustable strap
8 Adapter USB-A ↔ USB-C

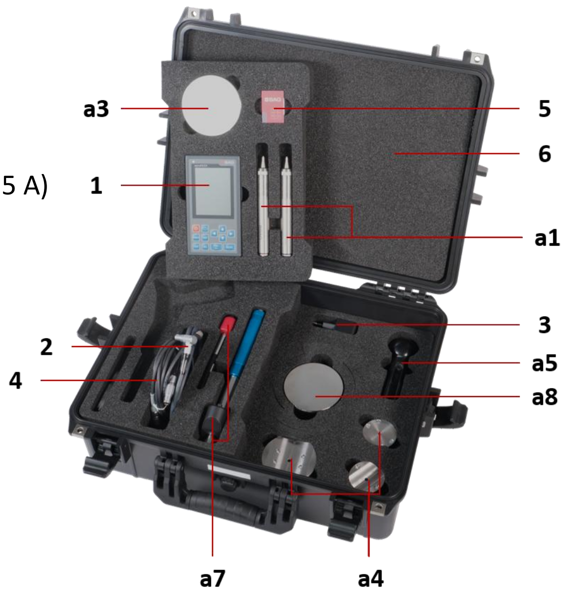


Fig. 1: Case with content (Pos. 7, 8 not visible)

Options available upon request (UCI):

a1 UCI-Probe
a2 BAQ Factory certificate for UCI-probes
a3 Certified UCI-Hardness test block (ISO and ASTM)
a4 Probe support for flat or curved surfaces
a5 Handle for probes (for 98N probes already included in standard delivery)
a6 High precision stand

Options available upon request (Leeb):

a7 Supplementary Leeb impact devices (refer to Fig. 17)
a8 DAkkS certified Leeb test blocks (ISO and ASTM)
a9 Prism attachments for measurements on curved surfaces

> *i* All articles incl. order codes are listed in Appendix 2: Order information.

3 Specification

Table 1: Specification alphaROCK

Dimensions	154 x 84 x 23 mm (H x W x D)		
Weight	430 g		
Display	3.5“-TFT-LCD color display 640 x 480 Pixel		
Battery pack	Integrated Lithium-Ion-Battery, 6800 mAh		
Operating time	approx. 12 h		
Charge time	approx. 4 h (from 10 to 80 % in disabled state)		
Memory	2 GB RAM, 32 GB eMMC-Flash-Memory		
Temperature ranges	Storage:	-20°C to 70 °C	-4°F to 158 °F
	Operation:	-15°C to 60 °C	5°F to 140 °F
	Charging:	0°C to 40 °C	32°F to 104 °F
Humidity	90 % max., non-condensing		
Environment	Suitable also for outdoor applications		
Connectors	USB-C (charging and data transfer) Socket for probe cable (UCI) / impact device cable (Leeb)		
Signal devices	Status-LED Beeper		
Languages	German, English		

Table 2: Specification UCI-probes

Testing method	Modified Vickers hardness acc. to UCI method DIN 50159, ASTM A1038 and VDI/VDE directives 2616, sheet 1. Measurement of indent takes place in presence of the test load.
Indenter	Diamond, Vickers pyramid with 136° acc. to DIN EN ISO 6507 respectively ASTM E92.
Admitted material	Preferably metals, provided that calibration by means of hardness test blocks or reference material is possible. Ceramics and glass may be tested as well, if comparative measurements for calibration are carried out.
Test load	3N 10N 20N 30N 49N 98N HV0.3 HV1 HV2 HV3 HV5 HV10 (depending on probe)
Dimensions (standard-probe)	Diameter: 19.5 mm Length: 175 mm
Weight	190 g
Interface	CAN
Measuring range	ca. 10 – 3000 HV Conversion acc. to EN ISO 18265 and ASTM E140
Precision*	< 2 % (100 – 1000 HV)
Repeatability*	< 2 % (100 – 1000 HV)
Resolution	1 HV
Test direction	In any orientation
Hardness scales	HV, HB, HRC, HRB, HRA, HRD, HRE, HRF, HR45N, HK, N/mm²
Temperature ranges	Storage: -20°C to 70 °C -4°F to 158 °F Operation: -15°C to 60 °C 5°F to 140 °F
Humidity	90% max., non-condensing

* Internal BAQ specification, valid for a set of 5 measurements on UCI hardness test blocks for all probes in state of delivery, regardless of test load. This precision considerably exceeds the requirements concerning deviations admitted by DIN 50159.

Table 3: Specification of impact devices

Indenter	Carbide ball acc. to DIN EN ISO 16859 and ASTM A956						
Impact devices	**Type**	**D**	**DL**	**D+15**	**DC**	**C**	**G**
	Impact speed [m/s]	2.05	2.05	2.05	2.05	1.39	2.98
	Mass of impactor [g]	5.45	7.25	7.75	5.45	3.1	20.0
	Ø Test tip [mm]	3	3	3	3	3	5
	Ø Support ring [mm]	20	-	14	20	20	30
	Length [mm]	147	75	162	86	141	254
	Weight [g]	50	50	80	50	75	250
Measuring ranges	Refer to Appendix 1: Hardness conversion validity ranges Table 21						
Resolution	1 HL						
Testing direction	Adjustable						
Hardness scales	HL, HV, HB, HRC, HRB, HRA, N/mm² (depending on impact device)						

Table 4: Accuracy and repeatability alphaROCK in accordance with DIN EN ISO 16859-2

Impact device type	***Hardness of the Leeb test block [HL]***	***Max. Error of the test device [%]***	***Acceptable coefficient of variation of the test device***
D, DC, D+15	< 500	± 4,0	2,5
	500 – 700	± 3,0	2,0
	> 700	± 2,0	1,5
DL	< 700	± 4,0	2,5
	700 – 850	± 3,0	2,0
	> 850	± 2,0	1,5
G	< 450	± 4,0	2,5
	450 – 600	± 3,0	2,0
	> 600	± 2,0	1,5
C	< 600	± 4,0	2,5
	600 – 750	± 3,0	2,0
	> 750	± 2,0	1,5

4 The alphaROCK in UCI-Mode

4.1 Introduction to the UCI Hardness Measuring Principle

4.1.1 The UCI Method

The UCI method (Ultrasonic Contact Impedance, as defined in ASTM A1038 and DIN 50159) is similar to the widespread Vickers principle, but manages without microscopic optical analysis. The hardness value is determined directly during the penetration process. The method therefore proves to be quick and simple, perfectly suited for mobile applications. A further benefit is its ease of automation.

Analogously to the Vickers procedure, an indent in the test object is created under defined load (3 – 98 N). The method makes use of a Vickers diamond with exactly defined geometry acc. to DIN EN ISO 6507-2 as well, but in this case mounted to the end of a vibrating rod. This rod, subjected to longitudinal vibrations generated by piezoelectrical crystals, initially vibrates at its natural resonance frequency f_0 of 66 kHz (refer to Fig. 2):

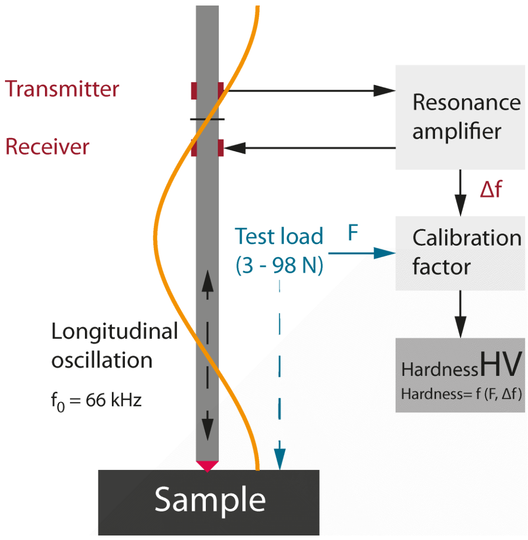


Fig. 2: Vibration of the UCI-rod

During the penetration of the diamond into the sample, the test load continuously increases, and the attenuation causes the resonance frequency to change. This change of frequency can precisely be measured. As soon as the preset test load (3 – 98 N) is achieved, the difference to the original natural resonance frequency f_0 is calculated and converted into a hardness result.

The frequency change generally depends on the size of the contact area between diamond and sample, and therefore also directly on the hardness. The area of the indentation under a given load is obviously larger for a softer material. The following applies in principle:

Hardness = f (F, Δf)   with: test load F and change of frequency Δf

As the frequency change depends also on the elastic modulus of the concerned material, this property must be taken into consideration. For this reason, calibration of the UCI – probes on hardness test blocks (steel plates with different hardness), is essential. The hardness is calculated from these calibration values together with the known test load and the measured frequency difference.

Within a specific material group (e.g. steel with 200 – 220 GPa), the fluctuation of the elasticity is very low, so its influence can be neglected. For material with considerably differing elasticity however, a calibration by means of a corresponding reference sample, is mandatory (refer to chapter 4.3).

The calibration procedure is as follows: The hardness of the material is measured on a stationary testing machine, and the result obtained this way serves as a reference for following UCI calibration measurements. Internally, the alphaROCK makes use of the UCI calibration measurements and the reference hardness of this material, to establish a new calibration curve, allowing for precise measurements of this material from now on.

4.1.2 Main Applications

The alphaROCK represents a practical mobile unit for UCI hardness measurement of metals. It is mainly used for:

- Incoming inspection
- Quality control during running production
- Mobile inspection of components directly “in the field”
- Tests independent of orientation
- As the size of the indents is very small, the method is acknowledged as nearly non-destructive
- Thanks to its speed, 100% inspection during running production is possible
- Positions with difficult access, narrow spaces or in presence of complex part geometry
- Inspection of heavy objects or parts difficult to move
- Weld seam inspection
- Layer hardness
- Tests to be carried out within shortest delay, e.g. after heat treatment or surface processing

These applications clearly illustrate the versatility and the significance of the method in numerous industrial sectors. Reliable and exact results considerably enhance the possibilities in quality control, failure analysis and material characterization.

4.1.3 Requirements for the application of the UCI procedure

To ensure efficient and precise hardness testing with the alphaROCK, some conditions must be observed. These are described in the following sections.

4.1.3.1 Qualification of Personnel

Reliable results of the UCI-hardness testing cannot be obtained without a certain knowledge and experience of the testing personnel. These include:

- Knowledge of the influence of material properties like microstructure and modulus of elasticity, in order to select and to implement a convenient testing method.
- Knowledge of the influence of the surface structure on the detected hardness value.
- Understanding of the conversion of UCI-hardness results (reference) into other hardness scales, as well as an overview of the different methods of hardness measurement.
- Practical experience in application of UCI probes.

4.1.3.2 Sample Properties

Even though the UCI-method is convenient for nearly all metallic materials, the properties of the sample itself should not be disregarded when interpreting a result. This circumstance, by the way, holds for every hardness testing method.

In this context, besides the surface structure, the sample thickness and weight as well as its homogeneity have to be mentioned. Strong scattering of results or major deviations may be caused by excessive roughness or insufficient sample thickness. For this reason, before initiating a test, verify the suitability of the sample and prepare it conveniently in case of need.

To ensure a reliable and reproducible test, the sample must fulfill the following requirements:

Table 5: Conditions for a sample to perform a UCI-test

<table>
<tr><td>Minimum thickness (without coupling)</td><td colspan="3">> 4 mm
(depending on sample geometry)</td></tr>
<tr><td>Minimum weight (without coupling)</td><td colspan="3">> 100 g
(depending on sample geometry)</td></tr>
<tr><td>Minimum distances</td><td colspan="3">To the border: 5 mm
Between two indents: 1 mm</td></tr>
<tr><td rowspan="6">Max. surface roughness</td><td rowspan="2">Test load</td><td colspan="2">Ra_{max} in µm</td></tr>
<tr><td>DIN 50159</td><td>ASTM A1038</td></tr>
<tr><td>98 N</td><td>1.0</td><td>15.0</td></tr>
<tr><td>49 N</td><td>0.8</td><td>10.0</td></tr>
<tr><td>10 N</td><td>0.5</td><td>5.0</td></tr>
<tr><td>3 N</td><td>n.s.</td><td>2.5</td></tr>
<tr><td>Test environment</td><td colspan="3">During the test, the sample should neither move nor be subjected to vibrations. Environmental influences like temperature and humidity must be taken into consideration, too.</td></tr>
<tr><td>Surface</td><td colspan="3">Cleanliness and absence of oxides, grease and foreign matter are imperative.
(Treatment with abrasive paper or isopropyl alcohol may be necessary)</td></tr>
<tr><td>Min. layer thickness</td><td colspan="3">10 x penetration depth
(refer to Fig. 4)</td></tr>
</table>

A drawback of the standard Vickers method consists in the fact that the diagonals of the indents are measured, but corners in rough surfaces often cannot exactly be determined. The UCI principle on the other hand takes into consideration the entire contact area - with the integrating effect, that the scattering of the results is considerably lowered.

If the maximum roughness depth values listed in Table 5 are exceeded, the sample surface may adequately be prepared e.g. by abrasive paper, in accordance with specifications. Partial grinding of the test point is sufficient, on the basis of the following table:

Table 6: Achievable R_a- values by grinding

Grain size acc. to FEPA Standard	120	180	240
Achievable roughness depth R_a	ca. 1.2 µm	ca. 1.0 µm	ca. 0.6 µm

Coupling / Embedding of a Sample

In the course of the UCI test, the rod oscillates at a frequency of more than 66 kHz. These vibrations transmitted to the sample, are spreading and reflected by boundaries, which gives rise to the following difficulty: In the case of small or thin components, when measuring in the vicinity of the border, the test result may be falsified by additional resonances.

To avoid this phenomenon, the sample may be coupled to a firm support by means of a thin oil film acting as couplant. A solid steel plate is recommended as a base, e.g. as used in the high precision stand. Otherwise a massive steel plate may be used.

Embedding the sample may be a further solution, taking care however that no gap between sample and investment material is introduced.

Homogeneity

As the indents created by the UCI-method (identically to Vickers tests) are relatively small, local variations of material properties like elastic modulus may have an effect on the result. Sufficient homogeneity of the material therefore is decisive, in order to carry out a meaningful test.

Furthermore, it is important that the size of the indent considerably exceeds the grain size. For some cast materials, even a test load of 98 N may no more be able to comply with this condition. In this situation, the measurements can be carried out with the alphaROCK in Leeb mode.

4.1.3.3 Elastic Modulus

As previously mentioned, the change of frequency occurring during increase of the test load, depends not only on the hardness, but also on the elastic modulus of the material in question.

The UCI probes are calibrated at the factory on hardness test blocks (reference plates made of steel with different hardness) with a modulus of elasticity of 210 GPa. The probes can therefore generally be used without further ado for materials with a modulus of elasticity of 210 ± 10 GPa, as the influence of minor fluctuations in the modulus of elasticity on the hardness value can be neglected.

For material with considerably differing elasticity however, a material calibration by means of a reference sample of the concerning material has to be carried out (refer to chapter 4.3). The hardness is measured on a stationary testing machine, and the following calibration obtained this way is stored in the internal memory of the alphaROCK for corresponding applications.

4.1.3.4 Regular Functional Control

Combined with the probes, the alphaROCK offers - if correctly used - a stable system with a long lifetime. Nevertheless, regular inspections are strongly recommended. This includes:

- Visual inspection of the diamond under a microscope.
- Verification of accuracy and repeatability, on hardness test blocks acc. to standard DIN 50159 or ASTM A1038 (refer to Table 7).
- Regular maintenance incl. calibration (annual interval recommended), performed by BAQ GmbH or an authorized service partner, is helpful to ensure accuracy of measuring results over the entire hardness range acc. to relevant standards.

DIN 50159-1 specifies in detail the periodic verification of UCI testing equipment by users. Prior to start-up, at least three measurements on an appropriate hardness test block are recommended. The maximum admissible deviation of the average is listed in the following table:

Table 7: Admissible deviation of the average

Hardness scale	***Maximum deviation of average [%]***			
	< 250 HV	***250 to < 500 HV***	***500 HV to 800 HV***	***> 800 HV***
HV 0.3	6	7	8	9
HV 1	5	5	6	7
HV 5	5	5	5	5
HV 10	5	5	5	5

i The internal quality requirements of BAQ considerably exceed the prescriptions of the standard. Only probes with a max. deviation of < 2 % for a set of 5 measurements are released for delivery.

i If during an inspection, a damaged diamond or excessive deviations/scattering of measuring results become obvious, the instrument should immediately be returned for maintenance to BAQ or an authorized service partner.

i Acc. to DIN 50159 – 2, only hardness test blocks with diameter of > 50 mm, thickness of > 15 mm and elastic modulus of 210 ± 10 GPa should be used for functional control. For smaller blocks, coupling is imperative.

! Triangular Vickers test blocks with a thickness of 6 mm or HRC test blocks are often used for mistake. For the latter items, surface treatment for UCI-tests is not admissible, as the hardness results may be lowered to an inadmissible degree.

! For verification of the alphaROCK, the material matching the hardness test block (or the reference part used) must be configured, and the appropriate hardness scale must be used (for standard UCI hardness test blocks: Material Standard/Steel and scale HV).

4.1.4 Selection of Test Probes

UCI probes are available with test loads ranging from 3 N (HV0.3) to 98 N (HV10) in different versions. In addition to standard types, models for specific applications like measurement on tooth flanks, SL- or SL-L probes are available upon request (refer to Fig. 3).

All of the probes are suitable for every hardness range, they only differ with respect to handling and size of indents. Selection of test load mainly depends on surface roughness of the inspected object. General rule:

"The required test load of the probe increases with surface roughness."

Typical examples for the selection of the test load are specified in standard DIN 50159-1:

Fig. 3: Standard UCI-probe (above), SL-probe (center); SL-L-probe (below)

Table 8: Admissible R_a-values and typical applications as a function of test load

Test load	***$R_{a,max}$ in µm***		***Typical applications***
	DIN 50159	***ASTM A1038***	
98 N	1.0	15.0	Small forgings, weld seam inspection, inspection of heat affected zone
49 N	0.8	10.0	Induction- or case-hardened machine components, e.g. camshafts, turbines, weld seams, inspection of heat affected zone
10 N	0.5	5.0	Ion nitrated stamping tools and matrices, molds and presses
3 N	n.a.	2.5	Layers, e.g. copper or chromium layers on steel cylinders (t ≥ 0.040 mm), copper gravure cylinders, hardened layers (t ≥ 0.020 mm)

In some applications, damage to the sample surface during test should be kept as low as possible. Generally, the UCI principle, due to the small size of the indent, is accepted to be nearly non-destructive. Fig. 4 shows the indentation depth in connection with sample hardness and test load.

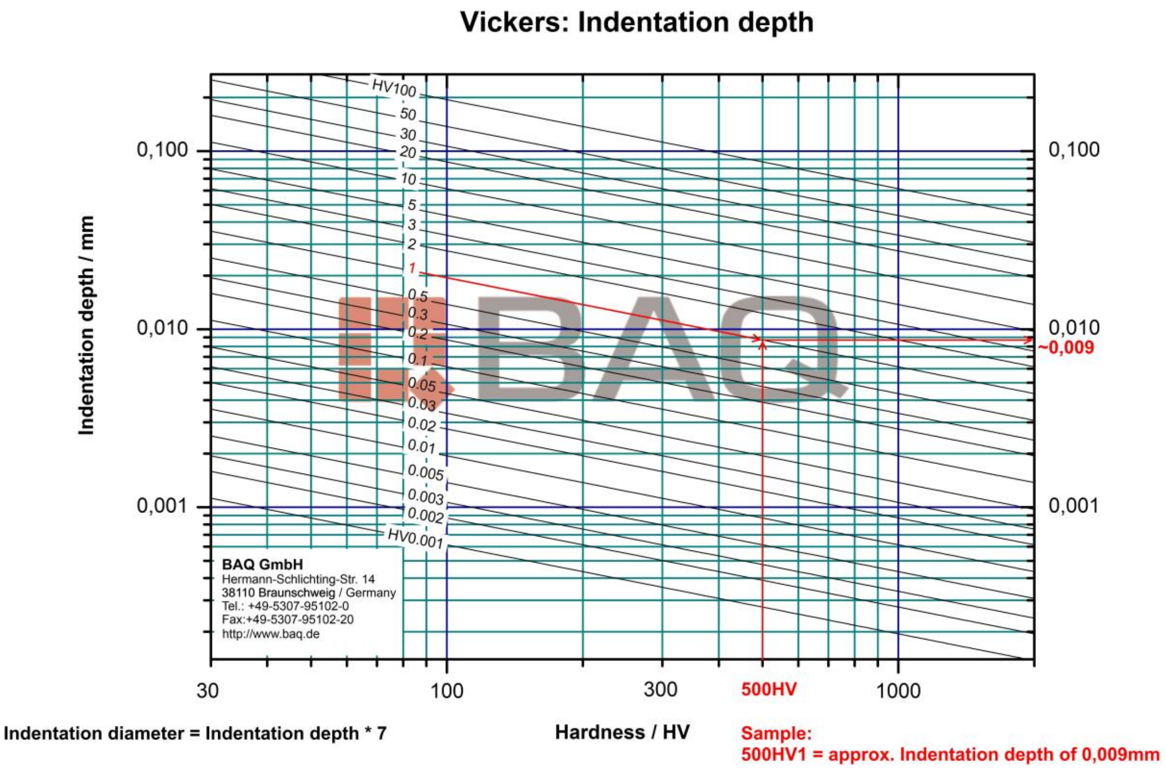


Fig. 4: Diagram of indentation depth

As an example, for three different sample hardness values, the indentation depths and diagonals, depending on the test load, are listed in the table below. This may be useful as a first overview.

Table 9: Indentation depths and diagonals in µm for different test loads and hardness values

Hardness	***HV0.3***		***HV1***		***HV5***		***HV10***	
	Diag.	***Depth***	***Diag.***	***Depth***	***Diag.***	***Depth***	***Diag.***	***Depth***
200 HV	56	8	98	14	210	30	315	45
500 HV	35	5	63	9	140	20	182	26
800 HV	28	4	49	7	105	15	154	22

Hardness test for coatings

For inspection of the hardness of layers, the UCI-method proves to be useful likewise. To avoid any influence from the base material, the penetration depth of the Vickers diamond should however be restricted to 1/10 of the layer thickness. For first orientation, refer to Fig. 4.

4.1.5 Applicable Standards

The UCI process is subject to different standards. Conformity of the measurements with these directives ensures correspondence to recognized international industrial standards and reliable results. For UCI-tests:

- DIN 50159 — Hardness testing with the UCI method
- ASTM A1038 — Standard Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method

For conversion of the results into other hardness scales:

- ASTM E140 — Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness and Scleroscope Hardness
- DIN EN ISO 18265 — Conversion of hardness values into other scales

4.2 Operation

The following chapter provides a comprehensive introduction to the alphaROCK hardness tester in UCI mode. It offers a detailed overview of the basic design and practical operation to ensure a smooth introduction to the use of this device.

4.2.1 Design and Connections

Fig. 5: Structure, operating elements and connections

Table 10: Connections and operating elements

No.	***Designation***	***Description***
1	Status-LED	Lights up with reduced brightness if the alphaROCK is being charged when switched OFF. After switching ON, this element is lit permanently.
2	USB-C	Interface for charging and data transfer to PC or USB stick.
3	Socket for connection of UCI probes	Attachment of probe cable, with marking and Push-Pull lock.
4	Display	3.5“-TFT-LCD color display.
5	Keyboard	The instrument is controlled by these buttons.
6	Fixing hole	Intended for strap.

4.2.2 Charging, Switching ON and OFF

Prior to initial use, charge the instrument completely by means of the power pack included in the delivery, first establishing a mutual connection via USB-cable provided. As soon as this connection exists, plug in the power pack into a power socket (for some countries, an adapter may be required). If the instrument is switched ON however, charging process becomes visible by a flash in the battery symbol within the status line. If the alphaROCK is being charged when it is switched OFF, the status LED lights up with reduced brightness.

> *i* The charging process from 10 to 80 % takes approx. 4 hours.

> *i* If the connector is plugged in too slowly, the charging process takes place at reduced speed for safety reasons, since the power management of the instrument within the default time limit cannot identify USB-cable and power module as safe.

The alphaROCK is switched ON and OFF by POWER button. After activation, the Status-LED is continuously lit, and after initialization the BAQ Boot Logo symbol appears. When the instrument is ready to operate, the screen shows either the main menu (if no test probe is connected) or instantaneously the Measurement window with the last settings (with probe connected).

4.2.3 General Operation

<u>Status Line</u>

The status line always appears in the upper zone of the display, showing time and charge level of the battery. According to the charging state of the battery, one of the following symbols is indicated:

 The charging process is running

 Battery level sufficient

 Low level

<u>Text Input</u>

Saving measuring data, parameters or material names requires text input. In these situations, a text input window is opened, such as the input of a material name shown in Fig. 6.

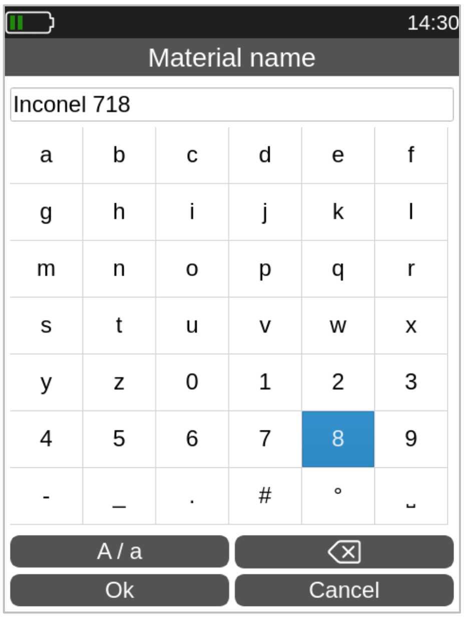


Fig. 6: Text input dialog (entry field is marked)

The current text (here: Inconel 718) is shown in the corresponding field, selectable characters appear below. The buttons shown in the lower area have the following functions:

A/a	Switch over between upper and lower case
OK	Accept the text and close text input window
⌫	Delete last character
CANCEL	Close text input window, discarding the changes made

Important key functions during text entry:

DEL:	Delete last character
ESC:	Close text input window, discarding the changes made
:	Change between text field, symbol table and buttons

Number Input

For input of numbers, corresponding fields are provided. Digits in these fields can be changed individually, by moving the cursor to the desired position by ◄ and ►. The active position is marked, and the corresponding value can be increased or lowered by ▲ and ▼. A further position can be added in leading position by ◄ cursor (to obtain larger values). Examples of number input fields are the entries of Upper tolerance limit, Lower tolerance limit and Number for statistics in the measurement parameter dialog, see Fig. 7:

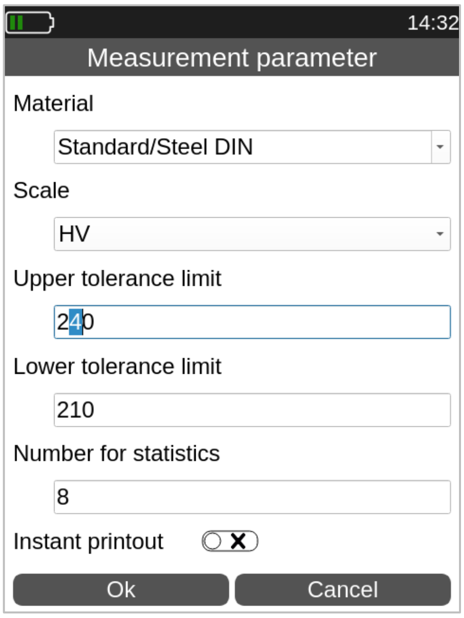


Fig. 7: Fields for number input

Important key functions during entry of numbers:

DEL: Set back number input

: The entry is accepted, and the next field becomes activated

Selection Dialogs

There are selection dialogs at various points in the alphaROCK, e.g. if a series or serial series is to be continued, deleted, displayed or transferred to a USB stick. Fig. 8 shows the selection of a series of a serial series as an example.

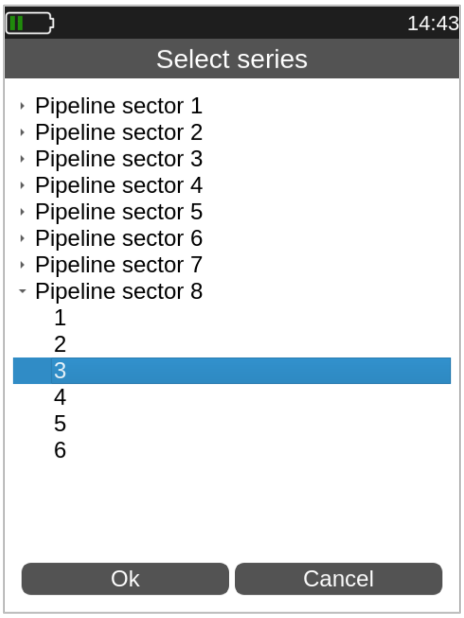


Fig. 8: Selection Dialog

In these dialogs, the desired data set is chosen by arrow keys. To select OK button, press . The corresponding action is finally put into effect by pressing ENTER.

4.2.4 Preparation of UCI Hardness Measurement, Basic Settings

Connection of the Probe

UCI probes are connected via probe cable included in the delivery. To avoid faulty connection, insertion has to be carried out always in specified orientation (red markings must be positioned on top of each other while plugging in).

The connections feature Push-Pull locks, reliably protecting from detachment and insensitive to vibrations, so the connection during operation remains stable. To disconnect, axially draw the outer sleeve of the plug.

> *i* Probes can also be attached or changed, while the instrument is switched ON.

Preparation

Before initiating the actual measurement, use a suitable UCI hardness test block to check functionality. Daily verification is recommended. Furthermore, it is essential that the sample is appropriate for UCI-testing and a corresponding material calibration has been established. If required, the sample has to be prepared according to instructions in chapter 4.1.3.2.

Adjustment of Measurement Parameters

Measurement parameters may have to be adjusted, whereas the test load of the connected probe is recognized automatically, not influenced by the user. Open the dialog for parameters either by menu point **Measurement parameter / Edit** or by means of the Settings buttons within the Measurement window. Generally, the parameters shown in Fig. 9 are provided. They are described in the following.

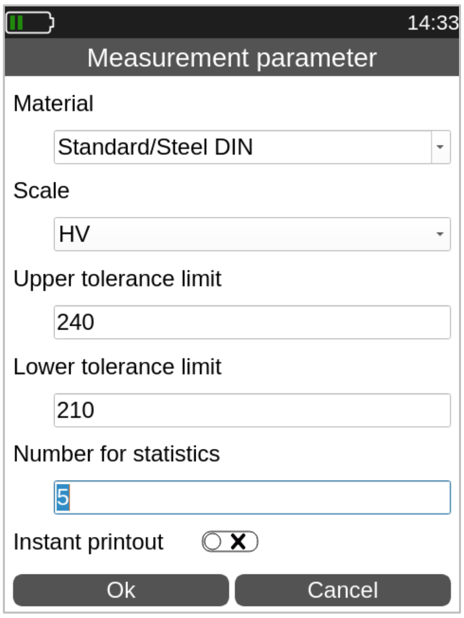


Fig. 9: Adjustment of measurement parameters

Material

This field shows the current material calibration. By the manufacturer, only material Standard/Steel has been implemented, intended for material with an elastic modulus of 210 ± 10 GPa.

Materials not valid for the currently selected conversion standard (DIN EN ISO 18265 or ASTM E140) are grayed out. Further information about material calibration is given in chapter 4.3. Within the Measurement window, the material can be changed by MAT key.

Hardness Scale

The results are displayed by means of the specified scale, with the Vickers hardness serving as reference scale. After selection of another scale, the results are transformed, if possible (refer to Appendix 1: Hardness conversion validity ranges). To changeover to another scale, press SCALE key in the Measurement window.

> *i* Hardness values that cannot be converted to the new hardness scale are displayed as 0.

Tolerance Limits

This function defines the tolerance range, to set up a distinction between OK and NOK results. Upper and/or lower limits can be specified. If “-” is entered for a particular limit, this limit is left aside.

Results beyond the tolerance range are marked in red, and a beeper alarm sounds (two short signals). An arrow shows whether the value is excessive or insufficient. Acceptable results are displayed in green, accompanied by a single acoustic signal.

Note that limits are stored only for one hardness scale. If limits are entered for another scale, existing input is overwritten.

Number for Statistics

This quantity describes the population, i.e. the number (n) of measurements to be included in statistical analysis. As soon as the value (n) is reached, the Statistics window opens automatically (refer to chapter 4.2.5.2). This function correspondingly offers an intermediate information within a series. If intermediate statistical analysis is deemed to be unnecessary, set this value to 0.

Instant Printout

If a mobile printer is connected, the feature of logging measuring results line-by-line, can be switched ON and OFF by means of this selector switch. If no printer is connected to the alphaROCK, the function is not available.

> *i* If instant printout is activated, deleting measuring results is no more possible.

Test load

As already mentioned, the test load is a parameter directly transmitted from the probe to the instrument and cannot be altered by the user. The test load is displayed in the Vickers scale.

i After switching ON, initially always the last used measurement parameters are active. Measurement parameters material, hardness scale and tolerance limits can directly be set in the Measurement window.

i For frequently arising measuring tasks, it is favorable to store measurement parameter sets; retrieve them whenever needed (refer to chapter 4.2.6).

4.2.5 Measurement Window

4.2.5.1 Overview and Settings

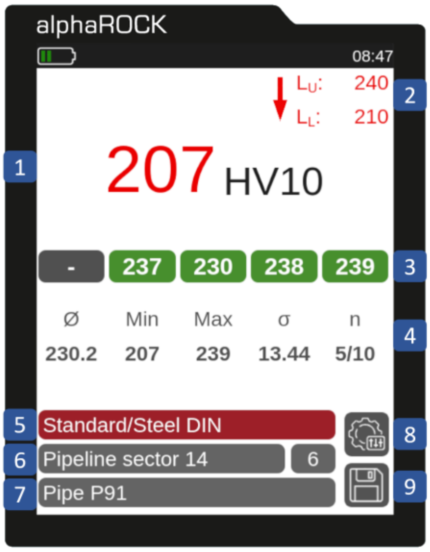


Fig. 10: Measurement window

Table 11: Measurement window

No.	Designation	Description
1	Hardness Value and Scale	Last result with assigned hardness scale.
2	Limits	Individually specified tolerance limits.
3	Result History	The last five results are displayed.
4	Statistics	Statistical analysis of the active series with average (Ø), minimum/maximum (Min/Max), standard deviation (σ), number of measurements (n; deleted measurements are not included).
5	Material	Material calibration currently in use (in state of delivery, only Standard/Steel is available).
6	Name and No. of series/ serial series	Designation of user defined series or serial series (if loaded) and No. of the series within the serial series.
7	Name of measurement parameter set	Designation of a user defined measurement parameter set (if loaded).
8	Settings	Adjustment of measurement parameters (refer to Fig. 9).
9	Save	The current measurement is saved.

Immediate visual supervision is simplified by partially colored presentation of the results, both within the Measurement window (hardness result and history) and in the Statistics window for display of individual results (refer to chapter 4.2.5.2). The color coding is as follows:

Table 12: Color Coding of Measuring Results

Color	***Meaning***
Dark Gray	**Result with no specified limits**
Green	**Result within tolerance**
Red	**The tolerance range has been exceeded**
Orange	**The converted hardness result is outside the definition area of conversion, but may be used as approximate value**
Light Gray	**Result has been deleted**

The operation is furthermore supported by several keys provided in the Measurement window, as detailed below:

-key:

The so-called TOGGLE key allows navigation within the Measurement window, to jump from one range or input field to another. First press to activate the Toggle mode. Afterwards, it is possible to change between Upper Limit, Lower Limit, Settings and Save button. The currently activated item is always marked, so that adjustments or other functions can be carried out.

> *i* Note that in Toggle mode SCALE, MAT, DEL and STAT keys are disabled.

SCALE-key:

This function is used to change the hardness scale. It is possible to decide within the systems settings whether a change is intended to take place either by automatic selection of the following valid scale, or via dialog window (refer to chapter 6.3). If possible, all results recorded up to that moment are automatically converted into the new scale, including statistics (refer to chapter 4.4).

i Hardness values that cannot be converted to the new hardness scale are displayed as 0.

MAT-key:

This function is used to change the material. It is possible to decide within the systems settings whether a change takes place by automatic selection of the following material valid for the current conversion standard scale, or via dialog window (refer to chapter 6.3). If the currently selected hardness scale is not defined for the material chosen, the hardness scale automatically returns to HV.

i When changing the material, results recorded up to that moment are automatically deleted and any limits entered and any measurement parameter set that may have been loaded are reset.

DEL-key:

The last measuring result is erased. It appears in the results history all the same, but appears grayed out. Pressing the DEL key again deletes the second last result etc.

i If six or more results have already been deleted, this function is also applied to results no more present in the results history.

STAT-key:

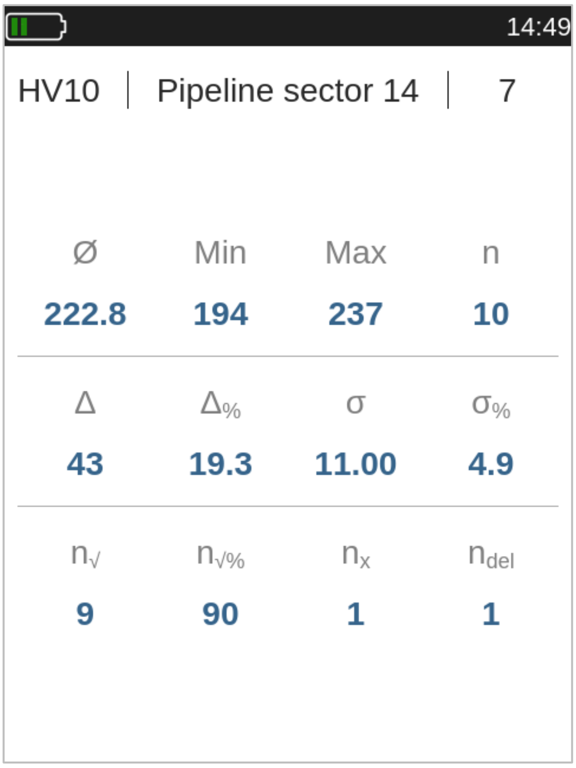
This key opens the Statistics window respectively toggles between Statistics window and display of individual results (refer to chapter 4.2.5.2).

4.2.5.2 Statistics Window

The statistic window is called up when:

- The number (n) of measurements specified in the measurement parameters has been reached,
- the STAT-key is pressed,
- a series of a serial series is complete,
- or a series is opened from the menu **Data management / Display series**.

Fig. 11 shows an example:



Header	Hardness scale | Name of series/serial series | No. of series within serial series
ø	Average
Min	Minimum
Max	Maximum
n	Number of measurements (deleted elements are not counted)
Δ	Absolute span between minimum and maximum
$\Delta_{\%}$	Relative span referring to average
σ	Absolute standard deviation
$\sigma_{\%}$	Relative standard deviation
$n_{\checkmark}$	Quantity of measurements within tolerance
$n_{\checkmark\%}$	Percentage of measurements within tolerance
$n_{\times}$	Percentage of measurements outside tolerance
n_{del}:	Quantity of deleted measurements

Fig. 11: Statistics window

Pressing the STAT-key from Statistic windows changes over to the display of individual results. All results of the series are listed and numbered, color coded as described in Table 12. Fig. 12 shows the display of individual results matching Fig. 11:

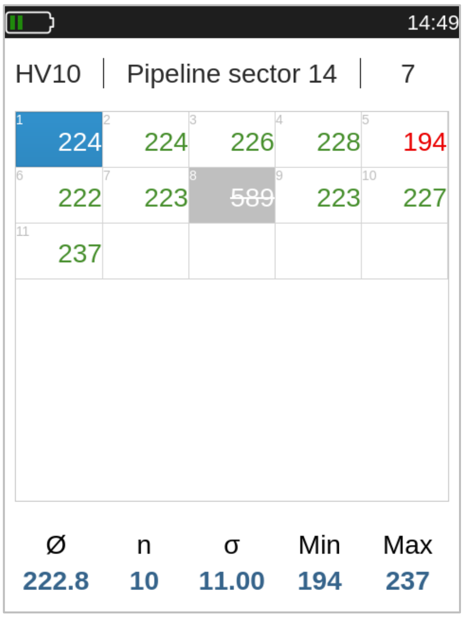


Fig. 12: Display of individual results

The currently selected result is marked. Use the arrow keys to change between the items, and the DEL – key to erase the currently selected element. In this case, the measured value is crossed out and displayed in gray and statistics are updated at once. If results have been deleted, a dialog appears during closure of the Statistics window, to decide whether modifications are intended to be accepted or discarded.

> *i* Activated instant printout blocks the DEL function. Subsequent deleting is also not possible, if a series has been called up via menu point **Data management / Display series**.

The Statistic windows is closed by ESC. If the preset number of measurements has not yet been reached (because the statistics by STAT key are activated earlier, or a result has been deleted during editing), the measurement continues.

In the configuration - refer to chapter 6.3 -, it is possible to decide, whether the Save dialog is not only intended to appear when closing the Measurement window, but also when leaving the Statistics window (provided that the specified number of measurements has been reached). In this case, the current results are stored as series and the preset number for statistics is reset, so that the series afterwards may be resumed.

4.2.6 Management of Measurement Parameter Sets

Generally, the measurement parameters specified under chapter 4.2.4, are provided. The system enables combinations of these parameters to be implemented and stored with a user defined name, so the desired parameter set may quickly be retrieved. This feature however requires a probe with test load matching the value defined in that parameter set, to be connected beforehand.

Storing a parameter set includes:

- A user defined name
- Test load (of the probe connected during storing process)
- Material
- Hardness scale
- Tolerance limits
- Instant printout (ON/OFF)
- Number for statistics

Currently selected measurement parameters can be edited under menu point **Measurement Parameters / Edit**. If this procedure is intended for a parameter set stored earlier, first load it.

In order to store the currently selected measurement parameters, use menu point **Measurement Parameters / Save**, which opens a dialog box to enter a new name for this set.

Parameter sets stored beforehand can be retrieved by **Measurement Parameters / Load**. When calling up the Measurement window for the next time, the designation of the loaded set is shown, and the parameters are automatically applied.

To erase a stored parameter set, use menu point **Measurement Parameters / Delete**.

i	When loading a set with a selected material not provided in the current conversion standard (DIN EN ISO 18265 or ASTM E140), the conversion standard is automatically changed over.

i	Editing, saving, and loading of parameter sets is only possible when a probe is connected.

i	When a probe is connected, only UCI parameter sets can be loaded.

i	Under **Measurement Parameters / Delete**, all stored parameter sets (UCI and Leeb) are always displayed. If both types are available, they are shown in a clear tree structure.

4.2.7 Management of Series and Serial Series

Up to 1.000.000 results may be stored within the internal memory of the alphaROCK, all of them organized in series of measurements. A measurement series is defined as a set of results, recorded in form of single series or serial series. A serial series consists of several single series with identical measurement parameters.

The Measurement window furthermore offers the possibility to capture measurements without establishing a series or serial series beforehand. When storing these elements by Save button, a selectable name may be assigned by text input. After completion of text entry, the measurements are saved as a single series under this chosen designation (refer to following section).

i In series or serial series SCALE and MAT keys are disabled.

4.2.7.1 Series

Already before starting the measurement, a series may be agreed under menu point **Data management / Start new series**, meanwhile specifying a name for subsequent identification. After completion of entry, the Measurement window opens automatically.

i Note that always the currently valid measurement parameters are used for a series. This means that the desired parameter set must be loaded beforehand, since a change of parameters is no more possible while the series is recorded.

When leaving the Measurement window, a dialog is opened to ask whether the series is intended to be stored. If this is confirmed, the measurements are saved under the previously defined name.

To resume a previously stored series, use **Data management / Continue series**. Results registered in the following, are appended to the already existing elements.

The content of a series may be viewed together with statistical information (refer to chapter 4.2.5.2). For this purpose, the menu point **Data management / Display series** is provided.

It is advisable to sometimes remove series no more required (by menu point **Data management / Delete series**). This may be of interest to prevent confusion.

4.2.7.2 Serial Series

A serial series measurement is composed of single series, all of them with identical measurement parameters and the same quantity of measurements. Within the serial series, the series are numbered consecutively, all of them with the same designation. A serial series therefore represents a comfortable tool to summarize series with identical parameters, e.g. for quality control of a large batch of equal objects.

In order to establish a serial series, use menu point **Data management / Start new serial series**, meanwhile specifying a new name and then the number of measurements to be performed per series. As soon as the entry is complete, the Measurement window automatically opens, and the first series may be launched. When the specified number of measurements is reached, the Statistics window automatically opens. After closure of this window, the system is ready for the next series. The number of series to be contained in a serial series is not limited. Name of serial series, number of the current series and quantity of measurements in this series are continuously displayed in the Measurement window.

Complete series of a serial series are stored automatically. If the Measurement window is left before the end of a series, a prompt appears to decide whether incomplete series are intended to be saved as well.

> *i* Note that always the currently valid measurement parameters are used for a serial series. This means that the desired parameter set must be loaded beforehand, since a change of parameters is no more possible with a serial series running.

To resume a previously stored serial series, select it and use menu point **Data management / Continue serial series**. Results recorded in the following, are appended to the loaded serial series, together with time and date. Measurement parameters are automatically reset to the settings valid for the selected serial series. In case of need, the system changes over to the chosen conversion standard (DIN EN ISO 18265 or ASTM E140). If the last subordinary series is not yet complete, it is continued, otherwise the next subordinate series is launched.

The content of a series measurement may be viewed together with statistical information (refer to chapter 4.2.5.2). For this purpose, the menu point **Data management / Display series** is provided. For series in a serial series, subsequent deleting of individual results is no more possible.

A serial series no more required can be removed by menu point **Data management / Delete series**. Note that particular series of a serial series cannot be discarded individually. Always the serial series as a whole disappears.

> *i* Starting and continuing (UCI) series is only possible when a probe is connected.

> *i* Under **Data management / Display series** and **Data management / Delete series**, all series (UCI and Leeb) are always displayed. If both types are available, they are shown in a clear tree structure.

4.2.8 Description of the Test Procedure

In order to perform a test by means of the alphaROCK, a probe must be connected and the Measurement window opened. For normal manual measurements, the test load of the probe is applied manually. Hold the probe perpendicularly to the sample surface, with a maximum inclination of 5°. The test load should be applied slowly and uniformly up to the mechanical stop. When the test load of the probe is reached, the hardness value is calculated at once and displayed on the screen. A single acoustic signal informs about the end of the measurement. Since the hardness result is calculated already before the mechanical stop is reached, an arising vibration does not affect the result.

Within a large range, the lowering speed does not influence the result. If the test speed is applied too fast however, or if the probe is left on the sample for too long, an error message appears.

To simplify handling, especially in the case of higher test loads, preferably make use of a handle for probes. This item additionally protects the angle plug of the probe cable (refer to Fig. 13).

Fig. 13: Probe handle

While placing the probe, act carefully in order not to damage the diamond. Between two measurements, the probe must always be lifted before repositioning. The sleeve of the probe does not only act as stop, but is also useful to protect the UCI-rod from damage. For that reason, do not remove it unless required for a particular measurement.

For new users intending to familiarize themselves with handling, it is recommended first to start with appropriate hardness test blocks, as the results can directly be checked on the basis of the nominal hardness value of this item. After short training already, reliable and reproducible results can be expected.

An essential aspect is the exactly vertical positioning of the probe. This task may be simplified by options to be purchased from BAQ. So-called probe supports are available for standard probes. These are bolted to the probe instead of the sleeve, and dispose of attachments for flat or cylindrical test objects. As control of the probe takes place by means of these attachments, vertical positioning on the sample is ensured (refer to Fig. 14 left side).

Fig. 14: Simplified handling by probe support (left) and high precision stand (right)

A further benefit of probe support is the protection of the Vickers diamond against unintentional damage. Place the probe at the desired position on the sample, and initiate the measurement. A stable test configuration however is imperative. While stabilizing the support with one hand, use the other hand to apply the test load of the probe.

i	Grease the thread inside the probe support from time to time.

Alternatively, a high precision stand is available upon request as well, favorable for increased test loads or frequent measurements (refer to Fig. 14 right side). It ensures the vertical placement of the probe likewise, allowing operator independent measurements. It is essential however that the sample is correspondingly oriented and securely fixed on the massive base plate of the stand. This option is useful also as supporting surface for coupling of small samples.

i	The probe can be clamped at any position of its perimeter, but preferably not at its upper end, as in this case an excessive torque could arise, due to the large distance between clamp and diamond tip.

!	Users should be aware of the fact that the lever of the stand could give rise to strong loads, largely exceeding the test load of the probes (98 N). To prevent damage, avoid overload.

4.2.9 Result Logs and Data Transfer

4.2.9.1 Copy of the Series to USB Stick

Use menu point **Data management / Copy to USB flash drive** to transfer series from the internal memory to USB stick. A USB stick together with manuals is included in the delivery, to be connected via adapter (USB A ↔ USB C), part of the delivery as well, to the instrument. Generally, the USB stick in use has to be formatted as FAT32 with MBR.

Files are stored on the stick in .csv format (character code UTF8), and can be opened for further analysis by all usual word processing or spreadsheet programs (e.g. Microsoft Excel). During import of a .csv file into a spreadsheet program, select character set Unicode UTF8, otherwise special characters cannot be correctly displayed. For separation, make exclusively use of semicolon. If analysis is expected to take place as a routine, prepare a template for the spreadsheet program, so that evaluation incl. diagrams, runs automatically during input of the .csv file.

During transfer of a serial series, several files are stored. On the one hand, a large file is created, summarizing all subordinate series, furthermore a subdirectory with the name of the serial series, in which all of the subordinated series are stored one by one (same format as single series).

i	The supplied USB stick contains a template for Excel that allows the exported measurement series to be easily imported and analyzed.

i	Under **Data management / Copy to USB flash drive**, all series (UCI and Leeb) are always displayed. If both types are available, they are shown in a clear tree structure.

4.2.9.2 Format of .csv files

<u>Single series and series of serial series</u>

Version; <(1, 0, 0)>

Probe type;<type description>

Name;<file name>

Test load;<e.g. 49>

Lower tolerance limit;<e.g. 0>

Upper tolerance limit;<e.g. 0>

Material section;<e.g. Standard>

Material name;<e.g. Steel UCI ISO>

Conversion standard; <e.g. DIN_ISO_18265_A1>

Hardness scale;<e.g. HV>

Number of readings;<e.g. 5>

Mean value;<e.g. 321.6>

Minimum;<e.g. 312>

Maximum;<e.g. 334>

Standard deviation;<e.g. 10.1>

rel. Standard dev. %;<e.g. 3.15>

Value /<Hardness scale>;Year;Month;Day;Hour;Minute;Deleted

312;2024;4;23;10;51; <reading 1>

…. <more readings>

320;2024;4;23;10;51; <reading n>

<u>Summary serial series</u>

Version; <(1, 0, 0)>

Probe type;<type description>

Name;<file name>

Test load;<e.g. 30>

Lower tolerance limit;<e.g. 0>

Upper tolerance limit;<e.g. 0>

Material section;<e.g. Standard>

Material name;<e.g. Steel UCI ISO>

Conversion standard; <e.g. DIN_ISO_18265_A1>

Hardness scale;<e.g. HV>

Number of series;<e.g. 25>

Number of readings series;<e.g. 5>

Series name;<name of subordinate single series: 1>

Number of readings;<e.g. 5>

Mean value;<e.g. 321.6>

Minimum;<e.g. 312>

Maximum;<e.g. 334>

Standard deviation;<e.g. 10.1>

rel. Standard dev. %;<e.g. 3.15>

Value /<Hardness scale>;Year;Month;Day;Hour;Minute;Deleted

312;2024;4;23;10;51; <reading 1>

…. <more readings>

320;2024;4;23;10;51; <reading n>

Series name;<name of subordinate single series: 2>

Number of readings;<e.g. 5>

Mean value;<e.g. 321.6>

Minimum;<e.g. 312>

Maximum;<e.g. 334>

Standard deviation;<e.g. 10.1>

rel. Standard dev. %;<e.g. 3.15>

Value /<Hardness scale>;Year;Month;Day;Hour;Minute;Deleted

312;2024;4;23;10;51; <reading 1>

…. <more readings>

320;2024;4;23;10;51; <reading n>

…. <more subordinate single series>

…. <more subordinate single series>

Series name;<name of subordinate single series: m>

Number of readings;<e.g. 5>

Mean value;<e.g. 321.6>

Minimum;<e.g. 312>

Maximum;<e.g. 334>

Standard deviation;<e.g. 10.1>

rel. Standard dev. %;<e.g. 3.15>

Value /<Hardness scale>;Year;Month;Day;Hour;Minute;Deleted

312;2024;4;23;10;51; <reading 1>

…. <more readings>

320;2024;4;23;10;51; <reading n>

i Incomplete series of a serial series are not transferred.

4.3 Material Calibration

> *i* In the main menu, the menu item **Material calibration** is only displayed when a UCI probe is connected.

As already outlined in the beginning of this manual, the frequency change of the vibrating rod, used for calculation of the hardness result, depends also on the elastic modulus of the inspected material. This means, that alphaROCK must be calibrated for every material, which is expected to be analyzed. In state of delivery, two calibrations are provided for low-alloy steels with an elastic modulus 210 ± 10 GPa. These default calibrations can neither be overwritten nor erased, and only differ with respect to the table used for conversion: Steel DIN is converted acc. to table A1 of DIN EN ISO 18265, Steel ASTM acc. to tables 1 and 2 of ASTM E140. For materials with a different modulus of elasticity, an additional material calibration must be recorded, which is permanently stored in the alphaROCK.

The material calibration has to take place on the basis of a reference sample with known hardness, determined e.g. by means of a stationary hardness testing machine. If corresponding equipment is not available, consult factory service, our staff is always at your disposal (service@baq.de).

The reference sample must meet the following conditions:

- Sufficient dimensions, essentially with respect to thickness. As a guideline, use requirements for hardness test blocks made of steel acc. to DIN 50159-2 (diameter > 50 mm; thickness > 15 mm).
- Finely finished surface (refer to roughness values specified in Table 8 in chapter 4.4). Higher roughness increases scattering of the results and consequently reduces the achievable accuracy of the calibration.
- For the same reason, a homogeneous hardness distribution of the sample is necessary.

To determine a calibration value on the basis of a reference sample, use menu point **Material Calibration / Calibration**. Four calibration parameters must be set beforehand:

- First select **Material Type** for conversion, otherwise the hardness results captured for this material cannot be converted into other hardness scales, apart from HV.
- Then specify the **Hardness Scale**, in which the calibration is carried out. It corresponds to the hardness scale used for measurement of the reference sample.
- Enter the **Reference Hardness** (i.e. the hardness of the reference sample, determined by stationary machine).

- By means of **Number of Measurements**, specify the quantity of measurements carried out during calibration. It is recommended to carry out more measurements for reference samples with increased surface roughness, as in these cases, large scattering must be taken into account. The standard value amounts to 5.

As soon as all parameters are set, jump to “Start” by , and launch the calibration by pressing ENTER key. The end of each calibration measurement is signaled by a single beeper sound. Important: Hold the probe in an orientation as vertical as possible, and lower it slowly and uniformly. After completion of the entire routine, absolute and relative standard deviation appear on the screen (refer to Fig. 15).

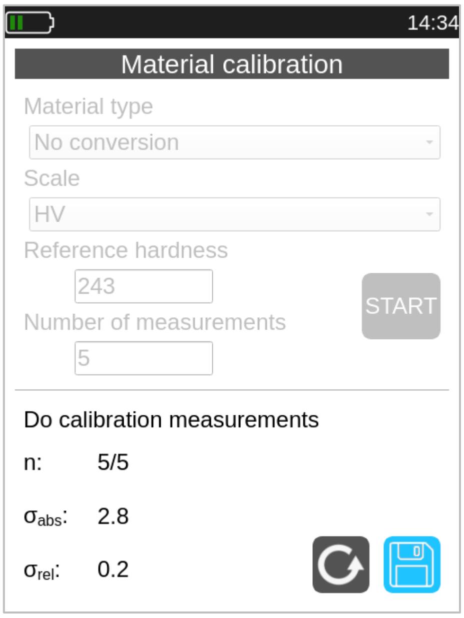


Fig. 15: Material calibration

If the standard deviation turns out to be excessive, repeat the calibration measurements by pressing . In the end, store it by Save button.

> *i* If no defective probe is used, the standard deviation may only be affected by two factors: The reference sample and the handling itself. If the probe has been placed correctly (vertically and without wobbling), check in case of need that the reference sample meets the conditions regarding dimensions, surface roughness and homogeneity. Check the probe as well (refer to chapter 4.1.3).

In the Save dialog, first specify whether a new material is created or a present calibration is intended to be overwritten.

For replacement of a present material calibration, select it from the dropdown list. The assigned material section (if provided) is automatically loaded and cannot be edited. For overwriting, press OK button.

For establishment of a new material, it can be assigned to a material section. Choose between the following three options:

- **No section**. In this case, after pressing OK, it is enough to specify the name of the calibration carried out.
- The material is assigned to a **present section**, which must be selected from the corresponding dropdown list. After pressing OK, only specify the name of the calibration carried out.
- The material is assigned to a **new section**. After pressing OK, first specify the name of this section and then the name of the calibration carried out.

The new material calibration is directly applied to the active measurement parameter set, is now available under menu point **Measurement Parameter / Edit / Material** and can be used for measurements of components consisting of the calibrated material.

> *i* If a large quantity of calibrations is stored, it is advisable to subsume materials under material sections, e.g. iron and aluminum alloys, so the overview is improved.

Under the menu point **Material calibration**, calibrations can be removed (**Delete**), transferred to a USB stick (**Save to USB flash drive**) or restored from a USB stick (**Import from USB flash drive**). It is also possible to view the parameters of a material calibration (**Show parameter**).

> *i* When transferring material calibrations between the alphaROCK and a USB stick, the data is merged. If there are calibrations with the same name on both media, the material calibration of the medium from which the transfer originates is adopted.

Under **Material calibration / Conversion standard**, the standard used to convert the hardness values can be selected. You can choose between DIN EN ISO 18265 and ASTM E140.

4.4 Conversion of Hardness Results

The alphaROCK allows to convert hardness results from one scale to another. In the measurement window, simply press SCALE key to view the results in various scales.

The memory of the alphaROCK features the current conversion standards acc. to ASTM E140 and EN ISO 18265, selectable by **Material Calibration / Conversion standard**. Conversions not comprised in these standards are not possible.

HV(UCI) hardness values represent the reference for conversion. Regardless of the currently chosen scale, these values are always determined. For this reason, sometimes a result may be transformed only into certain scales. If conversion into a particular scale is not possible, the message “Hardness value out of conversion range” is displayed. Note that the validity ranges for hardness conversion must be respected (refer to Appendix 1: Hardness conversion validity ranges).

Furthermore, the standards mentioned above contain partially values outside the definition area of the standardized hardness testing methods, which nevertheless may serve as approximate values. The alphaROCK includes these values in conversion, displaying them in orange on the screen.

Users must be aware of the fact that no global relation for conversion exists. The conversions should therefore only be used within a material group. The influence of different indenters and test loads in the particular test methods should not be neglected as well.

Always bear in mind the information from the standards about applicability, inaccuracy and difficulties for conversion of hardness results. Before a conversion is initiated, thoroughly check that all conditions are met.

5 The alphaROCK in Leeb-Mode

5.1 Introduction to the Hardness Testing Method acc. to Leeb

5.1.1 Measuring Principle

This hardness testing method invented by Dietmar Leeb evaluates the difference between impact speed and rebound speed of a small impact body, which is shot to the sample surface by the impact device at a precisely defined energy. As the plastic deformation of the surface consumes a certain amount of energy, the speed of the impact body during rebound becomes lowered. Both speed values are inductively measured 1 mm above the surface. The hardness value HL (hardness acc. to Leeb) is defined as the relation between rebound speed v_R and impact speed v_A, multiplied by factor 1000. The HL parameter is accompanied by a third or sometimes fourth letter specifying the type of impact device (impact device D → HLD).

$$HL = \frac{v_R}{v_A} * 1000$$

with: HL: Leeb Hardness
v_R: Rebound speed
v_A: Impact speed

As for a softer material the indentation is increased, the amount of consumed energy is higher, and the rebound speed is lower compared to a test on a hard material. For this reason, the calculated hardness result is lower as well. Note that the influence of gravity must be taken into consideration, so the alphaROCK enables the impact direction to be adjusted, to compensate for possible errors.

HL hardness results are dimensionless. It is important to know that they do not only depend on the hardness, but also on other properties of the material under test. On the basis of empirically determined conversion tables, HL results can be transformed to conventional hardness scales. For many material groups, conversions are stored in the alphaROCK, taking these properties into account. Within a particular material group however, the variation of properties can be neglected, as the hardness results remain unaffected.

As the hardness result for this dynamic measurement is determined directly after creation of the indentation, it proves to be very quick, thus perfectly suited for mobile applications.

5.1.2 Main Applications

The alphaROCK is a mobile hardness testing instrument making use of the Leeb method. It is intended for metals. Main applications include:

- Incoming inspection
- Quality control during running production
- Mobile inspection of components directly “in the field“
- Tests in any orientation
- Positions with difficult access, narrow spaces or in presence of complex part geometry
- Inspection of heavy objects or parts difficult to move
- Tests to be carried out within shortest delay

These applications clearly illustrate the versatility and the significance of the method in numerous industrial sectors. Reliable and exact results considerably enhance the possibilities in quality control, failure analysis and material characterization.

5.1.3 Requirements for the application of the Leeb procedure

To ensure efficient and precise hardness testing by means of the alphaROCK, observe the following conditions:

5.1.3.1 Qualification of Personnel

Sufficient knowledge and experience of the testing personnel is decisive, both with respect to hardness testing in general and particular features of the Leeb method itself, as follows:

- Knowledge of the influence of material properties like microstructure and modulus of elasticity, in order to select and to implement a convenient testing method
- Knowledge of the effect of the surface structure on the detected hardness value
- Understanding of the conversion HL hardness results into other scales, as well as an overview concerning the different methods of hardness measurement
- Practical experience in handling of impact devices

5.1.3.2 Requirements to the Sample

Even though the Leeb method is convenient for nearly all metallic materials, the properties of the sample itself should not be disregarded when interpreting a result. This circumstance, by the way, holds for every hardness testing method.

In this context, besides the surface structure, the sample thickness and weight as well as its homogeneity have to be mentioned. Strong scattering of results or major deviations may be caused by excessive roughness or insufficient sample thickness or weight. For this reason, before initiating a test, verify the suitability of the sample and prepare it conveniently in case of need. During preparation do not make use of procedures which in the following could affect the surface hardness (e.g. caused by overheating).

To ensure a reliable and reproducible test, the sample must fulfill the following requirements:

Table 13: Conditions for a sample to perform a Leeb hardness test

Type of impact device	**D / DC / DL / D+15**	**C**	**G**
Max. surface roughness R_a/R_t	2 µm / 10 µm	0.4 µm / 2.5 µm	7 µm / 30 µm
Roughness class ISO 1302	N7	N5	N9
Min. weight (without firm support)	> 5 kg	> 1.5 kg	> 15 kg
Min. weight (with firm support)	> 2 kg	> 0.5 kg	> 5 kg
Min. thickness (without coupling)	25 mm	10 mm	70 mm
Min. thickness (with coupling)	3 mm	1 mm	10 mm
Min. thickness of surface hardening	≥ 0.8 mm	≥ 0.2 mm	-
Min. distance to border	5 mm	5 mm	10 mm
Min. distance between two indentations	at least 3 x indentation diameter		
Test environment	During the test, the sample should neither move nor be subjected to vibrations. Environmental influences like temperature and humidity must be taken into consideration, too.		
Surface	Even and shiny metallic. Cleanliness and absence of oxides, grease and foreign matter are imperative. (Treatment with abrasive paper or isopropyl alcohol may be necessary).		

If the maximum roughness depths specified in Table 13 are exceeded, the sample surface may be prepared e.g. by means of abrasive paper. Partial whetting of the test point is sufficient.

Support for samples

- No support is required for heavy items (refer to Table 13).
- Medium weight specimens however need a flat, massive support (refer to Table 13).
- Place the sample on the support in a stable and levelled manner.
- During the test, the sample should neither move nor be subjected to vibrations.

Sample geometry

Even though the sample matches the requirements specified in Table 13, the impact in the case of large plates, long rods or bent items may give rise to smaller deviations or vibrations which affect the measuring precision. In corresponding situations, it is advisable to reinforce or to support the opposite side of the test point. Note that it is always advantageous to select a sample of compact shape or a measuring position in the surroundings of the mass concentration of the sample.

Bending radii

If no flat sample surface is available, surfaces with a bending radius of R < 30 mm (for impact devices type D, DC, D+15 and C) are possible, but they require the presence of a corresponding shaped support ring screwed on beforehand, so that the impact device can be safely positioned.

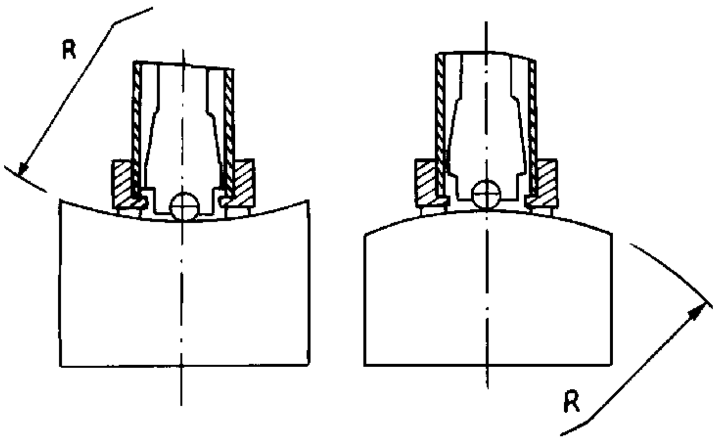


Fig. 16: Test on bent surfaces

Hardness test on coatings

As the Leeb method cannot manage without a certain penetration depth (refer to Table 14), it is not convenient for very thin coatings. The minimum thickness required for surface hardening is specified in Table 13.

Self-magnetism

Self-magnetism of the sample is not admissible, as the speed of the impactor may be influenced.

Homogeneity

Local variations of material properties like elastic modulus may have an effect on the result. Sufficient homogeneity of the material therefore is essential, in order to carry out a meaningful test. Furthermore, it is imperative that the size of the impression considerably exceeds the grain size.

5.1.3.3 Regular Functional Control

Combined with the impact devices, the alphaROCK offers - if correctly used - a stable system with a long lifetime. Nevertheless, regular inspections are strongly recommended. This includes:

- Visual inspection of the impact body under a microscope.
- Visual check of connecting cable, plug connections, support ring and impact device.
- Verification of accuracy and repeatability, on hardness test blocks acc. to standard DIN EN ISO 16859 or ASTM A956. The detected HL reading should not fall beyond the specified tolerances of the engraved value.
- Regular maintenance incl. calibration (annual interval recommended), performed by BAQ GmbH or authorized factory service, is helpful to ensure accuracy of the results over the entire hardness range acc. to relevant standards.

DIN EN ISO 16859-1 specifies in detail the periodic verification of Leeb hardness testing equipment by users. Prior to start-up, at least three measurements on an appropriate hardness test block (i.e. a test block with similar expected hardness) are recommended. The following conditions must be met:

1. Difference between average and engraved hardness value of the test block ≤ 5 %.
2. Max. span ≤ 5 %.

In the case of excessive deviation, first check:

- Has the correct test block been used? The surface must be clean and dry, no vibrations are admissible. If the test block has been used already for a long time, it may show too many impressions so the minimum distance between them is no more available. Exchange the item.
- Check and clean impact device and impact body (refer to chapter chapter 8).
- Do not forget to set the material corresponding to the test block and to use the correct hardness scale.

!	Often Vickers or Rockwall hardness test blocks are used for mistake, but they are intended for stationary hardness testing machines. Mass and thickness of these items are far too low for Leeb hardness tests (refer to Table 13).

i	With increasing number of tests on hardened components, the carbide ball in the impact body becomes flattened and must be exchanged – otherwise no more accurate results can be expected.

i	As soon as the results do not meet the requirements described above anymore, return the equipment to BAQ for calibration.

5.1.4 Selection of Impact Devices

In addition to impact device type D, which is suitable for most applications, various models for hardness tests acc. to Leeb are available, meeting the needs in different applications. They are illustrated in Fig. 17 and detailed in the following:

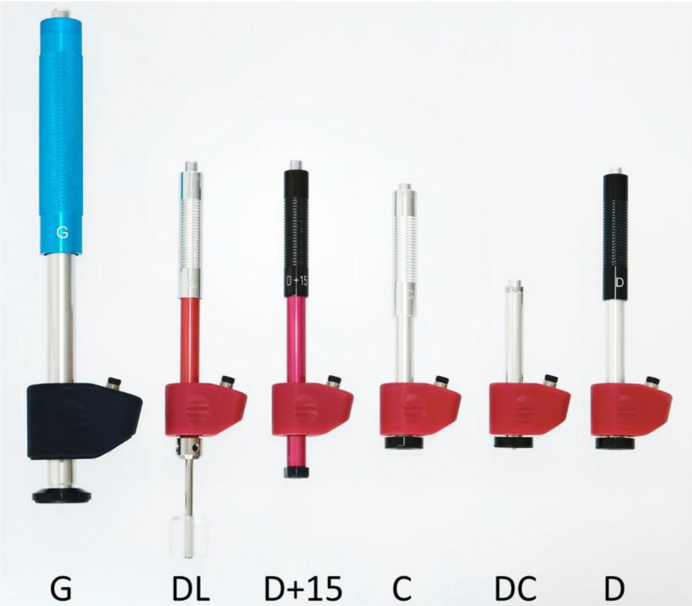


Fig. 17: Impact devices for hardness tests acc. to Leeb

Type D: Standard device, covering most of usual test purposes.

Type DC: Extremely short model, practical for positions with difficult access or in tubes.

Type C: For this type, the impact energy is reduced, which proves to be useful for surface hardened objects. Its impression size amounts only to the half of type D impressions, but the requirements to surface quality are higher.

Type D+15: Intended for measurements within grooves and recesses, this device disposes of a coil relocated by 20 mm and a smaller support area (11 mm x 14 mm instead of Ø20 mm, so grooves with a depth of up to 20 mm and a width of 11 mm can inspected).

Type DL: This item features an extended impact body. The diameter of the front tube amounts to 4.2 mm.

Type G: Heavy castings and forgings and castings require a higher impact energy. The requirements to surface -compared to measurements by type D- are reduced.

The different impact devices are equipped partially with different impact bodies, which consequently entail different impact energy and indentation size. The following table shows a selection of indentation diameters and depths for three sample hardness results, depending of the impact device in use.

Table 14: Size of impressions for different hardness results and impact devices

Hardness	***D / DC / DL / D+15***		***C***		***G***	
	Ø	***Depth***	***Ø***	***Depth***	***Ø***	***Depth***
300 HV / 30 HRC	0.54	24	0.38	12	1.03	53
600 HV / 55 HRC	0.45	17	0.32	8	0.90	41
800 HV / 63 HRC	0.35	10	0.30	7	-	-

According to the impact device, the HL result (which serves as reference and can be calculated anytime) can be converted into other hardness scales (e.g. HRC). In Appendix 1: Hardness conversion validity ranges Table 21 available hardness scales with their conversion ranges are specified for all materials and all impact devices.

5.1.5 Applicable Standards

The Leeb hardness test is defined in national and international standards, together with requirements to testing equipment and measurement procedure. Complying with these standards ensures an accurate hardness measurement with reliable results:

- DIN EN ISO 16859 Leeb Hardness Tests
- ASTM A956 Leeb Hardness Testing on Steel Products

5.2 Operation

The following chapter provides a comprehensive introduction to the alphaROCK hardness tester in Leeb mode. It offers a detailed overview of the basic design and practical operation to ensure a smooth introduction to the use of this device.

5.2.1 Design and Connections

Fig. 18: Structure, operating elements and connections

Table 15: Connections and operating elements

No.	***Designation***	***Description***
1	Status-LED	Lights up with reduced brightness if the alphaROCK is being charged when switched OFF. After switching ON, this element is lit permanently.
2	USB-C	Interface for charging and data transfer to PC or USB stick.
3	Socket for connection of Impact devices	Attachment of probe cable, with Push-Pull lock.
4	Display	3.5“-TFT-LCD color display.
5	Keyboard	The instrument is controlled by these buttons.
6	Fixing hole	Intended for strap.

5.2.2 Charging, Switching ON and OFF

Prior to initial use, charge the instrument completely by means of the power pack included in the delivery, first establishing a mutual connection via USB-cable provided. As soon as this connection exists, plug in the power pack into a power socket (for some countries, an adapter may be required). If the instrument is switched ON however, charging process becomes visible by a flash in the battery symbol within the status line. If the alphaROCK is being charged when it is switched OFF, the status LED lights up with reduced brightness.

> *i* The charging process from 10 to 80 % takes approx. 4 hours.

> *i* If the connector is plugged in too slowly, the charging process takes place at reduced speed for safety reasons, since the power management of the instrument within the default time limit cannot identify USB-cable and power module as safe.

The alphaROCK is switched ON and OFF by POWER button. After activation, the Status-LED is continuously lit. When the instrument is ready to operate, the screen shows either the main menu (if no impact device is connected) or instantaneously the Measurement window with the last settings (with impact device connected).

5.2.3 General Operation

<u>Status Line</u>

The status line always appears in the upper zone of the display, showing time and charge level of the battery. According to the charging state of the battery, one of the following symbols is indicated:

 The charging process is running

 Battery level sufficient

 Low level

<u>Text Input</u>

Saving measuring data or parameters requires text input. In these situations, a text input window is opened, e.g. when entering a name for a series measurement (see Fig. 19).

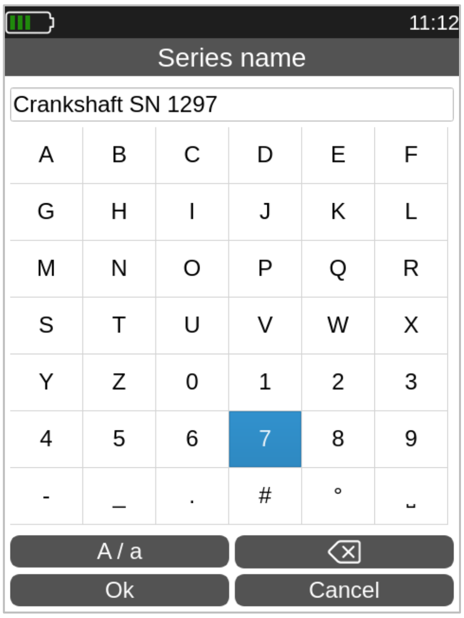


Fig. 19: Text input dialog

The current text (here: Crankshaft SN 1297) is shown in the corresponding field, selectable characters appear below. The buttons shown in the lower area have the following functions:

A/a	Switch over between upper and lower case
OK	Accept the text and close text input window
⌫	Delete last character
CANCEL	Close text input window, discarding the changes made

Important key functions during text entry:

DEL:	Delete last character
ESC:	Close text input window, discarding the changes made
:	Change between text field, symbol table and buttons

Number Input

For input of numbers, corresponding fields are provided. Digits in these fields can be changed individually, by moving the cursor to the desired position by ◄ and ►. The active position is marked, and the corresponding value can be increased or lowered by ▲ and ▼. A further position can be added in leading position by ◄ cursor (to obtain larger values). Examples of number input fields are the entries of Upper tolerance limit, Lower tolerance limit and Number for statistics in the measurement parameter dialog, see Fig. 20.

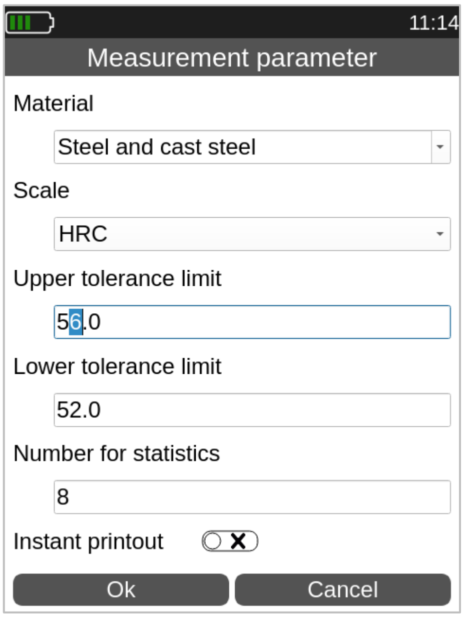


Fig. 20: Fields for number input

Important key functions during entry of numbers:

DEL:	Set back number input
:	The entry is accepted, and the next field becomes activated

Selection Dialogs

There are selection dialogs at various points in the alphaROCK, e.g. if a series or serial series is to be continued, deleted, displayed or transferred to a USB stick. Fig. 21 shows the selection of a series of a serial series as an example.

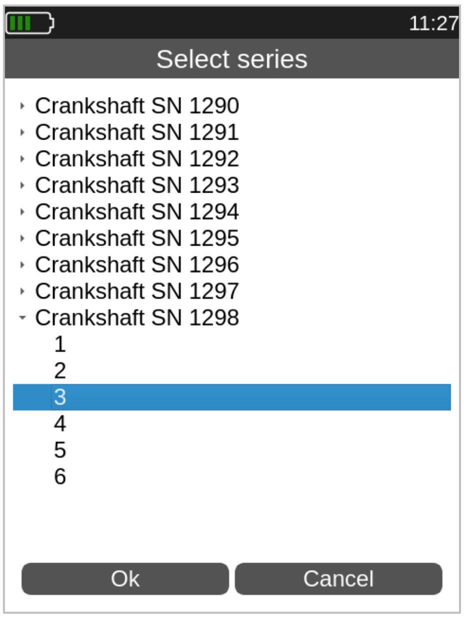


Fig. 21: Selection Dialog

In these dialogs, the desired data set is chosen by arrow keys. To select OK button, press . The corresponding action is finally put into effect by pressing ENTER.

5.2.4 Preparation and Basic Settings for Leeb Hardness Test

Connection of the impact device

Impact devices are connected via probe cable included in the delivery. To avoid faulty connection, insertion has to be carried out always in specified orientation.

The connections feature Push-Pull locks, reliably protecting from detachment and insensitive to vibrations, so the connection during operation remains stable. To disconnect, axially draw the outer sleeve of the plug.

> *i* Impact devices can also be attached or changed, while the instrument is switched ON.

Preparation

Before initiating the actual measurement, use a suitable Leeb hardness test block to check functionality. Daily verification is recommended. Furthermore, it is essential that the sample is appropriate for Leeb-testing. If required, the sample has to be prepared according to instructions in chapter 5.1.3.2.

Adjustment of Measurement Parameters

Measurement parameters may have to be adjusted, whereas the type of the connected impact device is recognized automatically, not influenced by the user. Open the dialog for parameters either by menu point **Measurement parameter / Edit** or by means of the Settings buttons within the Measurement window. Generally, the parameters shown in Fig. 22 are provided. They are described in the following.

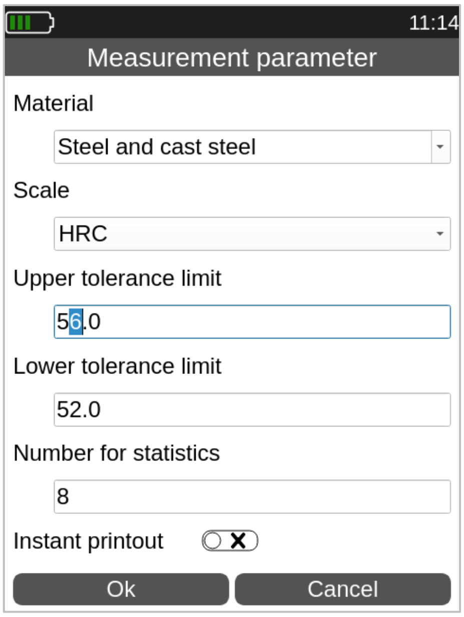


Fig. 22: Adjustment of measurement parameters

i	After switching ON, initially always the last used measurement parameters are active. Measurement parameters material, hardness scale and tolerance limits can directly be set in the Measurement window.

i	For frequently arising measuring tasks, it is favorable to store measurement parameter sets; retrieve them whenever needed (refer to chapter 5.2.6).

Material

This field shows the current material group. Within the Measurement window, it can be changed by MAT key.

Hardness Scale

The results are displayed by means of the specified scale, with the Leeb hardness serving as reference scale. After selection of another scale, the results are transformed, if possible (refer to Appendix 1: Hardness conversion validity ranges Table 21). To changeover to another scale, press SCALE key in the Measurement window.

> *i* Hardness values that cannot be converted to the new hardness scale are displayed as 0.

Upper/Lower tolerance Limits

This function defines the tolerance range, to set up a distinction between OK and NOK results. Upper and/or lower limits can be specified. If "-" is entered for a particular limit, this limit is left aside.

Results beyond the tolerance range are marked in red, and a beeper alarm sounds (two short signals). An arrow shows whether the value is excessive or insufficient. Acceptable results are displayed in green, accompanied by a single acoustic signal.

Note that limits are stored only for one hardness scale. If limits are entered for another scale, existing input is overwritten.

Number for Statistics

This quantity describes the population, i.e. the number (n) of measurements to be included in statistical analysis. As soon as the value (n) is reached, the Statistics window opens automatically (refer to chapter 5.2.5.2). This function correspondingly offers an intermediate information within a series. If intermediate statistical analysis is deemed to be unnecessary, set this value to 0.

Instant Printout

If a mobile printer is connected, the feature of logging measuring results line-by-line, can be switched ON and OFF by means of this selector switch. If no printer is connected to the alphaROCK, the function is not available.

> *i* If instant printout is activated, deleting measuring results is no more possible.

Impact device type

As already mentioned, the type of the impact device is a parameter directly transmitted from the impact device to the instrument and cannot be altered by the user.

5.2.5 Measurement Window

5.2.5.1 Overview and Settings

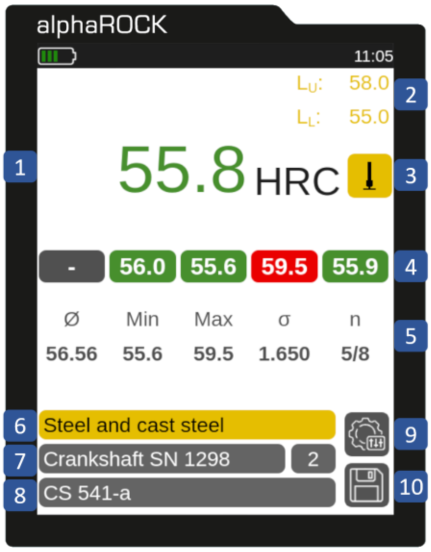


Fig. 23: Measurement window

Table 16: Measurement window

No.	***Designation***	***Description***
1	Hardness Value and Scale	Last result with assigned hardness scale.
2	Limits	Individually specified tolerance limits.
3	Impact direction	Selected impact direction (0°, 45°, 90°, 135°, 180°)
4	Result History	The last five results are displayed.
5	Statistics	Statistical analysis of the active series with average (Ø), minimum/maximum (Min/Max), standard deviation (σ), number of measurements (n; deleted measurements are not included).
6	Material	Material group currently in use.
7	Name and No. of series/ serial series	Designation of user defined series or serial series (if loaded) and No. of the series within the serial series.
8	Name of measurement parameter set	Designation of a user defined measurement parameter set (if loaded).
9	Settings	Adjustment of measurement parameters (refer to Fig. 22).
10	Save	The current measurement is saved.

Immediate visual supervision is simplified by partially colored presentation of the results, both within the Measurement window (hardness result and history) and in the Statistics window for display of individual results (refer to chapter 5.2.5.2). The color coding is as follows:

Table 17: Color Coding of Measuring Results

Color	***Meaning***
Dark Gray	**Result with no specified limits**
Green	**Result within tolerance**
Red	**The tolerance range has been exceeded**
Light Gray	**Result has been deleted**

The operation is supported by several keys provided in the Measurement window, as detailed below:

-key:

The so-called TOGGLE key allows navigation within the Measurement window, to jump from one range or input field to another. First press to activate the Toggle mode. Afterwards, it is possible to change between Upper Limit, Lower Limit, Impact direction, Settings and Save button. The currently activated item is always marked, so that adjustments or other functions can be carried out.

> *i* Note that in Toggle mode SCALE, MAT, DEL and STAT keys are disabled.

> *i* During the recording of a series (refer to chapter 5.2.7) only the impact direction can be toggled and changed.

SCALE-key:

This function is used to change the hardness scale. It is possible to decide within the systems settings whether a change is intended to take place either by automatic selection of the following valid scale, or via dialog window (refer to chapter 6.3). If possible, all results recorded up to that moment are automatically converted into the new scale, including statistics (refer to Appendix 1: Hardness conversion validity ranges Table 21).

> *i* Hardness values that cannot be converted to the new hardness scale are displayed as 0.

MAT-key:

This function is used to change the material. It is possible to decide within the systems settings whether a change takes place by automatic selection of the following material or via dialog window (refer to chapter 6.3). If the currently selected hardness scale is not defined for the material chosen, the hardness scale automatically returns to HL.

> *i* When changing the material, results recorded up to that moment are automatically deleted, a possibly loaded measurement parameter set is reset.

DEL-key:

The last measuring result is erased. It appears in the results history all the same, but appears grayed out. Pressing the DEL key again deletes the second last result etc.

> *i* If six or more results have already been deleted, this function is also applied to results no more present in the results history.

STAT-key:

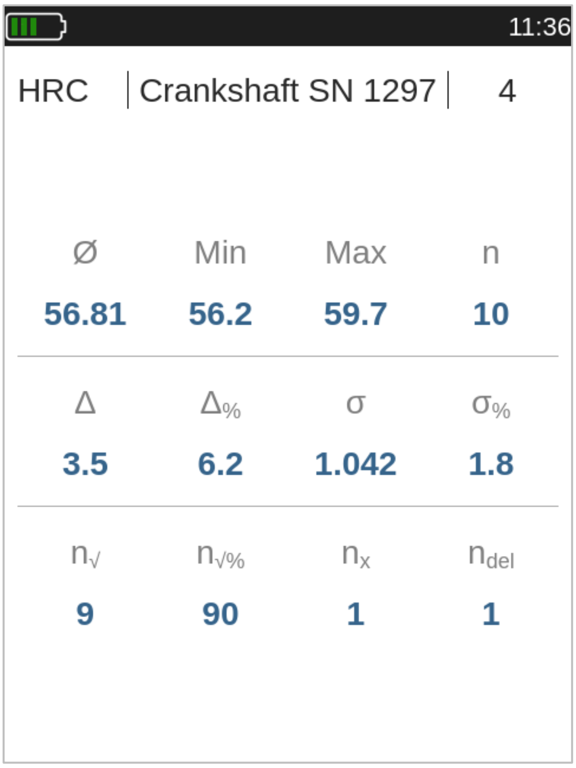
This key opens the Statistics window respectively toggles between Statistics window and display of individual results (refer to chapter 5.2.5.2).

5.2.5.2 Statistics Window

The statistic window is called up when:

- The number (n) of measurements specified in the measurement parameters has been reached,
- the STAT-key is pressed,
- a series of a serial series is complete,
- or a series is opened from the menu **Data management / Display series**.

Fig. 24 shows an example:



Header	Hardness scale | Name of series/serial series | No. of series within serial series
Ø	Average
Min	Minimum
Max	Maximum
n	Number of measurements (deleted elements are not counted)
Δ	Absolute span between minimum and maximum
$\Delta_{\%}$	Relative span referring to average
σ	Absolute standard deviation
$\sigma_{\%}$	Relative standard deviation
$n_{\checkmark}$	Quantity of measurements within tolerance
$n_{\checkmark\%}$	Percentage of measurements within tolerance
$n_{\times}$	Percentage of measurements outside tolerance
n_{del}:	Quantity of deleted measurements

Fig. 24: Statistics window

Pressing the STAT-key from Statistic windows changes over to the display of individual results. All results of the series are listed and numbered, color coded as described in Table 17. Fig. 25 shows the display of individual results matching Fig. 24.

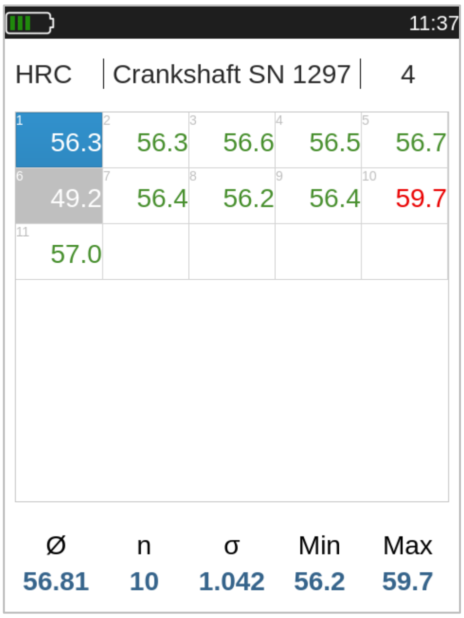


Fig. 25: Display of individual results

The currently selected result is marked. Use the arrow keys to change between the items, and the DEL – key to erase the currently selected element. In the latter case, the statistics are updated at once. If results have been deleted, a dialog appears during closure of the Statistics window, to decide whether modifications are intended to be accepted or discarded.

> *i* Activated instant printout blocks the DEL function. Subsequent deleting is also not possible, if a series has been called up via menu point **Data management / Display series**.

The Statistic windows is closed by ESC. If the preset number of measurements has not yet been reached (because the statistics by STAT key are activated earlier, or a result has been deleted during editing), the measurement continues.

In the configuration - refer to chapter 6.3 -, it is possible to decide, whether the Save dialog is not only intended to appear when closing the Measurement window, but also when leaving the Statistics window (provided that the specified number of measurements has been reached). In this case, the current results are stored as series and the preset number for statistics is reset, so that the series afterwards may be resumed.

5.2.6 Management of Measurement Parameter Sets

Generally, the measurement parameters specified under chapter 5.2.4, are provided. The system enables combinations of these parameters to be implemented and stored with a user defined name, so the desired parameter set may quickly be retrieved. However, this function requires that an impact device that corresponds to the type defined in this parameter set has been connected beforehand.

Storing a parameter set includes:

- A user defined name
- Impact device type (of the impact device connected during storing process)
- Material
- Hardness scale
- Tolerance limits
- Instant printout (ON/OFF)
- Number for statistics

Currently selected measurement parameters can be edited under menu point **Measurement Parameters / Edit**. If this procedure is intended for a parameter set stored earlier, first load it.

In order to store the currently selected measurement parameters, use menu point **Measurement Parameters / Save**, which opens a dialog box to enter a new name for this set.

Parameter sets stored beforehand can be retrieved by **Measurement Parameters / Load**. When calling up the Measurement window for the next time, the designation of the loaded set is shown, and the parameters are automatically applied.

To erase a stored parameter set, use menu point **Measurement Parameters / Delete**.

> *i* Editing, saving, and loading of parameter sets is only possible when an impact device is connected.

> *i* When an impact device is connected, only the corresponding Leeb parameter sets can be loaded.

> *i* Under **Measurement Parameters / Delete**, all stored parameter sets (UCI and Leeb) are always displayed. If both types are available, they are shown in a clear tree structure.

5.2.7 Management of Series and Serial Series

Up to 1.000.000 results may be stored within the internal memory of the alphaROCK, all of them organized in series of measurements. A measurement series is defined as a set of results, recorded in form of single series or serial series. A serial series consists of several single series with identical measurement parameters.

The Measurement window furthermore offers the possibility to capture measurements without establishing a series or serial series beforehand. When storing these elements by Save button, a selectable name may be assigned by text input. After completion of text entry, the measurements are saved as a single series under this chosen designation (refer to following section).

> *i* In series or serial series SCALE and MAT keys are disabled. Only the impact direction can be changed.

5.2.7.1 Series

Already before starting the measurement, a series may be agreed under menu point **Data management / Start new series**, meanwhile specifying a name for subsequent identification. After completion of entry, the Measurement window opens automatically.

> *i* Note that always the currently valid measurement parameters are used for a series. This means that the desired parameter set must be loaded beforehand, since a change of parameters is no more possible while the series is recorded.

When leaving the Measurement window, a dialog is opened to ask whether the series is intended to be stored. If this is confirmed, the measurements are saved under the previously defined name.

To resume a previously stored series, use **Data management / Continue series**. Results registered in the following, are appended to the already existing elements.

The content of a series may be viewed together with statistical information (refer to chapter 5.2.5.2). For this purpose, the menu point **Data management / Display series** is provided.

It is advisable to sometimes remove series no more required (by menu point **Data management / Delete series**). This may be of interest to prevent confusion.

5.2.7.2 Serial Series

A serial series measurement is composed of single series, all of them with identical measurement parameters and the same quantity of measurements. Within the serial series, the series are numbered consecutively, all of them with the same designation. A serial series therefore represents a comfortable tool to summarize series with identical parameters, e.g. for quality control of a large batch of equal objects.

In order to establish a serial series, use menu point **Data management / Start new serial series**, meanwhile specifying a new name and then the number of measurements to be performed per series. As soon as the entry is complete, the Measurement window automatically opens, and the first series may be launched. When the specified number of measurements is reached, the Statistics window automatically opens. After closure of this window, the system is ready for the next series. The number of series to be contained in a serial series is not limited. Name of serial series, number of the current series and quantity of measurements in this series are continuously displayed in the Measurement window.

Complete series of a serial series are stored automatically. If the Measurement window is left before the end of a series, a prompt appears to decide whether incomplete series are intended to be saved as well.

> *i* Note that always the currently valid measurement parameters are used for a serial series. This means that the desired parameter set must be loaded beforehand, since a change of parameters is no more possible with a serial series running.

To resume a previously stored serial series, select it and use menu point **Data management / Continue serial series**. Results recorded in the following, are appended to the loaded serial series, together with time and date. Measurement parameters are automatically reset to the settings valid for the selected serial series. If the last subordinary series is not yet complete, it is continued, otherwise the next subordinate series is launched.

The content of a series measurement may be viewed together with statistical information (refer to chapter 5.2.5.2). For this purpose, the menu point **Data management / Display series** is provided. For series in a serial series, subsequent deleting of individual results is no more possible.

A serial series no more required can be removed by menu point **Data management / Delete series**. Note that particular series of a serial series cannot be discarded individually. Always the serial series as a whole disappears.

i Starting and continuing (Leeb) series is only possible when an impact device is connected.

i Under **Data management / Display series** and **Data management / Delete series**, all series (UCI and Leeb) are always displayed. If both types are available, they are shown in a clear tree structure.

5.2.8 Description of the Test Procedure

In order to perform a test by means of the alphaROCK, an impact device must be connected and the Measurement window opened. Before initiating actual measurements, perform a functional control acc. to chapter 5.1.3.3.

i If the results should considerably deviate from the average of the test block or prove to be excessively scattering, return the equipment to BAQ.

Fig. 26 illustrates the components of impact device type D.

1 – Release button
2 – Tensioning sleeve
3 – Guide tube
4 – Coil part
5 – Support ring
6 – Impact body
7 – Connecting cable

Fig. 26: Components of impact device type D

After completion of functional control, set up or load the desired measuring parameters. Then the measurement itself can be started, strictly following the procedure described below.

<u>Tensioning</u>

Tensioning of the impact device is only admissible in absence of contact to the sample. For stretching, hold it with one hand by the case, while shifting the sleeve slowly and uniformly towards the case (with the other hand), up to the stop. Afterwards, the sleeve can be shifted back slowly to its initial position.

Positioning of the Impact Device

Position the impact device together with the support ring on the desired test point, so that the ring is in firm and even contact with the surface. With one hand, hold the impact device in place at the case.

> *i* The impact direction must correspond to the previously specified direction.

Measurement Start

Use the release button at the upper end of the impact device to initiate the measurement. It is essential that sample and impact device remain stably fixed in position the course of the test. After completion, the detected hardness value is immediately displayed on the alphaROCK, accompanied by an acoustic signal.

Fig. 27: Test with impact device type D

It is recommended to carry out several measurements (≥ 3) for each test point and to use the average. For this reason, repeat the described procedure. Minimum distances to the border and between two indentations must be respected, as listed in Table 13.

> **!** Never attempt to tension the device when it is already in position. This does not only affect the material of the intended test point, but may also damage the gripping mechanism.

Operators should familiarize themselves with the equipment by means of the test block included in the delivery. This way, detected results can be checked directly on the basis of the set value. After some training, they will be able to obtain reliable and repeatable results without any problem.

5.2.9 Result Logs and Data Transfer

5.2.9.1 Copy of the Series to USB Stick

Use menu point **Data management / Copy to USB flash drive** to transfer series from the internal memory to USB stick. A USB stick together with manuals is included in the delivery, to be connected via adapter (USB A ↔ USB C), part of the delivery as well, to the alphaROCK. Generally, the USB stick in use has to be formatted as FAT32 with MBR.

Files are stored on the stick in .csv format (character code UTF8), and can be opened for further analysis by all usual word processing or spreadsheet programs (e.g. Microsoft Excel). During import of a .csv file into a spreadsheet program, select character set Unicode UTF8, otherwise special characters cannot be correctly displayed. For separation, make exclusively use of semicolon. If analysis is expected to take place as a routine, prepare a template for the spreadsheet program, so that evaluation incl. diagrams, runs automatically during input of the .csv file.

During transfer of a serial series, several files are stored. On the one hand, a large file is created, summarizing all subordinate series, furthermore a subdirectory with the name of the serial series, in which all of the subordinated series are stored one by one (same format as single series).

> *i* The supplied USB stick contains a template for Excel that allows the exported measurement series to be easily imported and analyzed.

> *i* Under **Data management / Copy to USB flash drive**, all series (UCI and Leeb) are always displayed. If both types are available, they are shown in a clear tree structure.

5.2.9.2 Format of .csv files

<u>Single series and series of serial series</u>

Version; <(1, 0, 0)>

Impact device;<Probetype>

Name;<file name>

Lower tolerance limit;<e.g. 0>

Upper tolerance limit;<e.g. 0>

Material name;<e.g. Steel and cast steel>

Hardness scale;<e.g. HLD>

Number of readings;<e.g. 5>

Mean value;<e.g. 774.2>

Minimum;<e.g. 769>

Maximum;<e.g. 780>

Standard deviation;<e.g. 3.7>

rel. Standard deviation %;<e.g. 0.48>

Value /<Hardness scale>;Impact direction*;Year;Month;Day;Hour;Minute;Deleted

776;0;2024;9;23;10;51; <reading 1>

…. <more readings>

774;0;2024;9;23;10;51; <reading5>

Summary serial series

Version; <(1, 0, 0)>

Impact device;<Probetype>

Name;<file name>

Lower tolerance limit;<e.g. 0>

Upper tolerance limit;<e.g. 0>

Material name;<e.g. Steel and cast steel>

Hardness scale;<e.g. HLD>

Number of series;<e.g. 25>

Number of readings per series;<e.g. 5>

Series name;<name of subordinate single series: 1>

Number of readings;<e.g. 5>

Mean value;<e.g. 321.6>

Minimum;<e.g. 312>

Maximum;<e.g. 334>

Standard deviation;<e.g. 10.1>

rel. Standard deviation;<e.g. 3.15>

Value /<Hardness scale>;Impact direction*;Year;Month;Day;Hour;Minute;Deleted

312;0;2024;9;24;11;50; <reading 1>

…… <more readings>

330;0;2024;9;24;11;50; <reading 5>

Series name;<name of subordinate single series: 2>

Number of readings;<e.g. 5>

Mean value;<e.g. 322.4>

Minimum;<e.g. 316>

Maximum;<e.g. 329>

Standard deviation;<e.g. 4.3>

rel. Standard deviation;<e.g. 1.34>

Value /<Hardness scale>;Impact direction*;Year;Month;Day;Hour;Minute;Deleted

320;0;2024;9;24;11;52; <reading 1>

…… <more readings>

329;0;2024;9;24;11;52; <reading 5>

…….. <more subordinate single series>

Series name;<name of subordinate single series: 25>

Number of readings;<e.g. 5>

Mean value;<e.g. 320.8>

Minimum;<e.g. 315>

Maximum;<e.g. 328>

Standard deviation;<e.g. 4.5>

rel. Standard deviation;<e.g. 1.41>

Value /<Hardness scale>;Impact direction*;Year;Month;Day;Hour;Minute;Deleted

315;0;2024;9;24;12;18; <reading 1>

…… <more readings>

322;0;2024;9;24;12;18; <reading 5>

* The numbers for the impact direction stand for:

0 

45 

90 

135 

180 

Incomplete series of a serial series are not transferred.

6 System Settings

The following sections describe possibilities for changing the default system settings.

6.1 Language

Specify the desired language in the selection dialog under **System / Language**, confirm it by OK and press ENTER key.

6.2 Time and Date

Time and date can be manually altered under menu point **System / Set Date and Time**, whereas the date format is chosen under Configuration (refer to chapter 6.3).

> *i* It can sometimes take 1 or 2 minutes for the changed time to be adopted.

6.3 Configuration

Configuration possibilities are subdivided into user and instrument configuration, both of them available under menu point **System**.

User Configuration

These settings relate to the operation and procedures when performing tests, as follows:

<u>SCALE-key:</u>

Define the reaction of the SCALE key in the Measurement window. It is possible to decide whether a change of scale is intended to take place either by automatic selection of the following valid scale (**Next Scale**) or via dialog window (**Open Dialog**).

<u>MAT-key:</u>

Reaction of the MAT key in the Measurement window. Choose between **Next Material** (automatic selection of the following valid material) and **Open Dialog**.

<u>Tensile Strength unit</u>

Choose between MPa and N/mm².

Query: save series on close

Select whether during closure of the Measurement window an inquiry is intended to appear, which asks if results are to be stored as series. The inquiry can be activated or disabled by ENTER as well as by arrow keys ◄ and ►.

Query: save series if n is defined

For measurements with a defined number for statistics (n), it can be set whether an inquiry appears when leaving the statistics window (when n is reached) as to whether the measured results should be saved as a series. The inquiry can be activated or disabled by ENTER as well as by arrow keys ◄ and ►.

Query: print series on close

Select whether during closure of the Statistics window (if number for statistics is activated), an inquiry is intended to appear, if log printout is desired.

Device Configuration

Settings to be specified in this section mainly concern the display:

Date Format

Select	**DD.MM.YYYY**	with	DD: Day	MM: Month	YYYY: Year
or	**MM/DD/YYYY**	with	MM: Month	DD: Day	YYYY: Year
or	**YYYY-MM-DD**	with	YYYY: Year	MM: Month	DD: Day

6.4 Factory Settings

The alphaROCK can be set back to default settings by **System / Factory Settings**.

! Note that this step is irreversible, so data deleted are irrevocably lost.

6.5 System Information

Under **System / About**, the system information is displayed. This includes, among other things, the software version numbers and the board version. When a UCI probe is connected, the probe type, the probe serial number, the probe software version, and the number of measurements already performed with this probe are additionally shown. If an impact device is connected instead, its type and the number of measurements already performed with this impact device type are displayed.

6.6 Calibration of Impact Device

To each impact device, an individual calibration value is assigned which must be stored within the alphaROCK. For every device type, an own value can be implemented. Values of devices already included in the delivery have been stored by the manufacturer.

Whenever connecting a new impact device, or a device beforehand returned for calibration to factory service without the corresponding alphaROCK, the client himself is responsible for charging the calibration value. This value can be found on the USB stick included in the delivery. Connect the USB stick to the alphaROCK, and implement the calibration by menu point **System / Impact device calibration**.

7 Troubleshooting

Even though the alphaROCK, in combination with the UCI probes or Leeb impact devices, is a very robust measuring instrument, errors can never completely be excluded. Action to be carried out in case of need is described in the following.

7.1 Troubleshooting in UCI Mode

Incorrect Results

Faulty results in spite of a correct measuring procedure (refer to chapter 4.2.8) require functional control acc. to chapter 4.1.3.4, i.e. the diamond of the UCI – probe has to be checked, and measurements on hardness test blocks are advisable, of course in conformity with the instructions of this manual. Note that the UCI-method is not suitable for each and every material, so check its applicability (refer to chapter 4.1.3.2).

i If the problem persists, return the unit to BAQ or consult an authorized service partner.

Absent Connection between alphaROCK and UCI-Probe

If the error message "2-24 No probe connected" occurs despite the probe being connected, communication via the CAN BUS is faulty. This may be due to the alphaROCK, the probe cable or the UCI probe. In this case, all connections and the probe cable must be checked for damage. This also includes checking the pins in the respective sockets or plugs.

No Reaction of the alphaROCK

The absence of any reaction is very unlikely. In this case, perform a reboot by keeping pressed the POWER button for about 8 seconds. The system shuts down automatically and restarts afterwards.

Error Messages

To each error message, a number and a text is assigned. Follow the instructions appearing on the screen. Some of the problems however cannot be corrected by the operator himself, as follows:

Table 18: Error Messages

Error Message	***Possible Cause***
2-11: Probe error: Timeout Frequency Measurement	The board is defective and must be exchanged.
2-13: Probe error: zero frequency differs too much from reference value (without diamond being placed)	The Zero frequency of the UCI system is excessively shifted with respect to the default frequency of the probe.
2-16: Probe error: Frequency difference is below zero	The UCI-System does not oscillate at the correct frequency and must be exchanged (the piezo crystal may be defective).
2-18: Probe error: Please rise the probe (permanently, even though the diamond has not been placed)	The load characteristics must be readjusted.

i If one of the errors mentioned above is encountered, return the unit together with the probe to BAQ or consult an authorized service partner.

i If an error message not specified in the table above appears, accompanied by severe impairment of operation, immediately send a message to service@baq.de, return the unit together with the probe to BAQ or consult an authorized service partner

Error-Log

The alphaROCK automatically detects critical system errors and stores them in an error log file. Such errors can also occur internally within the device, so they may not be shown on the display. The error log file is solely for troubleshooting by BAQ. To send the file to BAQ, it can be transferred to a USB stick via the menu point **System / Copy error log to USB** and then sent by email to service@baq.de.

7.2 Troubleshooting in Leeb Mode

Incorrect Results

Faulty results occurring in spite of a correct measuring procedure (refer to chapter 5.2.8) require functional control acc. to instructions of chapter 5.1.3.3. This means that the impact body must be verified, and measurements on appropriate Leeb test blocks may be necessary, strictly in conformity with this user manual. Always check whether the sample is convenient for hardness measurements by the Leeb method (refer to chapter 5.1.3.2).

> *i* If the problem persists, return the unit to BAQ or consult an authorized service partner.

Absent Connection between alphaROCK and Impact device

Error message „2-24 No impact device connected“ originates from a perturbed connection, which may be due to the alphaROCK itself, the connecting cable or the impact device. Inspect the cable and all connectors including the pins inside the sockets respectively plugs.

No Reaction of the alphaROCK

The absence of any reaction is very unlikely. In this case, perform a reboot by keeping pressed the POWER button for about 8 seconds. The system shuts down automatically and restarts afterwards.

Error Messages

To each error message, a number and a text is assigned. Follow the instructions appearing on the screen. Some of the problems however cannot be corrected by the client himself. In this case contact service@baq.de or return the equipment incl. accessories to BAQ or authorized service partner.

Error-Log

The alphaROCK automatically detects critical system errors and stores them in an error log file. Such errors can also occur internally within the device, so they may not be shown on the display. The error log file is solely for troubleshooting by BAQ. To send the file to BAQ, it can be transferred to a USB stick via the menu point **System / Copy error log to USB** and then sent by email to service@baq.de.

8 Maintenance and Support

Regular cleaning and preventive maintenance of both alphaROCK and UCI-probes/Leeb-Impact devices contribute to trouble-free operation and extend the lifetime of the equipment. In order to constantly ensure reliable and repeatable measurements over the entire hardness range, yearly calibration by BAQ or an authorized service partner is advisable. Detailed information about recommended intervals is specified in the standards.

Cleaning

From time to time, clean the instrument itself, as well as the UCI-probes/Leeb-Impact devices, accessories and connection cables. A cloth soaked with isopropyl alcohol may be used for this purpose. For the test probe, do not forget to remove the protection sleeve, in order to clean the UCI-rod. Plugs and sockets can be cleaned by a clean and dry brush.

Cleaning of impact devices is imperative at the latest after 1000 measurements. For that purpose, unscrew the support ring, remove the impact body and insert the brush included in the delivery several times up to the end of the guide tube, meanwhile rotating counterclockwise, then pull it out. For the impact body, use a cloth soaked with isopropyl alcohol. After completion, reassemble the impact device.

> **!** Do not use sharp objects, aggressive substances or scouring agents.

Storage and Transport

The alphaROCK as well as accessories have to be stored in the case provided, in a dry, clean and dust-free environment. The cutouts within the case inlay reliably protect the content, so always make use of that case whenever transporting or shipping the instrument.

Updates

Software updates for the alphaROCK will be released throughout the product life cycle. To install a software update, a USB stick with the new software version must be inserted into the USB socket of the alphaROCK (if necessary, using the USB A ↔ USB C adapter included in the scope of delivery). The software update can then be started under the menu point **System / Software update**. Follow any further instructions on the display.

Disposal

The alphaROCK is not admitted for removal by conventional domestic, industrial or commercial waste. In case of need, consult us for information about correct removal of electronic equipment.

9 Appendix 1: Hardness conversion validity ranges

DIN EN ISO 18265 - Feb.2014

The DIN EN ISO 18265 - Feb. 2014 tables used for conversion in alphaROCK apply to the following materials and hardness scales:

Table 19: UCI Conversion Ranges according to DIN EN ISO 18265 – Feb. 2014

Material	from				to			
Steel, cast steel (A1)	80	HV	76	HB	650	HV	618	HB
	240	HV	20.3	HRC	940	HV	68.0	HRC
	85	HV	41,0	HRB	290	HV	105.0	HRB
	80	HV	255	MPa	650	HV	2180	MPa
	90	HV	82.6	HRF	250	HV	115.1	HRF
	240	HV	60.7	HRA	940	HV	85.6	HRA
	240	HV	40.3	HRD	940	HV	76.9	HRD
	240	HV	19.9	HR45N	940	HV	75.4	HR45N
Tempering steel, tempered (B2)	210	HV	205	HB	650	HV	632	HB
	210	HV	15.3	HRC	650	HV	57.5	HRC
	210	HV	94.8	HRB	410	HV	113.6	HRB
	210	HV	651	MPa	470	HV	1460	MPa
	210	HV	110.4	HRF	410	HV	121.5	HRF
	210	HV	57.2	HRA	650	HV	79.9	HRA
	210	HV	13.4	HR45N	650	HV	62.8	HR45N
Tempering steel, annealed (B3)	150	HV	152	HB	320	HV	316	HB
	160	HV	1.0	HRC	320	HV	33.6	HRC
	150	HV	81.0	HRB	320	HV	108.9	HRB
	140	HV	460	MPa	240	HV	826	MPa
	150	HV	102.5	HRF	320	HV	118.4	HRF
	150	HV	48.4	HRA	320	HV	67.2	HRA
	170	HV	0.8	HR45N	320	HV	35.0	HR45N
Tempering steel, hardened (B4)	580	HV	572	HB	720	HV	677	HB
	580	HV	54.0	HRC	720	HV	60.1	HRC
	580	HV	78.1	HRA	720	HV	81.7	HRA
	580	HV	59.5	HR45N	720	HV	66.4	HR45N

Material	*from*				*to*			
Cold work tool steel (C2)	**210**	HV	**205**	HB	**620**	HV	**600**	HB
	220	HV	**18.8**	HRC	**840**	HV	**65.8**	HRC
	210	HV	**95.6**	HRB	**340**	HV	**109.5**	HRB
	210	HV	**110.7**	HRF	**340**	HV	**118.6**	HRF
	220	HV	**59.4**	HRA	**840**	HV	**84.5**	HRA
	220	HV	**16.4**	HR45N	**840**	HV	**72.4**	HR45N
High speed steel (D2/4)	**589**	HV	**54.2**	HRC	**935**	HV	**67.6**	HRC
	589	HV	**77.9**	HRA	**935**	HV	**85.5**	HRA
	589	HV	**58.8**	HR45N	**935**	HV	**74.2**	HR45N
Hard metal (E2)	**780**	HV	**82.5**	HRA	**1760**	HV	**93.2**	HRA
Nickel and High-Nickel Alloys (F1)	**77**	HV	**77**	HB	**513**	HV	**479**	HB
	164	HV	**2.0**	HRC	**513**	HV	**50.0**	HRC
	77	HV	**30.0**	HRB	**309**	HV	**106**	HRB
	119	HV	**136**	HK	**382**	HV	**436**	HK
	77	HV	**73.0**	HRF	**309**	HV	**116.5**	HRF
	112	HV	**39.0**	HRA	**513**	HV	**75.5**	HRA
	112	HV	**8.0**	HRD	**513**	HV	**63.0**	HRD
	171	HV	**2.0**	HR45N	**513**	HV	**54.5**	HR45N
	77	HV	**70.0**	HRE	**188**	HV	**108.5**	HRE
Cartridge Brass (F2)	**45**	HV	**42**	HB	**196**	HV	**169**	HB
	60	HV	**10.0**	HRB	**196**	HV	**93.5**	HRB
	45	HV	**40.0**	HRF	**196**	HV	**110.0**	HRF
Copper (F3) (strips excluded)	**40**	HV	**42.8**	HK 0.5	**130**	HV	**133.8**	HK 0.5
	40	HV	**40.2**	HK 1	**130**	HV	**138.7**	HK 1
Wrought Aluminum Products (F4)	**44**	HV	**40**	HB	**189**	HV	**160**	HB
	80	HV	**28.0**	HRB	**189**	HV	**91.0**	HRB
	44	HV	**46.0**	HRE	**135**	HV	**101.0**	HRE
Aluminum and aluminum alloys (F5)	**18**	HV	**17.1**	HB	**210**	HV	**199.5**	HB
	80	HV	**31.9**	HRB	**210**	HV	**95.7**	HRB

Material	*from*				*to*			
Tool steel 1.1243 (G1)	**305**	HV	**297**	HB	**474**	HV	**474**	HB
	305	HV	**31.2**	HRC	**474**	HV	**48.0**	HRC
	305	HV	**950**	MPa	**474**	HV	**1550**	MPa
	305	HV	**65.9**	HRA	**474**	HV	**74.9**	HRA
Tool steel 1.2714 (G2)	**280**	HV	**279**	HB	**424**	HV	**419**	HB
	280	HV	**27.7**	HRC	**424**	HV	**43.1**	HRC
	280	HV	**880**	MPa	**424**	HV	**1370**	MPa
	280	HV	**62.9**	HRA	**424**	HV	**72.3**	HRA

ASTM E140 - 12b (2019)

The ASTM E140 - 12b (2019) tables used for conversion in alphaROCK apply to the following materials and hardness scales:

Table 20: UCI Conversion Ranges according to ASTM E140 - 12b (2019)

Material	*from*				*to*			
Non-Austenitic Steels (1/2)	100	HV	100	HB	832	HV	739	HB
	238	HV	20.0	HRC	940	HV	68.0	HRC
	100	HV	55.0	HRB	234	HV	99.0	HRB
	100	HV	112	HK	940	HV	920	HK
	100	HV	88.2	HRF	137	HV	99.6	HRF
	100	HV	37.2	HRA	940	HV	85.6	HRA
	238	HV	40.1	HRD	940	HV	76.9	HRD
	238	HV	19.6	HR45N	940	HV	75.4	HR45N
Nickel and High-Nickel Alloys (3)	77	HV	77	HB	513	HV	479	HB
	164	HV	2.0	HRC	513	HV	50.0	HRC
	77	HV	30.0	HRB	309	HV	106	HRB
	119	HV	136	HK	382	HV	436	HK
	77	HV	73.0	HRF	309	HV	116.5	HRF
	112	HV	39.0	HRA	513	HV	75.5	HRA
	112	HV	8.0	HRD	513	HV	63.0	HRD
	171	HV	2.0	HR45N	513	HV	54.5	HR45N
	77	HV	70.0	HRE	188	HV	108.5	HRE
Cartridge Brass (4)	45	HV	42	HB	196	HV	169	HB
	60	HV	10.0	HRB	196	HV	93.5	HRB
	45	HV	40.0	HRF	196	HV	110.0	HRF
Copper (7) (strips excluded)	40	HV	42.8	HK 0.5	130	HV	133.8	HK 0.5
	40	HV	40.2	HK 1	130	HV	138.7	HK 1
Alloyed White Irons (8)	380	HV	357	HB	1000	HV	903	HB
	380	HV	35.0	HRC	1000	HV	70.0	HRC
Wrought Aluminum Products (9)	44	HV	40	HB	189	HV	160	HB
	80	HV	28.0	HRB	189	HV	91.0	HRB
	44	HV	46.0	HRE	135	HV	101.0	HRE

Table 21: Leeb Conversion Ranges

Material	Hardness scale	Impact device type				
		D / DC	D+15	C	G	DL
Steel and cast steel	HRC	20.0 – 68.4	19.7 – 67.7	20.1 – 63.2	-	20.7 – 67.8
	HRB	38.4 – 99.5	-	-	47.7 – 99.9	38.4 – 99.5
	HB	81 – 654	82 – 637	80 – 683	90 – 646	82 – 644
	HV	81 – 955	81 – 928	80 – 789	-	81 – 939
	HS	29.7 – 99.5	33.6 – 98.9	31.8 – 87.2	-	30.9 – 96.2
	MPa / N/mm²	258 – 2180	-	-	304.1 – 2173	258 – 2159
Tempering steel, heat treated	HRC	20.0 – 68.4	-	-	-	20.7 – 67.8
	HRB	38.4 – 99.5	-	-	38.4 – 99.5	38.4 – 99.5
	HB	81 – 654	-	-	81 – 654	82 – 644
	HV	81 – 955	-	-	-	81 – 939
	HS	29.7 – 99.5	-	-	-	30.9 – 96.2
	MPa / N/mm²	654.2 – 1454	-	-	654.2 – 1460	651 – 1451
Tempering steel, annealed	HRC	20.0 – 68.4	-	-	-	20.7 – 67.8
	HRB	38.4 – 99.5	-	-	38.4 – 99.5	38.4 – 99.5
	HB	81 – 654	-	-	81 – 654	82 – 644
	HV	81 – 955	-	-	-	81 – 939
	HS	29.7 – 99.5	-	-	-	30.9 – 96.2
	MPa / N/mm²	460 – 826	-	-	503 – 823	460 – 826
Tempering steel, hardened	HRC	20.0 – 68.4	-	-	-	-
	HRB	38.4 – 99.5	-	-	38.4 – 99.5	-
	HB	81 – 654	-	-	81 – 654	-
	HV	81 – 955	-	-	-	-
	HS	29.7 – 99.5	-	-	-	-

Material	Hardness scale	Impact device type				
		D / DC	D+15	C	G	DL
Cold work tool steel	HRC	20.4 – 67.1	19.8 – 68.1	20.7 – 67.9	-	-
	HV	80 – 898	81 – 933	100 – 932	-	-
Stainless steel	HRC	19.6 – 62.4	-	-	-	-
	HRB	46.5 – 101.7	-	-	-	-
	HB	85 – 655	-	-	-	-
	HV	85 – 802	-	-	-	-
Grey cast iron	HB	93 – 334	-	-	92 – 326	-
Nodular cast iron	HB	131 – 387	-	-	127 – 364	-
Cast aluminum alloys	HB	19 – 164	-	23 – 210	32 – 168	-
	HRB	23.8 – 84.6	-	22.7 – 84.9	23.8 – 85.5	-
Brass (copper-zinc alloys)	HB	40 – 173	-	-	-	-
	HRB	13.5 – 95.3	-	-	-	-
Bronze (copper-aluminium /copper-tin alloys)	HB	60 – 290	-	-	-	-
Wrought copper alloys	HB	45 – 315	-	-	-	-

10 Appendix 2: Order information

Instrument and instrument accessories

Item-No.	*Description*
40-102	Combined UCI / Leeb hardness tester alphaROCK Basic device without probe, including power supply/charger, probe connection cable (UCI), USB-C adapter, and user manual on USB flash drive in a robust carrying case. Available UCI probes: 3N (HV0.3), 10N (HV1), 20N (HV2), 30N (HV3), 49N (HV5), and 98N (HV10) Available Leeb impact devices: D, DL, D+15, DC, C, and G + Made in Germany +
14-140	Carrying bag with shoulder strap
14-173	Power supply / battery charger incl. USB cable
14-173-UK	Adapter for Charger (UK, Connector type G)
14-173-US	Adapter for Charger (US/CA, Connector type A)

Leeb Packages and Leeb Accessories

Item-No.	*Description*
40-103	Leeb package D for alphaROCK hardness tester Consisting of: Impact device cable with screw lock and Leeb test block (approx. 790 HLD)
40-104	Leeb package G for alphaROCK hardness tester Consisting of: Impact device cable with screw lock and Leeb test block (500±40 HLG or 590±40 HLG)
40-172	Connection cable impact device - alphaROCK hardness tester Lemo push-pull connector and Binder screw lock

Additional Impact Devices and Accessories for Impact Devices

Item-No.	***Description***
22-120	Impact Device D for BAQ Leeb hardness tester Standard impact device for most hardness testing tasks
22-121	Impact device DL for BAQ Leeb hardness tester Impact device with thin extension (Ø4.2 mm), e.g. for measurements in drill holes
22-122	Impact Device DC for BAQ Leeb hardness tester Extremely short impact device for measurements at inaccessible locations
22-123	Impact Device D+15 for BAQ Leeb hardness tester The impact device has a recessed reactance coil and a smaller placement surface (11 mm x 14 mm instead of Ø 20 mm) for hardness measuring in slots and deepened areas.
22-124	Impact Device C for BAQ Leeb hardness tester Impact device with lower impact energy e.g. for measurements on surface-hardened parts. The impressions are approximately only half as deep as in case of impact device D, however, the requirements on the surface quality are higher.
22-125	Impact Device G for BAQ Leeb hardness tester Impact device with increased impact energy e.g. for measurements on heavy casting and forged parts. Measurement only in the Brinell range up to 650 HB. The requirements on the surface are not as extensive as with type D.
R-RP-SK-D	Impact body type D
R-RP-SK-DL	Impact body type DL
R-RP-SK-C	Impact body type C
R-RP-SK-G	Impact body type G
R-RP-AL-01	Support ring for Impact device, Ø14 mm
R-RP-AL-02	Support ring for Impact device, Ø20 mm
21-110	Set of support rings for convex and concave surfaces, 12 pieces

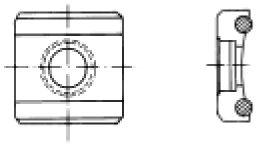
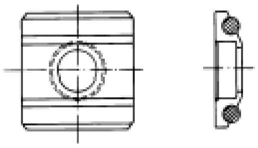
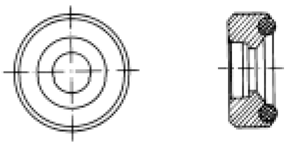
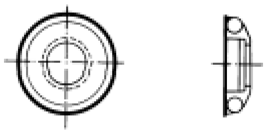
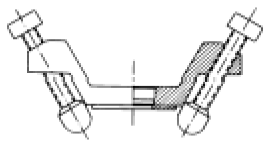
Leeb hardness test blocks

Item-No.	*Description*
HVP-HLD	Test block for Leeb hardness tester Ø90 x 55 mm, 2.73 kg Engraved hardness scales: HLD, HLDL, HLD+15, HLC Possible hardness values: 530±40 HLD, 630±40 HLD, 790±40 HLD
HVP-HLD-Z	Test block for Leeb hardness tester type HLD with DAkkS certificate conform to DIN EN ISO 16859 or ASTM A 956 Ø90 x 55 mm, 2.73 kg Possible hardness values: 530±40 HLD, 630±40 HLD, 790±40 HLD
HVP-HLG	Test block for Leeb hardness tester type HLG Ø120 x 70 mm, 6.17 kg Possible hardness values: 500±40 HLG, 590±40 HLG
HVP-HLG-Z	Test block for Leeb hardness tester type HLG with DAkkS certificate conform to DIN EN ISO 16859 or ASTM A 956 Ø120 x 70 mm, 6.17 kg Possible hardness values: 500±40 HLG, 590±40 HLG

Repair and calibration

Item-No.	*Description*
R-RP-KAL-01	Calibration of Leeb hardness tester including BAQ quality certificate. Test measurements on certified test blocks.
R-RP-KAL-02	DAkkS calibration for Leeb hardness tester with impact device D according to DIN EN ISO 16859-2 made by an official DKD accredited laboratory.
R-RP-KAL-03	DAkkS calibration for Leeb hardness tester with impact device D according to ASTM A 956 made by an official DKD accredited laboratory.

Table 22: Complete set of support rings (available as an option)

No.	Type	Drawing of the mounting ring	Notes
1	Z10-15		For convex surfaces R10 - R15
2	Z14.5-30		For convex surfaces R14.5 - R30
3	Z25-50		For convex surfaces R25 - R50
4	HZ11-13		For concave surfaces R11 - R13
5	HZ12.5-17		For concave surfaces R12.5 - R17
6	HZ16.5-30		For concave surfaces R16.5 - R30
7	K10-15		For balls SR10 - SR 15
8	K14.5-30		For balls SR14.5 - SR 30
9	HK11-13		For hollow bodies SR11 bis SR13
10	HK12.5-17		For hollow bodies SR12.5 bis SR17
11	HK16.5-30		For hollow bodies SR16.5 bis SR30
12	UN		For convex surfaces, Radius adjustable R10 bis ∞

Probe and probe accessories

Item-No.	*Description*
14-121	Probe with test load 3 N (HV0.3)
14-122	Probe with test load 10 N (HV1)
14-123	Probe with test load 20 N (HV1)
14-124	Probe with test load 30 N (HV3)
14-125	Probe with test load 49 N (HV5)
14-126	Probe with test load 98 N (HV10)
14-129A	Special probe SL for measurings e.g. in drill holes or cogwheels (Tooth base), available in all test loads Shaft diameter / length: 5 mm / 18 mm
14-129B	Special probe SL-L for measurings e.g. in drill holes or cogwheels (Tooth base), available in all test loads Shaft diameter / length: 5 mm / 34 mm
11-130	High precision stand
11-131	Probe support for flat specimen

Probe and probe accessories

Item-No.	*Description*
11-132	Probe support for round specimen 10 - 50 mm
11-133	Probe support for round specimen 50 - 250 mm
11-142	Handle for probes with ball knob
11-171	Protective sleeve for probe (Screwed on the probe for protection of the UCI-rod)
11-172	Probe cable for connection with the main unit

Hardness test blocks

Item-No.	*Description*
HVP-9016HV-EP	UCI Hardness test block (Vickers) with ISO and ASTM certificate Hardness value: approx. 160, 240, 300, 400, 510, 600, 700 or 830 Test load: HV0.3, HV1, HV2, HV3, HV5, HV10
HVP-9016HRC-EP	UCI Hardness test block (Rockwell) with ISO and ASTM certificate Hardness value: approx. 20, 30, 40, 50, 55, 60, 65 HRC

Repair and calibration

Item-No.	*Description*
R-S-KAL	Recalibration of the probe over the Vickers range from 120 HV to 850 HV and indirect approval according to DIN 50159-2 on ISO certified UCI hardness test blocks incl. BAQ certificate
R-AD-KAL-DIN	DAkkS-Calibration of a UCI-Hardness Tester with one Probe according to DIN 50159 by an accredited laboratory
R-AD-KAL-ASTM	DAkkS-Calibration of a UCI-Hardness Tester with one Probe according to ASTM A1038 by an accredited laboratory

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