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Operation Manual

NOVOTEST

Ultrasonic Flaw Detector NOVOTEST UD3701

CONTENT

Caution!
Please read this manual carefully before using the device – Ultrasonic Flaw Detector NOVOTEST UD3701.

This operating manual (hereinafter OM) includes general information in order to give the operating personnel understanding of functioning and operating rules of the Ultrasonic Flaw Detector NOVOTEST UD3701 (hereinafter referred to as the device or flaw detector). The document contains technical characteristics, description of the design and principle of operation, as well as information necessary for the correct use of the device. Before starting work, it is necessary to read this manual, as the device operation must be carried out by persons who are familiar with the operation principle and the device design.

Correct and effective use of the device requires obligatory availability:

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

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

The standard delivery kit of the device includes the operational documentation as a part of this OM.

The present OM applies to all modifications of the device.

GENERAL INFORMATION

Correct and effective use of flaw detector requires obligatory availability:

- Technical characteristics of flaw detector comply with requirements of test tasks;
- Relevant quality-control procedures;
- Well-qualified operator.

Present OM gives operator only instructions about intended use of the device. It does not give understanding about influencing factors while testing and basic principal of ultrasonic.

Ultrasonic

Operator must be familiar with basic principal of theory about propagation of ultrasonic waves, including understanding of sound velocity, damping, echo and reflected signal, limitations and boarders for sound beam, etc.

Study

Operator must complete relevant training courses for correct use of flaw detector, getting clear understanding about general principal of ultrasonic testing and practical skills for testing the particular kind of products.

Testing

For correct ultrasonic testing operator must have quality-control procedure for this particular product and must know special requirements for ultrasonic testing: aims of testing, choice of appropriative testing device (method of scanning), choice of the probe, determination of known testing conditions in materials of such kind, choice of reflector with minimal surface, cutting-off level, etc.

Evaluation of defect area

There are two main methods of evaluation of defect area.

1. By defect boarders:
   If the diameter of sound beam is less than defect area, then it can be used for determination of defect boarders. The less is beam diameter, the more accuracy in determination of defect boarders. And vice versa, when the beam is rather wide, then determined boarders could be quit differ from real ones.
2. By amplitude of echo-signal:
   If the beam radius is more than defect area, then defect area is evaluated by the next way: maximal echo-signal amplitude of the defect is compared to maximal amplitude of artificial reflector in a special test block. Usually, echo-signal amplitude of the real defect is less than amplitude of artificial reflector with the same area. This is because of not the exact perpendicular position of the real defect to the probe beam and irregular shape of defect surface, and it should be taken into account when testing.

Quality-testing procedures

User must know and understand quality-testing procedures, which are worked out for relevant products.

Thickness measurement

Thickness measurement by ultrasonic – is a result of mathematical multiplication of ultrasonic velocity in material and impulse passing time. Flaw detector allows to get the precise time value for ultrasonic waves. The correct velocity setting depends on operator.

Sound velocity

Accuracy for thickness measurement and for defect position evaluation basically depends on the correct setting of ultrasonic velocity in the material. Velocity depends on material physical characteristics and its temperature.

ABBREVIATION USED

In this OM following abbreviations and symbols are used:

DGS – distance–gain-size (defect);
DAC – distance amplitude curve;
DTC – defect control (automatic signaling of defects);
TVG – time varied gain;
LCD – liquid crystal display;
NDT – nondestructive testing;
TO – tested object;
UT probe – ultrasonic probe;
DEP – dual element probe;
SS – standard sample;
RB - Reference block;
SO-2 -Calibration Block SO-2 (GOST 14782-86);
SO-3 -Calibration Block SO-3 (GOST 14782-86);
UT – ultrasonic;
US – ultrasonic waves;
DSP – digital signal processor;
DA converter – digital-to-analog converter;
AD converter – analog-to-digital converter;
TPP – thermal power plant;
NPP – nuclear power plant.

1 DESCRIPTION AND OPERATION OF THE DEVICE AND ITS COMPONENTS

1.1 The purpose of the device

Flaw detector is designed for product testing as for the presence of defects, including:

- discontinuity and homogeneity of materials, semi-finished and finished products, welds;
- measuring depth and coordinates of defect;
- thickness measurement of the product;
- measuring UT waves velocity in the material.

Flaw detector implements shadow, echo and mirror-shadow testing methods. Flaw detector allows user to create, record and store in nonvolatile memory temporary implementation of pulsed ultrasonic signals and then further data loading to PC for analysis and documentation. Integrated liquid crystal display (LCD) provides a mapping of ultrasonic signals in the form of A-scan, as well as images of cross sections of testing objects in the form of B-scans. Ultrasonic Flaw Detector NOVOTEST UD3701 has extensional functions of modern professional device:

- color large 7-inch touch screen display of high resolution (800*480 pixels). Also, keyboard is available;
- lightweight, portable and ergonomic impact-resistant metal housing;
- high-capacity battery.

Flaw detector can be used in mechanical engineering, aerospace, metallurgy, transportation, while installation of steel constructions and equipment on TPP or NPP.

1.2 Technical characteristics of the device

Ultrasonic Flaw Detector NOVOTEST UD3701 is a portable device made in an impact-resistant housing, inside which a board with electronic components and accumulators is placed. The main characteristics of the device are presented in Table 1.1. Table 1.2 shows technical characteristics of the device.

Table 1.1 – The main characteristics of the device

Dimensions, mm	250x150x50
Display, mm	155x85 (7-inch touch screen)
Weight, not more, kg	1,4
Battery, A/h	12
Charger voltage, V	5
Operating time without charging, h	up to 20
Operating temperature range, °C	from -30 to +55
Humidity, not more, %	95 when 35 °C

Allowable range for absolute accuracy of the device when measuring depth of defects (thickness): not more ± (0,5 + 0,01·Hx) mm, where Hx – defect depth value (thickness) in mm.
Allowable range for absolute accuracy of the device when measuring coordinates of defects: ± (0,5 + 0,01·X) mm, where X – defect coordinate value in mm.
Allowable range for absolute accuracy of the device when measuring amplitudes ratio: ± 0,5 dB per every 10 dB.

Table 1.2 – Technical characteristics of the device

Scan, µs: – minimum – maximum	0 – 14 0 – 1000
Delay, µs	0 – 1000
Maximum thickness of tested object, mm	Up to 6000 (echo-signal) for steel
Velocity range, m/s	1000 - 9999
Delay in the prism, µs	0 – 100
Damping, Ohm	50
Input impedance	50 Ohm / 600 Ohm
Amplitude of the probe pulse, V	200 (U1); 150 (U2); 100 (U3)
Repetition frequency of the probe pulse, Hz	Automatically controlled from 10 to 100
Analog amplifier, MHz	wideband 0,4 – 20 (-6 dB)
Gain control range, dB	126
The range of variation of temporal sensitivity adjustment TVG, dB	Up to 70 (12 dB/µs)
Quantity of control points for TVG	16
Quantity of control points for DAC	16
Automatic signaling of defects (DTC – defect control)	dual-gates
Setting range of DTC gates, µs	from 0 to 1000
Limits setting of DTC gates, % display height	from 0 to 100
Signal detection	Positive or negative half-wave, wave, radiofrequency signal (in the whole scanning range)

Device body protection.

Level of the device body protection from penetration of solids and water is IP 65, according to required standard.

MTBF

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

Service time

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

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

1.3 Standard delivery set

- Electronic unit .... 1 pc.
- UT probes:
  - Straight beam probe .... 1 pc.
  - Angle beam probe .... 1 pc.

  *Type and quantity of probes could be changed or added according to the customer order.
- Charger .... 1 pc.
- Cable for PC .... 1 pc.
- Case .... 1 pc.
- Operation manual .... 1 pc.

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

In Figure 1.1 UT probes of different kinds are illustrated:

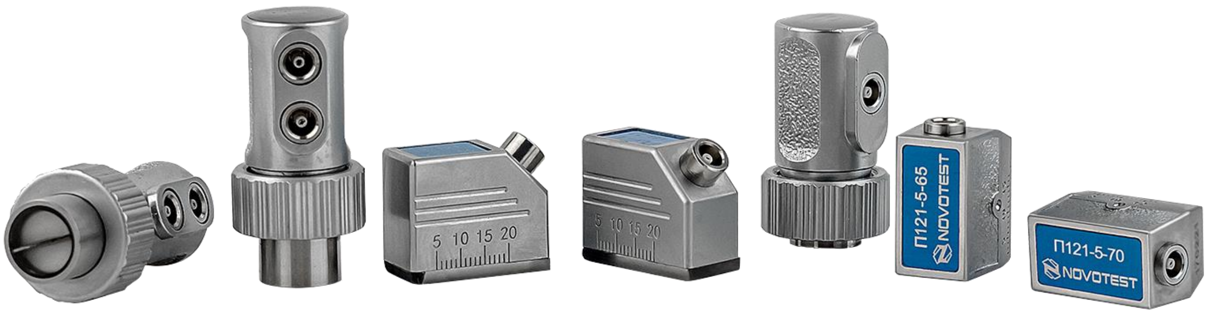


Figure 1.1 – UT probes

1.4 Parts

The device consists of an electronic unit and connected probes. User can control the device by keypad or touch screen display. Signals, measurement results, device modes and other information is indicated on color touch screen display.

UT probes are connected to the device through coaxial cables. Detachable connections (ports) are located on the upper end panel of the housing. The device is power supplied by internal recharging battery or charger. Charger is connected via USB port on the right side of the device housing and is included to the standard delivery set. Also, USB port is used for PC connection. Parts of the flaw detector are shown in Figure 1.2., and control keys are described in the Table 1.3.

1– port for single element probe and piezo-element output (transmitter); 2 – port for piezo-element input (receiver); 3 – colored 7-inch touch screen display; 4 – indicator of A gate; 5 – indicator of B gate; 6 – keyboard; 7 –USB port; 8 – battery indicator.

Figure 1.2 – Ultrasonic Flaw Detector NONOTEST UD3701

Table 1.3 – Control keys

	– power on/of
	– touch screen on/of
	– save measurements/settings
	– «freezing» of the screen
	– changing the parameter discreteness
	– opening the parameters group «Gates»
	– main display menu
	– opening the parameters window
	– Select/open/close key for parameters group
 	– Selection keys

1.5 Probes

Flaw detector is designed to operate with the contact, single and dual element UT probes.

The device uses a generator of bipolar sounding pulses with controlled duration, which provides operating with most probes on the market: with integrated terminating inductance and without it.

Depending on the type of probe it is used two types of cables and, correspondingly, two ways to connect the probe:

- Ultrasonic single element transducers (type S) are connected via single cable LEMO-LEMO to the left LEMO port;
- Dual element transducers (type D) are connected via double cable 2LEMO-2LEMO. Right port is used to connect the input piezoelectric element (receiver), left - output piezoelectric element (transmitter).

1.5.1 Probe types

P111 – Straight beam single element probe

Probes are used in flaw detection and thickness gauging for material testing by dilatational waves. In practice, these probes are applied for ultrasonic testing of sheets, plates, forgings, castings and determination of local thinning-out in product walls. Probes are used for evaluation of volume and flat defects – cavities, hairlines, delamination, etc.

Figure 1.3 – Appearance of the straight beam single element probe

P112 – Straight beam dual element probe

Probes are mostly used for determination of residual wall thickness and low depth defects. Thickness of tested objects usually is in the range 1-30 mm.

Figure 1.4 – Appearance of the straight beam dual element probe

P121– Angle beam single element probe

Probes are widely used for NDT of weld joints, sheets, plates, stampings, forgings and other objects. Probes allow to evaluate cracks, volume defects such as: nonmetallic impurities, cavities, welding gaps, shrink holes, etc. As general, characteristics of vertical orientated defects are found by this kind of probe.

Figure 1.5 - Appearance of the angle beam single element probe

P122 – Angle beam dual element probe

These probes mostly are used for NDT of girth welds of pipe elements from steel and polyethylene with 14-219 mm diameter and 2-6 mm thickness.

Probes are applied for testing of thin welds, mostly from stainless and mild steels, aluminum alloys. Characteristic feature of the probe – minimal dead zone and UT waves focus in the particular thickness range.

Figure 1.6 – Appearance of the angle beam dual element probe

1.6 Design and functioning

Operating principle of flaw detector is based on the ultrasonic contact NDT method, which uses the properties of UT waves to reflect from the borders between materials with different acoustic impedance.

UT waves are generated due to UT probe ability to transfer electric impulse into mechanical waves (UT waves). UT probe emits ultrasonic impulse into the tested object. Echo signal is reflected from the defect or the product back side and received by the ultrasonic transducer. Then received electrical signals are magnifying, converting to digital, are processing and outputting to the display. Received echo signals are performing on the device display as A-scan.

Operator analyzes A-scan and decides about presence of the defect in product, its location and equal dimensions. For determination of defect depth, the following formula is applied:

$$H = \frac{C \cdot t}{2}, \quad (3)$$

where H – distance between entry point of UT waves and defect, m;

C – velocity of UT waves in tested object, m/s;

t – time of UT waves to pass from entry point to the defect and turn back, s.

Flaw detector implements shadow, echo and mirror-shadow methods of UT testing.

As for structure, flaw detector consists of functional finished blocks (electronic plates). Electronic blocks are connected via detachable sockets (ports) (Figure 1.7).

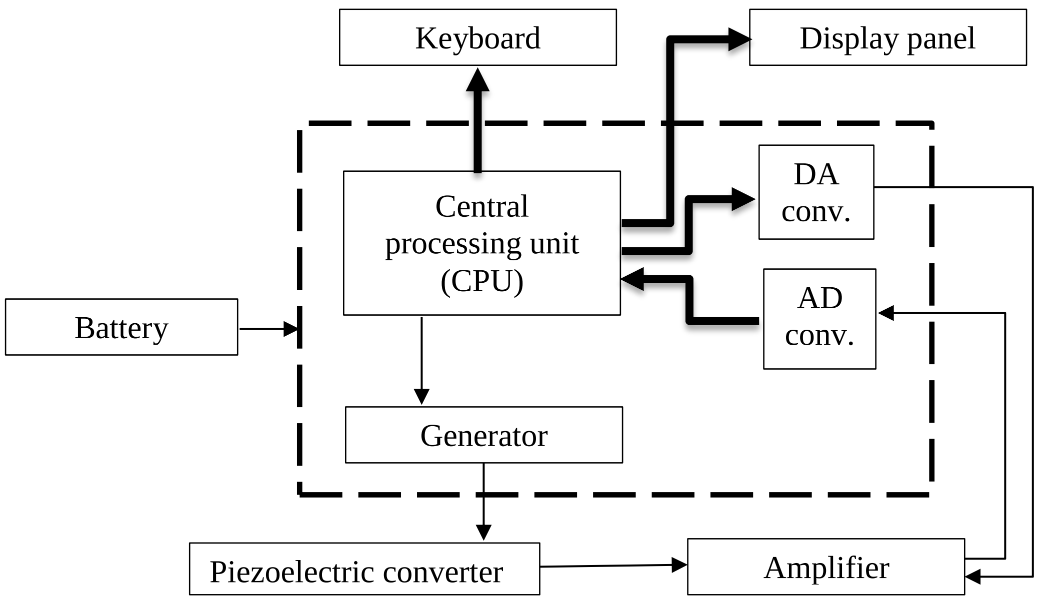


Figure 1.7 – Structural scheme of the flaw detector

Structurally flaw detector consists of display panel, central processing unit (CPU), DA converter, AC converter, analog board, memory and recharging battery.

Display panel is a 7-inch touch screen display with resolution of 800x480 pixels and dimensions of 155x85 mm.

Central processing unit (CPU) is made on the base of high-performance digital signal processor (DSP), which supports all control function of the flaw detector and signal processing.

Also, central panel contains elements of the device electro-acoustic tract: digital-analog converter (DA converter) and analog-digital converter (AD converter).

Analog board includes generator of probing impulse and amplifier.

Under DSP command, generator sends electric probing impulse to piezoelectric converter (UT probe) through transmitter port on the device. UT probe signal (UT wave) is sending inside the tested object. Reflected UT wave is converted in UT probe into electric impulse and through receiver port on the device comes to in-port of amplifier. Amplifier coefficient is set by DSP through DA converter of time varied gain. Multiplied electric impulse comes to in-port of AD converter. From out-port of AD converter digital signal comes to DSP for further processing and displaying.

1.6.1 Design of the flaw detector

The flaw detector consists of:

a) housing with keyboard, USB port (for PC connection and battery charging), ports for connector cables UT probe/electronic block;

b) touch screen display;

c) electronic board.

All the control keys for operating are placed on the front device panel. Side panel has USB port for PC connection and battery charging. Upper panel contains port for connector cables UT probe/electronic block.

1.7 Device modes

The device has following modes:

1. «FLAW DETECTOR»;
2. «ARCHIVE»;
3. «RESULTS»;
4. «THICKNESS GAUGE»;
5. «GUIDE»;
6. «SETTINGS»;
7. «INFORMATION».

1.7.1 «FLAW DETECTOR» mode

To enter «FLAW DETECTOR» mode, user has, after power-on the device (p. 2.3.2), to select «FLAW DETECTOR» in the main menu by selection keys «», «», «», «» and confirm by pressing «» or use touch screen (Figure. 1.9).

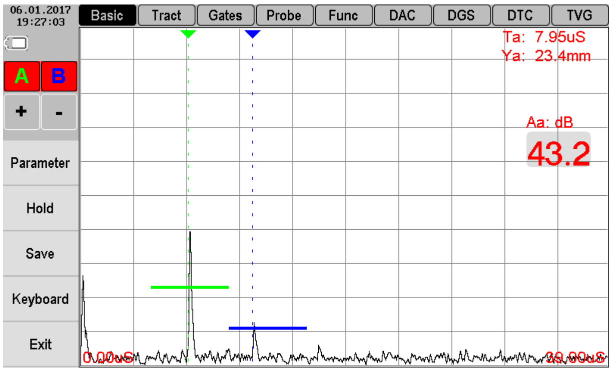


Figure 1.8 – «FLAW DETECTOR» mode

In «FLAW DETECTOR» mode user can make testing or set the device parameters according to the task. All measurement parameters of the device are divided into groups (Table 1.4). So, user has access to different parameters in accordance with chosen group.

Table 1.4 – Setting groups and its parameters

Groups	Parameters							
Basic	GAIN	VEL	SCALE	RANGE	DELAY	F.FILT	FILTER	ENVEL
Track	GAIN	RANGE	DELAY	DET	ENERGY	F.FILT	FILTER	REJ
Gates	GAIN	GATE	START	WIDTH	LEVEL	BIND	CAP	
Probe	DUAL	DELAY	ANGLE	X.VAL	FREQ	FORM	D / SIZE A	/ SIZE B
Func	VIEW	AVG	REF. H	Method	Calc			
DAC	GAIN	DAC	POINT	POS	dB	A LEVEL	SEARCH	CLEAR
DGS	GAIN	DGS	A LEVEL	REF	FLAW	CONTR	AVTO	
DTC	START	WIDTH	GATE	MEAS	MODE	CONTR	SEARCH	ALARM
TVG	GAIN	RANGE	DELAY	TVG	CLEAR	POINT	POS.	+dB

1.7.1.1 «Basic» parameters group

Measurement settings for «Basic» group are described in details in Table. 1.5. Figure 1.9 shows «Basic» group on display.

Table 1.5 – Description of measurement settings for «Basic» group

Parameters	Description
GAIN	Setting of gain for receiver path Range: from 0 to 126 dB, with steps of 0.1 or 1 dB
VEL	Setting of ultrasonic velocity in tested material. Range: from 1000 to 9999 m / s. Accuracy of measurement (depth, coordinates of defects and thickness) depends on correct velocity setting.
SCALE	Selection of the scale for displaying parameters. Two variants: microseconds (μs) or mm.
RANGE	Scanning time – time for depth sounding along the beam. Setting range: from 1 to 1000 μs. Flaw detector processes only signals within scanning time.
DELAY	Setting of time delay for scanning start in relation to the probe pulse. Setting range: from 0 to 1000 μs.
F.FILT	Setting of operating frequency for receiver path (frequency range selection of receiver path). Acceptable values range: from 1 MHz to 10 MHz Filter bandwidth ~ 1 MHz.
FILTER	Turn on/off frequency filter.
ENVEL	Turn on/off envelope curve.

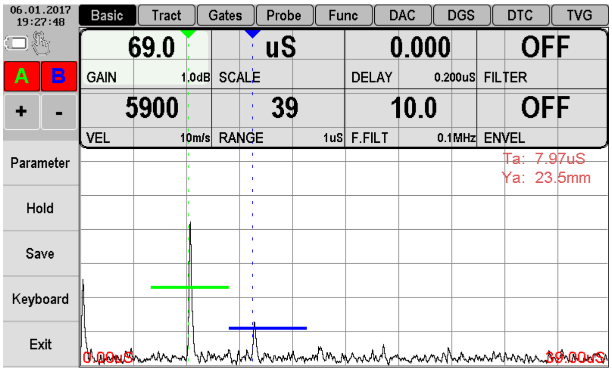


Figure 1.9 – «Basic» parameters group.

1.7.1.2 «Tract» parameters group

Measurement settings for «Tract» parameters group are described in details in Table 1.5. Figure 1.9 shows «Tract» group on display.

Table 1.6 – Description of measurement settings for «Tract» parameters group

Parameters	Description
GAIN	Setting of gain for receiver path Range: from 0 to 126 dB, with steps of 0.1 or 1 dB
RANGE	Scanning time – time for depth sounding along the beam. Setting range: from 1 to 1000 µs. Flaw detector processes only signals within scanning time.
DELAY	Setting the time delay for scanning start in relation to the probe pulse. Setting range: from 0 to 1000 µs.
DET	Selection of signal visualization type. Three variants: RADIO, HW1, HW2.
ENERGY	Setting level of excitation generator. Tree variants are available: 100V, 150V or 200V.
F.FILT	Setting of operating frequency for receiver path (frequency range selection of receiver path). Acceptable values range: from 1 MHz to 10 MHz Filter bandwidth ~ 1 MHz.
FILTER	Turn on/off frequency filter.
REJ	Parameter allows to set the minimum level of the signals displayed on the screen.

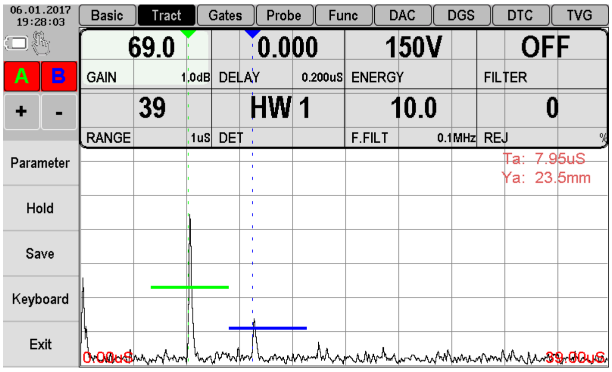


Figure 1.10 – «Tract» parameters group

1.7.1.3 «Gates» parameters group

Measurement settings for «Gates» parameters group are described in details in Table 1.7. Figure 1.11 shows «Gates» group on display.

Table 1.7 – Description of measurement settings for «Gates» parameters group

Parameters	Description
GAIN	Setting of gain for receiver path Range: from 0 to 126 dB, with steps of 0.1 or 1 dB
GATE	Selection of the gate: A or B.
START	Setting the coordinate of the beginning of the selected gate. Range: from 0 to the maximum value of scanning (time scanning).

WIDTH	Setting the width of the selected control gate along the beam. Range: from 0 to the maximum value of scanning (time scanning). Total sum of START and WIDTH of the selected gate cannot exceed the value of the maximum scanning (time scanning)
LEVEL	Setting limit for selected control gate in % of the screen height. Range: from 0 to 100% of the screen height.
BIND	Turn on/off BIND Allows to assign the gate to the signal level, when gain changing the gate level remains the same.
CAP	Turn on/off CAP Allows to set gain automatically in such a way, that signal reach the gate.

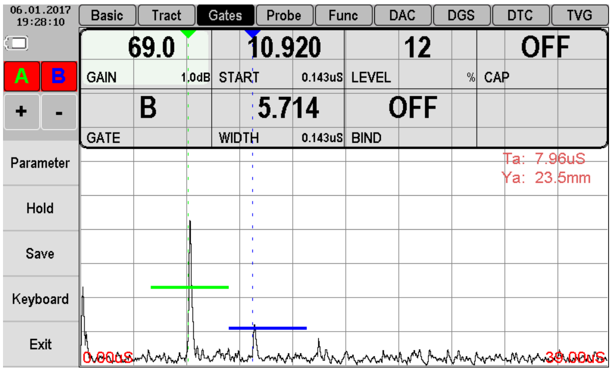


Figure 1.11 – «Gates» parameters group

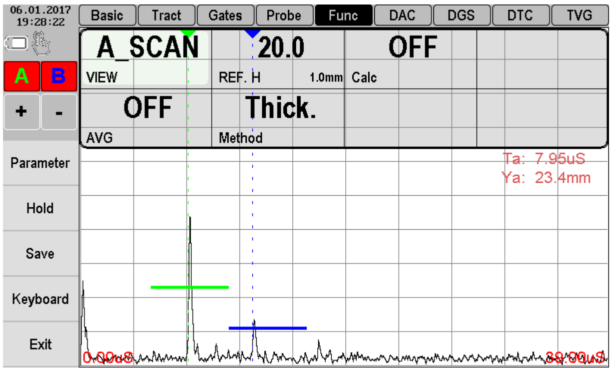
1.7.1.4 «Func» parameters group

Measurement settings for «Func» (function) parameters group are described in details in Table 1.8.

Figure 1.12 shows «Func» group on display.

Table 1.8 – Description of measurement settings for «Func» parameters group

Parameters	Description
VIEW	Selection of signal visualization type. Three variants: A-scan, FFT or RADIO.
AVG	Turn on/off averaging and setting of signals quantity
REF. H	Reference thickness value of the sample
Method	Selection of automatic calculation of the delay in UT probe prism. Three variants: Thick. (thickness), SO-3 or SO-3 2D
Calc	Turn on/off automatic calculation of the delay in UT probe prism.



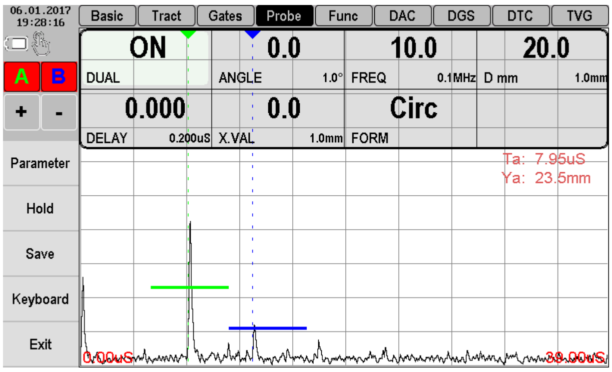
Picture 1.12 – «Func» (function) parameters group

1.7.1.5 «Probe» parameters group

Measurement settings for «Probe» parameters group are described in details in Table 1.9. Figure 1.13 shows «Probe» group on display.

Table 1.9 – Description of measurement settings for «Probe» parameters group

Parameters	Description
DUAL	Setting the type of the connected ultrasonic probe. Two variants: single element probe or dual element probe (OFF/ON).
DELAY	Setting the time delay for scanning start in relation to the probe pulse. Setting range: from 0 to 1000 µs.
ANGLE	The angle of entry of UT waves of the probe.
X.VAL	Setting the arrow of the probe Range: from 0 to 90 mm.
FREQ.	Setting the operating frequency of the probe. Range: from 1 MHz to 10 MHz.
FORM	Setting the shape of the transducer piezo-electric crystal plate. Two variants: circle («Circ») or rectangular («Rect»).
D mm or SIZE A	Setting the diameter of the transducer piezo-electric crystal plate or setting the A-side length of the transducer piezo-electric crystal plate.
SIZE B	Setting the B-side length of the transducer piezo-electric crystal plate (when FORM is «Rect»).



Picture 1.13 – «Probe» parameters group

1.7.1.6 «TVG» parameter group

Time varied gain (TVG) – is applied for equalizing of defect signal amplitudes for different defect depths. TVG is very important when automatic testing and data-result recording are used. TVG system control gain under the special rule, that provides compensation damping while defect depth increases.

Measurement settings for «TVG» parameters group are described in details in Table 1.10.

Figure 1.14 shows «TVG» group on display.

Table 1.10 – Description of measurement settings for «TVG» parameters group

Parameters	Description
GAIN	Setting of gain for receiver path Range: from 0 to 126 dB, with steps of 0.1 or 1 dB
RANGE	Scanning time – time for depth sounding along the beam. Setting range: from 1 to 1000 μs. Flaw detector processes only signals within scanning time.
DELAY	Setting the time delay for scanning start in relation to the probe pulse. Setting range: from 0 to 1000 μs.
TVG	Turn on/off TVG mode.
CLEAR	Reset TVG mode.
POINT	Selection of the TVG point and total number indication of points. The maximum number of TVG points - 15.
POS	Displays coordinates of current TVG point. Minimal distance between two neighboring points - 3 μs.
+dB	Gain of the current TVG point. The total gain sum of all the TVG points should be not more 40 dB. Setting accuracy: 0.1 dB

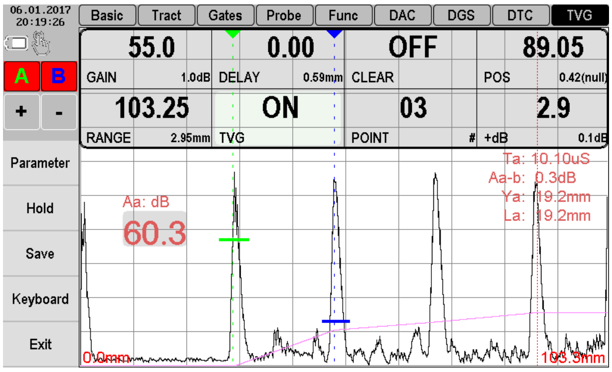


Figure 1.14 – «TVG» parameters group

1.7.1.7 «DAC» parameters group

Distance-amplitude curve (DAC) is used for construction a curve. The curve shows echo-signal amplitude dependence on reflectors, which have equal squares but different distance to the probe. These reflectors generate echo-signals with damping in far zone because probe beam is damping and scattering while passing through tested object. DAC curve makes a graphical correction for damping in tested material, near field effects and beam scattering.

Measurement settings for «DAC» parameters group are described in details in Table 1.11.

Figure 1.15 shows «DAC» group on display.

Table 1.11 – Description of measurement settings for «DAC» parameters group

Parameters	Description
GAIN	Setting of gain for receiver path Range: from 0 to 126 dB, with steps of 0.1 or 1 dB
DAC	Turn on/off DAC mode.
POINT	Selection of the DAC point and total number indication of points. The maximum number of DAC points - 15.
POS	Displays coordinates of current DAC point. Minimal distance between two neighboring points - 3 µs.
dB	Gain of the current TVG point. The total gain sum of all the TVG points should be not more 40 dB. Setting accuracy: 0.1 dB
A LEVEL	Setting the level/amplitude of the reference signal.
SEARCH	Setting the level of search area. The maximum value is 20 dB.
CLEAR	Reset DAC mode.

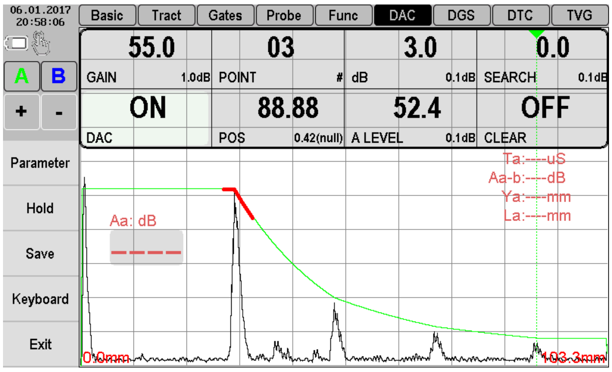


Figure 1.15 – «DAC» group

1.7.1.8 «DGS» parameters group

DGS (distance/gain/size) – it is a method of defect size determination by comparison of echo-signal amplitude of reflector (defect) to echo-signal amplitude of flat-bottomed hole (reference flaw) at the same depth or distance.

Measurement settings for «DGS» parameters group are described in details in Table 1.12.

Figure 1.16 shows «DGS» group on display.

Table 1.12 – Description of measurement settings for «DGS» parameters group

Parameters	Description
GAIN	Setting of gain for receiver path Range: from 0 to 126 dB, with steps of 0.1 or 1 dB.
DGS	Turn on/off DGS mode.
A LEVEL	Setting the level/amplitude of the reference signal.
REF	Setting the size of reference flaw.
FLAW	Allows to set the size for sorting out.
CONTR	Setting the size of control defect. The maximum value cannot exceed the value for rejection.
AVTO	Allow to set amplitude of the reference signal automatically.

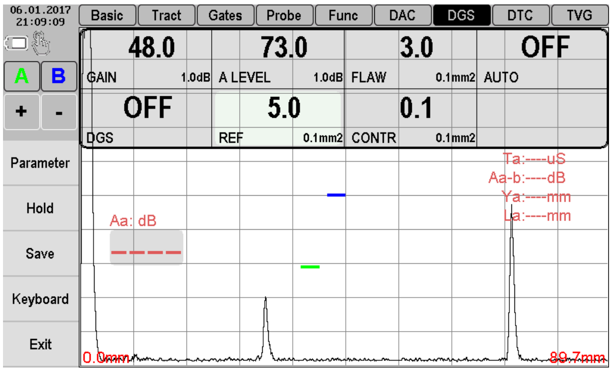


Figure 1.16 – «DGS» parameters group

1.7.1.9 «DTC» parameters group

System of automatic fault signalization (defect control - DTC) is applied for automatic defect detection and signalization.

Measurement settings for «DTC» group are described in details in Table 1.13.

Figure 1.17 shows «DTC» group on display.

Table 1.13 – Description of measurement settings for «DTC» parameters group.

Parameters	Description
START	Setting the coordinate of the beginning of the selected gate. Range: from 0 to the maximum value of scanning (time scanning).
WIDTH	Setting the width of the selected control gate along the beam. Range: from 0 to the maximum value of scanning (time scanning). Total sum of START and WIDTH of the selected gate cannot exceed the value of the maximum scanning (time scanning)
GATE	Section of the gate: A or B.
MEAS	Selection of method for determining the signal arrival time into the gate: - PEAK - "by the wave peak": when the signal is maximum in the control gate; - FLANG - “by the wave flang" - when the signal crosses limit at first time in the control gate.
MODE	Selection of the gate mode: MORE – echo-signal is higher than the control gate; LESS – echo-signal is lower than the control gate.
SEARCH	Setting the level of search area. The maximum value is 20 dB.
CONTR	Setting the control area. The maximum value of 20 dB, but cannot exceed the value of the search area.
ALARM	Turn on/off the sound signal.

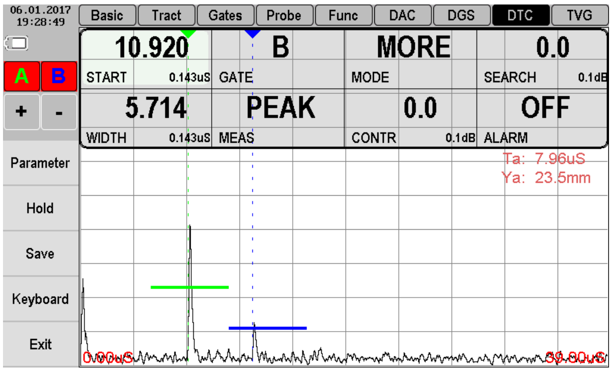


Figure 1.17 – «DTC» parameters group

1.7.1.10 Selection window for measured parameters displaying

User can see measured parameters in the right upper corner of the display (or can move to any place on A-scan).

Detailed descriptions of all the parameters, which user can select, are in table 1.14.

Figure 1.18 shows selection window on display.

Table 1.14 – Description of parameter values

Symbol	Description
Ta	Signal time value in A-gate, μs.
Tb	Signal time value in B-gate, μs.
Ta-b	Difference between signal time value in A-gate and signal time value in B-gate.
Aa	Signal amplitude value in A-gate.
Ab	Signal amplitude value in B-gate.
Aa-b	Difference between signal amplitude values in A-gate and B-gate.
Xba	Entry point distance of signal in A-gate.
Xbb	Entry point distance of signal in B-gate.
Xipa	Input signal distance in A-gate.
Xipb	Input signal distance in B-gate.
Ya	Coordinate of signal depth in A-gate.
Yb	Coordinate of signal depth in B-gate.
Ya-b	Difference between depths in A-gate и B-gate.
Sa	Equivalent size of the signal in A-gate.
Sb	Equivalent size of the signal in B-gate.
La	Distance to reflector along beam in A-gate.
Lb	Distance to reflector along beam in B-gate.
dAa	Signal level value (dB) from A-gate to maximum signal.
dAb	Signal level value (dB) from B-gate to maximum signal.
La - Lb	Difference between distances to reflectors in A-gate and B-gate.

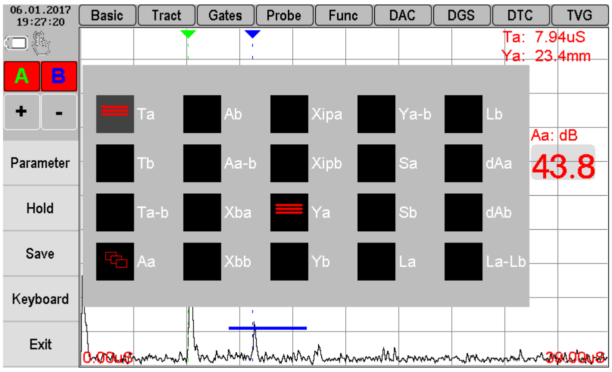


Figure 1.18 – Selection window for measured parameters to be displayed

For making measurements user has to stack control gate (A or B) with the tested signal. For determination differences between values (Ta-b, Aa-b, Ya-b и La – Lb) control gates (A and B) should be placed on two neighboring reflected signals.

1.7.2 «SETTINGS» mode

The mode is used for flaw detector setting (Figure 1.19), follow settings are available:

1. Screen:
   – Brightness;
   – Bright;
   – Aero;
   – Degree of transparency;
   – Antialiasing;
   – Palette;
   – Fly;
   – Grid;
   – Filling;
   – Fat line;
   – LEDs;
   – Language.
2. Sound:
   – Sound alarm;
   – Volume.
3. Date, time:
   – Date;
   – Time;
   – Clock 12-24.
4. Power:
   – Auto power;
   – Charger;
   – Retro.
5. Service:
   – Auto ZOOM;
   – Auto close menu;
   – Auto close keyboard.
6. Reset:
   – Factory RESET;
   – Clear SD.

7. About the device:
   - Number;
   - HW version;
   - SW version.
8. Status:
   - Battery voltage;
   - Current;
   - SOC;
   - Temperature;
   - Total time;
   - Operation time.

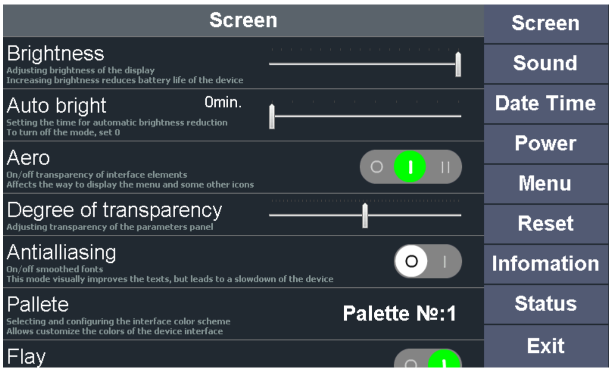


Figure 1.19 – «SETTINGS» mode

1.7.3 «ARCHIVE» mode

«ARCHIVE» mode allows user to look through all the earlier saved settings for the probe and measurement. In case of necessity user can download them for further operation with suitable settings (Figure. 2.20).

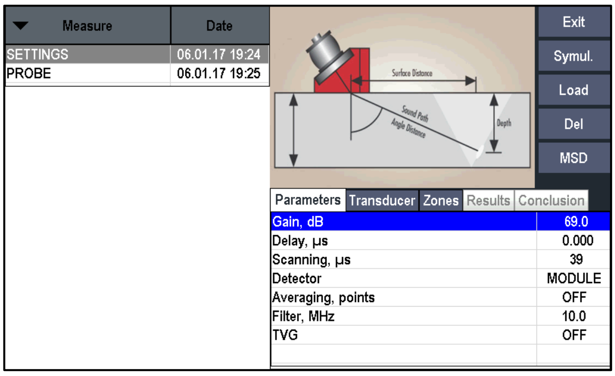


Figure 1.20 – «ARCHIVE» mode

1.7.4 «RESULTS» mode

«RESULTS» mode allows user to look through all the earlier saved measurement results. In case of necessity user can download them or start simulation mode (Figure 1.21). Also, in this mode user can see all the results and make data-report.

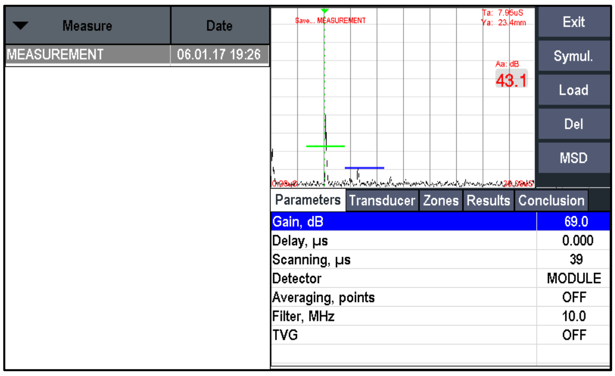


Figure 1.21 – «RESULTS» mode

1.7.5 «INFORMATION» mode

This mode contains information about dealers.

1.8 Means of measurement, tools and accessories

The correct work of the device is checked on calibration blocks. Mismatch readings must not exceed the permissible error. If the permissible error is exceeded, the device should be calibrated in accordance with p. 2.3.10.

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

1.9 Marking and sealing

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

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

1.10 Packing

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

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

2 UNTENDED USE

2.1 Maintenance limitations

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

Signal intensity of radio noise at the device location area should not exceed values, which can set out the flaw detector by generating voltage in the device amplifier input: when this voltage is exceeds a half value of maximal sensitivity.

In case of high signal intensity of radio noise, the device location area should be shielded from external electromagnetic field.

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

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

2.2 Preparing the device for use

2.2.1 Visual inspection

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

2.2.2 Charging the battery

To charge the battery, user must connect the device charger from the standard delivery set to the USB port on the right side of device housing. During charging the device can be used.

Full battery charging time - 14 hours. Always look after device when charging. Also, the device can be charged by PC connection.

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

2.2.3 Selection the probe

2.2.3.1 Testing of castings

Main types of defect in castings – gas cavities, shrink holes, slag inclusions. They are volume discontinuities. These defects are well determined in any scanning angle. As a rule, castings have coarse-grained structure and high heterogeneity of grains throughout the whole product. There is often structure-born noise while casting is scanning – plenty of echo-signals from grain boarders. Straight beam probes with rather low frequency are applied to avoid structure-born noise.

2.2.3.2 Testing of flat products, sheets, plates

Flat products, sheets, plates are made from castings by hot plastic deformation – rolling or stamping. Main product defects – delamination, hairlines, folds, cropping out cracks in case of technological process disruption. Besides, crack is the main operational defect.

Determination of delamination, hairlines, folds and so on is provided by straight beam probes. Determination of cropping out cracks is made by angle beam probes (single or dual element). It is better to use probes with entry angle 40 – 50 degrees, then angle reflectors (cracks) will send echo-signals of high amplitude. Recommendations as for angle beam probes are in Table 2.1.

Table 2.1 – Angle beam probes recommended

Probe type	Entry angle in steel (°)	Sheet thickness (mm)
P121-5.0-50	50	10 – 16
P121-2.5-50	50	12 – 28
P121-2.5-40	40	26 – 50
P121-1.8-40	40	40 – 110

2.2.3.3 Testing of weld joints

Ultrasonic testing of weld joints is widely used in all industries. Usually testing is made by angle beam UT-probes (Table 2.2). Deposited weld metal and heat effected zone are to be tested. Ultrasonic testing is made from heat effected zone by straight and one-time reflected beams.

Scanning of weld root must be made by straight beams of the probe. This requirement is provided by two parameters: entry arrow and angle.

Table 2.2 – Angle beam probes recommended

Probe type	Entry angle in steel (°)	Arrow (mm)	Sheet thickness (mm)
P121-10-70	70	4	4 – 6
P121-5.0-70	70	7	5 – 11
P121-5.0-65	65	7	10 – 16
P121-2.5-65	65	9	12 – 28
P121-2.5-50	50	9	26 – 50
P121-1.8-50	50	10	26 – 50
P121-2.5-40	40	9	40 – 110
P121-1.8-40	40	10	40 – 110

2.2.4 Connecting the probe

Caution!
To prevent damage of connectors and cables - follow the instructions below!

Used connectors in the device consist of two parts: socket (port) and the cable plug (Figure 2.1)

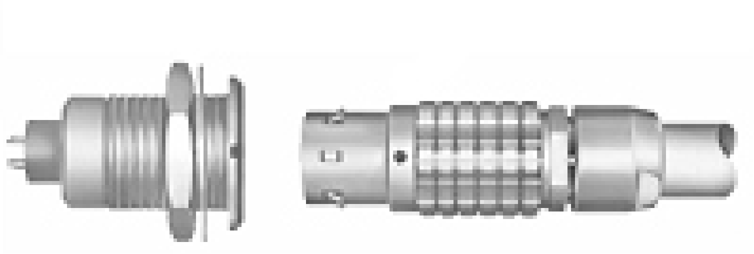


Figure 2.1 – Connectors in flaw detector

Method of connecting and disconnecting the plug to the socket is shown on Figure 2.2.
When connecting cable make sure that the red dot on the plug and socket are in line.

Caution!
When disconnecting the plug from the socket, hold its body in rifle area. Do not pull the cable!

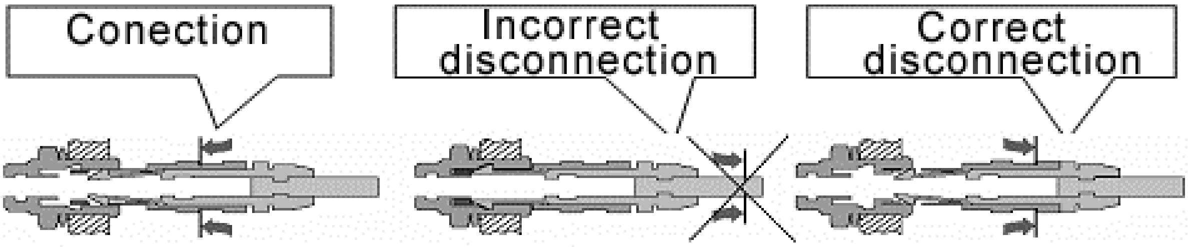


Figure 2.2 – Cable connection

Connect coaxial cable to the probe (Figure2.3).

Figure 2.3 – Connecting the cable to the single element probe

To connect single element probe user has to connect probe cable to the left socket (port) on the upper panel of device housing, insert the cable until lock clocks (Figure 2.4) and in «SETTINGS» mode set the «Probe» parameter - «DUAL» OFF.

To connect dual element probe user has to do the following: connect cable of probe transmitter to the left socket (port) on the upper panel of the device housing, connect cable of probe receiver to the right socket (port), insert cables until lock clocks, in «SETTINGS» mode set the «Probe» parameter - «DUAL» ON.

Figure 2.4 – Connecting the single element probe to the device

2.3 Preparing the object of testing

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

2.4 Using the device

2.4.1 Turning on

Turn on the device by long pressing the button «» on the keyboard until the short-time splash screen on the display. After this the device opens Main menu (Figure 2.5).

Figure 2.5 – Main menu

From Main menu user can enter:

1. «FLAW DETECTOR» mode;
2. «ARCHIVE» mode;
3. «RESULTS» mode;
4. «THICKNESS GAUGE» mode;
5. «HANDBOOK» mode;
6. «SETTINGS» mode;
7. «INFORMATION» mode.

After entering «FLAW DETECTOR» mode, display is divided into two areas: main area and information area (upper left part of display) (Figure 2.6).

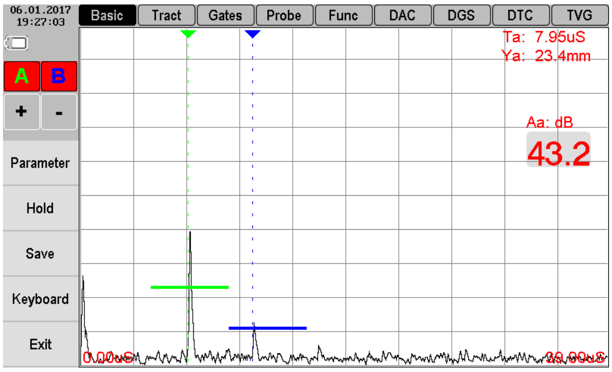


Figure 2.6 – «FLAW DETECTOR» mode on the screen

Main area is for operating. Information area displays battery level, PC connection, SD-card connection, touchscreen mode on/off, current time and date.

Before using the device, make sure that the batteries have enough power. Fully stocked LED (green) indicates that the battery is charged to 100%. If there is absence or lack of charge (red), charge the battery by a charger or by connecting the device to PC. Long press on the button «» makes the device to shut down.

2.4.2 Device navigation

2.4.2.1 Navigation by keys

Navigation keys «», «» are used to select parameter group in «FLAW DETECTOR» mode, by pushing key «» user confirms the selection. Selected parameter group is opened after confirmation.

Keys «», «» are used for parameter selection, keys – «», «» - for parameter changing.

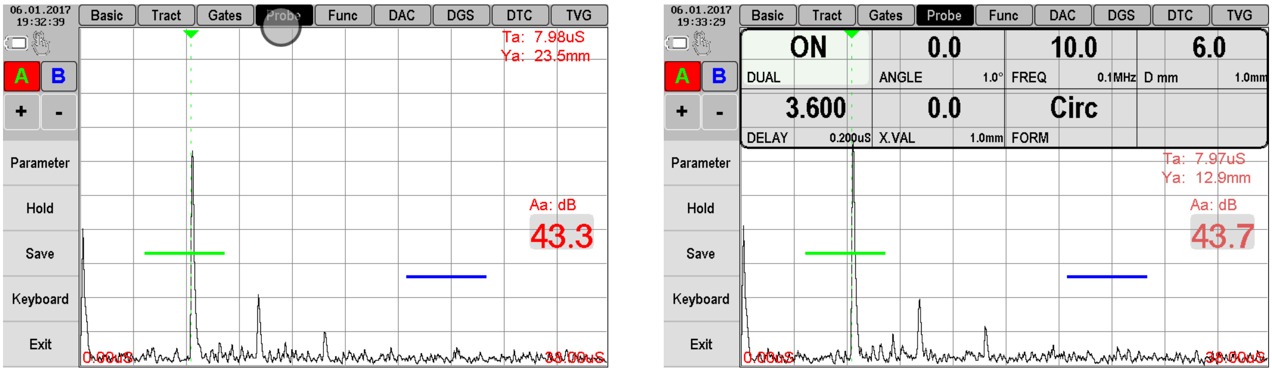
To change discreetness - press key «». Discreetness selected is displayed near changing parameter.

2.4.2.2 Navigation by touch screen display

Press key «» to turn on touch screen mode. After this, symbol «hand» appears in information area, it means touch screen mode is turned on.

To select parameter group user has to touch selected group by finger, and then selected group opens (Figure 2.7).

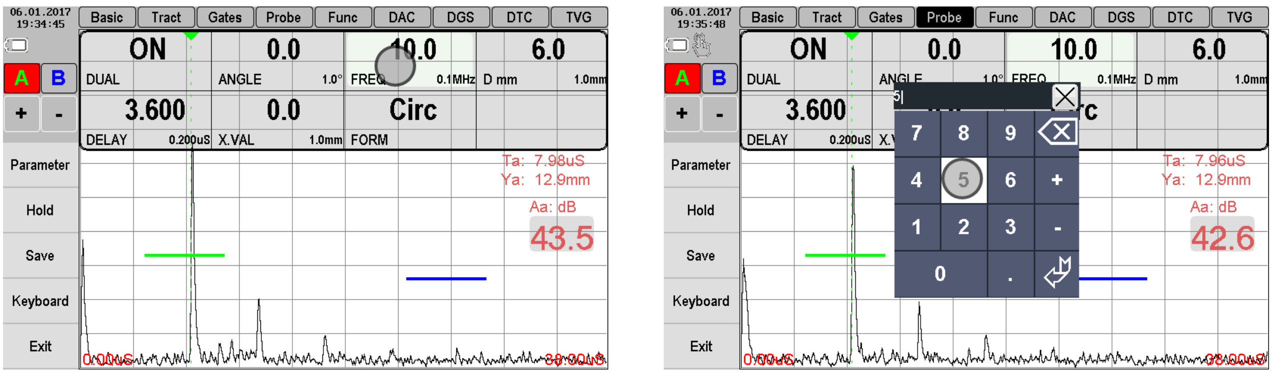
Note - <u>Place to touch is displayed on figures as « ».</u>



a) selection of the «Probe» group b) opened «Probe» group

Figure 2.7 – Selection of the parameter group

To select parameter user has to click on it one time, and for its setting user should open keyboard by double-click on «Keyboard» or double-click on parameter (Figure 2.8).

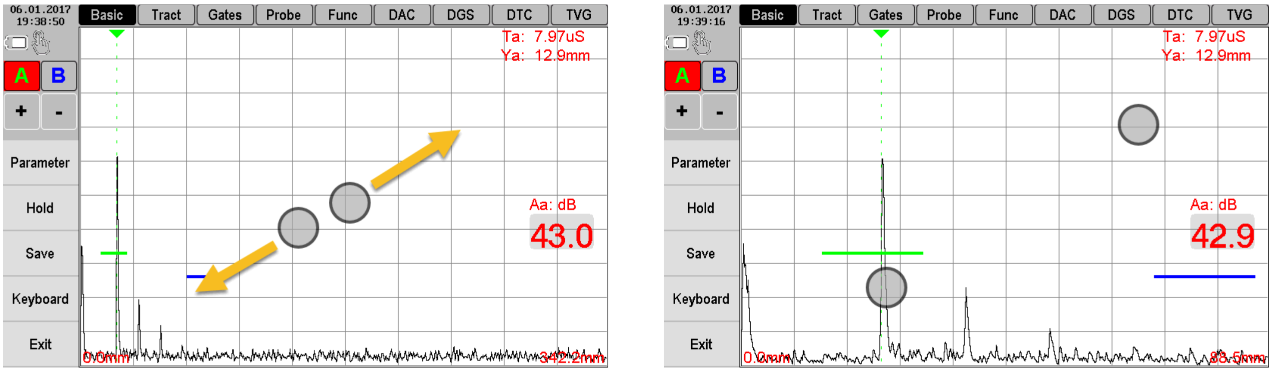


a) double-click on «FREQ» parameter (arrow) b) value setting by keyboard

Figure 2.8 – Setting of the parameter

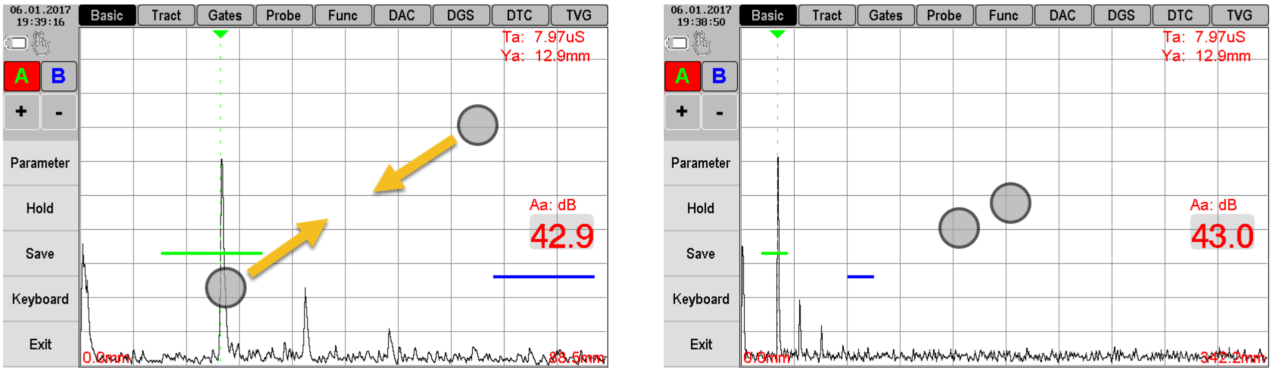
To change discreetness user has to click on discreetness value near parameter.

User can change scanning time by touching screen. For this use has to touch the screen by two fingers and move them in opposite direction (to reduce scanning time, Figure 2.9) or move fingers to each other (to increase scanning time, Figure 2.10)



a) scanning time is 342,2 mm b) scanning time is 88,5 mm

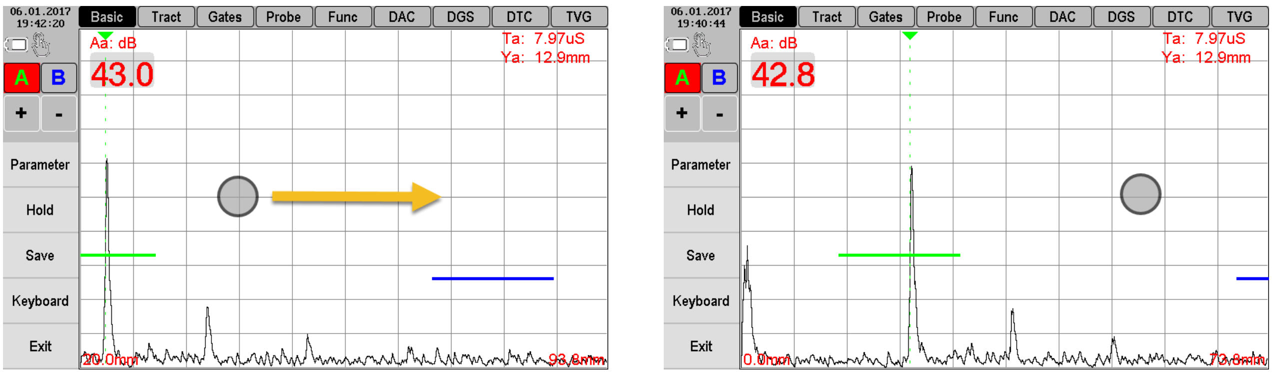
Figure 2.9 – Reduce scanning time



a) scanning time is 88,5 mm b) scanning time is 342,2 mm

Figure 2.10 – Increase scanning time

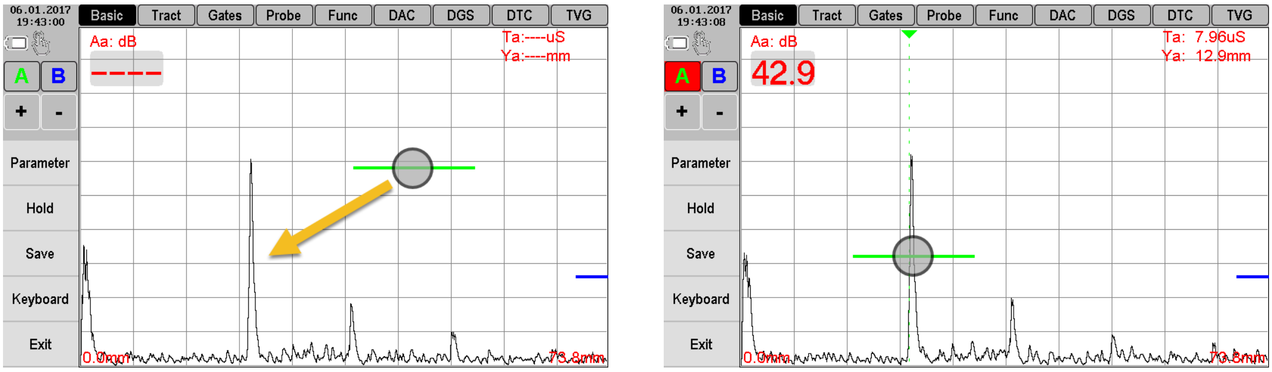
User can change delay of scanning by touch screen. For this user has to click on display and move finger right to reduce the delay (Figure 2.11) or move finger left to increase the delay (Figure 2.11).



a) delay of scanning is 20,0 mm b) delay of scanning is 0,0 mm

Figure 2.11 – Reduce delay of scanning

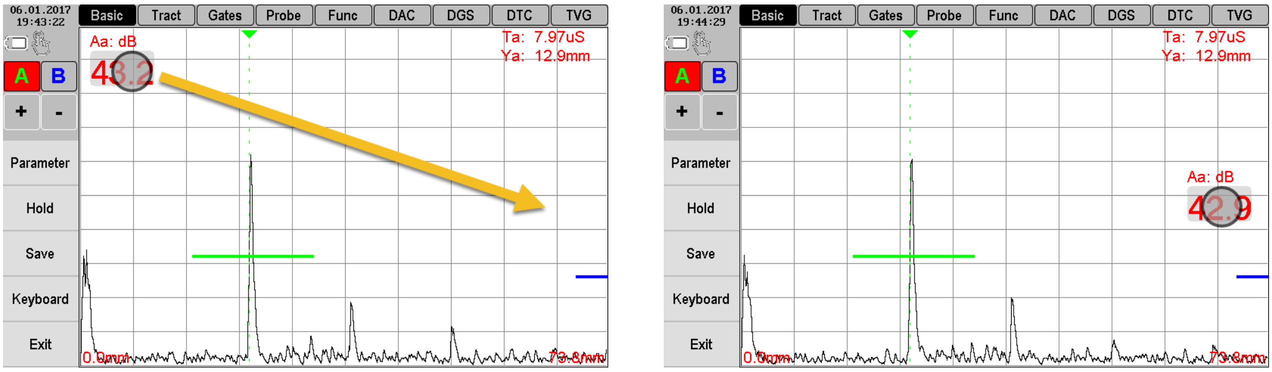
For setting the gate position user has to click by finger the selected gate and move it to necessary place of A-scan (Figure 2.12).



a) the gate is out of signal b) signal crosses the gate

Figure 2.12 – Relocation of the gate

Displayed values of testing parameters could be moved to any new place of A-scan, if this function is set by the device for the particular parameter (Figure 2.13).



a) parameter in start position b) parameter after relocation

Figure 2.13 – Relocation of the parameter value

2.4.3 Settings

After selection in Main menu «SETTINGS» mode (Figure 2.14) the device is ready for setting the follow parameters:

1. Screen:
   - Brightness. *Setting of the screen brightness. The higher is brightness the lower is operating time of the scanner battery*;
   - Bright. *Setting the time of automatic brightness reducing*;
   - Aero. *Turn on/off edge visibility of interface elements. It has influence on visibility of menu some other elements*;
   - Degree of transparency. *Setting degree of transparency for parameter panel*;
   - Antialiasing. *Turn on/off antialiasing. The mode makes shifts visual better but makes operating slower*;
   - Palette. *Selection and setting the color palette of interface. User can set colors of the screen by himself*;
   - Fly. *Allows move parameter values on A-scan. Parameter value could be moved to any place of A-scan*;

- Grid. *Turn on/off grid on A-scan*;
- Filling. *Turn on/off signal filling for better visualization. Signal on A-scan is filling paint of the same color as the impulse line*;
- Fat line. *Turn on/off the thicker signal line. Signal line is thicker*;
- LEDs. *Turn on/off LEDs on the device housing*;
- Language. *Selection the language*.

2. Sound:
   - Sound alarm. *Turn on/off sound. Turning off sound, including defect signalization*;
   - Volume. *Volume setting*.
3. Date, time:
   - Date. *Setting the date of the system clock*;
   - Time. *Setting the time of the system clock*;
   - Clock 12-24. *Selection of clock mode*.
4. Power:
   - Auto power. *Setting the time of automatic turn off*;
   - Charger. *Turn off backlight when charging the turned-off device*;
   - Retro. *Automatic saving of settings after the device is turned off.*
5. Service:
   - Auto ZOOM. *Turn on automatic electronic lens, which allow focus scanning on the selected gate after pushing symbol of gate signalization*;
   - Auto close menu. *Allows automatically close menu when pushing another element*;
   - Auto close keyboard. *Allows automatically close keyboard after entering the value;*
6. Reset:
   - Factory RESET. *Reset to manufacturer settings. Allows to return the device to manufacturer settings*;
   - Clear SD. *Clear internal memory card*.
7. About the device:
   - Serial. *Serial number of the device*;
   - HW version. *Version of the device hardware*;
   - SW version. *Version of the device firmware*.
8. Status:
   - Battery voltage. *Recharging battery voltage*;
   - Current. *Absorbed current of the device*;
   - SOC. *Capacity of the recharging battery*;
   - Temperature. *Battery temperature*;
   - Total time. *Total working time of the device*;
   - Operation time. *Working time of the device in «MESUREMENT» mode*.

In «SETTINGS» mode for input and selection of parameter, touchscreen could be used

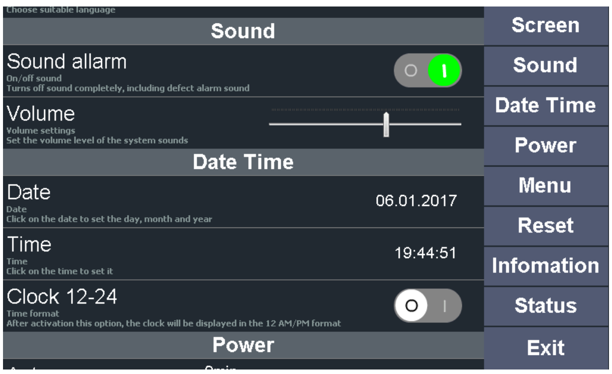


Figure 2.14 – «SETTINGS» mode

2.4.4 Setting the probe parameters

Setting the probe parameters is made in «Probe» parameters group (Figure 2.15).

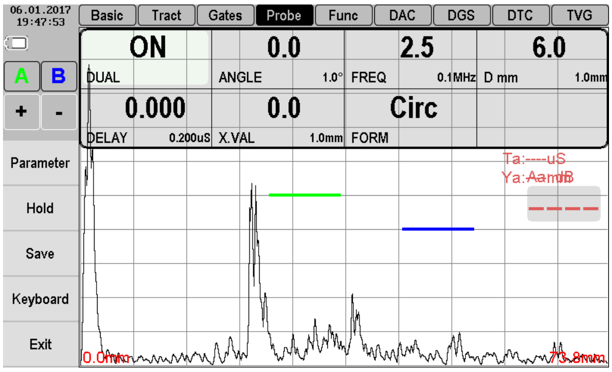


Figure 2.15 – «Probe» parameters group

Following parameters should be set:

1. Probe type. Select parameter «DUAL» and set the correct type (single element «OFF» or dual element «ON»).
2. Operating frequency of the probe «FREQ» (Figure 2.16).

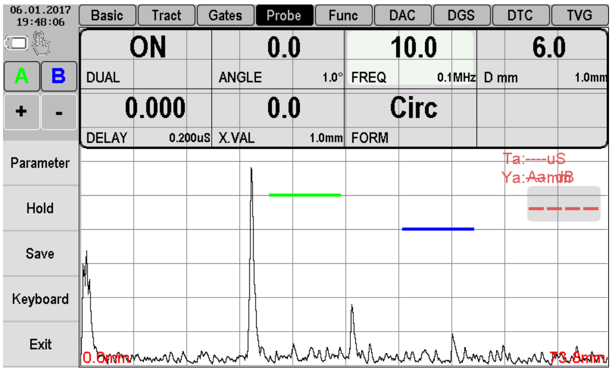
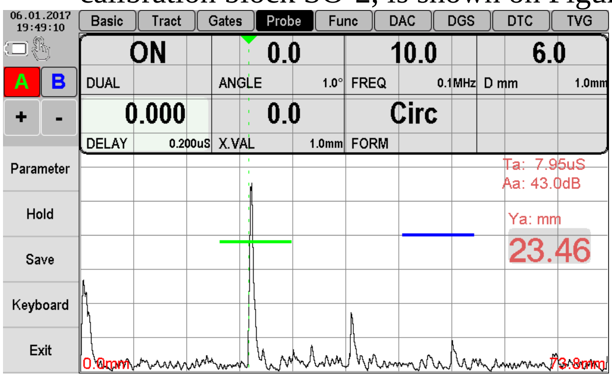
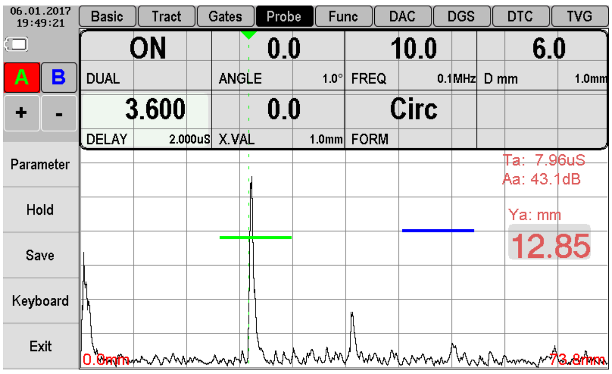


Figure 2.16 – Setting the operating frequency of the probe - «FREQ» parameter

3. Delay in the prism of the probe «DELAY» (delay value in µs). While using the probe, delay can change due to scuffing of the prism. Delay could be determined by standard calibration blocks (see paragraph about calibration 2.5.1 or 2.5.2). Delay determination, using the calibration block SO-2, is shown on Figure 2.17.



a) delay in the prism is 0 µs



б) delay in the prism is 3,600 µs

Figure 2.17 – Setting delay in the probe prism - «DELAY» parameter

4. Entry angle of UT waves «ANGLE». For straight beam probe angle is equal 0 (Figure 2.18). In dependence with material of tested object, entry angle of UT waves can be changed. Angle could be determined by means of standard calibration block, made from the same material as tested object, see paragraph about calibration (2.5.3).

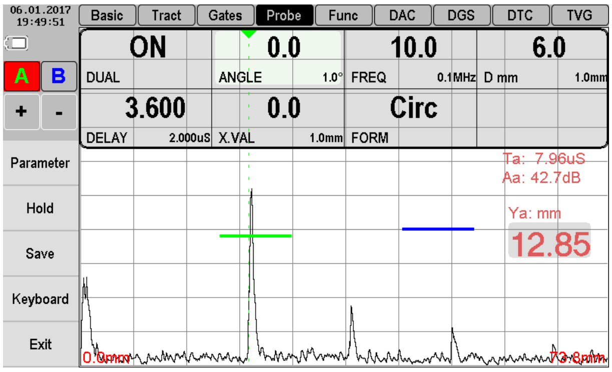


Figure 2.18 – Setting entry angle of UT waves - «ANGLE» parameter

5. Form of the piezo-electric crystal plate «FORM», could be rectangular «Rect» or circle «Circ». In dependence with selected form user can input diameter of the plate (Figure 2.19), or sides dimensions (Figure 2.20). These parameters are necessary for building DGS diagrams (see p.2.4.10).

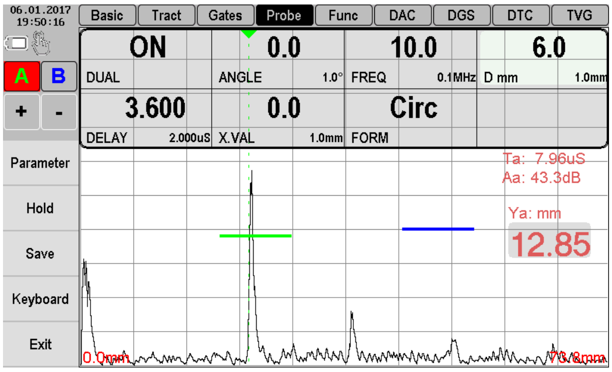


Figure 2.19 – Setting the diameter of the piezo-electric crystal plate - «FORM» parameter

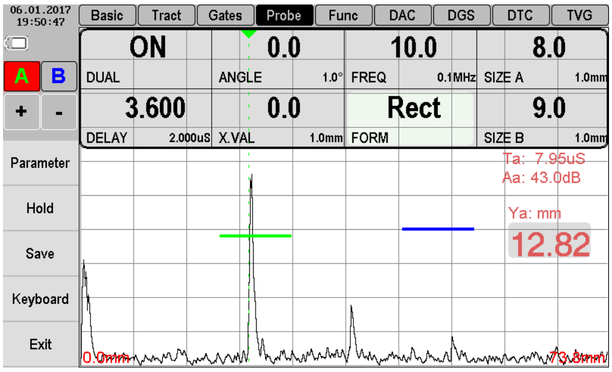


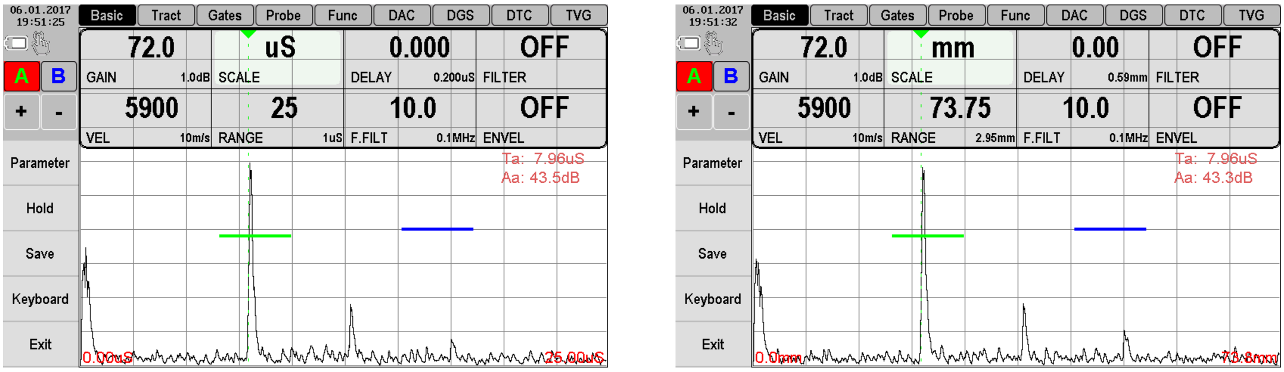
Figure 2.20 – Setting the sides dimensions of the quadrangular piezo-electric crystal plate – SIDE A and SIDE B parameters

6. Probe arrow «X.VAL». While using the probe, arrow changes due to scuffing of the prism. Arrow could be determined by standard calibration blocks (see paragraph about calibration p.2.5.4).

2.4.5 Setting the signal view

Ultrasonic flaw detector displays on the screen A-scan with material depth as horizontal axis and signal amplitude as vertical axis. Basic measuring value on horizontal axis – it is time between one start moment (for example, start of output impulse) and another event moment (for example, received echo-signal). All the other values are derivatives (distance, thickness) and are mathematically calculated by means of arithmetic and trigonometric dependences and input values of UT waves velocity, entry angle and arrow of the probe, delay in the prism and so on.

First of all, user must set units of settings and parameters of the flaw detector (Figure 2.21) in group of settings «Basic»: select parameter of units «SCALE» and set value (µs or mm).



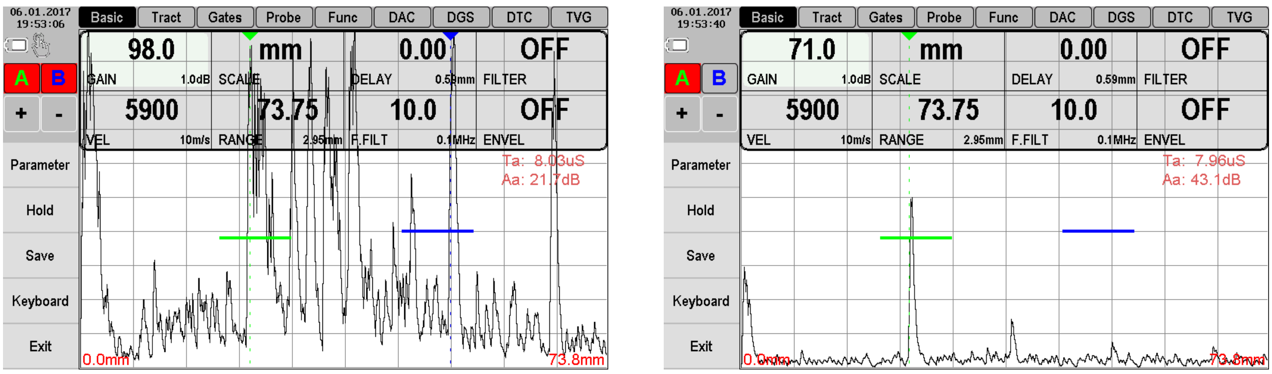
a) µs b) mm

Figure 2.21 – Selection of units for settings and parameters of the device - «SCALE» parameter

Further settings of signal displaying are made in parameter group «Tract».

To make setting the following parameters are to be set:

1. Set gain of input pulse «GAIN», setting range: from 0 to 126 dB, with step 0,1 or 1 dB. Gain should be set in a way, that echo-signals are within the screen and are not very small (for example, the highest peak is about 85% of the screen). See Figure 2.22.

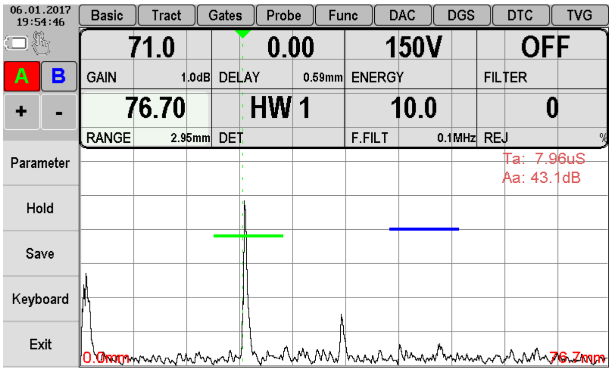


a) gain is 98,0 dB b) gain is 71,0 dB

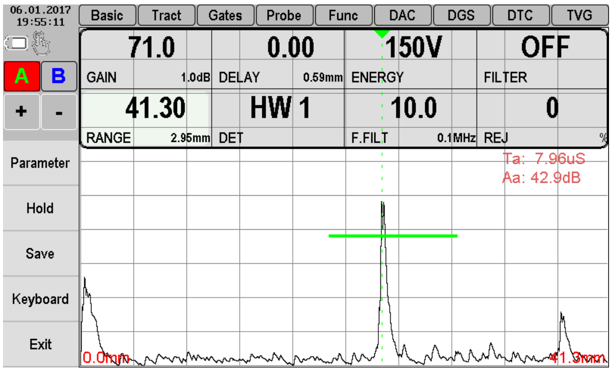
Figure 2.22 – Setting the gain of input pulse - «GAIN» parameter

2. Set time of scanning «RANGE» (Figure 2.23), setting range: from 14 to 1000 µs. User can change scanning time by touching screen. For this use has to touch the screen by two fingers and move them in opposite direction (to reduce scanning time, Figure 2.9) or move fingers to each other (to increase scanning time, Figure 2.10.

Note – <u>The device operates with signals within scanning time only.</u>



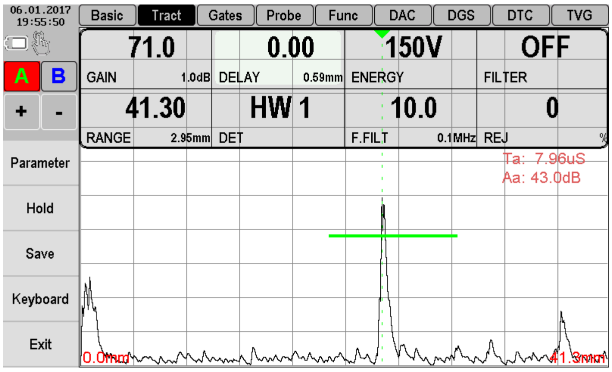
a) time of scanning is 96,70 mm



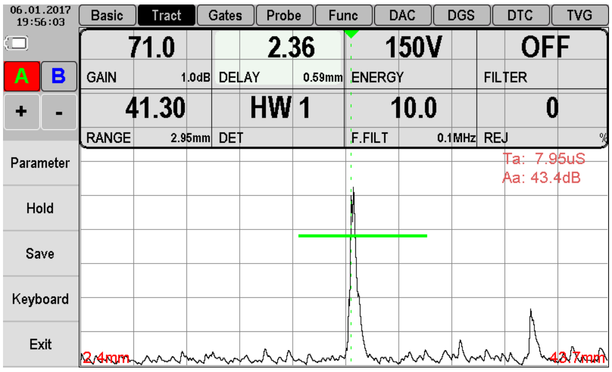
b) time of scanning is 41,30 mm

Figure 2.23 – Setting the scanning time - «RANGE» parameter

3. Set time delay of scanning start as for the probe pulse «DELAY», setting range: from 0 to 1000 µs. Delay dependence curve moves A-scan to the left or right and is used regulation screen view (Figure 2.24). Also, user can change delay of scanning by touch screen. User clicks on display and move finger right to reduce the delay (Figure 2.11) or move finger left to increase the delay (Figure 2.11)



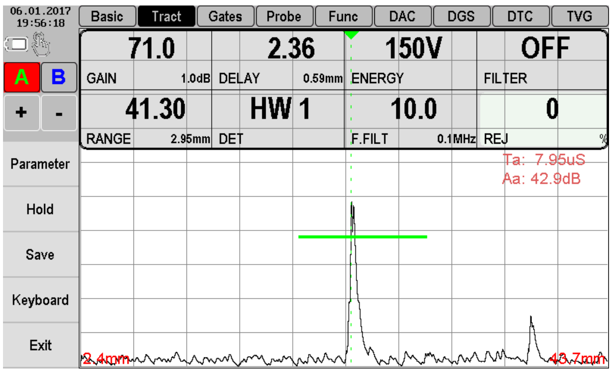
a) delay of scanning is 0 mm



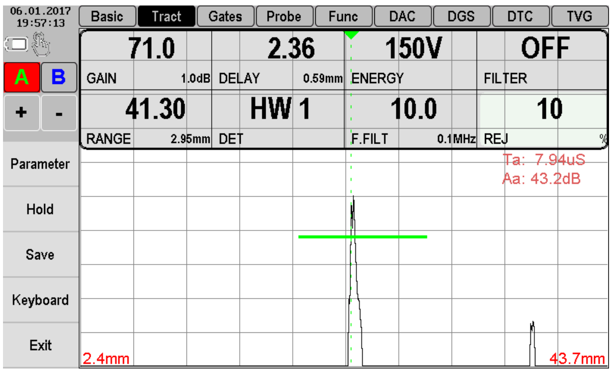
b) delay of scanning is 2,36 mm

Figure 2.24 – Setting the delay of scanning start - «DELAY» parameter

4. Setting the level of cutting-off the signal «REJ», value: in % of the screen height. A-scan part, that is lower of this level, is not processed and displayed for better signal visualization (Figure 2.25).



a) cutting-off level is 0 %



b) cutting-off level is 10 %

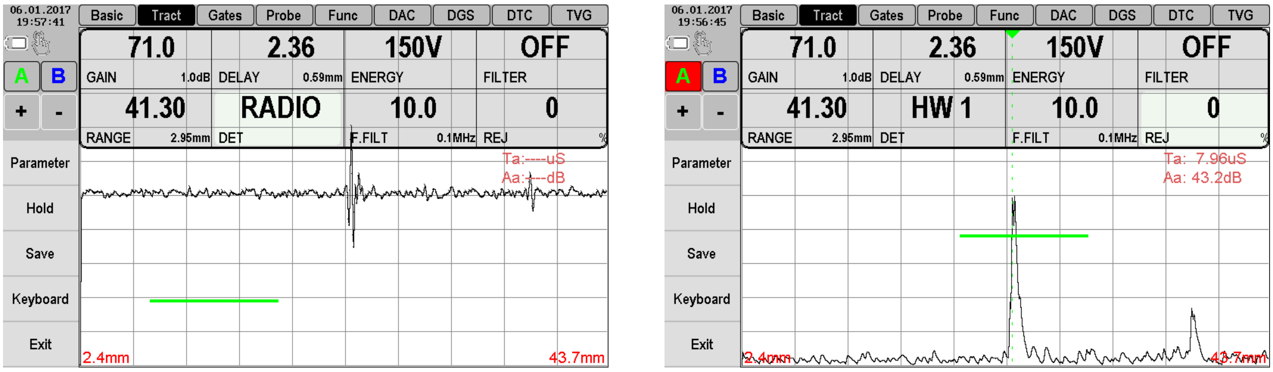
Figure 2.25 – Setting the cutting-of level for signal - «REJ» parameter

5. Selection of A-scan mode of the flaw detector «DET», three modes are available: «RADIO», «HW 1», «HW 2». A-scan mode provides view (visualization) of the received signal on the

screen (Figure 2.26). Received signal is a bidirectional radio-frequency signal, that can be displayed on the screen in different modes:

5.1 «RADIO» – signal is represented in radio-frequency mode;

5.2 «HW 1»; «HW 2» – signal is represented with rectification.



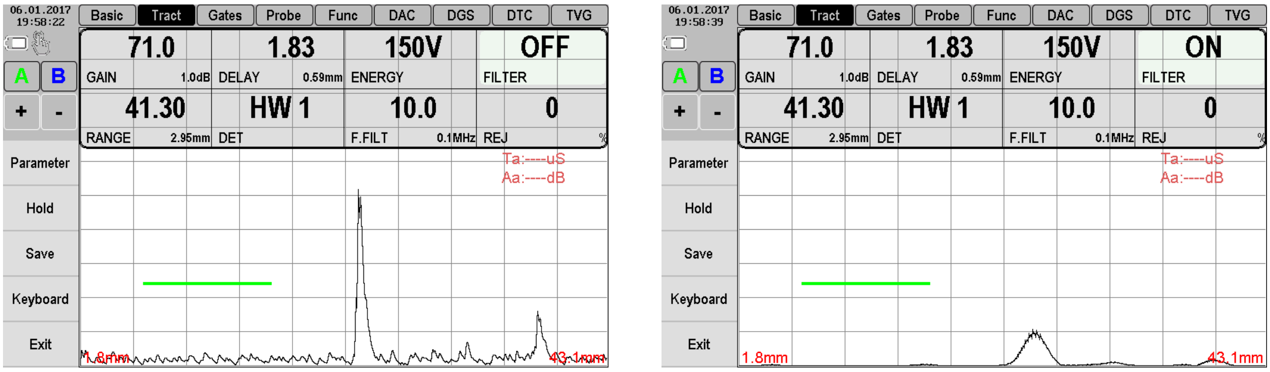
a) RADIO b) HW 1

Figure 2.26 – A-scan modes - «DET» parameter

Also, in «Tract» parameters group user can turn on and set in digital band filter, that allows to improve ratio signal/noise. Better effect from the filter user can get when high gain is set and when testing materials are of high damping.

Note – <u>For most standard device application user does not need to turn on the filter.</u>

So, to set in the filter user has in parameter «F.FILTER» input central operating frequency. Filter band is constant ~ 1 MHz. To turn on the filter: in parameter «FILTER» select «ON» (Figure 2.27).



a) filter is turn off b) filter is turn on

Figure 2.27 – Usage of the digital band filter - parameter «FILTER»

In case of testing very thin objects, it is possible to reduce the “dead” zone of the probe by reducing the generator level «Energy» (100V, 150V, 200V).

2.4.6 Setting the device for testing

For correct measurement of defect coordinates and thickness of tested object it is necessary to set the correct velocity for UT waves propagation into the tested material (velocity measurement find in p.2.5.5). Velocity of UT waves propagation is set in parameters group «Basic», parameter «VEL» (from 1000 to 9999 m/s), Figure 2.28.

Caution!

Correct measurement of defect coordinates and thickness of tested object depends on correct setting of velocity.

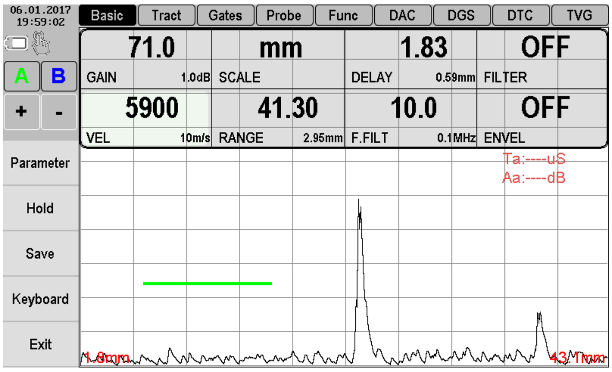


Figure 2.28 – Velocity setting for UT waves propagation into the tested object - parameter «VEL»

2.4.6.1 Configuration of control A-gate and B-gate

Setting the A-gate and B-gate positions is the first step in the device setting for defect determination and material thickness measurement.

Settings of the gates is made in «Gates» parameters group. For setting the gates do the following:

1. Select the gate (A or B) for setting in parameter «GATE» (Figure 2.29). After this, all settings are made for this particular gate.

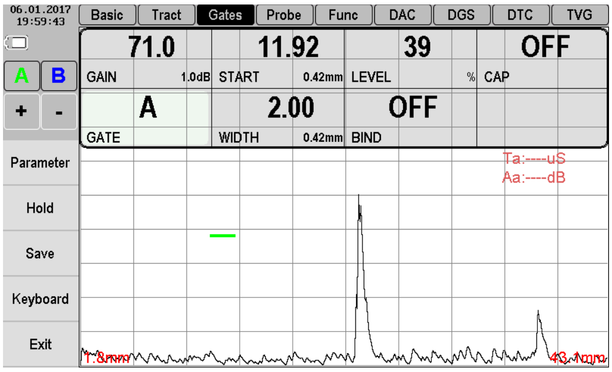


Figure 2.29 – Gate selection in parameter «GATE»

2. Input the start coordinate for the gate «START» (Figure 2.30), setting range: from 0 to maximum value of scanning time. Also, setting of the gate position user can make by touch screen: touch the selected gate by finger and move it to any other location on the A-scan.

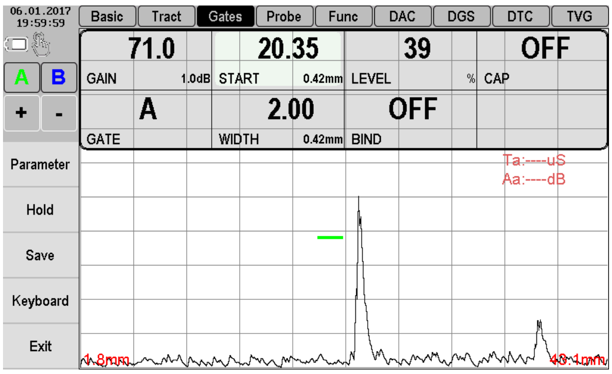
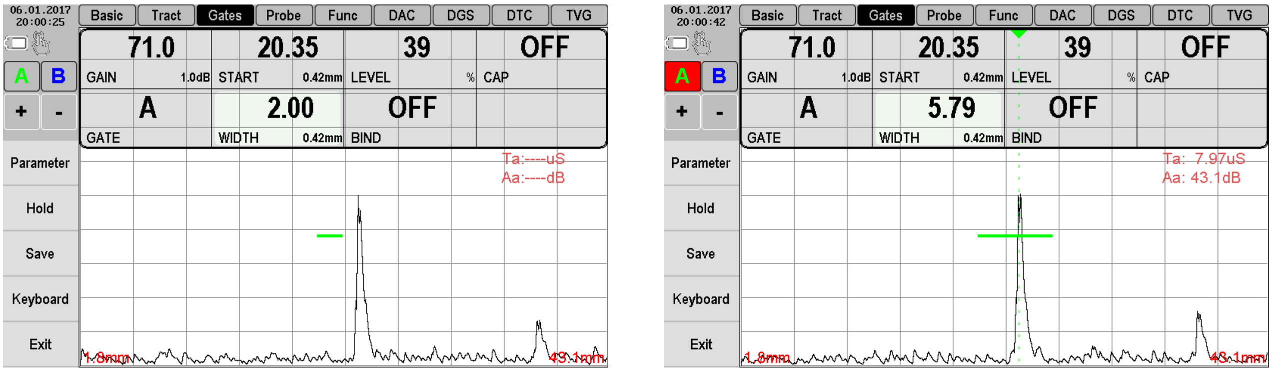


Figure 2.30 – Setting the start coordinate for the gate - «START» parameter

3. Input the width of the gate «WIDTH» (Figure 2.31), setting range: from 0 to maximum value of scanning time. The bigger is value of the width gate, the bigger is depth for testing.

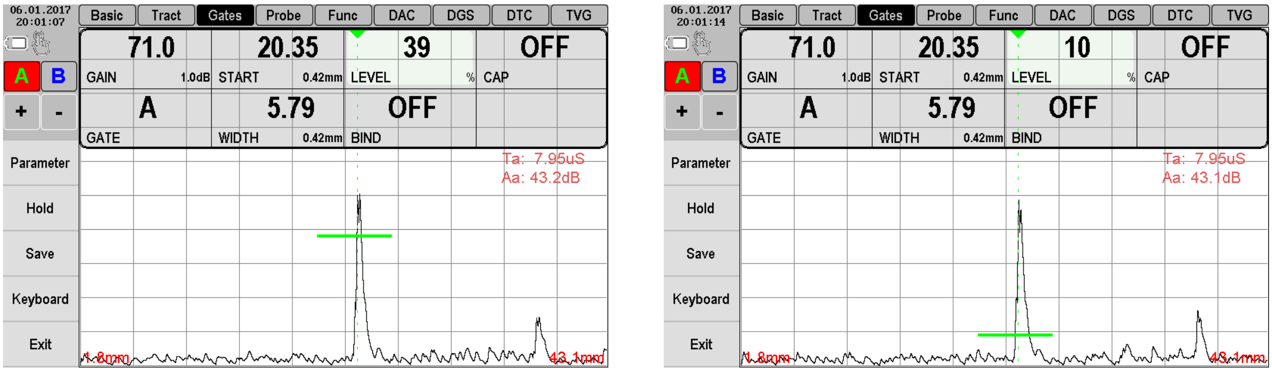


a) width is 2 mm b) width is 5,79 mm

Figure 2.31 – Setting the gate width - «WIDTH» parameter

Note – *Total sum of the start coordinate and the gate width could not exceed* maximum value of scanning time.

4. Set the gate level «LEVEL» in % of screen height, setting range: from 0 to 100% of screen height (Figure 2.32). Gate level means that only the signals with amplitude above the level are processed.

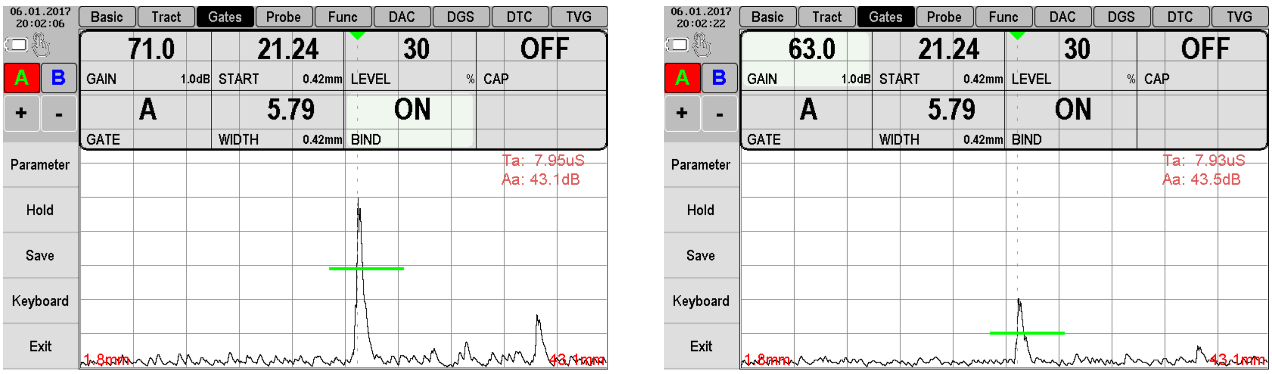


a) gate level is 39% b) gate level is 10%

Figure 2.32 – Setting the gate level - «LEVEL» parameter

Parameters group «Gates» includes additional settings for more convenient operation with the device.

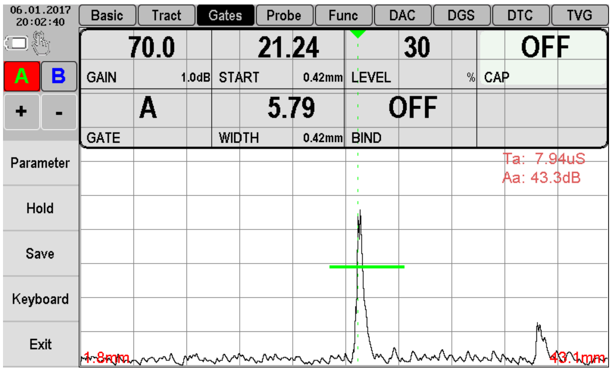
Parameter «Bind» allows to fix the gate on selected signal level. So, when signal gain is changing the gate level stays the same (Figure 2.33). To turn on this parameter user has to change parameter «Bind» value to «ON».



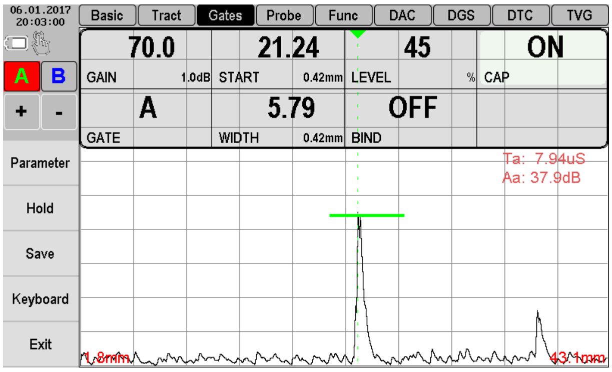
a) turn on «Bind» b) reducing the signal gain

Figure 2.33 – Applying of the «Bind» parameter

Parameter «CAP» allows to correct gain automatically so, that the signal runs up to the gate (see Figure 2.34). To turn on user has to change parameter «CAP» value to «ON».



a) «CAP» is turned off



b) «CAP» is turned on

Figure 2.34 – Applying of the «CAP» parameter

2.4.6.2 Selection of displaying measurements

To open the window with displaying measurements (parameters) press key «» or «PARAMETER» (Figure 2.35) on the screen. After this, in opened window selected parameters are to be displayed. Double-click sends the parameter to A-scan, and user can move it on A-scan if this device function is turned on in «SETTINGS».

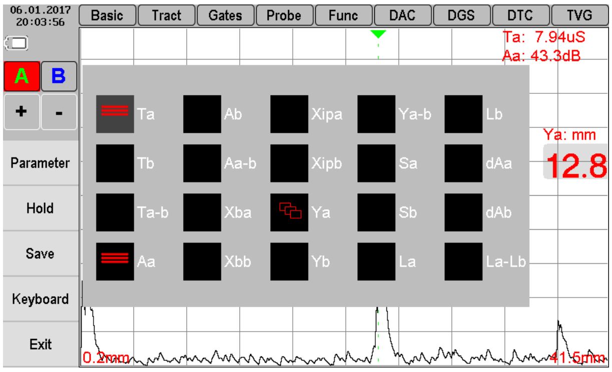


Figure 2.35 – Window for selection of displaying measurements

After parameter selection close the window by double-click key «» or «PARAMETER», and selected measurements (parameters) appear on the screen (Figure 2.36).

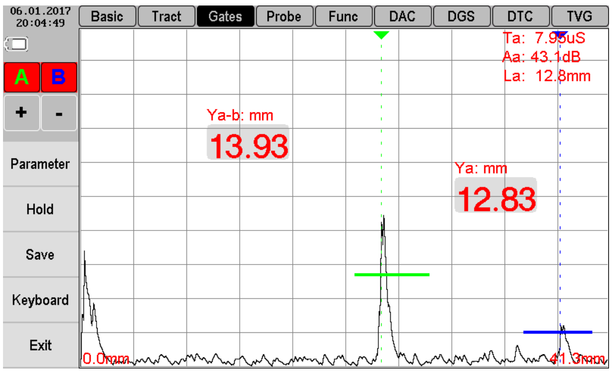


Figure 2.36 – Displaying measurements (parameters)

Parameters are to be measured by the flaw detector:

- Ta, Tb – Signal time value in A-gate (B-gate), µs.
- Ta-b – Difference between signal time value in A-gate and signal time value in B-gate.
- Aa, Ab – Signal amplitude value in A-gate (B-gate).
- Aa-b – Difference between signal amplitude values in A-gate and B-gate.
- Xba, Xbb – Entry point distance of signal in A-gate (B-gate).
- Xipa, Xipb – Input signal distance in A-gate (B-gate).
- Ya, Yb – Coordinate of signal depth in A-gate (B-gate).
- Ya-b – Difference between depths in A-gate and B-gate.
- Sa, Sb – Equivalent size of the signal in A-gate (B-gate).
- La, Lb – Distance to reflector along beam in A-gate (B-gate).
- La - Lb – Difference between distances to reflectors in A-gate and B-gate.
- dAa, dAb – Signal level value (dB) from A-gate (B-gate) to maximum signal.

2.4.7 Automatic signalization of defects

Automatic signalization of defects (or defect control - DTC) is used for automatic determination and signalization of the defect.

To turn on and to set DTC user has to enter «DTC» parameters group.

In order to turn on/off «DTC» sound alarm when the signal crosses the gate level, user has, first of all, to select the gate (A or B) in «Gates» parameter and then in «ALARM» parameter (Figure 2.37) set «ON» or «OFF».

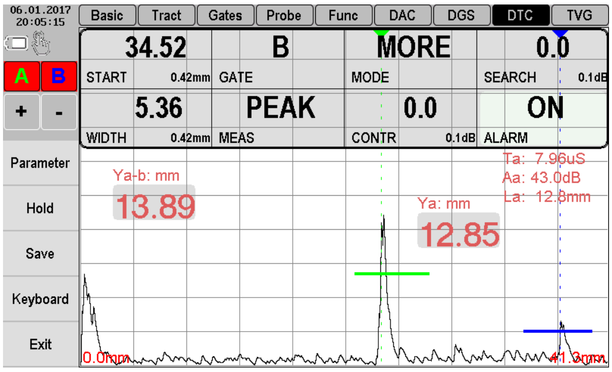
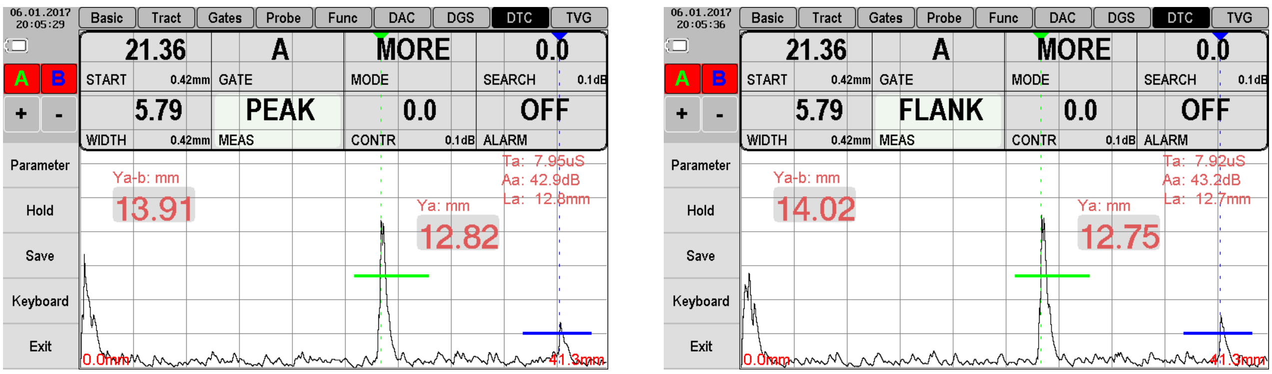


Figure 2.37 – Turning on the DTC sound alarm

1. For setting the measurement mode in tested area «MEAS» parameter should be set. For «MEAS» parameter there are two variants only: «PEAK» or «FLANK» (Figure 2.38). When parameter is «PEAK» the peak signal within the gate is measured. When parameter is «FLANK» the flank signal is measured.



a) measurement on the peak signal b) measurement on the flank signal

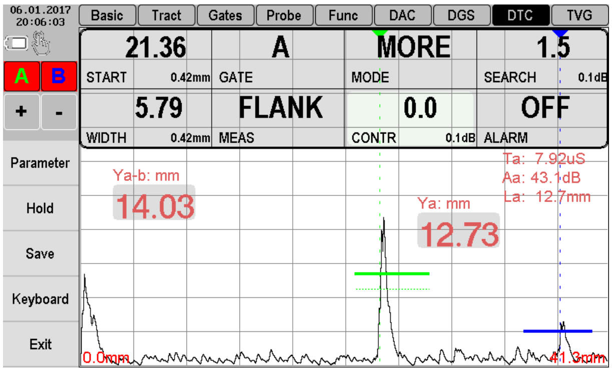
Figure 2.38 – Setting the measurement mode - «MEAS» parameter

2. Flaw detector allows DTC activation neither when signal is higher nor lower than the gate level (DTC is activated when signal is higher than the gate level in «MORE» mode and in «LESS» mode - when signal is lower than the gate level). To select mode for DTC user has to set «MODE» parameter («MORE» or «LESS»).

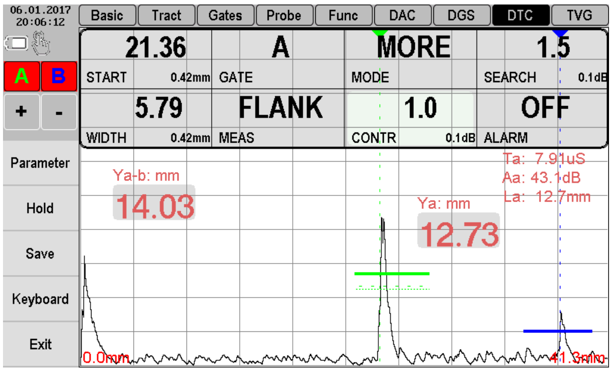
Also, the device allows setting of additional levels in the gate: control and search. Additional levels are set in dB for every gate separately in dependence to the main level of the gate.

To set additional control levels user has in «DTC» parameters group input the necessary values for parameters «CONTR» and «SEARCH» for the particular gate.

Additional control and search levels of the gate are displayed on the screen, below the main level of the gate (Figure 2.39).



a) additional search level



b) additional control level

Figure 2.39 – Additional levels of the gate - parameters «CONTR» and «SEARCH»

2.4.8 «TVG» mode

TVG mode allows to compensate damping influence and display signals from reflectors with different depths as signals with equal height (amplitude). It is possible because of different gain in different A-scan points in dependence with depth and signal damping in tested material.

Usually reference points are determined by standard calibration block (or standard sample – SS) with reference reflectors of equal size and located on different depths. The first reflected signal of every of these reflectors should be recorded. The only one chain of reference points could be input per one time (in one setting).

To turn on and set TVG user has to enter «TVG» parameter group.

To input reference points following operations are to be made:

1. Keep sure, that input function for reference points is turn on («TVG – ON»).
2. Clear (in case of previous TVG points are recorded and new ones are to be created). For this, in «CLEAR» parameter set «ON».
3. Put the probe on the SS and set the scanning time so, that signals of all the reflectors in probable tested zone would be displayed on the screen.
4. Find the maximum signal from the nearest reflector, and set the signal top on the screen level of 50-80 % by changing the gain (Figure 2.40).

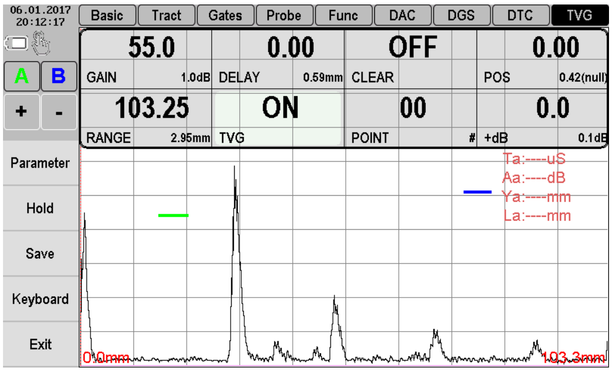


Figure 2.40 – Turning on TVG mode

5. Overlap A-gate on the signal from the nearest reflector (Figure 2.41).

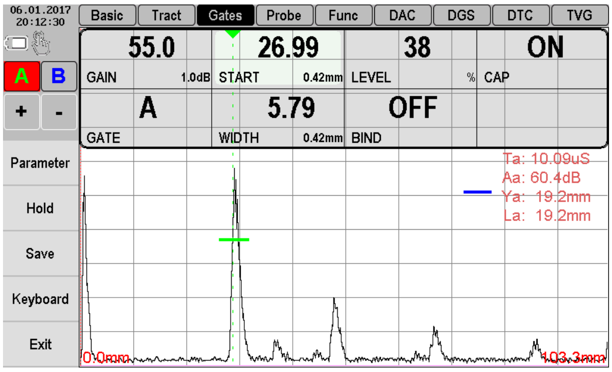


Figure 2.41 – Overlapping of A-gate on the signal from the nearest reflector

6. Turn on parameter of signal amplitude in A-gate – Aa (Figure 2.42).

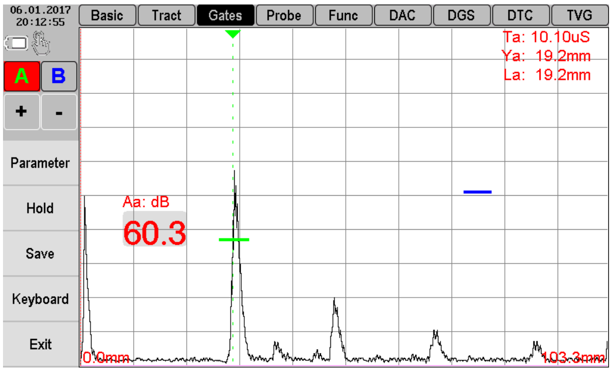


Figure 2.42 – Turning on the parameter displaying: signal amplitude in A-gate

7. Turn on the mode of amplitude envelope («ENVEL») and settle the maximum signal in A-gate from the nearest (first) reflector (Figure 2.43).

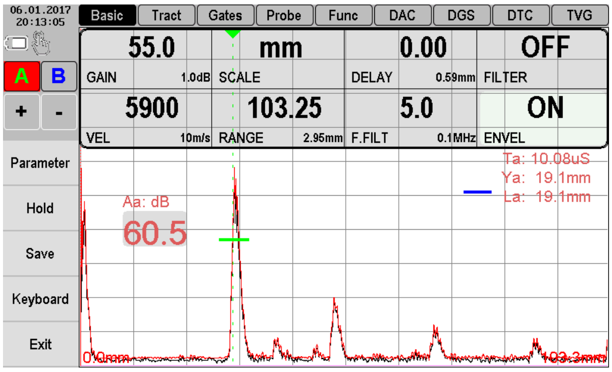


Figure 2.43 – Turning on the mode of amplitude envelope

8. Select the point number (00 by default) for the first echo and set its position («POS» parameter) on the signal top on A-scan (Figure 2.44).

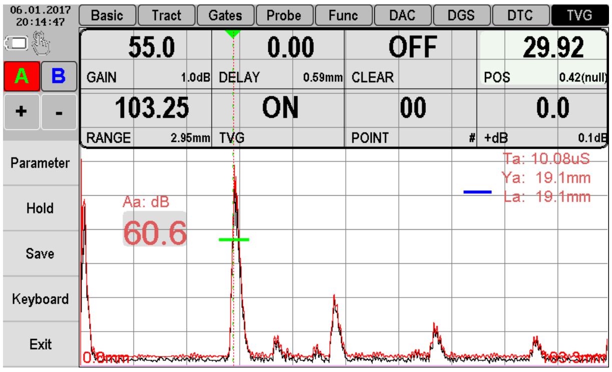


Figure 2.44 – Selection of the first TVG point

9. Overlap B-gate on the second echo (Figure 2.45), and turn on displaying of difference between signal amplitude values in A-gate and B-gate – Aa-b.

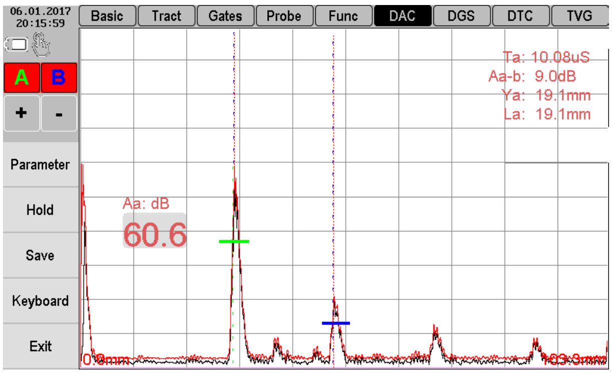


Figure 2.45 – Overlapping of B-gate on the second reflected signal

10. Select point number 01 for the second reflected signal and set its position («POS» parameter) on the top of the second reflected signal (Figure 2.46)

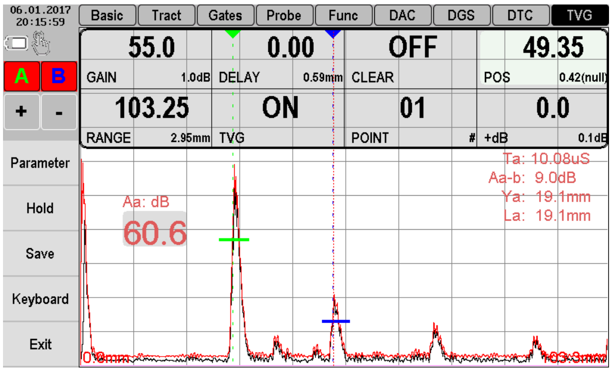


Figure 2.46 – Selection of the second (01) TVG point

11. By setting the gain of reference point 01 («+dB» parameter) equal to difference between amplitudes of current and previous signal, level up the second signal peak to the first one (Figure 2.47).

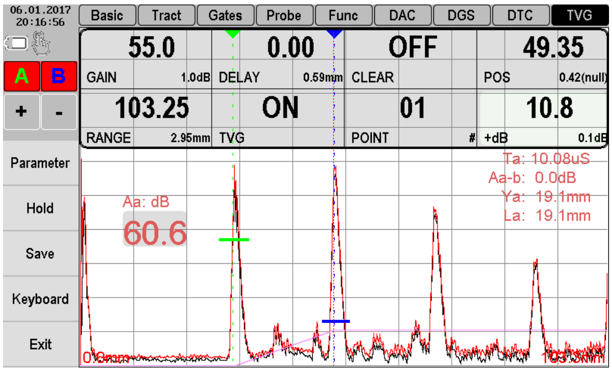
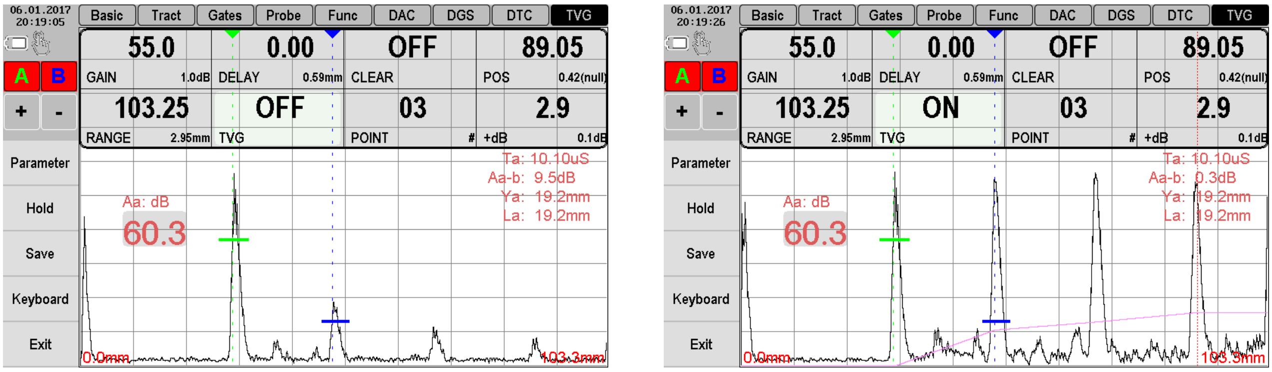


Figure 2.47 – Gain verification of the second point

12. For every next reflector make record of the reference point in the same way as for 01 point. The device operating in TVG mode is shown in Figure 2.48.



a) TVG mode is turned off b) TVG mode is turned on

Figure 2.48 – TVG mode

2.4.9 «DAC» mode

DAC mode shows echo-signals with their real amplitudes without any compensation. In DAC mode the device builds dependence curve of echo-signal amplitude variation with respect reflectors with equal size and different distances to the probe. DAC curve graphically makes a correction for damping in the material, near-field effects and beam scattering.

Usually reference points are determined by standard calibration block (or standard sample – SS) with reference reflectors of equal sizes and different depths. The first reflected signal from every reflector should be recorded only. The only one sequence of reference points could be input for one time (for one setting).

To turn on and set DAC mode user has to enter «DAC» parameter group.

To input the reference points following operations should be made:

1. Do not turn on the input function of DAC («DAC – OFF»), Figure 2.49.

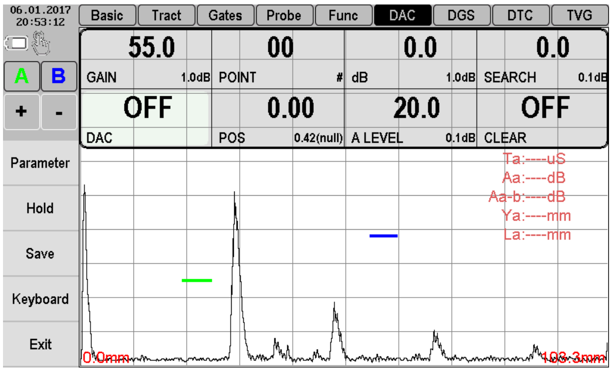


Figure 2.49 – DAC mode off

2. Put the probe on SS and set the scanning so, that signals from all the reflectors in probable testing zone would be displayed on the screen
3. Find the maximum signal from the nearest (first) reflector by varying the gain, and then settle the signal top on the 50-80% level (height) of the screen.
4. Overlap A-gate on the signal from the nearest reflector.
5. Turn on displaying of the signal amplitude value in A-gate - Aa (Figure 2.50).

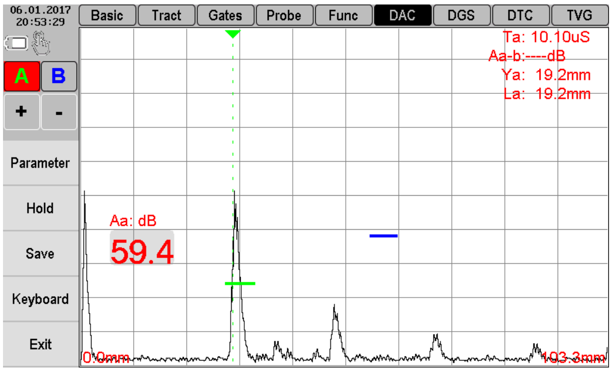


Figure 2.50 – Displaying of the signal amplitude value in A-gate - Aa

6. Turn on envelope curve mode («ENVEL») and fix the maximum signal amplitude in A-gate from the nearest (first) reflector (Figure 2.51).

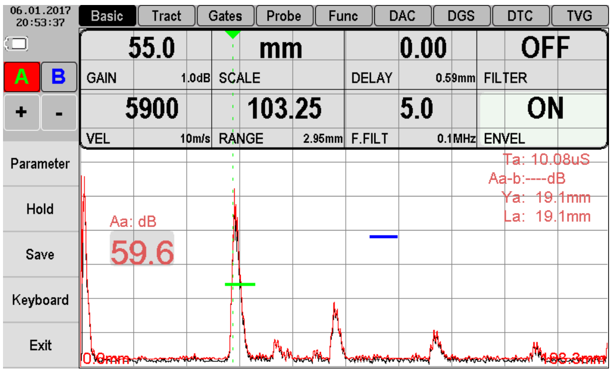


Figure 2.51 – Fixing the maximum signal amplitude in envelope curve mode

7. Set the reference signal amplitude «A Level» as the maximal amplitude from the first reflector (Figure 2.52) and turn on the input function of DAC («DAC – ON»),.

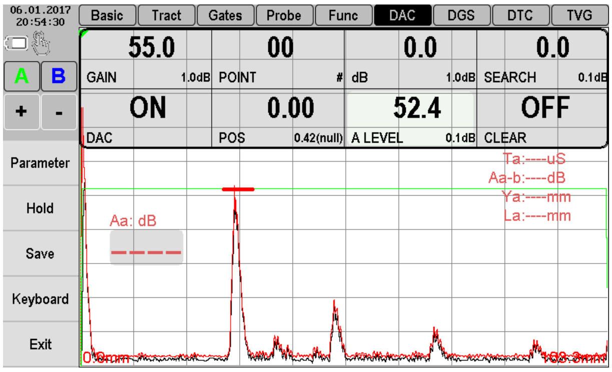


Figure 2.52 – Setting the reference signal for DAC mode

8. Select the point number (00 by fault) for the first reflected signal and set its position («POS») on the signal peak on A-scan (Figure. 2.53).

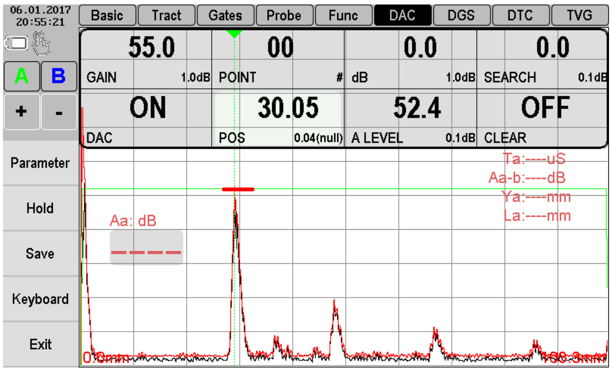


Figure 2.53 – Setting the position of the reference DAC point

9. Set damping «dB» equal to 0.0 dB.
10. Find the maximum signal from the next (second) reflector.
11. Select point number 01 for the second reflected signal and set its position («POS») on the peak of the signal on A-scan (Figure 2.54).

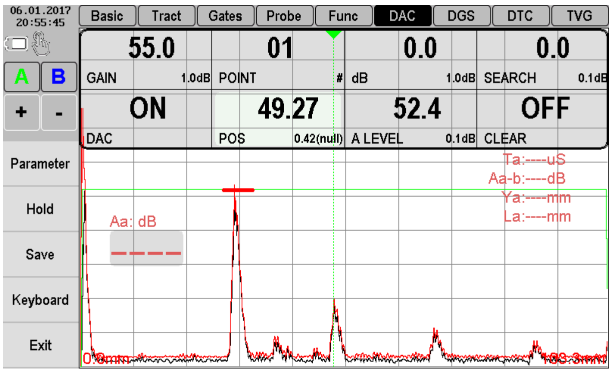


Figure 2.54 – Setting the position for the second reference DAC point

12. Set damping «dB» in a way, that DAC curve comes down to the level of the second signal peak (Figure 2.55).

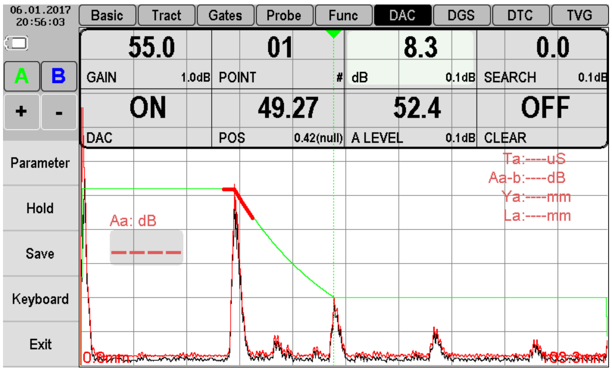


Figure 2.55 – Setting the damping for the second point signal

13. Find the maximum signal from the next (third) reflector.
14. Select point number 02 for the third reflected signal and set on A-scan its position («POS») on impulse peak of the third reflected signal (Figure 2.56).

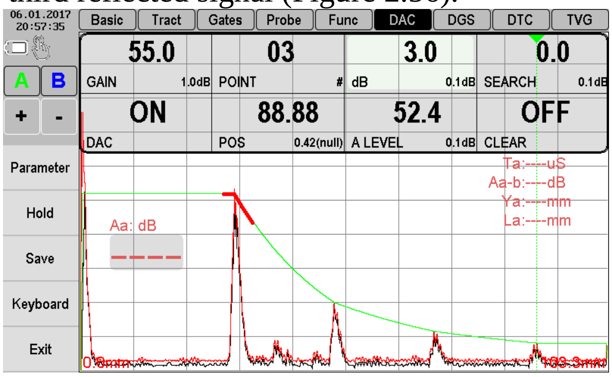


Figure 2.56 – Setting the position of the third reference DAC point

15. Set damping, that DAC curve comes down to the third reflector peak (Figure 2.57).

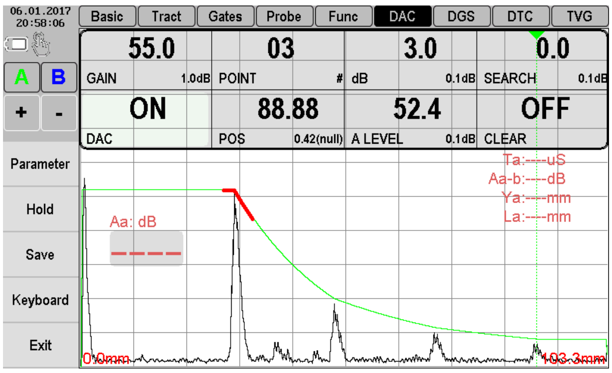


Figure 2.57 – Setting the damping of the third reference point

16. For every next reference point setting make similar operations as for points 01 and 02.

Note: The only one difference of DAC mode from the usual measurement mode is displaying of DAC curve. Echo-signals are displayed on the screen in real time without compensation

In DAC mode user can compare echo-signal amplitude with DAC curve, which allows to determine size of the real reflector in comparison to reference reflectors used for DAC curve making.

2.4.10 «DGS» mode

DGS curve describes amplitudes dependence on calibration reflector with different depths in material. For correct DGS setting should be input the right size of piezo-electric crystal plate of the probe in «Probe» parameters group (see p. 2.4.4).

Further DGS settings are made in «DGS» parameters group.

Settings are made on the standard sample (SS) with known equivalent area of reflector.

For setting it is necessary:

1. Put the probe on SS and find the maximum signal from the reflector with known equivalent size;
2. Input the size value of reference reflector to parameter «REF» (in mm^2), Figure 2.58.

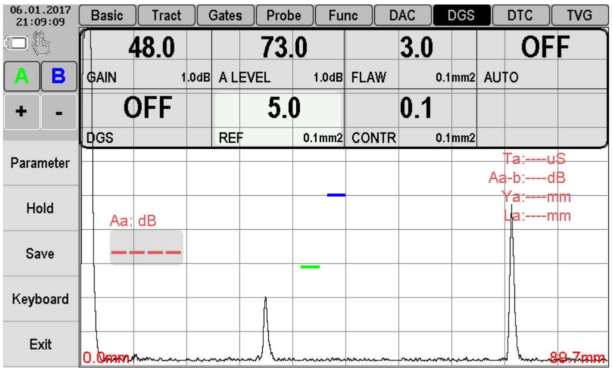


Figure 2.58 – Setting the equivalent reflector size - «REF» parameter

3. Get the reflected echo-signal from the equivalent reflector and overlap A-gate on it (Fig. 2.59).

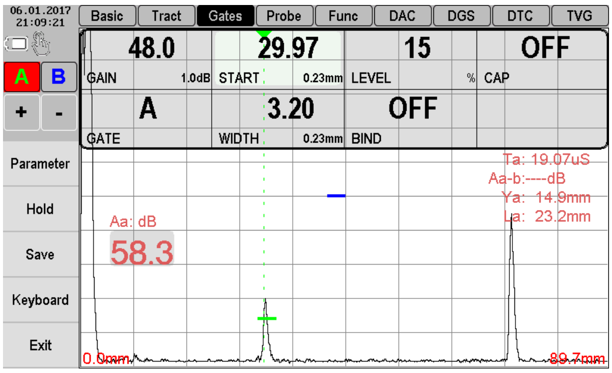


Figure 2.59 – Overlapping the gate on the reflected signal

4. Turn on the envelope curve mode and find the maximum reflector amplitude (Figure 2.60).

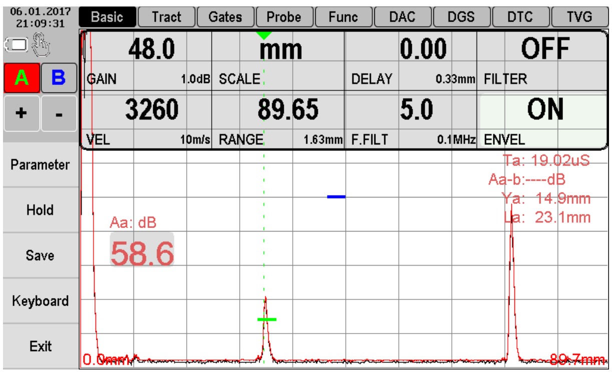


Figure 2.60 – Turning on the envelope curve mode

5. Turn on DGS mode by selection «ON» in «DGS» parameter.
6. Turn on the automatic DGS curve plotting by selection «ON» in «AUTO » parameter. The device automatically determines reference signal amplitude. Also, reference signal amplitude user can input manually via «A Level» parameter (Figure 2.61).

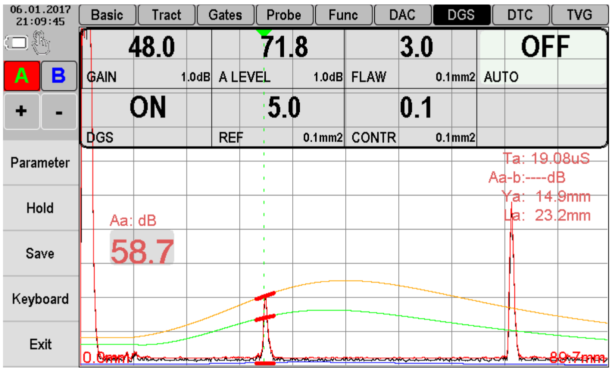


Figure 2.61 – DGS curve plotting - «AUTO» parameter is turned on

When using DGS mode, two additional curves could be made – rejection (sorting out) and control. To add the curves user has to open «FLAW» and «CONTR» parameters and to input the reflector size for rejection and for required control.

2.4.11 Additional modes

2.4.11.1 Envelope mode

In some cases, it is necessary to determine the signal maximum and get envelope curve when scanning one or another reflector (Figure 2.62). To turn on envelope mode user has to select parameter «ENVEL» in «Func» parameter group and set «ON».

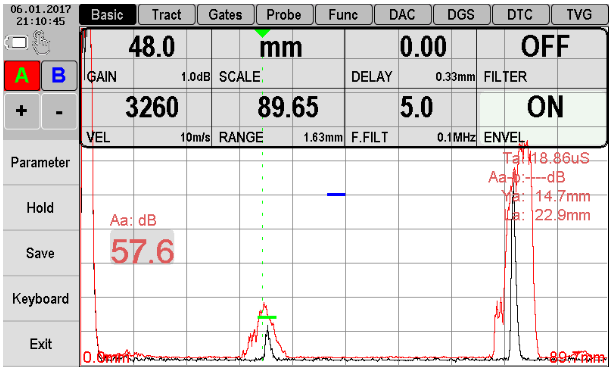


Figure 2.62 – Envelope mode is turned on - parameter «ENVEL»

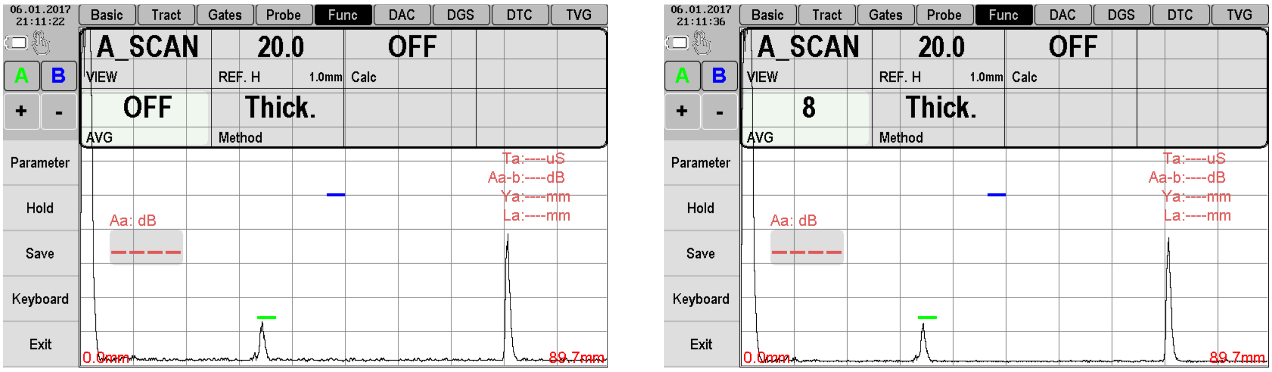
2.4.11.2 Measurement mode with signal averaging

In some case, when testing materials with high damping or large-sized objects, or when operating with long scanning time, noise amplitude could be equal to the valid signal amplitude. And due to high noise, it becomes difficult to identify the valid signal.

For these cases measurement mode with signal averaging is used over 2, 4, 8 and 16 signals. To turn on averaging mode user has to activate parameter «AVG» in parameter group «Func» by setting required quantity of signals for averaging (Figure 2.63).

Caution!

When averaging mode is tuned on, period for signal updating becomes longer.



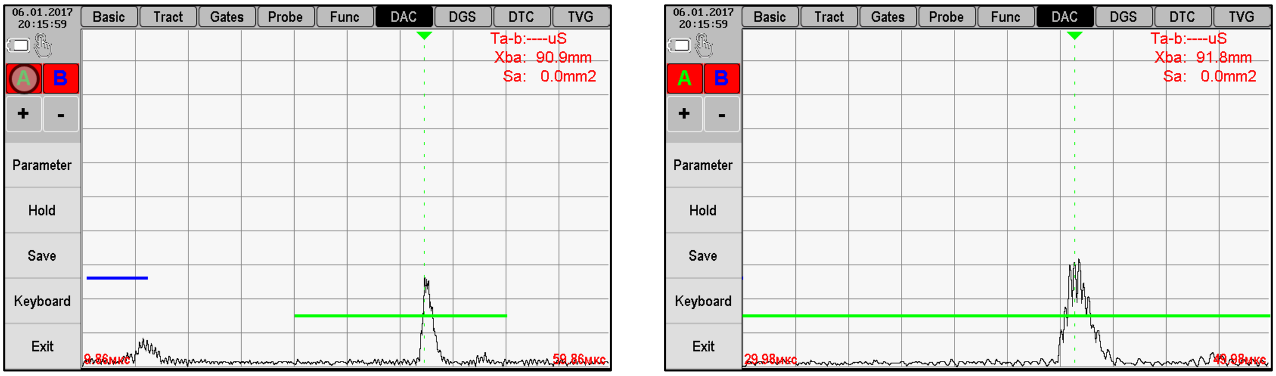
a) averaging mode is turned on b) averaging mode over 8 signals

Figure 2.63 – Measurement mode with signal averaging - «AVG» parameter

2.4.11.3 «Auto ZOOM» mode

«Auto ZOOM» mode allows to focus scanning time on the signal, that crosses the gate. To turn on the mode user has to select «ON» in «Auto ZOOM» parameter, in «SETTINGS».

Focusing on A-gate is made by touching the symbol of gate signalization «A» (Figure 2.64, a), focusing on B-gate - by touching the symbol «B».



a) selection of «Auto ZOOM» mode for A-gate b) «Auto ZOOM» mode for A-gate

Figure 2.64 – «Auto ZOOM» mode for A-gate

To turn off «Auto ZOOM» mode user has to touch once more the symbol of the gate signalization.

2.4.12 Operating with device memory

There are two modes for operating with device memory: «ARCHIVE» and «RESULTS».

2.4.12.1 Saving of measurement results and device settings

Saving of the current settings or measurement results is made in «FLAW DETECTOR» mode by pushing key «» or «SAVE». After this, panel for saving type selection is appeared on the screen (Figure 2.65).

User selects the required type of saving by navigation keys «», «» and confirm the selection by pushing key «» or touching the selected type by finger on the screen. After type selection of saving keyboard appears on the screen for entering the name of saving (Figure 2.66).

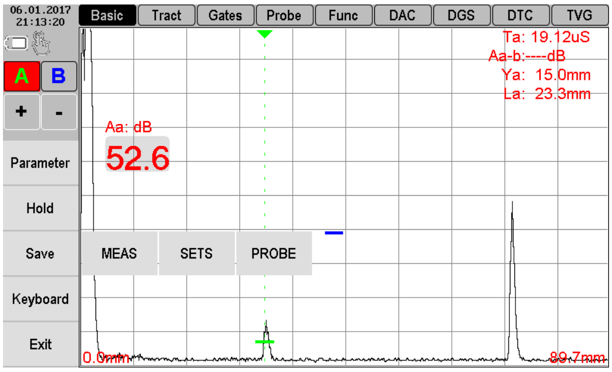


Figure 2.65 – Type selection for saving

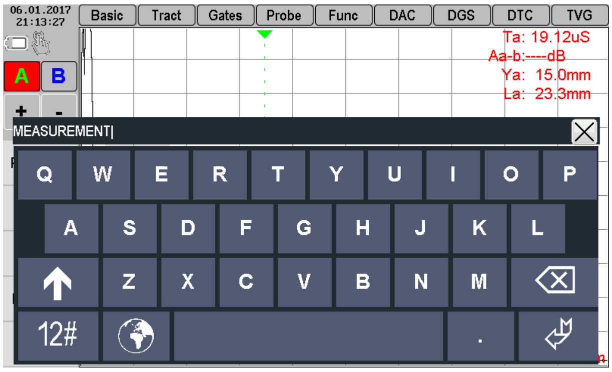


Figure 2.66 – Input the name of saving

Input of the name for saving is made by touch screen. To finish the input and save the results push key «ENTER». After name input, measurement result saved as separate file. After saving «SUCCESSFUL» appears on the screen.

2.4.12.2 «ARCHIVE» mode

«ARCHIVE» mode is used to operate with saved settings for measurements and probes. The mode allows user to see all previously saved settings for measurements (Figure 2.67) and probes (Figure 2.68), if necessary; user can download them in order to continue testing with required settings.

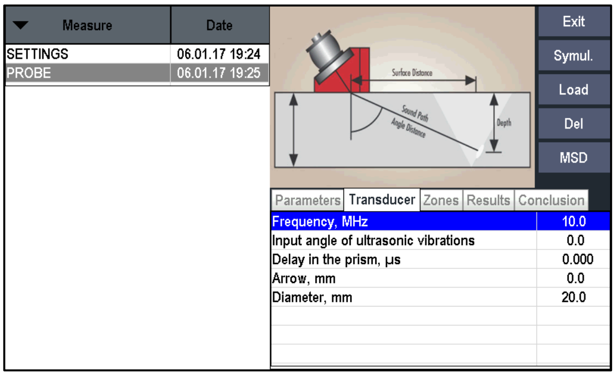


Figure 2.67 – View of previously saved settings for measurements

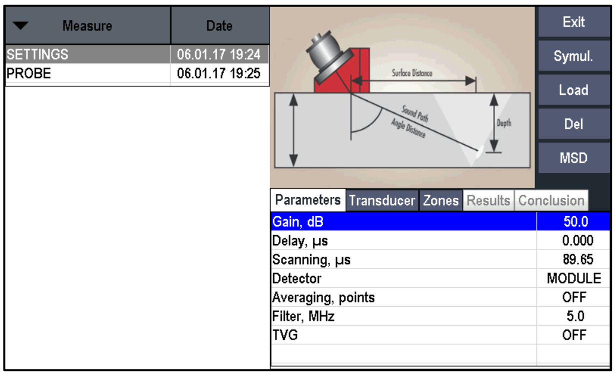


Figure 2.68 – View of previously saved settings for probes

Previously saved results are performed as a list and could be sorted over creation date or saving name. For operation with file user has to select required one by finger. After this, file information and file manipulations are available. User can look through parameters of saved settings by selecting tabs («PARAMETERS», «PROBE», «GATES») in the right part of the screen, download settings to the device («LOAD») or delete from device memory («DEL»).

2.4.12.3 «RESULTS» mode

«RESULTS» mode allows to see all previously saved measurement results (Figure 2.69) and, if necessary, to select file in order to continue testing with required settings.

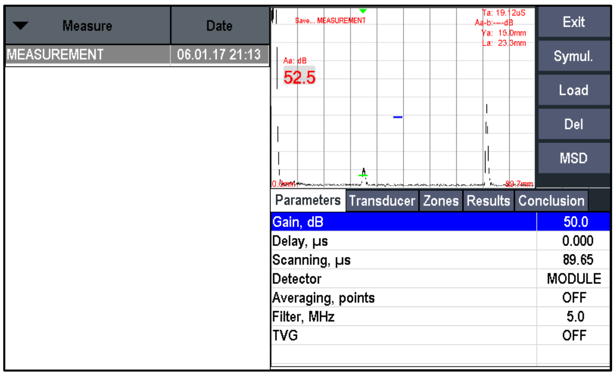


Figure 2.69 – View of the saved measurement results

Previously saved results are performed as a list and could be sorted over creation date or saving name. For operation with file use has to select required one by finger. After this, file information and file manipulations are available.

Available file manipulations:

- View, by selecting tabs («PARAMETER», «PROBE», «GATES», «RESULTS») in the right part of the screen;
- Start simulation mode («SIMULATOR»);
- Download results to the device («LOAD»);
- Delete results from device memory («DEL»);
- Write a report about made testing.

2.4.12.4 «SIMULATOR» mode

«SIMULATOR» mode is used for simulation of previously made and saved testing in «FLAW DETECTOR» mode.

This mode allows to make full-scaled testing of the received signal on the sample. All the device functions are available, the same as in «FLAW DETECTOR» mode when testing the real signal, except «GAIN» function.

So, user can study previously saved testing more detailed with possible displaying of additional parameters on the screen.

2.5 Calibration of flaw detector

2.5.1 Determination of delay in the prism for straight beam probe

While operating with straight beam probe, the prism of the probe is scatting. As a result, signal delay in the prism changes. Taking into account, that time of UT waves penetration into the probe prism makes a big influence on correct calculation of reflector coordinates, it is very important to make precise measurement of delay in the prism and to correct this parameter regularly.

Determination of delay in the prism of the straight beam probe is made by standard calibration block SO-2.

For determination of delay in the probe prism user has to get the first reflected signal (first echo-signal) on standard calibration block SO-2 along the 59 mm side and put this signal in one of the control gates, for example in A-gate.

Delay measurement could be made by time or distance of UT waves penetration.

Method 1: by time:

Select measurement parameters to display – output on the screen the value of penetration time for required control gate, in this particular case – Ta.

Time (in microseconds) of UT waves penetration in the prism of the probe is equal to:

$$2t = t_1 - t_{block}, \tag{2.1}$$

where t_1 – time between excitation impulse and echo-signal from the surface of the calibration block SO-2 along the 59 mm side, when the probe is set in position for getting the maximum echo-signal amplitude, in our case – value of the parameter Ta;

t_{block} (≈ 20μs) – time of UT waves penetration in the calibration block SO-2 along the 59 mm side.

Method 2: by distance:

Select measurement parameters to display – output on the screen the value of the reflector distance along the probe beam or coordinate of signal depth for required control gate, in this particular case – La and Ya respectively.

Set the parameter «VEL» (velocity of UT waves penetration in the calibration block, is taken from the block specification).

By changing parameter «DELAY» in parameter group «Probe» make the value of La or Ya, equal the value from the block specification or measured by caliper.

2.5.2 Determination of delay in the prism for angle beam probe

While operating with angle beam probe, the refractive prism of the probe is scatting. As a result, signal delay in the prism changes. Taking into account, that time of UT waves penetration into the probe prism makes a big influence on correct calculation of reflector coordinates, it is very important to make precise measurement of delay in the prism and to correct this parameter regularly.

For determination of delay in the probe prism, standard calibration block SO-3 is used.

For determination of delay it is necessary to get the signal, that reflects from the radius surface of the standard calibration block SO-3.

Procedure of delay determination the prism for angle beam probe:

1. Set the probe, through contact lubricant layer, on the standard calibration block CB3 in a way, that output point of the probe beam coincides with zero point of the block (figure 2.70).

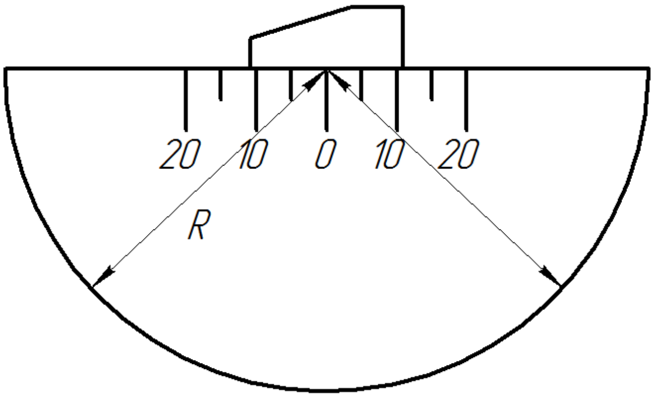


Figure 2.70 – Setting the probe on calibration block SO-3

2. On the device screen multiple reflection echo appears. Find the maximum amplitude value.
3. Using gain, make two first signals exceed the standard level (the signal should be within screen boarders, if necessary, use TVG).
4. Overlap A-gate on the first reflected signal, B-gate – on the second.
5. Output parameter values «La», «Lb» and «La-Lb» on the screen. Beam will be equal to calibration block radius.
6. Make «La-Lb» value equal to 110 mm by changing parameter «VEL».
7. By changing parameter «DELAY» in parameter group «Probe» make «La» value equal to radius of calibration block SO-3, according to the specification - 55 mm.
8. Repeat procedure of delay determination 3-5 times to get better accuracy.

2.5.3 Determination of entry angle of the probe

Determination of entry angle of the angle beam probe in A or B position (Figure 2.71). Moving of angle beam probe near these positions, user seek maximum of the echo signal from the reflector (cylindrical hole Ø 6 mm. located at a depth of 44 mm or 15 mm for the various positions of probes). Value of the angle is specified on the marks of the corner scale opposite the output point of ultrasonic beam.

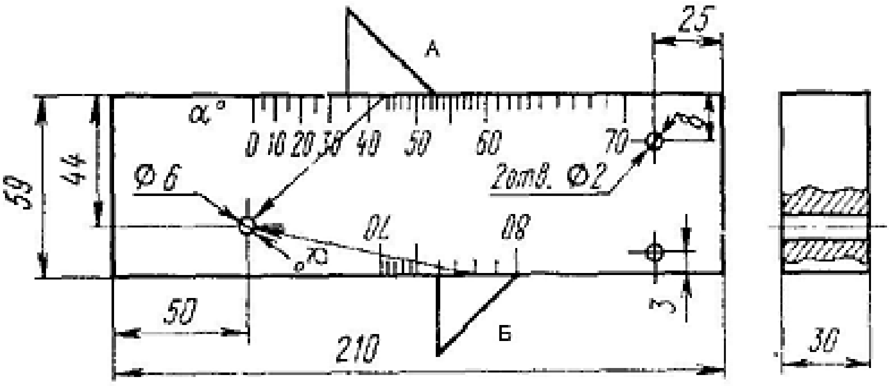


Figure 2.71 – Test block №2

2.5.4 Determination of probe arrow

To find output point “0” for ultrasonic beam of angle beam, put probe on the central mark "0" (Figure 2.72) and by shifting motions find probe position, that is corresponding to the maximum echo signal. Output point is located exactly above the center mark of the sample.

Arrow of the probe is defined in millimeters as a distance from the output point of the ultrasonic beam to the end of the transducer body in the direction of scanning (measured by side scale in millimeters).

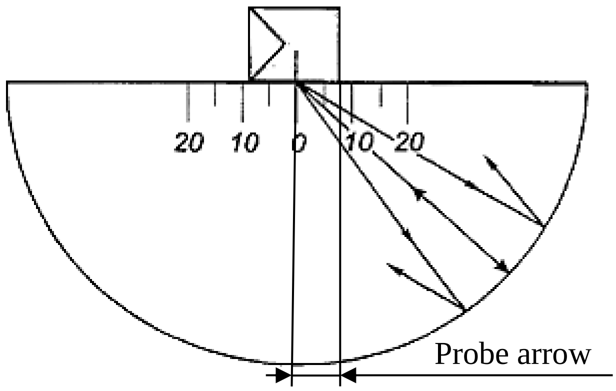


Figure 2.72 – Determination of probe arrow by standard calibration block SO-3

2.5.5 Determination of UT waves velocity in the tested object by straight beam probe

Measurement the velocity of ultrasonic can be performed directly on the tested object or with the samples made from the same material.

For velocity measurement do the following:

1. Select the place on the product (or on the sample made from the same material) where thickness measurement of the sample could be measured by using appropriate probe.
2. Mechanically, with required accuracy make measurement of real thickness at the testing point.
3. Set the probe, through couplant, on the sample with known thickness (Figure 2.73).

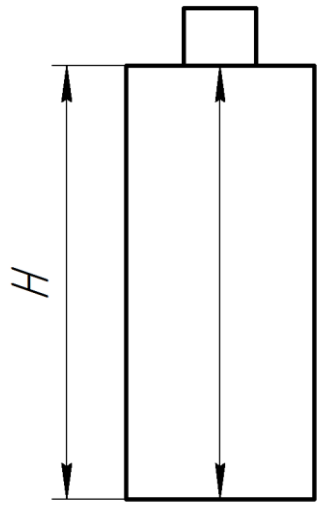


Figure 2.73 – Setting the probe on the sample

4. On the device screen multiple reflection echo appears (1H, 2H, 3H etc.).
5. Using gain, make two first signals exceed the standard level (the signal should be within screen boarders, if necessary, use TVG).
6. Overlap A-gate on the first reflected signal, B-gate – on the second.
7. Check setting «0» of parameter «ANGLE» in parameter group «Probe».
8. Output parameter values «Ya», «Yb» and «Ya-Yb» (for straight beam probe it is possible to use «La», «Lb» and «La-Lb», beam will be equal to the depth).
9. By changing parameter «VEL» make «Ya-Yb» value equal to measured value H on the sample.
10. By changing parameter «DELAY» in parameter group «Probe» make «Ya» value equal to measured value H on the sample.
11. Repeat procedure of delay determination 3-5 times to get better accuracy.

2.6 Connecting the device to PC

2.6.1 Software installation AWP_UD3701

While the device is connected to PC, user can send data from the device and vice-versa on the device (Flash mode of memory). In the device saved data is stocked in archive.

For device connection to PC, user should do the following:

1. Copy driver «CP210x_VCP_Windows» and program «AWP_UD3701» to PC hard drive or download actual version from the official site.
2. After downloading, open archive - two folders will be available: one with driver and other with program (Figure. 2.74).

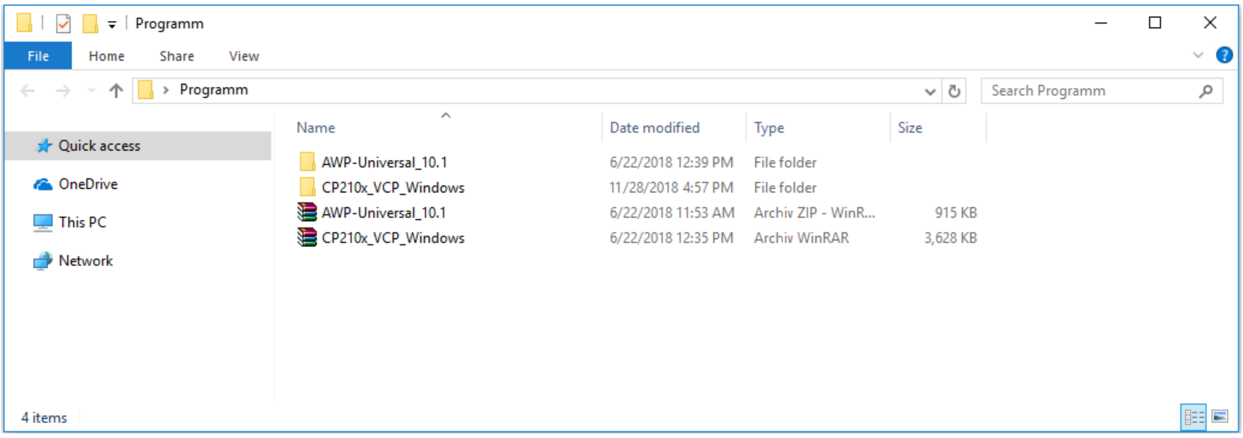


Figure 2.74 – Software downloaded

3. Install driver on PC.

Note – <u>After message about successful downloading it is recommended to restart PC</u>

4. Now the device could be connected to PC via USB cable from the standard delivery set. After connection, PC founds a new device and starts required driver.
5. Install the program for device operation. For this launch installation file (setup.exe) from folder «AWP_UD3701» and click «Install» (Figure. 2.75).

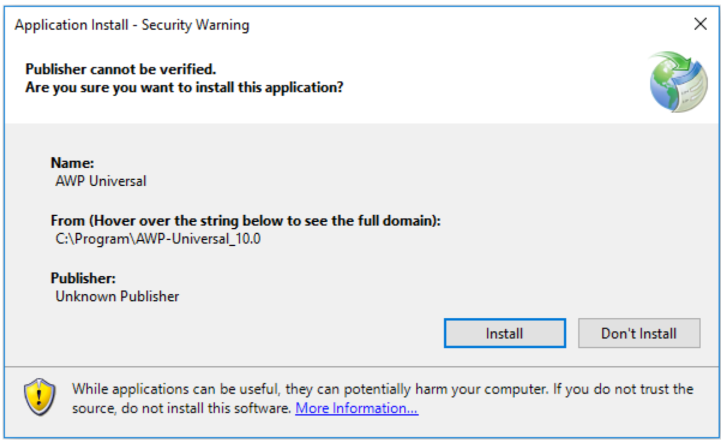


Figure 2.75 – Installation AWP_UD3701

6. After installation finished, the program starts automatically and program label «AWP_UD3701» appears on the PC desktop.

2.6.2 Software operation AWP_UD3701

When program starts at first time, selection window is opened, where user has to choose the location of archive for measurement data storage (figure. 2.76). After this program main window opens (Figure 2.77). To change archive location, user must click on archive path and chose new location.

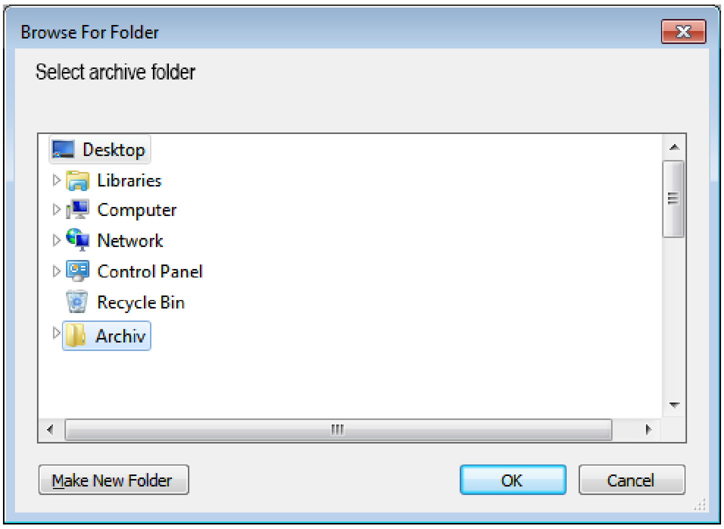


Figure 2.76 – Selection of archive location

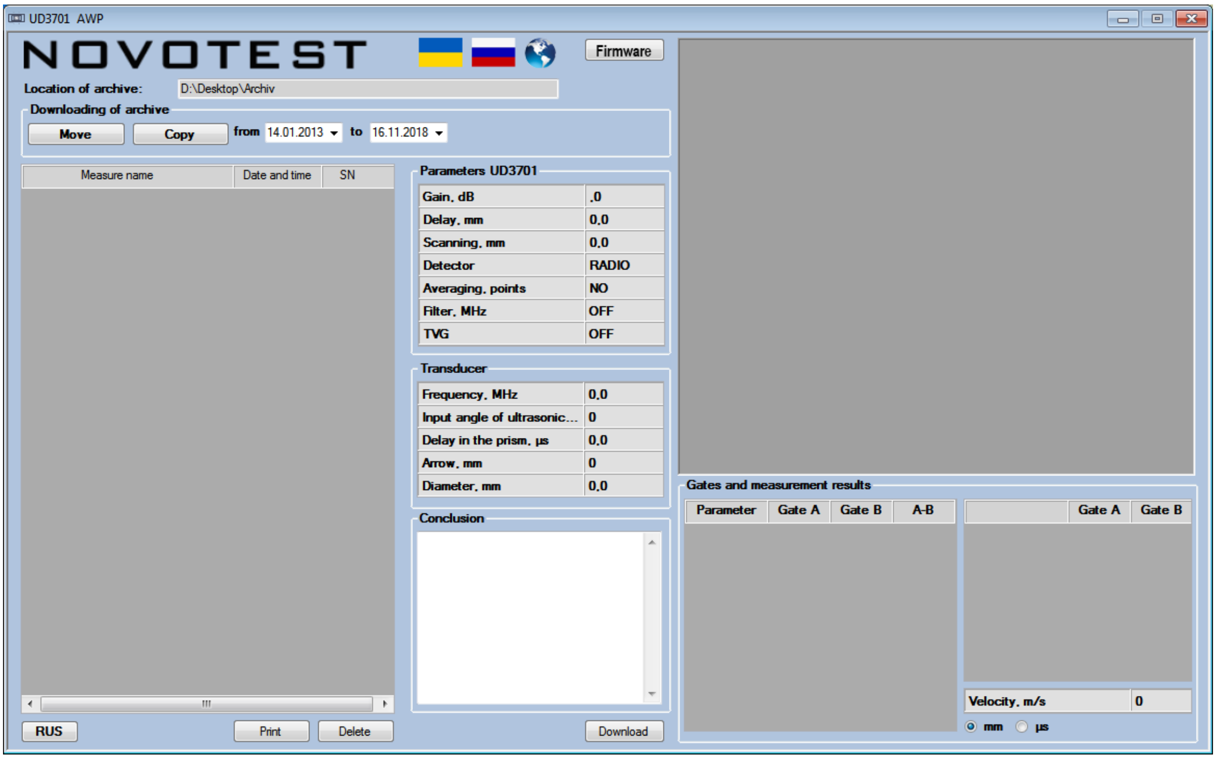


Figure 2.77 – Program «AWP_UD3701»

Selection of the program language (Russian/English) is made by clicking the button «ENG/RUS».

Note – <u>To visit our site user must click one of the flags (Ukrainian and Russian sites) or “Planet” icon (international site in English). After that, site opens in browser by default.</u>

2.6.2.1 Data transfer to PC

To transfer saved in device memory data to PC, user has to connect flaw detector to PC end enter the device «MAIN MENU». For correct data transfer to PC, user should set time period of measurements in program and push button «COPY».

Note – <u>If user push button «MOVE», data is not only moved to PC, but also is deleted from device memory.</u>

Program determines quantity of saved measurements and then proposes to download (Figure. 2.78). Data downloading starts after clicking «Yes» button.

Note – <u>Connection is successful, if two boxes are green on the device (Figure 2.79). If only the right box is green, then USB cable is not connected. If one of the boxes is red, it means that driver was installed with an error or was not installed at all.</u>

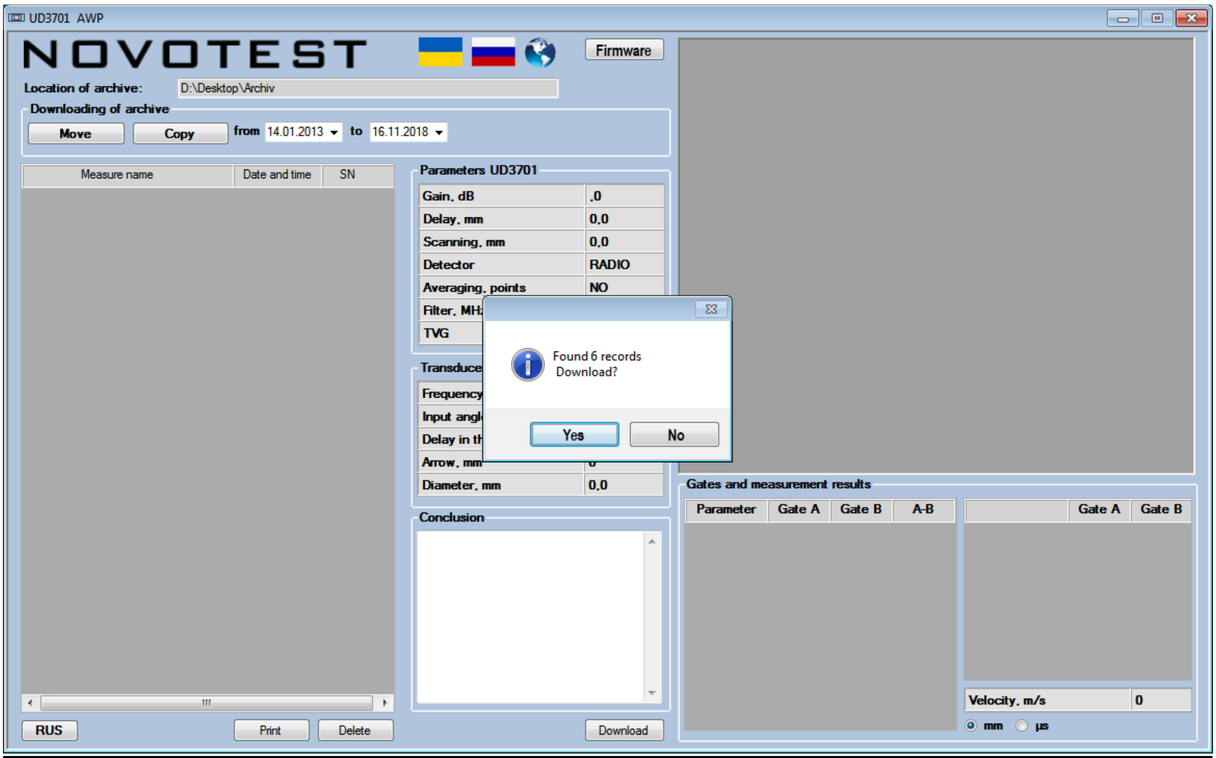


Figure 2.78 – Downloading of saved measurements to PC

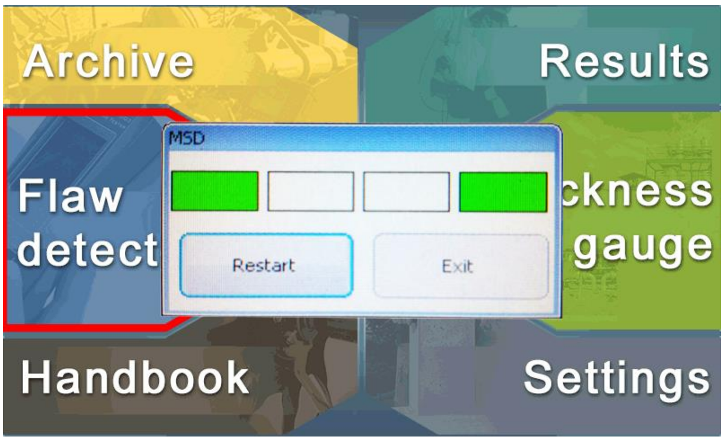


Figure 2.79 – Indication in case of successful connection to PC

Note – <u>After data downloading to PC, the devise restarts automatically.</u>

2.6.2.2 Data processing on PC

Due to program «AWP_UD3701» (Figure. 2.80) user can look through, copy, transfer and print data from the device archive, which was downloaded to PC. Also, user can delete result information by clicking button «Delete».

Every result is saved with full information about measurement, in result window short information is shown:

– Measurement name;
– Date and time;
– Serial number of the device.

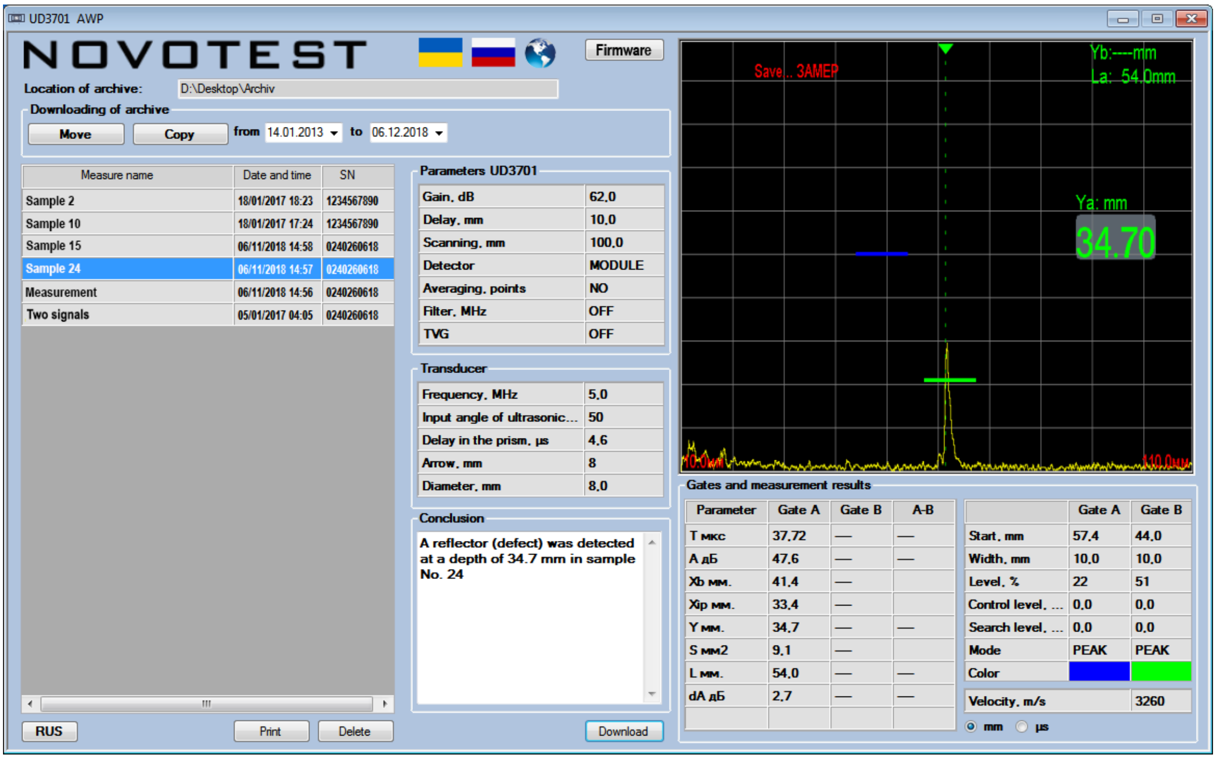


Figure 2.80 – Program «AWP_UD3701» with downloaded results.

In program windows parameters are displayed, which were set in the device at the time of saving the measurement result:

– Gain, dB;
– Delay, mm;
– Scanning, mm;
– Detector;
– Averaging, points;
– Filter, MHz;
– TVG;

and installed parameters of the probe:

– Frequency, MHz;
– Entry angle of UT waves;
– Delay in the prism, µs;
– Arrow, mm;
– Diameter, mm.

In the window «GATES AND MEASUREMENT RESULTS» measurement results are displayed:

- Signal time value (T), µs;
- Signal amplitude value (A), dB;
- Front surface distance of the signal (Xb), mm;
- Input signal distance (Xip), mm;
- Coordinate of signal depth (Y), mm;
- Equivalent size of the signal (S), mm^2;
- Distance to reflector along beam (L), mm;
- Signal level value (dB) from A-gate (B-gate) to maximum signal, dB;

and gate parameters:

- Start, mm;
- Width, mm;
- Level, %;
- Control level;
- Search level;
- Mode;
- Color.

Also, in the window «GATES AND MEASUREMENT RESULTS» velocity of UT waves propagation in material is displayed in m/s.

In the window «Report» is displayed information about testing, which was made by user. In program user can make additional about measurements were made and save them by clicking button «Save».

User can change units of measurements in program: mm or µs.

This information user can print in a moment by pushing button «Print». Window for printing opens (Figure 2.81), where user can select printer and its parameters for data printing. After clicking button «OK», window shows a previewing of testing report (UD3701) (Figure 2.82).

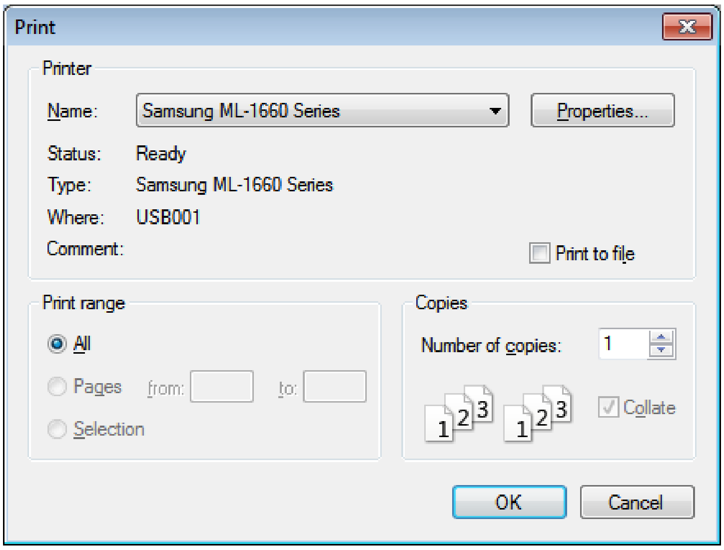


Figure 2.81 – Print window

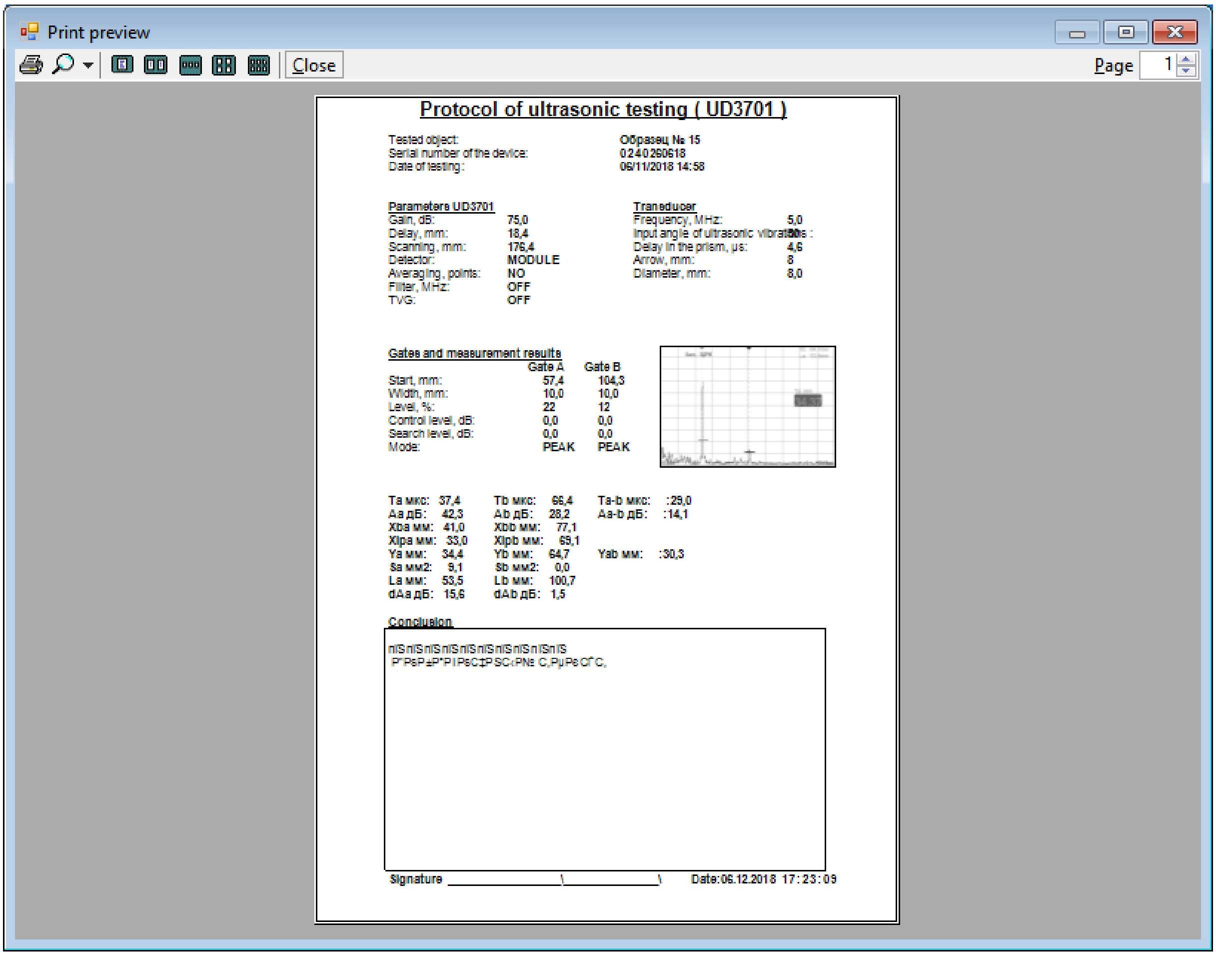


Figure 2.82 – Previewing of testing report (UD3701)

2.6.2.3 Updating of device software

All NOVOTEST devices allow user to upgrade software by himself. It is very convenient because devices are improved. Thus, user can get additional functions for free by upgrading software.

For new software installation user must click on button «Firmware». After this, updated version of software will be downloaded to UD3701 from company server. After downloading, proposition to restart your PC will appear.

Note – <u>PC should have internet connection for downloading.</u>

After downloading finished, the device restarts by default. It is recommended to enter «SETTINGS» mode and make reset to manufacturer settings (factory RESET).

3 TECHNICAL MAINTENANCE OF THE PRODUCT AND ITS COMPONENTS

3.1 Safety measures

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

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

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

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

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

3.2 Verification

The recommended verification interval is at least once a year.

The verification procedure (calibration; hereinafter - verification) applies to Flaw Detector NOVOTEST UD3701 and establishes methods and means of their primary and periodic verification.

3.2.1 Verification and verifying instruments

During the verification, it is necessary to carry out operations and to apply verifying instruments specified in Table 3.1. Main metrological and technical characteristics of verifying instruments are specified in Table 3.2.

Table 3.1 – Operations and verification means

Verification operation	Paragraph number	Verifying instruments
Visual inspection	3.2.3	
Testing	3.2.4	Set of industry standard blocks KMD 4
Determination of the modal accuracy when measuring echo-signal amplitudes from defects	3.2.5	Ultrasonic tester MX01-UZT-1, generator Tektronix AFG320
Checking the nonlinearity of vertical scanning	3.2.6	Ultrasonic tester MX01-UZT-1, generator Tektronix AFG320
Determination of reference values of conventional response, range of the control gate and signal/noise ratio	3.2.7	Set of industry standard blocks KMD 4, set of KOU-2
Determination of the basic accuracy when measuring distance to the defect (thickness) by straight beam probes	3.2.8	Set of industry standard blocks KMD 4

Table 3.2 – Verifying instruments and their main metrological and technical characteristics

Verifying instruments	Main metrological and technical characteristics
Oscillograph Tektronix TDS 1002	Frequency range: from 0 Hz too 60 MHz; Amplitude of testing signals with divider: 1:10 to 500 V; Accuracy for amplitude measurement: ± 5 %
Generator Tektronix AFG320	Frequency range: from 0,01 Hz to 16 MHz; Amplitude: from 50 mV to 10 V; Phase angle: from 0 to 360 °
Ultrasonic tester MX01-UZT-1	Radio-impulse frequency, MHz: 0,6; 1,2; 1,8; 2,5; 5,0; 10,0; Range of amplitude attenuation: from 0 to 101, step 0,1 dB; Radio-impulse delay: from 0,5 to 6500 μs.
Set of thickness standard blocks for US testing KUSOT-180 (40X13)	Range of effective thickness (depth) for 40X13 steel when velocity of UT waves propagation is 6050 ± 30 m/s: from 0,2 to 300,0 mm, Δ = ± 0,7 % for range 0,2 – 5,0 mm, Δ = ± 0,4 % for range 6,0 – 10,0 mm, Δ = ± 0,3 % for range 12,0 – 300,0 mm.
Set of industry standard blocks KMD 4	Reflector diameter, mm: from 1,0 to 3,2; Reflector depth, mm: from 1,0 to 180
Standard calibration block SO-1 from the set KOU-2 TU 25-0618847-78	Reflector diameter, mm: 2,0; Reflector depth, mm: from 5,0 to 60,0

Note:

1 *Other verifying instruments are available, which allow to define metrological characteristics within maximum permissible accuracy.*

2 *Verifying instruments, which are applied, should include valid Verification certificates.*

3.2.2 Requirements for verification officer qualification, requirements for safety and verification conditions

For verification are only allowed personnel, which have valid certificates of verification officer, are certified according to established procedure, get through a safety precautions training, have read and understand this operation manual and operation instructions for verifying instruments.

While making verification, electrical safety precautions are to be kept up in accordance with operation instructions for verifying instruments.

All the mains-operated devices should be electrically grounded.

Verification process does not have relation to harmful working conditions and does not damage the environment.

Verification of the device is carried out under climatic conditions:

– temperature from 15 to 28^{0}C;
– relative humidity 65 ± 15 %;
– pressure 101 ± 2 kPa.
– AC mains supply voltage: from 187 to 242 V and frequency 50 ±1 Hz;
– maximum harmonic distortions of AC mains – not more 5%.

Before verification (calibration) are carrying out, flaw detector should stay in above conditions at least 8 hours.

Before verification (calibration) starts, verifying instruments and flaw detector are to prepared in accordance with their operation instructions.

3.2.3 Visual inspection

Visual inspection is necessary to check:

- completeness of equipment according to OM;
- no mechanical damages to the flaw detector and its parts: probes, connectors and connecting cables;
- no foreign particles inside the device user could found when tilts it;
- marking to identify type and serial number of the flaw detector.

3.2.4 Functionality test

Before connecting the flaw detector to AC mains supply, it is necessary to connect external mains adapter to the socket on bottom part of the device. Plug in the mains adapter.

For functionality test of the device do the following:

1. Turn on flaw detector by power-on key on the front panel. Main menu appears on the screen (settings of parameters and modes are according to the last device operation).
2. Test the keyboard functionality: navigation keys, parameter changing, direct gain control, mode selection. Check the possibility of coarse and precise parameter setting.
3. Check the possibility to change by flaw detector following parameters: measurement range, US velocity, scanning delay, beginning, duration and level of the gate, selection of monitoring pulse mode.
4. Enter parameter group «Probe» and set the parameter «DUAL – OFF» (single-element probe).
5. Connect single-element probe P111-2,5-K12 to generator output (left socket) on the upper panel of flaw detector.
6. Set in parameter groups of the device following parameter values:
   - velocity of UT propagation 6063 m/s («VEL – 6063 m/s»);
   - measurement range 100 mm («RANGE – 100 mm»);
   - probe frequency 2,5 MHz («FREQ – 2,5 MHz»);
   - generator voltage probe pulse – U3 (parameter group «Tract» parameter «Energy – U3»);
   - level of the gate – 50 % (parameter group «Gates» parameter «Level – 50%»);
   - method of echo-signal measurement – by peak («MEAS – PEAK»).
7. Put couplant on MD4-0-6 with height H = 20 mm and set the probe on MD4-0-6 surface with no defects. Get view of five echo-signals by changing gain with 1,0 dB step. They should be located on marks of scanning: 2, 4, 6, 8 and 10 marks.
8. Check functionality of all the device tabs by keyboard.

Detector is passed inspection, if all operations of functionality are tested successfully.

3.2.5 Determination of the modal accuracy when measuring echo-signal amplitudes from defects

For determination of the modal accuracy when measuring echo-signal amplitudes from defects it is necessary:

1. Make a connection diagram shown in Figure 3.2, where R = 51 Ohm (C2-10-0,25-51 Ohm ± 0,5%).

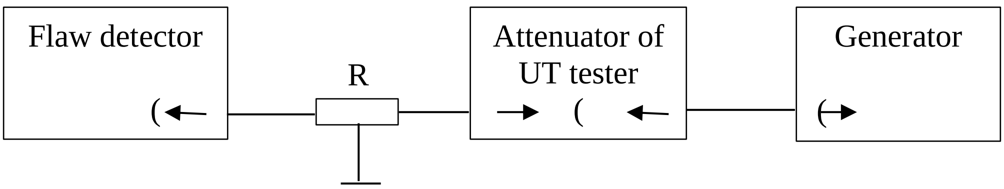


Figure 3.2 – Connection diagram of flaw detector for determination of the modal accuracy when measuring echo-signal amplitudes from defects

Set generator AFG320 controls in the following positions:
- function FUNC – SINE;
- frequency FREQUENCY – 2,5 MHz;
- amplitude AMPL – 2 V;
- offset OFFSET – 0 V;
- mode MODE – CONT;
- modulation MODULE – OFF;
- phase angle PHASE – 0°;
- channel 1 CH 1 – ON.

2. Set flaw detector parameters in the following way:
   - velocity of UT propagation 6063 m/s («VEL – 6063 m/s»);
   - measurement range 100 mm («RANGE – 100 mm»);
   - probe frequency 2,5 MHz («FREQ – 2,5 MHz»);
   - level of excitation generator – U1 («Energy – U1»);
   - level of the gate – 50 % (parameter group «Gates» - parameter «Level – 50%»);
   - method of echo-signal measurement – by peak («MEAS – PEAK»);
   - averaging of signals – 4 (parameter group «Func» - parameter «AVG – 4»);
   - probe type – dual element («DUAL – ON»).
3. Set in device parameter gain equal to 30 dB, set attenuation of tester attenuator - 1 dB.
4. Make the standard level (50% of the device screen) for displaying signal by keys of gain control of generator AFG320.
5. Overlay the gate on the signal. Make the exact position of the signal on standard level (50% of the device screen).
6. Increase gain of flaw detector on 10 dB with parallel increasing of attenuation of test attenuator, that required to return signal to standard level (50% of the device screen) Record determined value of increasing of attenuation of test attenuator $N_{att.}$
7. Calculate accuracy:

$$\Delta N = 10\ dB - N_{att.} \tag{3.1}$$

8. Repeat p.7 until gain 90 dB.
9. Algebraic sum of measurement accuracy ΔN should not exceed 2 dB.
10. Repeat p.4-10 for frequencies: 1,2; 1,8; 5,0; 10 MHz.

3.2.6 Checking the nonlinearity of vertical scanning

1. Make a connection diagram shown in Figure 3.2 (p. 3.3.6).
2. Set generator AFG320 controls in the following positions:
   - function FUNC – SINE;
   - frequency FREQUENCY – 2,5 MHz;
   - amplitude AMPL – 2 V;
   - offset OFFSET – 0 V;
   - mode MODE – CONT;
   - modulation MODULE – OFF;
   - phase angle PHASE – 0°;
   - channel 1 CH 1 – ON.
3. Set flaw detector parameters in the following way:
   - velocity of UT propagation 6063 m/s («VEL – 6063 m/s»);
   - measurement range 100 mm («RANGE – 100 mm»);
   - probe frequency 2,5 MHz («FREQ – 2,5 MHz»);

- level of excitation generator – U1 («Energy – U1»);
- level of the gate – 50 % (parameter group «Gates» parameter «Level – 50%»);
- method of echo-signal measurement – by peak («MEAS – PEAK»);
- averaging of signals – 4 (parameter group «Func» parameter «AVG – 4»);
- probe type – dual element («DUAL - ON»).

4. Get on the screen the signal from generator. Overlay A-gate on it.
5. Set alarm activation DTC for A-gate when the signal is higher the gate level (mode «MORE»).
6. Set minimum time for the gate, but under the condition that the whole signal is within the gate.
7. Set A-gate level 80 % of the screen.
8. Correct the signal level on the screen to 80 % of flaw detector screen by control keys of generator AFG320 amplitudes AFG320 (by visual monitoring and alarm activation DTC).
9. Determine the signal amplitude on the screen by changing the «Attenuation» controls of tester attenuator according to Table 3.3. Amplitude height should not exceed permissible values from Table 3.3.
10. Repeat p. 2 – 10 for frequency values: 1,2; 1,8; 5,0; 10 MHz.
11. For every frequency value, signal amplitude on the screen should comply with values shown in Table 3.3.

Table 3.3 – Receiver level for linearity of vertical scanning

Setting of external attenuator, dB	Reference amplitude, % of the screen	Measured amplitude, % of the screen
0	90	88 - 92
1	80	Starting level
3	64	62 - 66
5	50	48 - 52
7	40	38 - 42
11	25	23 - 27
13	20	18 - 22
19	10	8 - 12
25	5	3 - 7

3.2.7 Determination of reference values of conventional response, range of the control gate and signal/noise ratio

1. Connect single-element angle beam probe P121-5-50-M-003 to generator output.
2. Set the following flaw detector parameters:
   - measurement range 100 mm («RANGE – 100 mm»);
   - receiver frequency 5 MHz («FREQ – 5 MHZ»);
   - probe angle – 50° («ANGLE – 50»);
   - level of excitation generator – U3 («Energy – U3»);
   - gate level – 50 % (parameter group «Gates» parameter «Level – 50%»);
   - method of echo-signal measurement – by peak («MEAS – PEAK»);
   - probe type – single element («DUAL – OFF»).
3. Put the probe, through couplant, on the standard calibration block SO-1 and receive echo-signal from the nearest reflector with 2 mm diameter and 5 mm depth. Drive echo-signal to normal level (50 % of screen height) by gain control keys. Record value of conventional response in dB (N_s).

4. Drive noise-signal to normal level (50 % of screen height) by gain control keys. Record value of conventional response in dB (N_n).
5. Calculate signal/noise ratio:

$$N_{s/n} = N_s - N_n \tag{3.2}$$

6. Put the probe, through couplant, on the standard calibration block SO-1 and receive echo-signal from the most distance reflector with 2 mm diameter and 25 mm depth. Drive echo-signal to normal level (50 % of screen height) by gain control button. Record value of conventional response in dB (N_s).
7. Repeat operations from p. 4. Signal/noise ratio in every point should be at least 16 dB. Measured gain ratio and conventional response should not exceed values shown in Table A.1 (see Appendix A).

3.2.8 Determination of the basic accuracy when measuring distance to the defect (thickness) by straight beam probes

1. Connect single-element straight probe P111-2,5-K12 to generator output and make verification (p. 2.5).
2. Set flaw detector parameters in the following way:
   – velocity of UT propagation 6065 m/s («VEL – 6065 m/s»);
   – measurement range 30 mm («RANGE – 30 mm»);
   – probe frequency 2,5 MHz («FREQ – 2,5 MHz»);
   – probe angle – 0 («ANGLE - 0»)
   – level of excitation generator – U3 («Energy – U3»);
   – level of the gate – 50 % (parameter group «Gates» parameter «Level – 50%»);
   – method of echo-signal measurement – by peak («MEAS – PEAK»);
   – probe type – single element («DUAL – OFF»);
   – turn off TVG («TVG - OFF»;
   – cutting off – 0% (REJ – 0)
3. Output on the screen depth value «Ya».
4. Put couplant and put the probe on calibration block MD4-0-12 (depth 10 mm). Drive echo-signal of flat surface reflector-defect to 50 % of the screen by gain of flaw detector.
5. Overlay the gate on echo-signal. Measured value of reflector depth is displayed on the screen.
6. Set the depth value equal to reference reflector depth (10 mm) by changing parameter «DELAY» in parameter group «Probe».
7. Cover couplant and put the probe on calibration block MD4-0-14 (depth 180 mm). Increase scanning time up to 210 mm («RANGE – 210 mm»). Drive echo-signal of flat surface reflector-defect to 50 % of the screen by gain control.
8. Overlay the gate on echo-signal. Measured value of reflector depth is displayed on the screen.
9. Set the depth value equal to reference reflector depth (180 mm) by changing parameter «VEL» in parameter group «Basic».
10. Repeat p. 4 – 9 at least two times.
11. Determine the reflector depth for both calibration blocks MD4-0-12 (10 mm) and MD4-0-14 (180 mm). On every block make at least 5 depth measurement.
12. Calculate the basic absolute accuracy when measuring reflector depth in every standard block:

$$\Delta H = H_{cp} - H \,, \tag{3.3}$$

where H_{av} – average depth readings of flaw detector;
H – reference reflector depth in standard block.

Basic absolute accuracy ΔH when measuring reflector depth should not exceed ± (0,5+0,01·H) mm.

3.2.9 Data-report of verification

Data-report of device verification, recognized as operational, is confirmed by Certificate of verification (sealed and adopted).

Negative result is documented by letter of device unfitness with specifying the reason.

3.3 Warranty

The following warranty information is valid for all NOVOTEST products.

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

3.3.1 Basic Warranty

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

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

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

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

3.3.2 Extended warranty

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

3.3.3 Warranty for repaired or replaced parts

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

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

3.3.4 Wear parts

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

3.3.4.1 Parts replaced with routine maintenance

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

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

3.3.4.2 Wear parts

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

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

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

3.3.5 Duties of the owner

The “Operation Manual” contain information on the proper operation and maintenance of the device.

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

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

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

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

3.3.6 Warranty Limitations

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

- Damage caused by negligent/improper device operating, a natural disaster, water intrusion by an accident into the device, probe, accessories and parts of the device (not a manufacturing defect) or off-label device use;
- Operational wear of parts;

- User does not provide maintenance of the device within the specified time in accordance with NOVOTEST recommendations;
- Violation of the operating conditions of the device, recommended by NOVOTEST;
- Changes in the design of the device or its components, interference with the operation of the instrument systems, etc., without agreement with the manufacturer;
- Usage of batteries and other components of improper quality;
- Voltage drop in mains;
- When refuse to repair in time any damage identified during routine maintenance;
- Factors beyond NOVOTEST responsibility, for example: air pollution, hurricanes, chipped piece of damage, scratches and use of unsuitable cleaners;
- Application of repair technologies not approved by NOVOTEST;
- Usage of non-original NOVOTEST spare parts and fluids.

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

3.3.7 Other cases not covered by the warranty

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

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

3.3.8 Guarantees and consumer legislation

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

3.4 Maintenance of the device

This maintenance information is valid for all NOVOTEST products.

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

- preventive;
- planned.

Preventive maintenance is carried out at least once per three months and includes external inspection, clearing and greasing.

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

It is very important to carry out its maintenance in a timely manner throughout the life of the device. At the same time, it is necessary to follow the schedule presented in tab. 3.4 (focusing on the development of the device or the months of its operation, whichever comes first).

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

Records on the routine maintenance of the device are made in the passport for the device. Information about maintenance is very important, it is necessary to implement your rights to warranty repair of the device. Therefore, always check that at the end of the maintenance period your authorized NOVOTEST service center has stamped passport (other document is available) in the appropriate place under the record of the procedures performed.

Table 3.4 - Maintenance schedule for NOVOTEST

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

In case of the device fault detection, the device must be shipped to the manufacturer for maintenance. In Table. 3.5. Faults that can be fixed by user.

Table 3.5 - Possible malfunctions and methods of their elimination

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

4 MAINTENANCE

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

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

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

Warranty repair is carried out in the presence of a completed passport.

5 STORAGE

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

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

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

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

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

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

Devices should be stacked on shelves or stacked in transport packaging.

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

6 TRANSPORTATION

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

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

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

7 RESYCLING

The product does not contain in its design any dangerous or poisonous substances that can harm human health or the environment and do not pose a threat to life, health of people and the environment at the end of their service life. In this regard, the recycling of the product can be made according to the rules for the disposal of general industrial waste. Recycling is carried out separately by groups of materials: plastic elements, metal fasteners.

The content of precious metals in the components of the product (electronic cards, connectors, etc.) is extremely small, so it is not appropriate to produce their secondary processing.

APPENDIX A

Calculation of reflector equivalent area

For calculation of reflector equivalent area, it is necessary to know the following parameters:
α – entry angle of UT waves into the material;
v – velocity of UT waves propagation in the material;
f – probe frequency;
R – radius of the side drill hole;
x – defect depth;
r – distance of UT waves to defect along the beam;
λ = v/f – wave length in the material;
r_0 – length of near-field zone of the probe;
π = 3,1415 – constant;
Sp – effective area of the probe;
Lpr – beam path length in the prism (for approximate calculation could be 0);
vpr – velocity of UT waves in the prism.

$$L_{pr} = \frac{T_{pr} \cdot v_{pr}}{2} \cdot \frac{v_{pr}}{v}, \quad \text{(B.1)}$$

$$r = L_{pr} + \frac{x}{\cos[\alpha]}, \quad \text{(B.2)}$$

$$r_0 = \frac{S}{\lambda \cdot \pi}. \quad \text{(B.3)}$$

Reflector equivalent area for the side drill hole:

$$S = \lambda \cdot \sqrt{\frac{R \cdot r}{4}}. \quad \text{(B.4)}$$

For flat surface (angle):

$$S = \frac{r \cdot \lambda}{2}. \quad \text{(B.5)}$$

Example:

Approximate calculation of equivalent area of side drill hole for standard block SO-3R with diameter 6 mm and depth 44 mm for straight beam probe with frequency 2,5 MHz:

$$\lambda = \frac{5,9}{2,5} = 2,36мм; \quad r = 44 - \frac{6}{2} = 41мм; \quad S = 2,36 \cdot \sqrt{\frac{\frac{6}{2} \cdot 41}{4}} \approx 13,09мм^2.$$

Approximate calculation of equivalent area of side drill hole for standard block SO-3R with diameter 6 mm and depth 44 mm for angle beam probe with entry angle 40º and frequency 2,5 MHz:

$$\lambda = \frac{3,2}{2,5} = 1,28мм; \quad r = \frac{44}{\cos[40°]} - \frac{6}{2} = 54,44мм; \quad S = 1,28 \cdot \sqrt{\frac{\frac{6}{2} \cdot 54,44}{4}} \approx 15,08мм^2.$$

NOTES