alphaDUR II

Manual

Version 2.7

BAQ

1 Introduction

The alphaDUR II is a portable hardness tester. UCI-probes and impact probes can be connected.

UCI-probes measure Vickers hardness according to the UCI (Ultrasonic Contact Impedance) method. The alphaDUR II offers the opportunity to convert the measured Vickers hardness according to DIN EN ISO 18265 or ASTM E140 to other hardness scales.

The measurement of the impact probes is implemented according to the Leeb hardness testing method. Using this method, most metallic materials can be measured within a large measuring range.
For different applications, six impact device types are available. The type of the connected impact device is identified automatically.
Measurements can be made at any angle, even overhead.
The hardness is displayed directly in the hardness scales HRB, HRC, HV, HB, HS or tensile strength (MPa; measurable only with the impact device types D, DC and G). A limit-value acoustic alarm facilitates the evaluation.

Up to 500 000 readings including hardness, date, time and measuring parameter can be stored to the internal memory of the alphaDUR II.
The readings are arranged in series of measurements. A series of measurements is an aggregation of several readings. In addition to ordinary measurement series, serial measurement series which consists of multiple subordinate measurement series, can be recorded. Saved series of measurements, including statistics, can be displayed, printed or copied to a USB flash drive at any time.

2 The test probes

2.1 UCI probes

2.1.1 Probe selection

alphaDUR II UCI test probes are available with test loads of 10, 20, 30, 49, and 98 N. This corresponds to HV1, HV2, HV3, HV5 and HV10 (1, 2, 3, 5 and 10 kg).

For rough surfaces, high test loads are recommended, which leads to greater indentations. If many measurements follow one another, tests could be difficult without using a bench stand to apply test loads like 10 kg steadily and vertically.

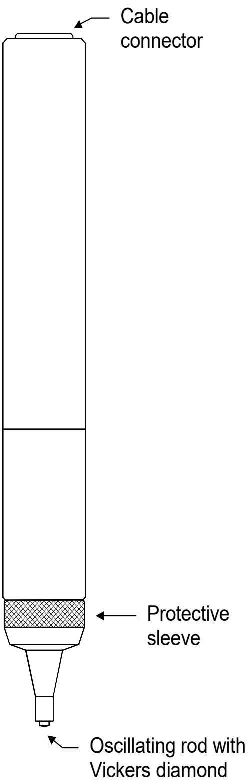


Fig. 1

2.1.2 Probe handling

The protective sleeve serves 2 purposes:

It protects the UCI rod against damages (as distortion).

It serves as a mechanical stop for the deflection of the rod during measurement.

To conduct a measurement, the probe must be held perpendicular to the specimen surface. (The alphaDUR II has to be calibrated to the material and must be in measuring mode.) The Vickers diamond may touch the surface slightly, but not for too long (otherwise an error occurs). Then the probe is pressed to the specimen until the protective sleeve hits the surface.

An acoustic signal indicates the completion of the measurement. To achieve an accurate measurement, the probe must be pressed steadily and vertically onto the specimen.

To facilitate the measurement procedure, probe supports can be attached to the probe in place of the protective sleeve. These probe supports are obtainable for flat and convex surfaces.

A high precision stand is available, which eases load application, particularly when a large number of measurements has to be taken or in case of a high test load.

2.2 Impact probes

2.2.1 Impact device type D

1 - Release button

2 - Bolt-arming sleeve

3 - Guide pipe

4 - Reactance coil part

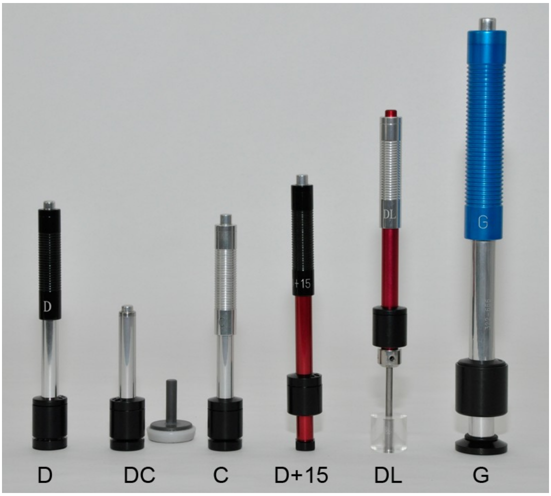
5 - Placement ring

6 - Impact body

7 - Connection cable

2.2.2 Special impact device types

The technical specifications of the individual impact devices are indicated in Table 4, the requirements on the sample surface in Table 5 and the diameters and depths of the arising impressions in Table 6.



Type D : Standard impact device for most hardness testing tasks

Type DC : Extremely short impact device for measurements at inaccessible locations or in pipes

Type C : 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.

Type D+15: The impact device has a recessed reactance coil and a smaller placement surface (11 mm x 14 mm instead of ∅ 20 mm) for hardness measuring in slots and deepened areas.

Type DL : Impact device with longer impact body. The diameter of the front pipe is 4.2 mm.

Type G : The impact energy increased with type 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.

The measurement range of the impact device types is summarized in Table 3 in chapter 18.

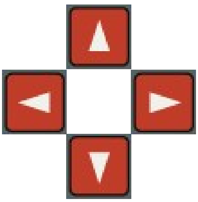
3 General working instructions

3.1 Key functions

Switching on/off the device.

Press this key to cancel the current action or to return to the superior menu item. Changes are not assumed.

Press this key to select a menu item. This key is also used to select the characters in the text input.



Cursor keys
Use these keys to navigate through the menus or select the value in an input field.
In drop-down lists, subordinate entries (marked with a preceding '+') can be opened by pressing the right cursor key.

Under certain circumstances, the function keys F1 – F4 will be used to ease the operation. E.g. in the measurement dialogue, the hardness scale can be switched by the F1 key, so you don't have to click through the menu to change it.

3.2 Status bar

On the status bar the battery charge condition, the current time and the selected conversion standard are displayed.

3.3 The menus

A menu consists of a list of available menu items. The active menu item is marked by a red bar. This bar can be moved by means of the cursor keys. Press the ENTER key to select a menu item. Either a window or a sub-menu will be opened, depending on the chosen menu item.

Press ESC to return to the previous menu.

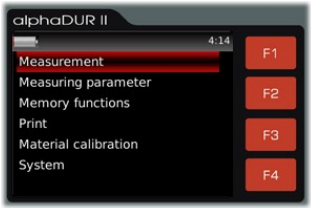


Fig. 2: Main menu

3.4 Text input

Whenever a set of measuring parameters is to be stored, a new series of measurement should be created or a new material should be calibrated, a name must be given in plain text. In all these cases, the text input dialog is opened.

Fig. 3 : Text input

In the upper field (hereinafter referred to as text field) the so far entered text is displayed. In the rows below, the available characters are shown. The blank is marked by [].

Select a character by means of the cursor keys and press ENTER to append it to the text in the text field.

F1 switches the available characters between upper- and lower-case.
Press F2 to delete the last character in the text field.
Press F4 to accept the input and close the dialog.
F3 or ESC discards the input and closes the dialog.

3.5 Numeric field

Numerical data are entered in a numeric field. A numeric field consists of mostly multiple digits, which can be individually altered. The active digit is marked by a red background and can be selected with the cursor keys LEFT/RIGHT. To change the active digit, press the cursor keys UP/DOWN.
To add new digits to the left of the number, press the cursor key LEFT until the desired number of digits is reached.
Press F4 to accept the input and close the dialog.
F3 or ESC discards the input and closes the dialog.

4 UCI measurement

4.1 Specimen requirements for UCI measurements

As in all hardness tests, besides the hardness of the specimen some other characteristics can influence the measurement result. These characteristics include the surface quality, the thickness and the homogeneity of the specimen.

Some essential requirements have to be fulfilled to achieve reliable reproducible hardness values.

- **Surface quality**

The surface quality should be the same as for optical Vickers hardness tests according to DIN standard. For low test loads, the quality has to be higher than for high test loads. The surface must be free from oxides, impurities and lubricants. According to DIN 50159 the surface roughness should not exceed the following values (Ra in µm):

- 0.5 Ra with probes of 10 N test load
- 0.8 Ra with probes of 49 N test load
- 1.0 Ra with probes of 98 N test load

- **Thickness**

For optical Vickers hardness tests, the thickness of the specimen should be at least ten times higher than the penetration depth. This applies also to the thickness of coatings.

The UCI method requires a higher thickness, because the oscillations of the UCI rod are transmitted to the specimen. They spread over the specimen and will be reflected at the boundaries. These reflected oscillations influence the frequency shift in the UCI rod and affect the accuracy of the measurement.

To avoid this effect, the specimen has to be thick enough to allow the oscillations to attenuate before the diamond is reached. With thin speci-

men, the mass of the specimen has an effect. If the mass of the specimen is high enough, a thickness of 8 mm for flat specimen or 10 mm for round stock is sufficient. If a specimen does not meet these requirements, it can be acoustically coupled to a massive support e.g. with a thin oil film between specimen and support. A solid steel plate is recommended as support (e.g. the precision stand comes with an appropriate plate).
Small, irregular shaped parts can be embedded in plastic material.

- **Homogeneity**

  As in optical Vickers hardness tests, the indentations are relative small. Therefore the homogeneity of the specimen can possibly influence the measurement results. To achieve reproducible hardness readings, the indentation must be significantly greater than the grain size of the test material. This may be not the case for some cast material even with a test load of 100N.

4.2 Measuring parameter settings

The measuring parameter must be set according to the demands. The parameter are in particular:

Material
Hardness scale
Rating
Statistics
Instant printout

These parameter are described in detail in chapter 8.1. Select the menu item **Measuring parameter/Edit** to set them. If a set of measuring parameter that meets the requirement already has been saved, you can use the menu item **Measuring parameter/Load** (see 8.2.3) to reload them.
After power-up, the alphaDUR II restores the measuring parameter which were last used.

4.3 Measuring procedure

Select **Measurement** from the main menu to start a measurement.

The test load of the connected probe will be detected automatically.

To take a measurement, put the probe vertically onto the specimen and press it down steadily as far as it will go. The hardness value will be determined shortly before the protective sleeve touches the surface of the specimen. Therefore vibrations caused by the protective sleeve hitting the surface will not influence the measurement result. The measurement is completed when you hear the beep. Within certain boundaries, the speed with which the probe is pressed down has no influence on the measurement result. If the probe is lowered too fast or if the probe is not raised from the specimen for some time, an error message will be shown.

Fig. 4: Measuring window

The number of fractional digits shown depends on the hardness scale. Rockwell scales will usually be displayed with 1 fractional digit, Vickers, Brinell and tensile strength without any fractional digits. If the measured values have been converted from Vickers to another hardness scale, the hardness values lying outside of the definition range of the standardized hardness testing method (but may be used as approximate values) are displayed in red.

In the lower part of the measuring window the selected material and, beneath it, the last measured values are displayed.

The hardness scale can be switched by the F1 key if the data storage is not in progress. When the scale is switched, the tolerance limits will be set to 0.

5 Impact measurement

5.1 Preparation of the sample for impact measurements

The preparation of the sample surface should correspond to the relevant specifications from Table 5 (on Page 52 in the appendix).

- In case of sample preparation, procedures which can influence the surface hardness of the sample, such as e.g. overheating, cooling etc., should be avoided as far as possible.
- If the surface of the sample is too uneven, measuring errors can occur. The sample surface should shine metallic, be smooth, level and free of dirt and oil.
- Underlay for test specimens:
  - In case of heavy test specimens, no underlay is necessary (see Table 5 (Page 52 in the appendix): *Minimum weight of the sample)*
  - Test specimens of medium weight require a flat, solid underlay (see Table 5 (Page 52 in the appendix): *Minimum weight of the sample*)
  - The sample must be placed onto the underlay so that it is stable and flush
- In case of measurements on large plates, long rods or curved work pieces, the impact effect of the impact device can cause small deformations or vibrations which lead to measuring errors, also when the weight of the sample corresponds to the specifications in Table 5 (on Page 52 in the appendix). In such cases, the sample should be reinforced or supported on the opposite side of the measuring point.

- In the ideal case, the sample surface should be level. In case of surfaces with a radius of curvature R<30 mm (with impact devices of the type D, DC, D+15, and C) and R<50 mm (with impact devices of the type G), a correspondingly shaped placement ring, which is adapted to the radius of curvature, must be screwed onto the impact device for the secure mounting of the impact device.

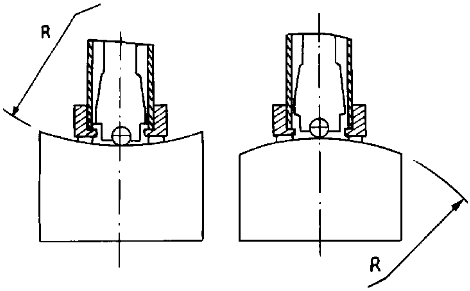


Fig. 5:

- In case of samples with hardened surface, the case hardening depth should correspond to the specifications in Table 5 (on Page 52 in the appendix).
- The sample should not indicate any internal magnetism, since this can influence the measurement of the speeds of the impact body.

5.2 Measuring parameter settings

The required measuring parameters must be set-adjusted according to requirements. It involves the following :

Material
Hardness scale
Impact direction
Tolerance limits

Statistics

Instant printout

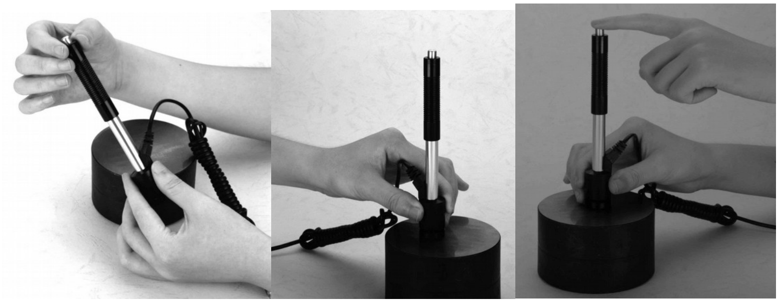
The measuring parameters are described in Chapter 8.1 .

5.3 Measurement

Before the measurements, the test device should be checked by means of a hardness comparison block. The precision and repeatability of the measurements should lie within the limits from Table 2 (on Page 50 in the appendix).

5.3.1 Preparation of the impact device

Slide the bolt-arming sleeve down slowly and uniformly to the stop. Then slowly bring the bolt-arming sleeve into the starting position again.



5.3.2 Mounting the impact device

Press the placement ring of the impact device firmly and without wobbling onto the test specimen. The impact direction must correspond to the set-adjusted direction.

5.3.3 Measuring

Press release button above on the impact device. Sample and impact device must be held steady and stable in this case.

For every measuring point, 5 measurements should be carried out whose deviation should not exceed ±15 HL .

The minimum distance between two measuring points, and the minimum distance between a measuring point and the edge of the sample, should correspond to the specifications in Table 1.

Impact device type	Separation distance between the center points of two impressions	Separation distance between the center point of an impression and the edge of the sample
	Not less than /mm	Not less than /mm
D / DC	3	5
DL	3	5
D+15	3	5
G	4	8
C	2	4

Table 1

The measurement is completed with the acoustic signal.

The result of measurement is displayed immediately according to measurement implemented. The number of decimal places indicated is dependent on the hardness scale. The Rockwell scales are usually indicated with 1 decimal place, Vickers, Brinell, Shore and tensile strength without any decimal place. If the measured value lies within the tolerance limits, a short beep is emitted, otherwise a longer beep.

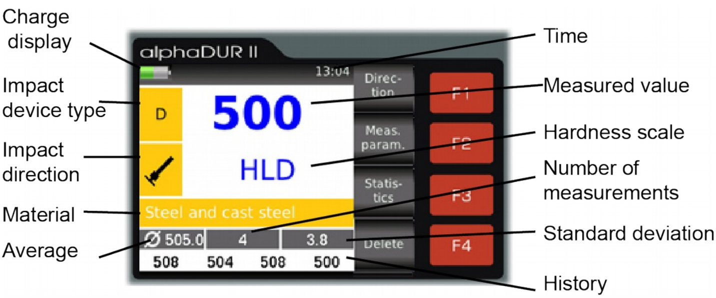


Fig. 6

6 Statistics

The values of a measuring series can be evaluated statistically at all times. If any measurement parameter is changed by key press from the measurement window, the statistics are reset.

6.1 Display of statistics

The statistics will be displayed when the predetermined number of measurements (measuring parameter, see chapter 4.2 and chapter 5.2) have been made, when the F3 key (Statistics) is pressed or if a measuring series is completed (see chapter 11.3). First, mean value, standard deviation, relative standard deviation (standard deviation in % of the average value), minimum, maximum and the number of data will be shown. Standard deviation and mean value are displayed with one one decimal place more than usual for the hardness scale. Vickers, Brinell and tensile strength are displayed without any decimal place, the others with one decimal place. The relative standard deviation is displayed with two decimal places.

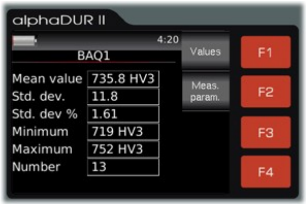


Fig. 7: Statistics

The measuring parameters can be displayed with F2 (Meas. param.).

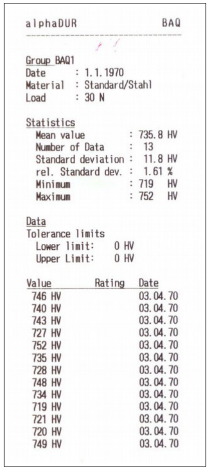
Press F1 (Values) to show the statistical data. Clearly wrong values can be deleted. To delete a value, move the marker with the cursor keys to the value you want to delete and press F2 (Delete).
F3 (Cancel) or ESC closes the statistical data windows and discards all changes. Press F4 (Save) to close the window and save all changes. The statistics will be refreshed.

Fig. 8: Values

Press ESC to close the display of statistics. If the predetermined number of statistical data not yet reached (because the display of statistics was started with F3 or because a value has been deleted) the measurements will be continued. If the predetermined number of data is reached, the data can be saved as a new series. Also, the data can be printed, even if they have not been saved as a new series.

7 Instant printout

If a mobile printer is connected, a consecutive printout can be made. The measured data are then instantly printed. The instant printout mode stays active when the measuring window is closed. It must be explicitly deactivated (see chapter 8.2.1).



alphaDUR BAQ

Group BAQ1
Date : 1.1.1970
Material : Standard/Stahl
Load : 30 N

Statistics
Mean value : 735.8 HV
Number of Data : 13
Standard deviation : 11.8 HV
rel. Standard dev. : 1.61 %
Minimum : 719 HV
Maximum : 752 HV

Data
Tolerance limits
Lower limit: 0 HV
Upper Limit: 0 HV

Value	Rating	Date
746 HV		03.04.70
740 HV		03.04.70
743 HV		03.04.70
727 HV		03.04.70
752 HV		03.04.70
735 HV		03.04.70
728 HV		03.04.70
748 HV		03.04.70
734 HV		03.04.70
719 HV		03.04.70
721 HV		03.04.70
720 HV		03.04.70
749 HV		03.04.70

Fig. 9

8 Measuring parameter

After power-up, the alphaDUR II restores the last used measuring parameter.

8.1 Description

UCI Measurement parameter:

Material: This is the currently selected material calibration. Materials that are not valid for the selected revaluation standard (see chapter 9.1.1) are displayed in gray. For details about material calibration see chapter 10.

Hardness scale: This is the hardness scale to which, if necessary, the readings will be converted. The result of an UCI measurement is Vickers hardness. If another hardness scale is selected, the values will be converted (see chapter 9.1). To change the hardness scale, select the menu item **Measuring parameter / Edit / Hardness scale** or press the F1 key in the measuring window. If the instant printout mode or the datalogger s activated, the hardness scale can no longer be switched by the F1 key of the measuring window.

Rating: These are the upper and lower limits for rating. A long beep sounds if a measured value lies outside these limits. A short beep indicates that the value is rated GOOD.

If both limits are set to 0, no rating will be done.

It is self-evident, that the upper limit must be higher than the lower limit.

Statistics: The number of measured values which should be statistically evaluated without the use of the measured value memory is defined here. If this number of measured values is reached, the statistics window is opened automatically (see 6.1).

Instant printout: If a mobile printer is connected, a consecutive printout can be made (see 7). This parameter can be set On or Off.

Impact measurement parameter:

Impact direction: The impact direction is set-adjusted with the aid of the key F1 in the measurement window.

Material: The currently selected material.

Hardness scale: The current hardness scale into which the measured values are converted as appropriate.

Rating: Upper and lower limit for the rating GOOD are stored here. If a measured value lies outside of these limits, an acoustic signal is triggered with the measurement (2 short tones). If the measured value lies within the limits, an individual tone indicates the successful measurement.
If the value 0 is entered for upper and lower limit, no verification of the measured value is implemented.
The value for the lower limit must of course be smaller than that of the upper limit.

Statistics: The number of measured values which should be statistically evaluated without the use of the measured value memory is defined here. If this number of measured values is reached, the statistics window is opened automatically (see 6.1).

Instant printout: If a mobile printer is connected, a consecutive printout can be made (see 7). This parameter can be set On or Off.

8.2 Managing sets of measuring parameter

Sets of measuring parameter can be stored to the alphaDUR II. So parameter combinations required for a particular application can conveniently be read back.

For UCI measurements the following parameter will be saved:

- Name
- Test load
- Material
- Hardness scale (HV, HB, HRC, HRB or tensile strength [N/mm^2])
- Upper and lower limit for rating
- Instant printout state (on or off)
- Number of readings that should be used for the statistical evaluation

For Impact measurements the following parameter will be saved:

- The assigned name
- The material
- The hardness scale
- The upper and lower limit for the rating ´GOOD´
- The test report printout (on or off)
- The number of readings that should be used for the statistical evaluation

8.2.1 Editing measuring parameter

Select menu item **Measuring parameter / Edit** to set the measuring parameter.

Only the active parameter can be changed. To alter a stored set of parameter, this set must first be loaded and stored again, when the changes are done.

8.2.2 Saving sets of measuring parameter

Select menu item **Measuring parameter / Save** to save the active measuring parameter. A name must be entered by means of the text input dialog (see 3.4). If you close the text input with the F4 key (Ok), the parameter set will be saved, otherwise the saving will be cancelled.

8.2.3 Loading a set of measuring parameter

Choose menu item **Measuring parameter / Load** to read back a set of measuring parameter.
Select the measuring parameter set from the list by means of the cursor keys. Then press F4 (Ok) to load the parameter or F3 (Cancel) to cancel the action.

8.2.4 Deleting a set of measuring parameter

Select menu item **Measuring parameter / Delete** to delete a set of measuring parameter which is no longer needed.
Choose the measuring parameter set from the list by means of the cursor keys. Then press F4 (Ok) to delete the set or F3 (Cancel) to cancel the action.

9 Hardness conversion

9.1 Conversion of UCI measurements

The alphaDUR II can convert hardness values to another hardness scale. The tables DIN EN ISO 18265 - Feb.2014 and ASTM E140 - 12b (2019) are used for the conversion. These tables partly contain values, which are outside of the definition area of the standardized hardness testing method, but may be used as approximate values. In the alphaDUR mini, these approximate values are considered in the conversion and shown in red on the display.

When applying revaluations, it should be noted that there is no universal conversion relation. That is why the conversions should only be used within a material group. The impact of different indenters and test loads should always be considered. The information given in the standards on the applicability, inaccuracy and the difficulties when converting hardness values should be taken into account. Before using the conversion it should be checked if all requirements for the conversion are met.

The alphaDUR II determines the Vickers hardness according to the UCI (Ultrasonic Contact Impedance) method (see chapter 14.1). In contrast to the classical method according to DIN EN ISO 6507-1, the measurement is done while the test load is applied. Still the results of the UCI-Vickers and the Standard-Vickers are comparable to the classical method, as long as the elastic part of the deformation is negligible compared to the plastic part. This applies to metals and e.g. ceramics.

To change the hardness scale, select the menu item **Measuring parameter / Edit / Hardness scale** (see chapter 8.2.1) or press the F1 key in the measuring window. The F1 key will be deactivated if the instant printout mode (see 7) or the measured value memory (see 11) is activated.

The ranges of validity for hardness conversion are shown in chapter 17 Appendix 1: Hardness conversion validity ranges.

9.1.1 Selection of the conversion standard to be used

In the menu item **Material calibration/ Conversion standard** can be selected if the DIN EN ISO 18265 or the ASTM E140 should be applied.

9.2 Conversion of Impact measurements

From the HL values, hardness numbers in the usual hardness scales are obtained using empirically-determined revaluation tables. These revaluations are dependent on material.

If the Leeb hardness is to be converted into another hardness scale, a benchmark comparison test must be carried out in order to obtain a suitable conversion factor for the corresponding material. Test measurements are carried out on the same sample with a well calibrated Leeb hardness testing device, and with another hardness tester, according to the required hardness scale. For every hardness number, 5 measurements with the Leeb hardness testing equipment must be carried out, uniformly distributed around a hardness impression of the other hardness testing device. At least three hardness impressions should be measured. The average value of the Leeb hardness and the average value of the measured values in the other hardness scale are used for the generation of a comparison hardness curve. The comparison hardness curve should be calculated from at least three series of corresponding values.

10 Material calibration for UCI measurements

For UCI measurements, the alphaDUR II has to be calibrated for every material that should be measured. These calibrations can be permanently stored to the device.

For measurements on samples made of the calibrated material, the corresponding material calibration must be selected. (Measuring parameter: Material see chapter 8.1)

In order to convert the measured hardness values to a hardness scale other than HV (see chapter 3.1), the material type for the conversion must be selected during the material calibration. If no material type is selected, the hardness scale cannot be switched to scales other than HV for measurements with this material calibration.

When delivered, there are already two material calibrations for steel in the alphaDUR II installed. These cannot be overwritten or deleted. They only differ in the table that has been chosen. Steel DIN is converted according to the table A1 of DIN EN ISO 18265, Steel ASTM according to table 1 and 2 of ASTM E140.

The calibrations can be grouped to sections. So a two-level hierarchy is established to keep things clear if lots of calibrations shall be saved. E.g. ferrous materials and aluminium alloys can be assigned to different sections.

To calibrate a material, select menu item **Material calibration / Calibrate**. You will need a material sample of known hardness (reference sample) for the calibration.
This reference sample must fulfil the following requirements:

- Sufficient size. Especially the thickness should not be less than 16 mm (as for standard test blocks).
- The surface should be finely lapped. The dispersion of measured hardness values will rise with greater roughness of the surface and will lead to inexact calibrations.
- The hardness of the sample should be as homogeneous as possible over the total surface. Variability of the hardness effects the measurement and leads to inexact calibrations.

The hardness of the reference sample can be determined e.g. with a stationary hardness tester. If such an instrument is not available, the manufacturer of the alphaDUR II can assist you.

First the three calibration parameter must be set:

1. Select the material type for the calibration. If no material type is selected, the hardness values determined with this material cannot later be converted to a hardness scale other than HV.
2. Afterwards the hardness scale in which the calibration should be made, must be selected. This corresponds to the hardness scale of the reference sample.
3. Enter the hardness of the reference sample.
4. Enter the number of measurements that should be included for calibration. Usually 4 to 5 measurements are sufficient. If great dispersions are to be expected, e.g. for rough surfaces, the number should be increased.

Now, take the measurements for calibration. The alphaDUR II sounds a beep at the end of each measurement. Hold the probe perpendicular to the sample surface and lower it evenly and steadily.
When the calibration is done, the standard deviation of the measurements will be displayed (in units of the selected hardness scale and as percentage of the mean value). This allows conclusions regarding the quality of the calibration. If the standard deviation is to high, press the appropriate function key to repeat the calibration. As for regular hardness measurements, the standard deviation of the calibration depends on surface quality, homogeneity and correct probe handling (perpendicular, without shaking). The standard deviation will be displayed with 1 more fractional digits than usual for the hardness scale (Vickers, Brinell and tensile strength are displayed without any fractional digits, all other hardness scales with one fractional digit). The standard deviation as percentage of the mean value will be displayed with 2 fractional digits.

When the calibration turns out satisfactory, it can be saved. Now you have to decide if the new calibration shall replace an older one, or if the calibration should be saved as a new one.

In the former case, you have to select the material that should be replaced.

In the second case, there are 3 alternatives:

1. The material calibration should be assigned to an existing section. By these sections, the calibrations can be organized in a two-level hierarchy, so that you can keep track even if lots of calibrations are needed. E.g. ferrous materials and aluminium alloys can be assigned to different sections. In the simplest case, the section 'Standard' can be selected.
2. If a new section should be created, you are first asked to enter the name of the section, then you are asked to enter the name of the calibrated material.
3. If the material calibration shall not be assigned to any section, just enter the name of the calibrated material.

Now, the new calibration can be selected in **Measuring parameter / Edit / Material**.

11 Memory functions

The alphaDUR II can store up to about 500.000 readings. These readings are organized in series of measurements.
A measurement series is defined as an aggregation of several readings.

In addition to ordinary measurement series, serial measurement series which consists of multiple subordinate measurement series, can be recorded. All subordinate measurement series of a serial measurement have the same measurement parameter and the same number of readings. The subordinate series of a serial measurement will be numbered consecutively. Serial measurement series simplify the measuring process, if several series with the same parameter should be recorded, e.g. during the quality inspection of many identical parts.

As soon as the set number of values for a subordinated measurement series is recorded, the statistic is displayed. After pressing the MENU; ESC or ENTER key within the statistics window a prompt appears whether the subordinate series should be saved. Confirmed by ENTER, a new subordinated series of measurements starts. Rejected with ESC, the just completed subordinated series of measurements must be restarted. If readings have been deleted in the statistic window (see chapter 6.1) the corresponding number of measurements have to be redone.

Every series of measurements is named, by which it can be displayed, printed or exported later on. The hardness values will be saved including time and date of measurement. In addition, the active measuring parameter are also saved.

For UCI measurements the following parameter will be saved:

- Probe type
- Test load
- Material
- Hardness scale
- Upper and lower limit for rating GOOD

For Impact measurements the following parameter will be saved:

- Impact device type
- Material
- Hardness scale
- Upper and lower limit for rating ´GOOD´

While values are saved to a series, the F1 and F2 keys (measuring parameter and hardness scale) are disabled in the measuring window.
When a series is displayed or printed, standard deviation and mean value will be included.

11.1 Creating a new series

Select the menu item **Memory functions / New series** to start a measurement series. After you entered a name for the series (see 3.4), the measuring window will open and the following readings are saved to this series.
The measuring parameter cannot be changed, while a series of measurements is taken.
Press ESC of F4 (Main menu) to close the series. You will then be asked, if the series should be saved finally.

11.2 Continuing a series

To append further data to a series, select the menu item **Memory functions / Append data to series**. The new data will be saved with the current time and date.
The parameter are automatically set to the settings of the selected series. If applicable the selected conversion standard (ISO or ASTM) is adapted.

11.3 New serial measurement

Under the menu item **Memory functions / New serial measurement,** a new serial measurement can be started. After defining the name of the new serial measurement with the text input function (see 3.4), the number of measuring points per subordinate series must be entered.
When this is completed, the measuring window will open automatically. The parameters set before starting the new series are applied. These parameters cannot be changed, while a new serial measurement is recorded. The recording of a new serial measurement is completed, if the measuring window is closed.

11.4 Continuing a serial measurement

Under the menu item **Memory functions / Continue serial m.,** a serial measurement can be selected, to which the now taken values should be added. The new readings are saved incl. the current date and time.
The measuring parameter are automatically set to the settings of the selected serial measurement. If applicable the selected conversion standard (ISO or ASTM) is adapted. If the last subordinated series is not completed, it is continued, otherwise a new subordinated series is created.

11.5 Deleting a series

Select menu item **Memory functions / Delete** to delete a series. The subordinated series, belonging to a serial measurement cannot be deleted separately. The complete serial measurement has to be deleted.

11.6 Displaying a series

Select menu item **Memory functions / Show** to display a series and the related statistics (see 6.1). If it is a single measurement series, single values can be deleted in the statistics view. This is not possible, if this series belongs to a serial measurement.

11.7 Copying of series to an USB flash drive

The measurement series can be copied to a USB flash drive under the menu item **Memory functions / Copy to USB flash drive**. Thus it is possible to transfer the series.
The files will be stored on the USB flash drive in CSV format (character set Unicode UTF8). The CSV-Format can be opened by all popular word processing and spreadsheet programs, which allows a comfortable evaluation of the measuring results. When importing the CSV files in word processing and spreadsheet programs, the character set 'Unicode UTF8' must be selected, otherwise the special characters will not be displayed correctly.

Only semicolons should be selected as the separator option when opening with a spreadsheet.
The USB flash drive should be formatted as MBR with FAT or FAT32. The included manual USB flash drive can be used without a problem.

When transferring serial measurements, several files are saved. This contains a huge file, in which all subordinated series are summarized as well as a sub-directory (under the name of the serial measurements) in which the subordinated series are saved separately (under the same format as the single series).

11.7.1 CSV file format

11.7.1.1 UCI measurements

Single series and subordinated series of a serial measurement

Probe type;< type description>
Name;<file name>
Test load;<e.g. 30>
Lower rating limit;<e.g. 0>
Upper rating limit;<e.g. 0>
Material section;<e.g. Standard>
Material name;<e.g. Steel>
Conversion table; e.g. DIN_ISO_18265_A1
Hardness scale;<e.g. HV>
Number of Data;<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>;Day;Month;Year;Hour;Minute
312;23;4;2020;10;51 <reading 1>

…. <mopre readings>

320;23;4;2020;10;51 <reading n>

Summarized serial measurements

Probe type;< type description>

Name;<file name>

Test load;<e.g. 30>

Lower rating limit;<e.g. 0>

Upper rating limit;<e.g. 0>

Material section;<e.g. Standard>

Material name;<e.g. Steel>

Conversion table; e.g. DIN_ISO_18265_A1

Hardness scale;<e.g. HV>

Number of subordinate single series;<e.g. 25>

Number of data per subordinate single series;<e.g. 5>

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

Number of Data;<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>;Day;Month;Year;Hour;Minute

312;23;4;2020;10;51 <reading 1>

…. <more readings>

320;23;4;2020;10;51 <reading n>

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

Number of Data;<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>;Day;Month;Year;Hour;Minute

312;23;4;2020;10;51 <reading 1>

…. <more readings>

320;23;4;2020;10;51 <reading n>

…. <more subordinate single series>

…. <more subordinate single series>

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

Number of Data;<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>;Day;Month;Year;Hour;Minute

312;23;4;2020;10;51 <reading 1>

…. <more readings>

320;23;4;2020;10;51 <reading n>

11.7.1.2 Impact measurements

Single series and subordinated series of a serial measurement

Probe type;< type description>

Name;<file name>

Lower rating limit;<e.g. 0>

Upper rating limit;<e.g. 0>

Material section;

Material name;<e.g. Steel>

Hardness scale;<e.g. HL>

Number of Data;<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>; Impact direction*;Day;Month;Year;Hour;Minute

312;0;23;4;2020;10;51 < reading 1>

…… <more readings>

330;0;23;4;2020;10;51 < reading n>

Summarized serial measurements

Probe type;< type description>

Name;<file name>

Lower rating limit;<e.g. 0>

Upper rating limit;<e.g. 0>

Material section;

Material name;<e.g. Steel>

Hardness scale;<e.g. HL>

Number of subordinate single series;<e.g. 25>

Number of data per subordinate single series;<e.g. 5>

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

Number of Data;<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>; Impact direction*;Day;Month;Year;Hour;Minute

312;0;23;4;2020;10;51 < reading 1>

…… <more readings>

330;0;23;4;2020;10;51 < reading n>

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

Number of Data;<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>; Impact direction*;Day;Month;Year;Hour;Minute

312;0;23;4;2020;10;51 < reading 1>

…… <more readings>

330;0;23;4;2020;10;51 < reading n>

…. <more subordinate single series>

…. <more subordinate single series>

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

Number of Data;<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 /HV; Impact direction*;Day;Month;Year;Hour;Minute

312;0;23;4;2020;10;51 < reading 1>

…… <more readings>

330;0;23;4;2020;10;51 < reading n>

*meaning of impact direction:

0 

45 

90 

135 

180 

12 System settings

12.1 Language

Select the menu item **System / Language** to set the language. Select the desired language by means of the cursor keys. The chosen language will become active when you close the dialog by pressing F4 (Ok).

12.2 Ports

To change the serial port parameter, select the menu item **System / Ports**. Baud rate, number of data and stop bits and parity can be set.
Default is:

115200 Baud
8 Data bits
1 Stop bit
No Parity

12.3 Time

Select the menu item **System / Time** to set the current time. The format is HH:MM (hour:minute). Press F4 (Ok) to save the time. To cancel the input, press F3 or ESC.

12.4 Date

Choose the menu item **System / Date** to set the current date. Select the month from the list in the upper left corner of the window. The year is displayed in the upper right corner. In the central part of the window, the day can be selected. Press F1 to switch between these 3 fields. The value can be selected by means of the cursor keys.
Press F4 (Ok) to save the current time. To cancel the input, press F3 or ESC.

12.5 System information

Select **System / Info** from the menu to display the system information. The version numbers of software, kernel and system will be shown. If a probe is connected, the serial number of the probe, the version of probe software and the number of measurements done with this particular probe will be displayed additionally.

13 Maintenance and inspection

13.1 UCI probes

Periodically checks of the device should be executed with standard hardness test blocks. The thickness of the test block is very important, due to the measuring method. It should be no less than 15 mm. Test blocks of lesser thickness (e.g. 6mm) aren't suitable. The edge length of the hardness test block must be at least 50 mm. These special UCI hardness test blocks, including ISO and ASTM, are available in various hardnesses from the manufacturer of the device.

Depending on the frequency of use, a check / maintenance of the probes should be performed at intervals of 1 to 2 years.

13.2 Impact probes

The impact device should be cleaned with the delivered cleaning brush after 1000 to 2000 measurements. For this purpose, the placement ring is screwed off, the impact body removed and the brush inserted into the guide tube rotating anti-clockwise approx. five times to the end stop, and pulled out again. After that, the impact body is again installed and the placement ring screwed on.

After use of the impact device, the spring should be decompressed.

No lubricants may be employed when cleaning the impact device!

If the measuring error of the device is greater than 2 HRC in case of measurements on the hardness comparison block supplied, the impact body or the test tip may possibly have to be replaced.

In case of all other functional disturbances, the device must be sent to the technical service. Replacement services cannot be made in case of repairs carried out by yourself.

14 Measurement methods

14.1 The UCI method

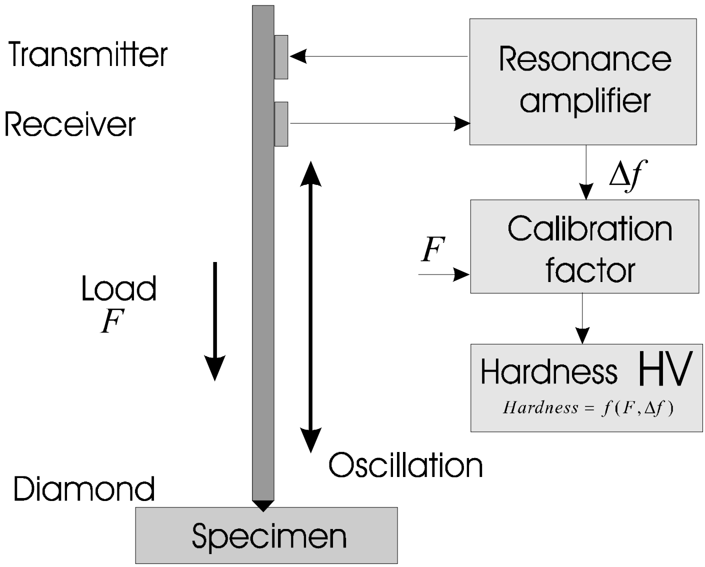
The UCI method (Ultrasonic Contact Impedance) is successfully used in hardness testing since many years.

A rod is excited into a longitudinal oscillation. At the tip of the rod, a Vickers diamond is placed. This diamond is pressed to the specimen with a discrete test load. Mostly the test load F is applied through a spring.

The rod oscillates with its self-resonant frequency which depends essentially on its length. When the Vickers diamond penetrates the specimen, the oscillation of the rod is damped. This causes a shift Δf of the resonance frequency, which can easily be measured.

The damping of the rod and the resulting shift in resonance frequency depends on the size of the area of contact between the diamond and the specimen and therewith on the hardness of the material if the test load is constant. Beneath the hardness, the elastic modulus of the material also affects the frequency shift.

The hardness of the material can be calculated from the known test load, the measured frequency shift and the material calibration factor (for taking the elastic modulus into account).



The advantages of the UCI method are the ease of automation and the very good reproducibility of the hardness readings. The reproducibility of the measurements is better than with optical methods of hardness testing because the total area of contact (proportional to d^2) enters into the measurement and not only the diagonal d or a diameter. Moreover the measurement results are independent from the subjective view of a single examiner and the test is very fast executable.

For carbon steel and low alloyed steel, hardness reference samples are used for purpose of calibration. The low variation of the elastic modulus of this group of materials can be neglected.

14.2 The Impact (Leeb hardness) measurement method

The measurement process employed here exploits the difference between the impact and rebound speed of a small impact body. This is fired in the impact device onto the sample surface with an exactly defined energy. The plastic deformation on generating the impression on the sample surface requires energy. Therefore the rebound speed of the impact body is lower than the speed before the impact. Both speeds are measured inductively 1 mm above the surface.

The hardness number is calculated according to the following formula:

$$HL=\frac{1000*VB}{VA}$$

Where:

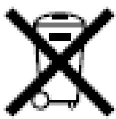
HL - Leeb hardness

VB – Rebound speed

VA – Impact speed

From the HL values, hardness numbers in the usual hardness scales are obtained using empirically-determined revaluation tables. These revaluations are dependent on material.

15 Proper disposal



Consumers are legally required to dispose of batteries at suitable collection points, vending points or dispatch bays. The crossed-out wheeled bin means that batteries must not be disposed of in the household waste. Pb, Cd and Hg designate substances that exceed the legal limits.

15.1 German

Verbraucher sind gesetzlich verpflichtet Altbatterien zu einer geeigneten Sammelstelle/Verkaufsstelle/Versandlager zu bringen. Die durchgestrichene Mülltonne bedeutet: Batterien und Akkus dürfen nicht in den Hausmüll. Pb, Cd und Hg bezeichnet Inhaltsstoffe die oberhalb der gesetzlichen Werte liegen.

15.2 French

La législation exige des consommateurs le dépôt des piles usagées dans un lieu de collecte approprié, un point de vente ou un entrepôt d’expédition. La poubelle barrée signifie qu’il est interdit de jeter les piles et les batteries avec les ordures ménagères. Pb, Cd et Hg désignent les substances dont les valeurs dépassent les limites légales.

15.3 Italian

Per legge, i consumatori sono obbligati a depositare le batterie esaurite presso i punti di raccolta, i punti di vendita o i magazzini di spedizioni. Il simbolo del contenitore dei rifiuti sbarrato indica che è vietato smaltire le batterie con i rifiuti domestici. Pb, Cd e Hg indicano le sostanze presenti con valori superiori alla norma.

15.4 Spanish

Los usuarios están obligados por ley a depositar las pilas viejas en un punto de recogida adecuado /punto de venta/centro de envío. El contenedor de basura tachado significa: la pilas no deben desecharse en la basura doméstica. Pb, Cd y Hg designan sustancias que se encuentran por encima de los valores establecidos por ley.

16 Technical Data

16.1 UCI probe

Test method	Vickers hardness according to the UCI-method (DIN 50159 and VDI/VDE Guideline 2616, Part 1). Measurement is done with test load applied	
Indenter	Diamond, Vickers pyramid angle 136°	
Test materials	Preferably metals, to which the alphaDUR II can be calibrated with standard hardness test blocks. Tests on ceramics, glass and plastics are also possible using comparison measurements for calibration purposes.	
Test load	10, 20, 30, 49 or 98 N, depending on the UCI probe	
Measurement range	HV 10 - approx. 3000 Conversion range see chapter 17	
Uncertainty of measurement	<2% to the value of the hardness test block	
Dimensions	Diameter	19,5 mm
	Length	175 mm
Weight	190 g	

16.2 Impact probe

Measurement range	170 HLD to 960 HLD
Impact direction	360°
Hardness scale	HL, HB, HRB, HRC, HV, HS and tensile strength

The precision and reproducibility of the measured values is represented in table 2.

16.3 Basic device

Memory	32MB Flash memory for approx. 512.000 readings divided into variable groups. Storage includes date, time and Pass/Fail evaluation	
Statistics	Mean value, minimum, maximum and standard deviation (absolute and relative). Single readings can be deleted and redone.	
Interfaces	USB-Master, USB-Slave, RS232, 10/100 MBit Ethernet	
Power supply	Mains adaptor/battery charger Input: 100 - 240 V AC Output: 12V DC $LiFePO_4$ 6,6 V / 2500 mAh	
Operating time	Battery operation: approx. 7 hours	
Temperatures	Operating range	10°C to 40°C
	Storage	-10°C to 60°C
Dimensions	Height	78 mm
	Width	198 mm
	Depth	160 mm
Weights	1400 g	

17 Appendix 1: Hardness conversion validity ranges

17.1 DIN EN ISO 18265 - Feb.2014

The tables of DIN EN ISO 18265 – Feb.2014, used for conversion in the alphaDUR mini, apply to the following materials and hardness scales:

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,.** 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	**60.6** HR45N
Tempering steel, annealed (B3)	**150** HV	**152** HB	**320** HV	**316** HB
	160 HV	**1.0** HRC	**320** HV	**336** 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	**78.1** HRA

Material	from				to			
	580	HV	**59.5**	HR45N	**720**	HV	**66.4**	HR45N
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	**54.4**	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
Tool steel 1.1243 (G1)	**305**	HV	**297**	HB	**474**	HV	**474**	HB
	305	HV	**31.2**	HRC	**474**	HV	**48.0**	HRC

Material	from		to	
	305 HV	**950** MPa	**474** HV	**1550** MPa
	305 HV	**65.9** HRA	**474** HV	**74.9** HRA
Tool steel 1.2741 (G1)	**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

17.2 ASTM E140 - 12b (2019)

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

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	**54.4** 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

Material	from				to			
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

18 Appendix 2

No.	Impact device type	Hardness of the Leeb hardness comparison block	Fault of the measured value	Repeatability
1	D	760 ±30 HLD 530 ±40 HLD	±6 HLD ±10 HLD	6 HLD 10 HLD
2	DC	760 ±30 HLDC 530 ±40 HLDC	±6 HLDC ±6 HLDC	6 HLD 10HLD
3	DL	878 ±30 HLDL 736 ±40 HLDL	±12 HLDL	12 HLDL
4	D+15	766 ±30 HLD+15 544 ±40 HLD+15	±12 HLD+15	12 HLD+15
5	G	590 ±40 HLG 500 ±40 HLG	±12 HLG	12 HLG
6	C	822 ±30 HLC 590 ±40 HLC	±12 HLC	12 HLC

Table 2

Material	Hardness scale	Impact device				
		D / DC	D+15	C	G	DL
Steel and cast	HRC	20,0 – 68,4	19,7 – 67,7	20,1 – 63,2		20,7 – 67,8

steel	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	
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				
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-aluminum / copper-tin alloys)	HB	60 – 290				

Wrought copper alloys	HB	45 – 315				

Table 3

Impact device type	DC/D/DL	D+15	C	G
Impact energy Weight of the impact body	11 mJ 5.5 g /DL: 7.2 g	11 mJ 7.8 g	2.7 mJ 3.0 g	90 mJ 20.0 g
Hardness of the test tip Diameter of the test tip Material of the test tip	1600 HV 3 mm Tungsten carbide	1600 HV 3 mm Tungsten carbide	1600 HV 3 mm Tungsten carbide	1600 HV 5 mm Tungsten carbide
Diameter of the impact device Length of the impact device Weight of the impact device	20 mm 86(147)/75 mm 50 g	20 mm 162 mm 80 g	20 mm 141 mm 75 g	30 mm 254 mm 250 g
Maximum sample hardness	940 HV	940 HV	1000 HV	650 HB

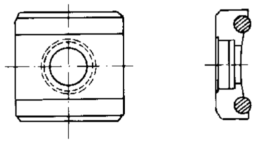
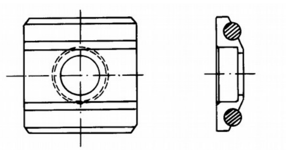
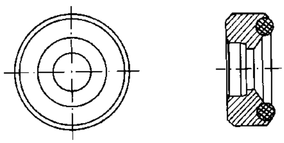
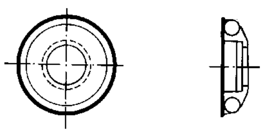
Table 4 Properties of the impact devices

Impact device type	DC/D/DL	D+15	C	G
Surface Roughness Ra / Rt ISO Class	2 µm/10 µm N7	2 µm/10 µm N7	0.4 µm / 2.5 µm N5	7 µm / 30 µm N9
Minimum weight of the sample For direct measurement On stable underlay	 > 5 kg 2 - 5 kg	 > 5 kg 2 - 5 kg	 > 1.5 kg 0.5 - 1.5 kg	 > 15 kg 5 - 15 kg
Minimum thickness of the surface hardening	≥ 0.8 mm	≥ 0.8 mm	≥ 0.2 mm	

Table 5 Requirements on the sample

	D / DC / DL	D+15	C	G
At 300 HV, 30 HRC Diameter/Depth	0.54mm/24µm	0.54mm/24µm	0.38mm/12µm	1.03mm/53µm
At 600 HV, 55 HRC Diameter/Depth	0.45mm/17µm	0.45mm/17µm	0.32mm/8µm	0.90mm/41µm
At 800 HV, 63 HRC Diameter/Depth	0.35mm/10µm	0.35mm/10µm	0.30mm/7µm	

Table 6 Size of the impressions in case of different hardening and impact devices

No.	Type	Sketch of the placement ring	Remarks
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 spheres SR10 - SR 15
8	K14.5-30		For spheres SR14.5 - SR 30
9	HK11-13		For hollow bodies SR11 to SR13
10	HK12.5-17		For hollow bodies SR12.5 to SR17
11	HK16.5-30		

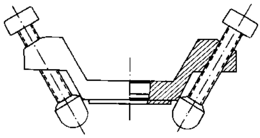
No.	Type	Sketch of the placement ring	Remarks
			For hollow bodies SR16.5 to SR30
12	UN		For convex surfaces, Radius adjustable R10 - ∞

Table 7

A complete set of placement rings is available as an option.

Appendix 3: License information

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1) Free Software which is licensed under the GNU General Public License (GPL) or under the GNU Lesser General Public License (LGPL). The free software source code can at least for a period of 3 years be requested from BAQ GmbH. However, please be noted that we cannot provide guarantee with the source code, and there is also no technical support for the source code from us.
2) Crc16.c

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