Hardness Measurement Device
Shore A

Type SHA.03

Manual / Device Documentation

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Preface

Congratulations. With the hardness test device Shore A Type SHA.03 you have chosen a powerful measurement instrument that facilitates Shore measurements efficiently, and highly increases the quality of measuring results.
The friction-free system allows reproducible measurements over the entire hardness range from -7.3 to 100 Shore A. The integrated **SPC** permanently controls measurements for device-related deviations. If an error-induced deviation occurs and the set error-reporting threshold is reached, an automatic signal is given. Errors, such as dirty sensors, friction or a damaged unit-load are accurately determined.

You will be surprised how easy and safe you can use our test device.

Our aim is a reliable measurement technique at a proven high quality level combined with a rational and easy operation. Technical developments and practical applications continuously change the requirement profile. Information about feature enhancements and errors support us in the further development and redesign of devices. We are very obliged if you inform us about positive and negative user experiences.

We wish you every success

Q-tec GmbH

Table of contents

5. Error Treatment

6. Options

6.1 Accessory

6.2 Interfaces (PC, Printer, Host; …)

6.3 Software-Modules

6.4 Hardware to present and record measurement results

7. System Components

8. EMSR-Technology

9. Appendices

A. Technical Data
B. User administration
C. Design/Illustrations
D. EU-Declaration of Conformity
E. Standards/References
F. Device history (Orders/Alterations/Errors/…)
G. General information/Publications/…
H. Brochures / Device information

1. Hardness test after Shore

1.1 Shore-Hardness

The hardness test after Shore is one of the most applied parameter to characterise the hardness of non-metallic materials. It is an easy-to-use system that allows in a short time to determine an important product property.

By hardness after Shore A we understand the resistance against the penetration of a body of a certain form (frustum) at a defined spring force. Shore D uses a taper rounded at the top. The hardness scale covers a range of 0.0 up to 100.0 hardness units whereby 0.0 corresponds to the smallest and 100.0 to the highest hardness. The needle normally is pre-loaded to the 0 Shore value and therefore does not allow measurements smaller than approx. 10 Shore A. The new measurement procedure functions without needle preloading and therefore permits the measurement of very soft materials being smaller than 0 Shore A (up to approx. -5 Shore A). The theoretically lowest measured value is -7.3 Shore A.

Soft materials oppose a smaller penetration resistance to the spring-loaded needle than harder ones. Due to the penetration depth depending power (deep penetration depth - minor force) and the progressive sample geometry (frustum or taper respectively), Shore A / Shore D measurements allow to test a very large hardness range. The Shore hardness is calculated from the linear dependence of the needle penetration depth to the Shore value according to a defined measurement time.

1.2 Shore Test Methods

The Hardness test after Shore differs by two methods.
For soft materials and elastomers: **Shore A**
For harder materials and plastics: **Shore D**
The construction of the penetration needle and the spring characteristics are different and stipulated in accordance with DIN 53505, DIN ISO 7619-1, DIN EN ISO 868 and/or the corresponding ASTM or JIS standards.

The Nano Shore A-measurement corresponds in its physical load properties to the standard Shore A-test. The load pressure and the dependent load surface are reduced by a factor of 100. The separate surface fuser unit and the active needle positioning allow measurements independent of the surface form. A flat bearing surface as needed for the pre-loaded needle is no longer necessary.

1.3 Hardness Measurement Shore A (Standard-method)

The standard test after Shore A in accordance with DIN 53505 / DIN EN ISO 868 / DIN ISO 7679-1 allows to determine the hardness of specimen made of elastomers. The measured values depend on their visco-elastic properties, in particular on the tension values in accordance with DIN 53504. The Q-tec standard hardness device after Shore A is applicable for the range -5 up to 90 Shore A. Harder specimen are measured after Shore D. Due to the friction- and load free needle positioning, even very soft specimen up to -5 Shore A can be measured without any problems.

The standardised hardness test after Shore A is currently subject to major measurement inaccuracies that can be influenced by the tester, the measurement device and the sample quality. In order to increase the accuracy of the measurement procedure, the causes for deviations need to be eliminated.
Tests yielded that measurements of products of a Shore A hardness within the range of 25 to 50 and of a standardised sample thickness of 6.3 ±0.3 mm systematically lead to hard measurement results. The reason is too small a sample thickness.

The absolutely hard contact surface influences the outcome towards too hard. With an actual product Shore A hardness of 30, this leads to a result of about 31 Shore A points: The Shore A difference is about +1 point.

1.4 Hardness Measurement Inaccuracy

1.4.1 Permitted geometry tolerances of the measuring needle

The geometry of the measuring needle systematically influences the measurement results**.** Manufacturing and wear tolerances result in measurement result tolerances. Example: The diameter tolerance of the needle's truncated cone in accordance with DIN 53 505 / DIN ISO 7619-1 is 0.79 ±0.01 mm and signifies a Shore A-tolerance of approx. ±0.15 Shore units (fig. 4). The deviations were determined in experiments.

1.4.2 Permitted tolerances of the positioning sensor

To the path measurement of the penetration needle, even for standard measurements high requirements have to be made, as a deviation of ± 0.1 Shore A causes a change of path of ±0.0025 mm. To keep the total error low, an accurate distance measurement with a resolution of 1 µm is demanded.

1.4.3 Permitted tolerances of the spring characteristic

Tolerances in accordance with DIN 53 505, DIN ISO 7619-1: ± 0.0375 N.
The tolerance comes from the spring constant deviation and friction factors of the needle bearing. The tolerance of ±0.0375 N corresponds to a Shore A-tolerance of ± 0.50 Shore A-units. Minimizing the measurement deviations implies a smaller deviation from the nominal linear spring rate. Besides the exact positioning of the spring constant, a high-quality measuring pin bearing is necessary in order to exclude friction influences. The gradient and linearity deviation of the spring characteristics must not exceed
±0.1 Shore units in order to meet the high measurement demands. The maximum load deviation to get the measurement accuracy must not exceed ± 0.1 Shore A ± 0.005 N (5mN).

1.4.4 Form error of the test specimen surface

Positioning of the measurement sensors on the specimen surface:
In order to avoid measurement errors, the measurement sensor must rest plane parallel on the test specimen surface in accordance with DIN 53 505 / DIN ISO 7619-1 / DIN EN ISO 868. The specimen must have a thickness of 6.3 ±0.3 mm. Other thicknesses have to be separately agreed upon. To exclude measurement errors the measurement device has to compensate plane parallel errors of the test specimens. The measurement sensor must align itself on the test specimen surface automatically. Form defects lead to higher, non quantifiable stochastic Shore measurement errors.

1.4.5 Sensor touch-down speed

To get a precise Shore measurement the sensor touch down speed has to be defined. Due to different touch down conditions the Shore measurement value is influenced. The deviation is not definable.
A touch down speed of 500 mm/min has proved well. A non-defined touch down speed affects inter alia the active measuring time of the needle with a defined force. In accordance with DIN 53505, section 7.4 / DIN ISO 7619-1, section 4.1.5, the hardness is determined by a defined time after the contact between the bearing surface of the hardness test device and the specimen.

The needle however already hits onto the specimen surface before it touches the sensor bearing surface. Thus the penetration time changes according to the touch down speed.

1.4.6 Test specimen quality

The test specimen must be manufactured according to defined procedures. It must neither in production nor in positioning be mechanically loaded (bent, stretched, etc.) Improper test specimen wear leads to non-recognizable stochastic measurement errors. Product specific properties, such as aging and manufacturing methods have to be considered.

1.4.7 Measurement temperature influence

The test has to be made in accordance with DIN 53505, DIN ISO 7619-1 at a temperature of 23 ±2° C. A temperature deviation of 5° C causes at systems with a pre-loaded needle a device specific measurement deviation depending on the utilised load needle. If the measurement sensors are exposed to other than standardised temperatures while measuring, this has to be separately reported. The automatic calibration of the Q-tec standard device permits correct measurements at ambient temperatures deviating from 23° C.
This error analysis is independent of changes of the Shore hardness of the measured product.

1.5 Statistical Process Control (SPC)

Measurement values to evaluate the product need to be measured with a provable tolerance in order to permit a clear evaluation. If this is not assured, a non-definable device measurement error can enter into the test results. Measurement device errors can occur at different times due to sensor pollution or an increased bearing friction, etc. SPC methods allow a reliable recognition of such systematic measuring errors during the normal measuring operation.

The notification threshold of deviations and its statistical evaluation can be configured on the measurement device. If a deviation limit of e.g. 0.5-Shore values is configured, a warning signal on the monitor follows as soon as this value is reached or exceeded. In the statistics display the deviation can be judged.

The SPC is based on the comparison of parallel measuring sensors.
It detects all deviations that do not occur simultaneously at all sensors in the same size. Error detection is therefore very universal and does not depend anymore on test dates. Errors are recognized very early, usually within ten measurements.
A possible automatic error correction is not made in order to maintain measuring certainty permanently. A measurement result evaluation is therefore even possible for incorrect measurements, as the error variance value of the measurement is known.

1.5.1 Basic SPC procedures for the error control

The error control is achieved by a SPC consideration of the parallel working single- sensor measurement values to their mean value. Constantly the deviations of the single sensor to their mean value are added and via a series of measurements a systematic deviation is recognized. The stochastic portions, which usually represent the product spread width, are used as measuring results to evaluate the product.

As method the EWMA procedure (exponentially weighted moving average variation) – is used. It allows a trend computation because of a logarithmic correction of past average value deviations. The weighting between older logarithmic decreasing and new measured values is obtained by method m, i.e. mean accumulation of the value results. The weighting of the last measured value thereby is 1/m. For m = 5, i.e. a weighting of 0.2 and/or 20% respectively.

For the measurement device configuration this means:
If Config is set at a weighting of 20 %, the last measurement is evaluated by
1/m= 0.2 (20 %). Former measurements are evaluated by 80%. Larger stochastic measurement value fluctuations still enter by an error evaluation of at least 20 %. If a measurement range of m equal to 10 measurements is used, the last measurement is evaluated by 1/m=0.1 (=10%) and earlier statistically spread measurements are evaluated by 90%.
Stochastic product defects can only appear at most by a weighting of 10 % in the error evaluation. The recognition rate is still very high, since significant systematic deviations are safely recognized within a series of 10 measurements. On the measurement device intervention limits can be set via the reporting threshold in Config. If the notification threshold is reached, a report is on the screen and/or the interface of the superior BDE system. (Factory data capture system)

2. Installation/ Start-up

The test device is supplied with a calibration plate 100 Shore A, a user guide and a power cable. Please do keep the original card box after unpacking, as well as the packing material, in case you want to dispatch or transport the test device later.

The Shore test device is a precision measurement device and must not be exposed to strong vibrations. It is appropriate for a long life span and a constant measuring quality.

Warning:

Check the device for damages in transit!

Connect the device to duly earthed sockets only!

Case parts must be removed by a technician only.

2.1 Installation:

The device is transportable and can be placed on any solid table or suitable even firm surface. You can work with the device while you are sitting or standing. The installation place should be protected against humidity and fulfil the measuring conditions such as temperature. Distance to the back 10 mm at minimum.

The place should not be exposed to strong vibrations. Vibrations lead to substantially longer measuring times, since surface recognition requires more time by iterative approximation.

Procedure:

1. Take the device out of the transport box.

2. Put the device horizontally on the measuring place. Fastening is not required.

3. **Prior to connect the device remove the transport locks (Fixation of the measuring head).**

4. Check the device for damages in transit.

5. Attach the included keyboard to one of the two USB ports on the device.

6. The device is connected with the included power cable to a duly earthed socket.

2.2 Start up

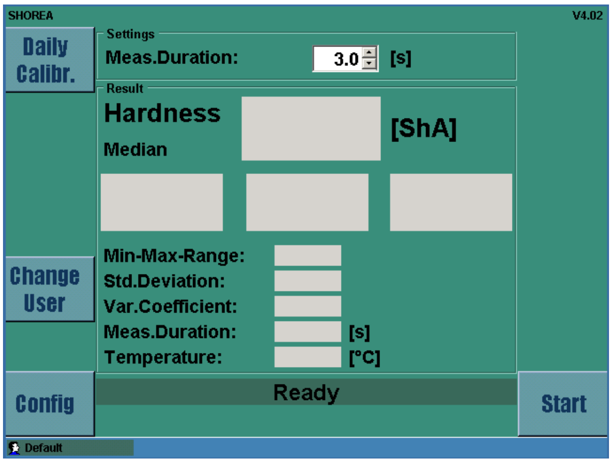
For start-up of the Shore measurement device please proceed as follows:

1. At the rear panel of the device, turn on the power switch next to the IEC connector.

2. After switching on, the Windows Operating System embedded starts automatically. On your VGA screen you see the start up routines. During launch the system components are initialised and the measuring device is checked for active transport securing devices

   In order to guarantee a high accuracy, the measurement device should be switched on - for at least 30 minutes - prior to measuring for the first time.

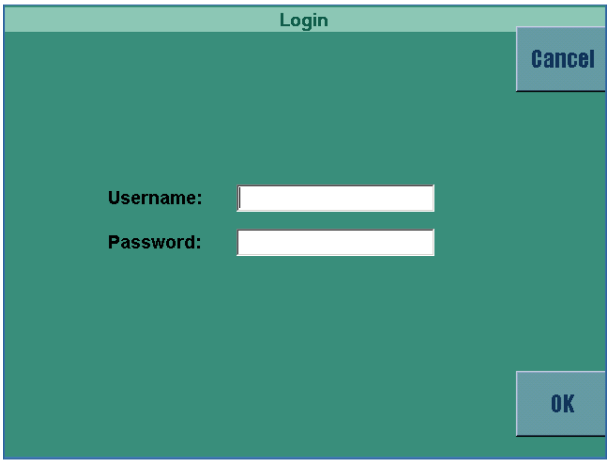
   The device is now "**ready**" for measurement and displays the measurement data screen. .



By pressing the key **[Start]** (selection key on the monitor, or a green start key at panel respectively) the measurement of the displayed standard configuration is started.
By measuring on a hard surface, e.g. on the included calibration plate 100 ShA, you can check if the measurement results in 100 Shore A. Should the value be <100, the measurement device was switched on too short, it is not calibrated (see below: Daily calibration) or it dirt sticks on the surface of the measuring heads.

With a multi-state application system, the device is configured according to demands and the safe-guarding of the measurement targets is carried out.
The registration can be started by pressing the key **[Change User]:**

You see the login screen and in-put fields:



Username:
Password:

If no entry is made “default” is set automatically and the system is left via **[Cancel]** or **[OK]** but this does not change the settings.

If the User logs in with the appropriate password as an poweruser/administrator, the module Config is active and callable by the key [**Config**]. The key [**Config**] however is only visible if the User is logged in as an poweruser/administrator.

By pressing the key **[Config]** the configuration module is started and permits specific settings concerning the measurement procedure, communication and the measurement value display.

For a detailed explanation of the configuration, see section 3.4. in this user guide.

3. Operation

The user guidance is given by a control panel with display and function keys.
The measurement sequence is fully automatic.

The single operational steps are:

3.1 Positioning of the test specimen

3.2 Start measurements by pressing key START

3.3 Display of measurement results on the screen

3.4 Configuration

3.1 Positioning of test specimen:

The measurement is made on test plates of ≥6 mm thickness.
The measuring points with the sensor supports are located on a circle with 20 mm in diameter (see design "measuring point arrangement" in appendix B designs). The sensor supports align themselves automatically on the even test plate.
The positioning is marked on the support plate of the measurement device thus giving the optimal position for the calibration plate 100 ShA.

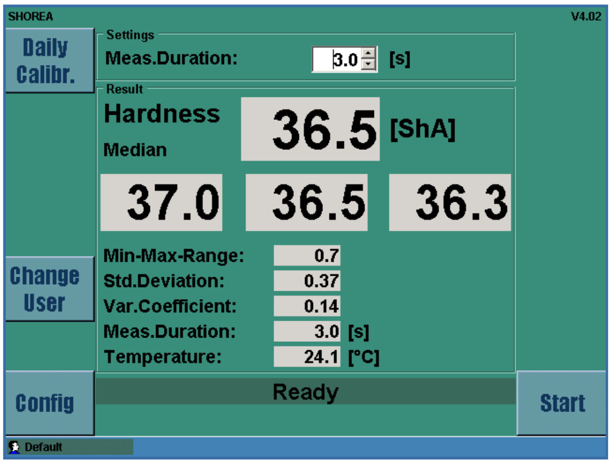
3.2 Start measurement by pressing [Start]

Measurement is released by pressing key [**Start**] (selection key on the screen and/or green start key on the control panel).
The measuring conditions such as measuring time, statistic evaluation, calibration registration, decimal digits, communication interfaces and so on are defined via the Config function. In future, as for the adjustment and changes of Config values the registration as an Administrator is necessary (login is effected by pressing the key **[User Change],** see section 3.4).

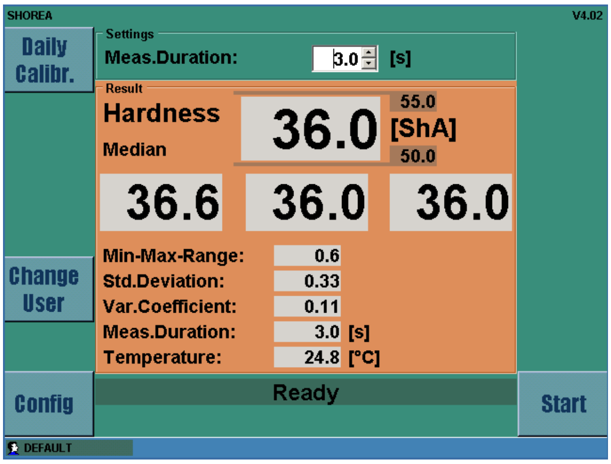
After the start, the measurement is fully automatic and permits no manual interference. The three measuring heads carry out the necessary tests and return into starting position after measuring.
Due to the parallel measuring technique the statistical results such as median/average value, standard deviation and variation coefficient of the sample are displayed immediately.
The measurement device is optional fully remote controllable and thus easily to integrate into automated systems.

3.3 Display of measurement results on the screen

A typical result is displayed on the following screen



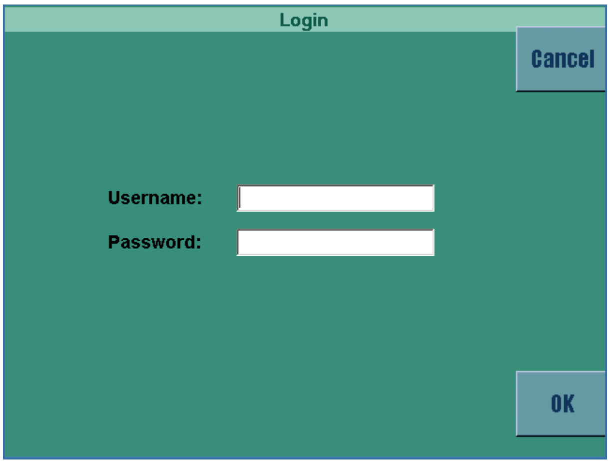
The measurement results are immediately displayed after the measuring time/run time on the VGA screen. The display remains until the next keystroke or measurement is made. Displayed are the median/average value, single values in Shore A and values of temperature, statistical parameters and the set measurement time.
If the data results are within defined limits the basic colour is green, if they are outside the min-max control the colour is orange and it is red for incorrect measurements. The following display shows a view when the set limits are exceeded or fall below.



3.4 Configuration

By a multi-stage sign-in system, the device can be configured according to requirements and the safeguarding of measurement guidelines can be carried out.
The login can be started by pressing the key **[Change User]**
The device has 3 User level.
- Default (ordinary test sequence without config changes)
- poweruser (required for configuration changes)
- administrator (required for LAN-settings/service
- System Administrator (Factory settings for the basic configuration of the test device)

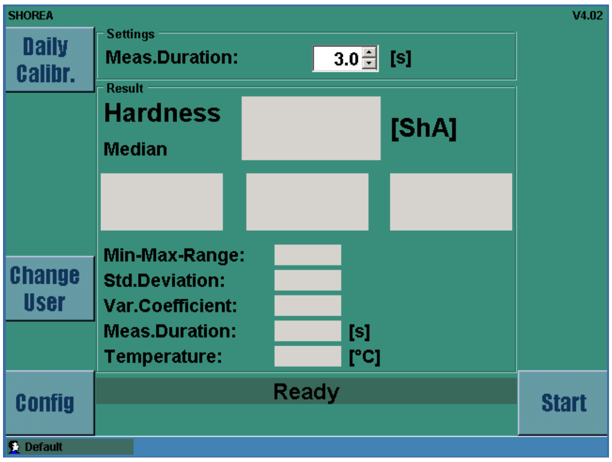
You see the login screen and in-put field.



User name:
Password:
(see Appendix B: User administration for username and password)

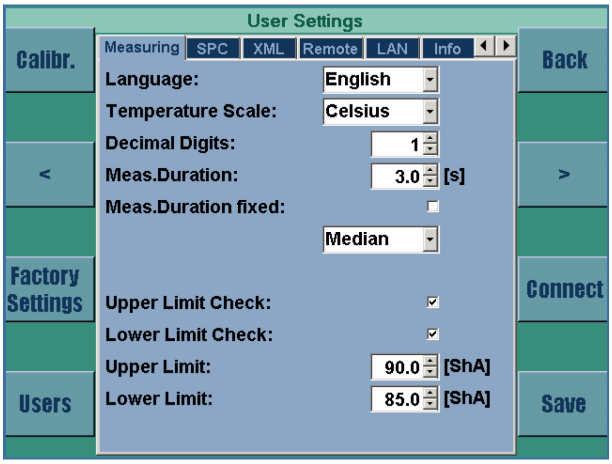
If no entry is made “default” is automatically set and the system is left via **[Cancel]** or **[OK]** but this does not change the settings.

If the User logs in with the appropriate password as a “poweruser”, the module Config is active and callable by the key [**Config**]. The key [**Config**] however is only visible if the User is logged in as a “poweruser”.
If the User logs in with the appropriate password as an “administrator”, the module LAN-settings/service in the module Config is active.



By pressing the key **[Config]** the configuration module is started and permits specific settings concerning the measurement procedure, communication and measuring tools: By pressing the key **[Back]** you can switch to the measurement value display again.

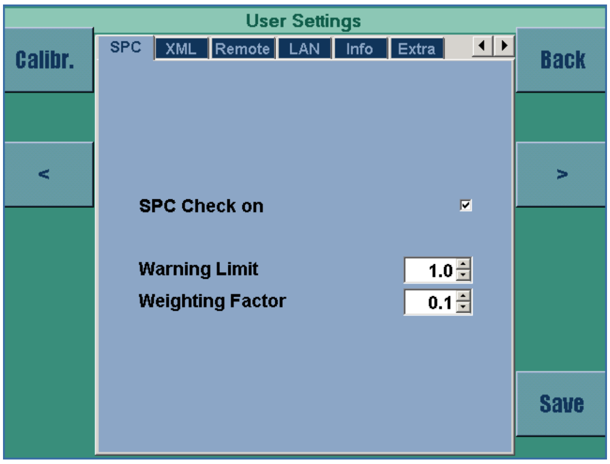
The automatic test sequence is defined via the config-function. It is callable by pressing the key **[Config].**
The Config screen is divided into menus for the different functional areas.



Menu Measurement

Language:	Select
Temperature Scale:	° Celsius or ° Fahrenheit
Decimal Digits:	1 or 2
Measurement Duration:	1.0 to 100.0 seconds (default 3.0 sec)
Measurement duration fixed:	yes (not changeable on the screen)
Statistical measurement:	median or mean (standard median)
Upper limit check:	yes (upper limit check on)
Lower limit check:	yes (lower limit check on)
Upper Limit:	-7.4 to 100.0 Shore A
Lower Limit:	-7.4 to 100.0 Shore A
Factory Settings:	Pressure on touchpad sets the settings to factory default

If the upper or lower limit check is not activated, the values do not appear on the measuring screen.

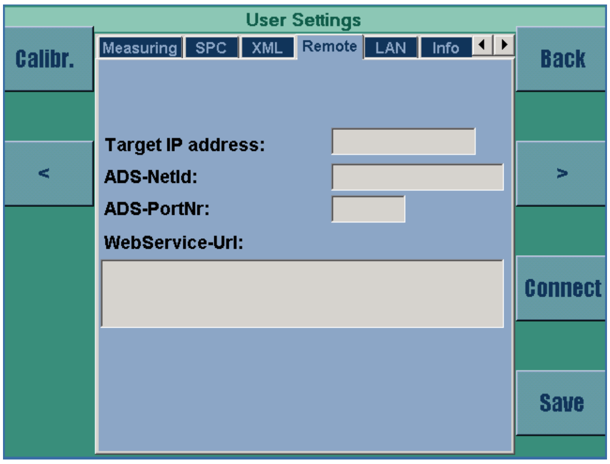


Menu SPC

Here the device self-monitoring is set for continuous measurement accuracy. By marking the selection key, the SPC is activated.
Adjustable is the limit of deviation at which a warning is displayed on the screen.
With the weighting factor the SPC reaction is set for error detection (see section 1.5.1 Function-based SPC procedure for error control).

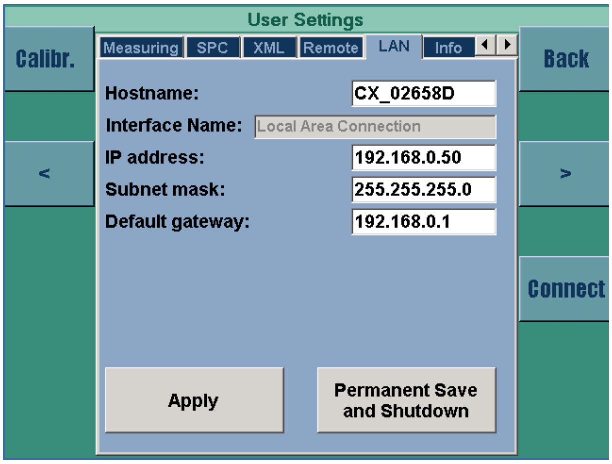
Menu XML

Here, the XML data exchange and storage locations for the file storage can be configured.
Configuration and measured values, as well as curve values are transferred.



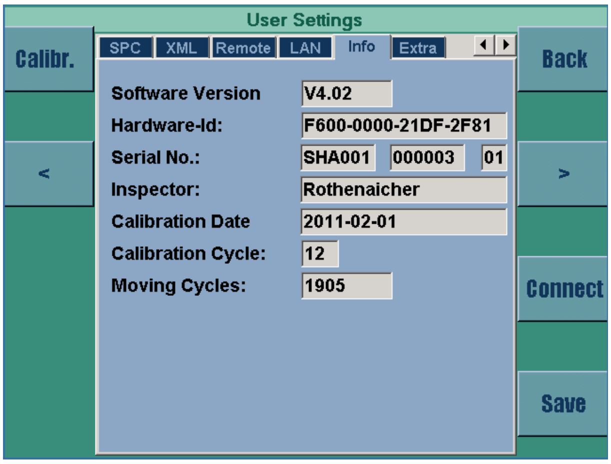
Menu Remote Control

Here, the parameter for the Remote Control are set.



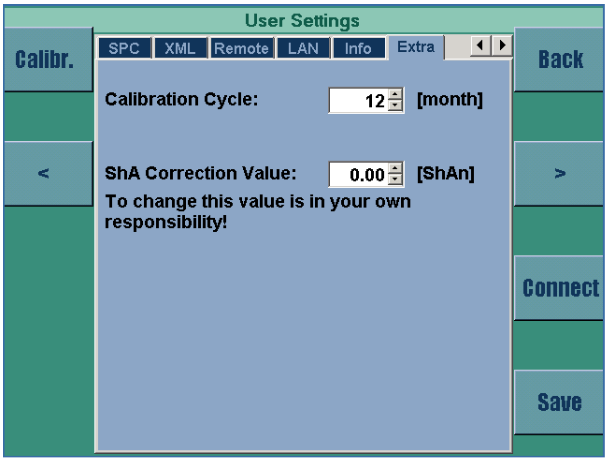
Menu LAN

Here, the IP-addresses for the communication are set.
By pressing the key **[Apply]** and **[Permanent Save]** the set values can be stored temporarily or permanently.



Menu **Info**

Here, the general device information is displayed.



Menu **Extra**

Here, the calibration cycle for the maintenance of the device is set.
The setting value ranges between 1 and 36 months.

The ShA correction value allows via an addition of the correcting value with the measured value to adjust the measured value. This allows for known measurement deviations due to special measuring conditions such as very thin samples or penetration depth, a correction of the measurement results to the physically correct values. To this end comparative measurements are essential.

4. Maintenance

4.1 Maintenance work

The test device is designed to be maintenance-free. Except for the manual cleaning of normal dirt there is no permanent maintenance necessary.

4.2 Calibration / Adjustment

Essential for the application of a test device is the quality of the test result. In order to prove the quality of measurements two methods are applied. Both have a vital influence on the measuring safety in test engineering.

Calibration

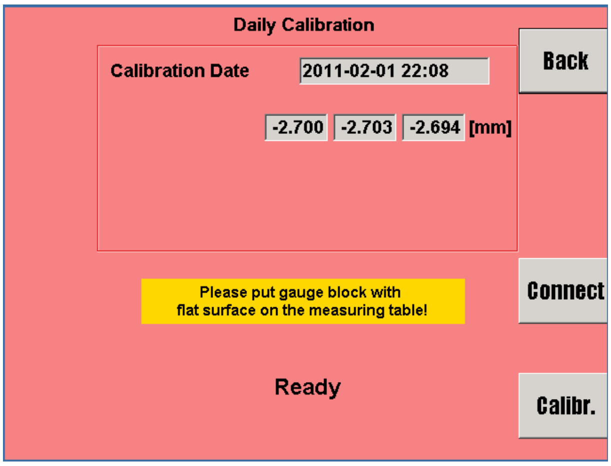
Calibration of measuring devices means to compare it to well-known physical dimensions and to document the result. If the result is not within the tolerable range of the measuring device, calibration or adjustment is necessary.
In accordance with DIN ISO 9000ff the measurement equipment must be controlled at all times. The monitoring has to be given in form of traceability of all measurements and calibrations based on national standards. This procedure is necessary to ensure, that a measurement device does not only measure tolerances with utmost precision, but also on provable levels. Incorrect measurement standards lead in consequence to false adjustments of the device and to unrecognisable systematic measuring errors.

Calibration Periods

Daily Calibration:

The daily calibration controls the accuracy of the measurement sensors and detects measurement errors by measuring on a special calibration plate with a flat surface. Thus errors that may occur due to a changing measurement temperature or because of offset drifts are corrected.
The daily calibration should be performed daily or at a change of the measurement environment (temperature). The device should be switched on for at least 30 minutes.
The daily calibration is made by placing the calibration plate with the flat surface on the measuring table and by pressing the key **[Daily Calibration]**

The screen displays Daily calibration:



By pressing the key **[Calibr.]** the daily calibration is automatically made and the measurement values are recorded together with the calibration date.
By pressing the key **[Back]** the calibration process is terminated.

Factory Calibration

The calibration of the hardness test device is usually made in intervals of
6 months to 2 years and depends on the frequency of utilization and environmental conditions. When using the SPC system the calibration interval can be extended to up to 3 years, depending on application criteria, since the device safely detects measurement errors by its internal control. Shorter intervals are not needed as no discernible deviations should be expected.

Calibration procedure

The calibration demands the observation of specifications in the Manufacturer's test certificate M in accordance with DIN 55350, section 18. The calibration is made with special calibrating tools by technical personnel. The single values, specified in the test report (see section 4.4) have to be observed, in order to ensure the accuracy of measurement results.

4.3 Calibration periods

Customer specific statements of calibration periods

4.4 Calibration Certificates / Test reports

Filing of the calibration certificates and test reports

5. Error Treatment

Error treatment needs a chronological recording of occurred errors and measures of troubleshooting. A useful listing is provided in Appendix E “Equipment history” in this manual. ‘By a permanent recording the test device quality can be proved in a very simple way.

5.1 Error status

5.1.2 The device is not ready for use

Check power supply (94 … 264 V ~ 47 … 66 Hz)
Check input fuse of the IEC connector at the rear panel of the equipment and replace it, if necessary. If both systems are in good order, the device must be checked by a qualified electrician.

6. Options

6.1 Accessory

6.1.1 Standard Accessory

- User guide
- Power cable
- Daily calibration plate
- Keyboard with trackball

6.1.2 Additional components

- Calibration standard references for specific Shore-A hardness

6.2 Interfaces (PC, Printer, Host,…)

The device is controlled via an „Embedded-PC“ and has various interfaces for communication purposes:

- Ethernet RJ45
- USB

6.3 Software-Module

6.3.1 Standard

6.3.2 Additional Modules

6.4 Hardware to display and record measured results

Appendix A

Technical Data

Appendix B

User administration (key **[Change User]**)

Default user:	Username: Password:	default 1234	default
PowerUser:	Username: Password:	poweruser config	(for measuring config)
Administrator:	Username: Password:	administrator master01	(for LAN-settings/service)

Appendix C

Designs / Illustrations

Appendix D

EU-Declaration of Conformity

Appendix E

Standards / Literature References

Appendix F

Device History (Orders / Alterations / Errors etc.)

Appendix G

General Information / Publications/…

Appendix H

Brochures / Device information