“ACS-Service” Ltd.

Methodical Guidelines on using 1550 IntroVisor Ultrasonic Flaw Detector with digitally focused arrays in TOMOGRAPH mode

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Contents

1. General Provisions

1.1. Application Range

Current Guidelines set the procedure of preparation actions and ultrasonic inspection procedure using the A1550 IntroVisor Ultrasonic Flaw Detector with digitally focused arrays manufactured by “Acoustic Control Systems” Ltd. in the “TOMOGRAPH” mode.

Current Guidelines is based on current regulatory documents on ultrasonic inspection and their requirements.

1.2 Abbreviations used

DFA – antenna array (digitally focused)

TCG – time corrected gain (or DAC)

RR – reference reflector

CB – calibration block

1.3 Requirements for examination areas

Surface, on which the digitally focused array will be moved, shall be free from dust, dirt and rust. Surface roughness must be at least Rz 40. Surface waviness (ratio of maximum amount of deflection to waviness period) should not exceed 0.015.

1.4 Work activity management

The following working conditions should be met when doing inspection:

– framing and scaffolding should provide convenient position of the nondestructive inspection operator relative to the flaw-detection equipment, blocks (samples) and object under examination;

– bright light sources (electric welding and metal arc cutting stations, direct sunlight) must be screened;

– works causing vibration and making the nondestructive inspection operator and object under examination dirty with abrasive dust, must neither be simultaneous with inspection nor be held at the inspection place.

The inspection shall be carried out at ambient air temperatures and temperatures of the object surface at the place of inspection within range from –10 to +40°C.

The surface of the welded joint prepared for the inspection must be checked for compliance with the requirements specified in paragraph 0. Thoroughly wipe the surface with a cloth and apply a layer of the contact liquid on it prior to the inspection.

Contact liquid (lubricant) must be harmless for the nondestructive inspection operator. Above all, it must not irritate the skin. Use the lubricant of thicker consistency if the curvature of the surface of the object under examination is great and at high ambient air temperature.

1.5 Requirements for personnel

Only properly trained persons (those persons who have undergone training and successfully pass the qualification tests) shall be allowed to carry out the nondestructive inspection. Those persons must be certified on I, II or III qualification level according to PB 03-440-02 for the corresponding method of NONDESTRUCTIVE INSPECTION; have corresponding operating certificate of prescribed form, and they should as well undergo additional certification in accordance with OR-03.120.00-KTN-071-09.

Specialists performing the nondestructive inspection must have no medical contraindications for health reasons.

The procedure for issuing the licenses, their validity and extension mechanism is specified in PB 03-440-02.

Only specialists of the qualification level at least II according to PB 03-440-02 possess the right to issue decisions on the results of the nondestructive inspection.

Only specialists of the qualification level at least II according to PB 03-440-02 by at least two inspection methods, one of which is visual and measuring control, and other one – protection radiation survey or ultrasonic inspection shall be allowed to manage the quality control laboratory(group). At that their working experience in the nondestructive inspection field should be three years at least.

2. Carrying out inspection with a direct DFA M9060

2.1 Adjustment of the parameters of the basic configuration

Reference blocks are required for adjustment of the Flaw Detector, which are used for straight beam piezoelectric transducers in accordance with regulatory technical documentation. As a rule, these are reference blocks with flat bottom holes. Reference blocks must be made of the same material as the object under examination.

Let's consider operations on adjustment of the Flaw Detector and carrying out inspection using the example of inspection of the forging 160 mm thick. We use a reference block with the reference reflectors of the flat bottom drilling type, 2 mm diameter, for adjustment. Reference reflectors RR1. RR2. RR3. RR4. RR5 are located at depth h1=20 mm, h2=50 mm, h3=80 mm, h4=100 mm, h5=150 mm.

Connect DFA M9060 to the electronic unit of the Flaw Detector. Insert a large LEMO end fitting to the ARRAY connector, carefully aligning the red marks on both connectors. Insert the red end fitting into the OUT connector, and a black one – into the IN connector. Always switch off the instrument prior to connection/disconnection of the DFA.

Switch on the instrument. Switch to the "TOMOGRAPH" operation mode as follows:

– Press and hold the 

key;

– Use the  keys to select the operation mode in the opened window listing the modes (Figure 1);

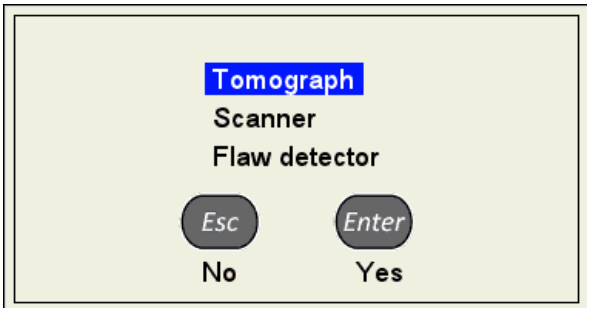


Figure 1 Mode selection window

– Press the 

key to conform the selected option.

Press the  key to enter the CONFIGURATIONS-TOMOGRAPH mode. At that the instrument's screen will display some information according to Figure 2. Use the  arrow keys to select the "Base straight" option. Press the key to confirm. A sign √ will appear next to the selected option (the option will be flagged).

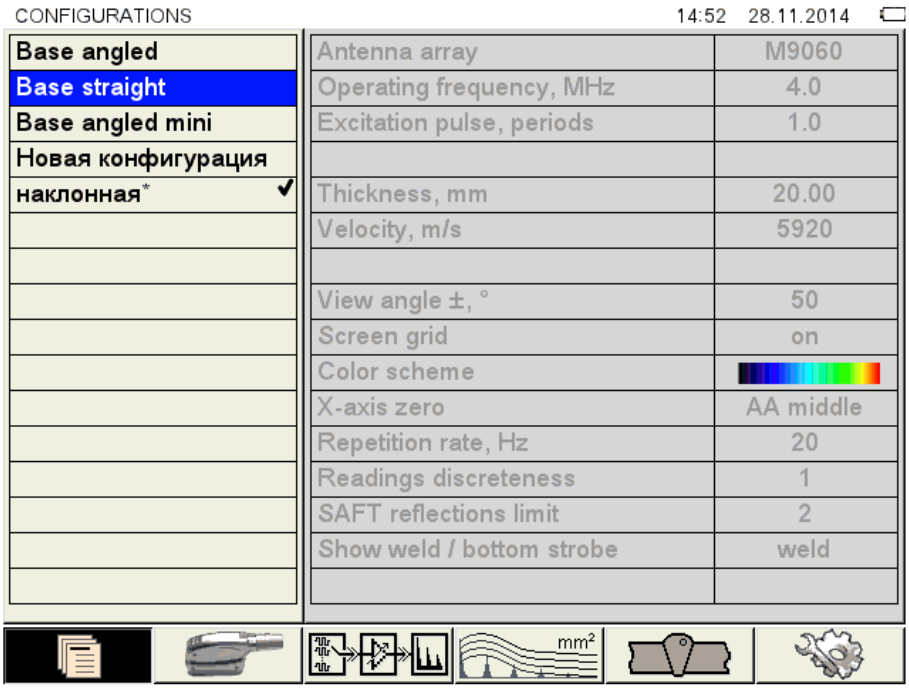


Figure 2 Entry point of the CONFIGURATIONS-TOMOGRAPH mode.

Press the  key to edit the values of the configuration parameters.

First tab – icon  – crowds the pack of the measurement parameters.

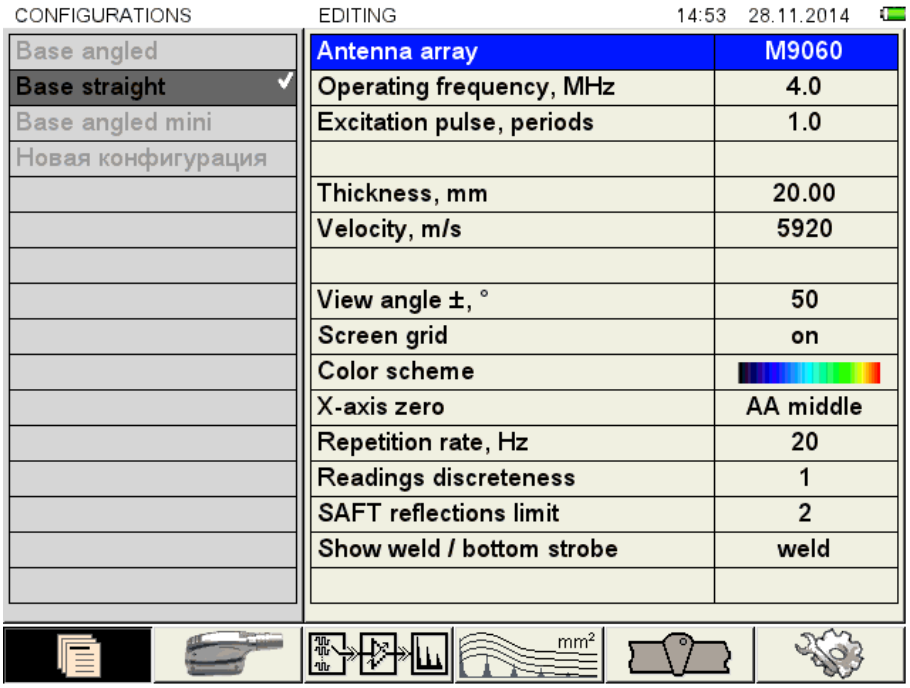


Figure 3 Configurations mode. First tab

Enter the following parameters:

Antenna array – M9060 is set by default. Do not change this option;

Operation frequency, MHz – at this point we do not change the default value of nominal frequency 4 MHz. Operation is possible within the frequency range from 1 to 10 MHz. Our purpose: in the process of setting select the best frequency at which the amplitude of the signals will be a maximum one, signal-to-noise ratio is optimal and the phantom signals will be missing;

Excitation pulse, periods – at this point we do not change the default value 1.0. It determines the quantity of the oscillation periods in the emission pulse. Our purpose in the process of setting select an optimal value, at which the amplitude of the signals will be a maximum one; signal-to-noise ratio and sizes reflectors will be optimal;

Thickness, mm – is set for operation of the reconstruction modes of the tomogram of the angle antenna array. It is not used in the operation of the direct array;

Ultrasonic velocity, m/s – the default value is 5920 m/s (average propagation velocity of the longitudinal wave in the carbon steel). We don't change it. If the object under examination is manufactured of different material, then set the velocity value for this material, listed in the tables or measured according to the methods listed in the books on ultrasonic inspection (e.g., "Reference book. Nondestructive inspection. Volume 3" under the general editorship of Kluev V.V.);

View angle ±, ° - the default value is 50**°.** We don't change it. It determines angular limits of the coverage sector of the DFA. Increasing of the value will result in increasing of noise; decreasing of the value will result in decreasing of noise, though at the same time it will as well result in decreasing of amplitudes of the signals in the remaining coverage sector. The process of setting may require decreasing the size of the sector to delete the phantom images;

Color scheme – selection of the color scheme of the screen. Select a default one;

X-axis zero – setting of the reference point of the X axis (coordinate axes of the defects parallel to the scanning surface) relative to the DFA. We set value «Center of the antenna array»;

Repetition rate, Hz – frequency setting of the information update displayed on the screen. It considers image persistence. We don't change the set value 20 Hz.

Readings discreteness – setting the category of the value of the parameter being measured in the panel of the measurement results, e.g., 1 or 0.1 mm. We recommend setting the value to 0.1 during adjustment; during inspection – to 1;

SAFT reflections limit – corresponds to number of the considered rereflections at boundaries of the object under examination when the image is being formed (for all reconstruction algorithms of the tomogram, except the «Unknown thickness» mode). It is not used for the array. It will be considered for the angle antenna array.

Welded seam/bottom strobe – allows drawing the welded seam (butt) on the screen image or enable the bottom strobe when the mirror through transmission method of inspection is used. In this case it is not used.

Second tab – icon  – here the parameters of the DFAs are stored. These parameters are displayed in the first line of the first tab.

Sign √ stands against the DFA selected in the first line of the first tab. In this case it is M9060. Right part of the working window is not active. The parameters of the DFA are editable. The user shall edit them carefully and accurately.

For experienced users: press and hold the  *key during 2 seconds to switch to adjustment of the parameters of the DFA. The instrument's screen will display an image represented on Figure 4.*

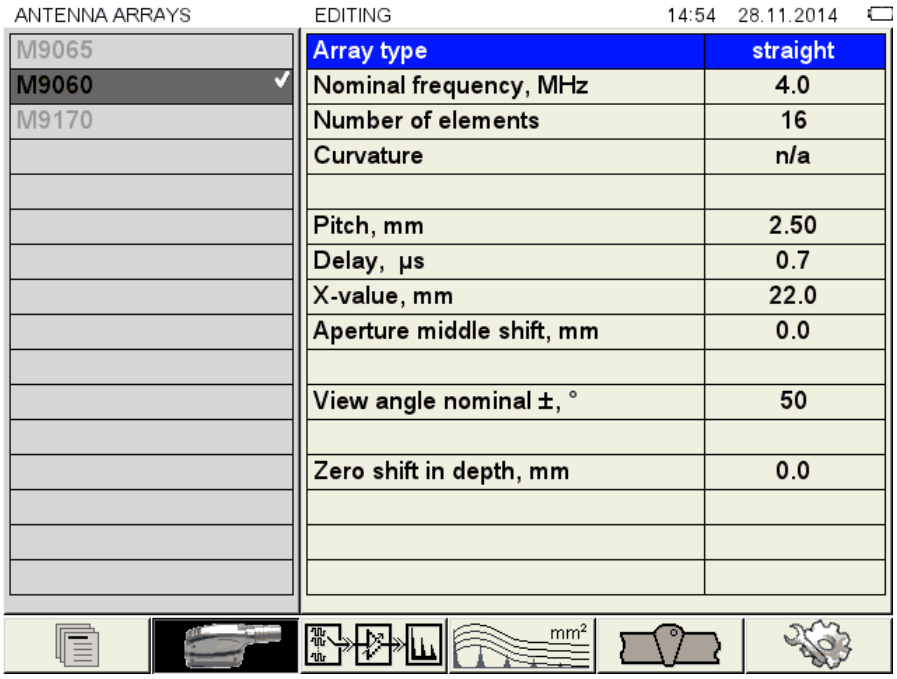
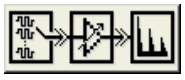


Figure 4 Second tab of the Configurations mode

These parameters are described in the Operation Manual. Value of the DFA parameters must comply with the certified values.

There is not need to edit the array parameters for our example.

Third tab – icon  – allows selection of the gain in the instrument's receiver and functionality check of the DFA.

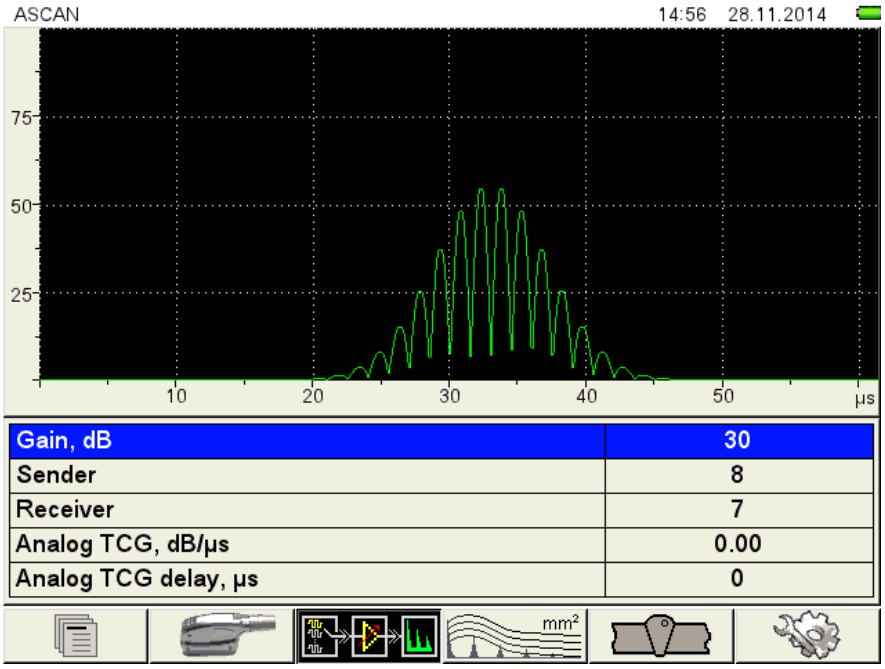


Figure 5 Third tab of the Configurations mode

Press the key  to enter the operation mode. In the third icon F3 the "Unknown thickness" tomogram reconstruction algorithm is set by default.

Note: Only this algorithm can be used with a direct DFA. Other algorithms work with an angled antenna array only.

Figure 6 Tomogram reconstruction modes – F3 key

2.2 Adjustment of amplification of the receiver

Place the DFA on the reference block and find an image of the first hole RR1 at 20 mm depth.

Figure 7 Placing the DFA over RR1

The screen of the Flaw Detector displays the following image

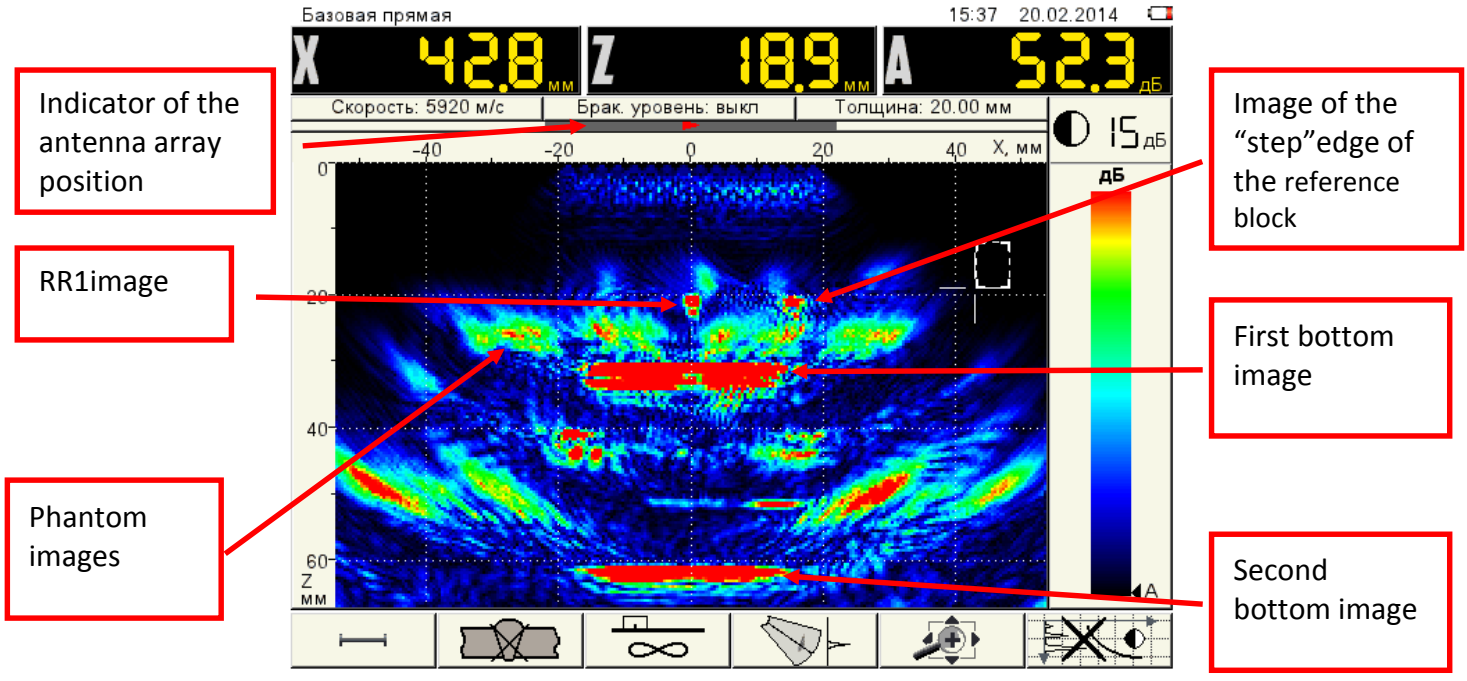


Figure 8 Operation mode. RR1 h=20 mm

There are lots of phantom images on the screen. To delete them: go back to the Configurations mode, to the first tab and set the value to 30° in the **View angle** line.

Further, the position indicator of the DFA indicates the right position (cable to the left, a front edge of the DFA to the right). We need the left position. Press the **F5** key and then press the Enter key. The position indicator of the DFA will display a green triangle pointing to the left.

Figure 9 Right position Figure 10 Left position

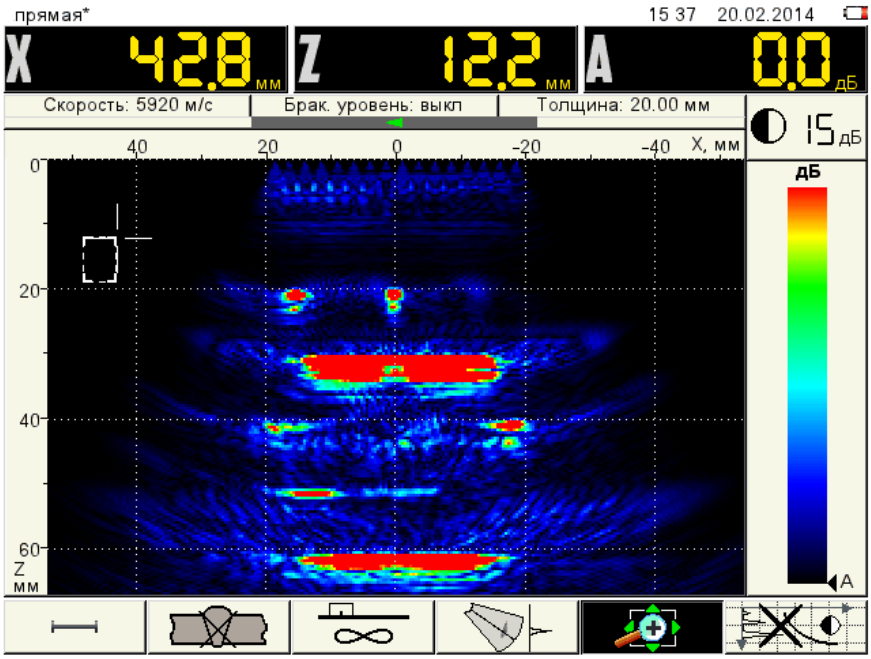


Figure 11 Operation mode. View angle is 30°.

Press the + key to increase the sweep to 30 mm depth. Press the key to open the third tab.

Now set “Sender – 8”, “Receiver – 9” and » and find the signal peak from RR1 on the A-Scan in the 7 µs area (time of double transmission of the wave from the DFA to the notch and back).

Note: functionality(performance) of all 16 elements of the DFA is checked by sequentially switching the numbers of the Sender and Receiver. Performance criterion is the presence of the emission pulse and reflected signals on the A-Scan.

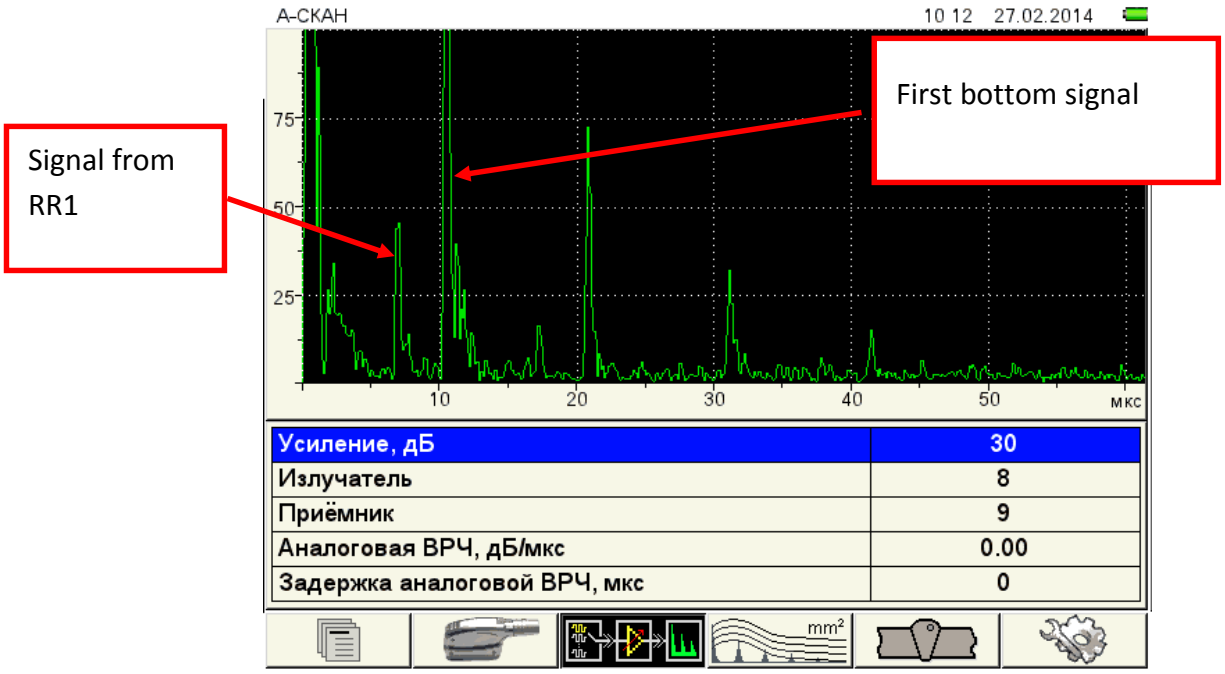


Figure 12 Third tab of the Configurations mode

Our purpose is to select such gain value at which a signal from RR1 will be within the range of 50-75% of the screen. Use the  key to set the gain value to 31 dB.

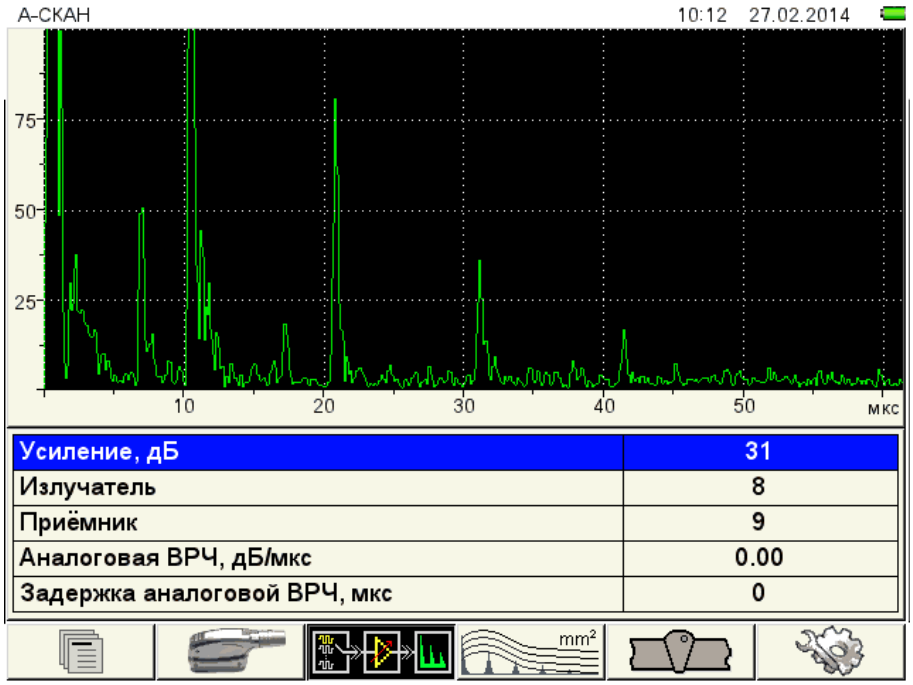


Figure 13 Setting a signal from RR1 to 50% of the screen

2.3 Adjustment of TCG

Now we will find the maximum images from the nearest reference reflector RR1 and the farthest RR5, and measure their amplitude to determine specifications of TCG. To do it, press the arrow keys and move the first strobe and place a signal from RR1 inside the strobe.

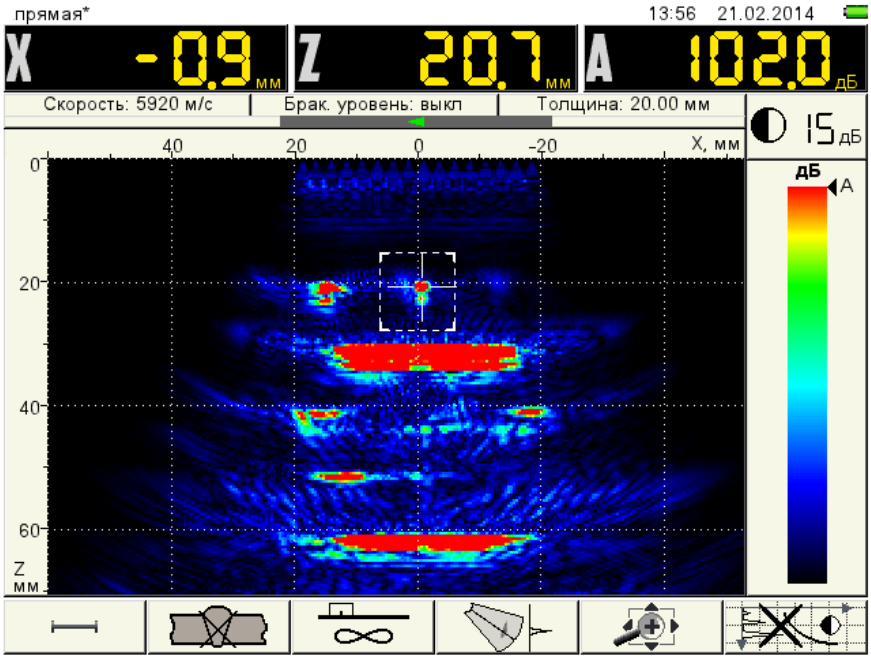


Figure 14 RR 1 Depth Z1=20.7mm, Amplitude A1=102 dB

Press the **F5** key and use the  key to change the image scale to 160 mm depth.

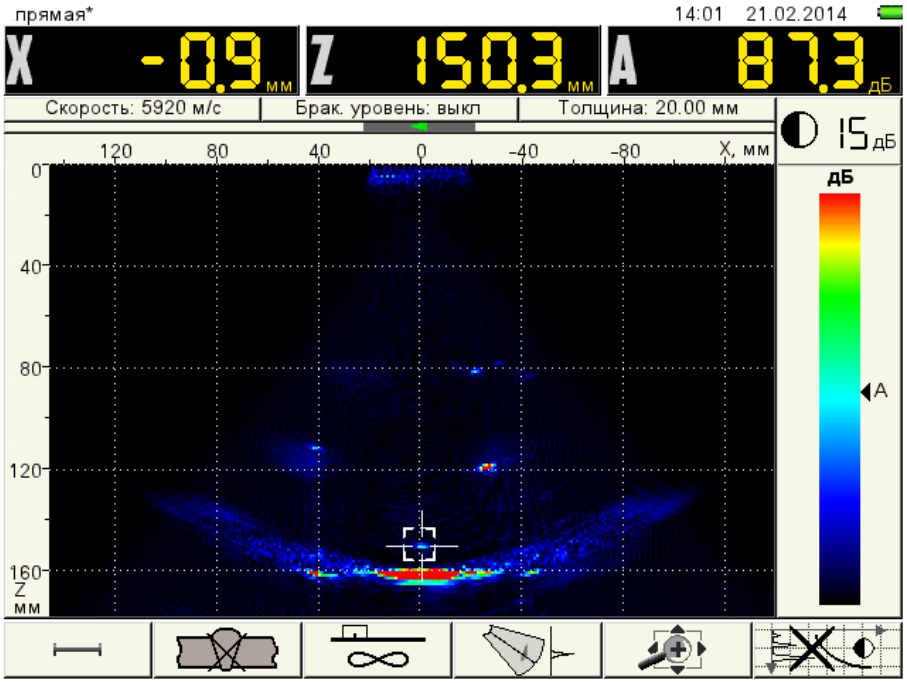


Figure 15 RR5 Depth Z5=150.3 mm, Amplitude A5=87.3 dB

Before performing further actions lets see how the changes of the operating frequency and excitation pulse influence the view of the image RR5.

Switch to the Configurations mode (first tab), select the **Operation frequency** line and use the  key to set the value to 2.5 MHz.

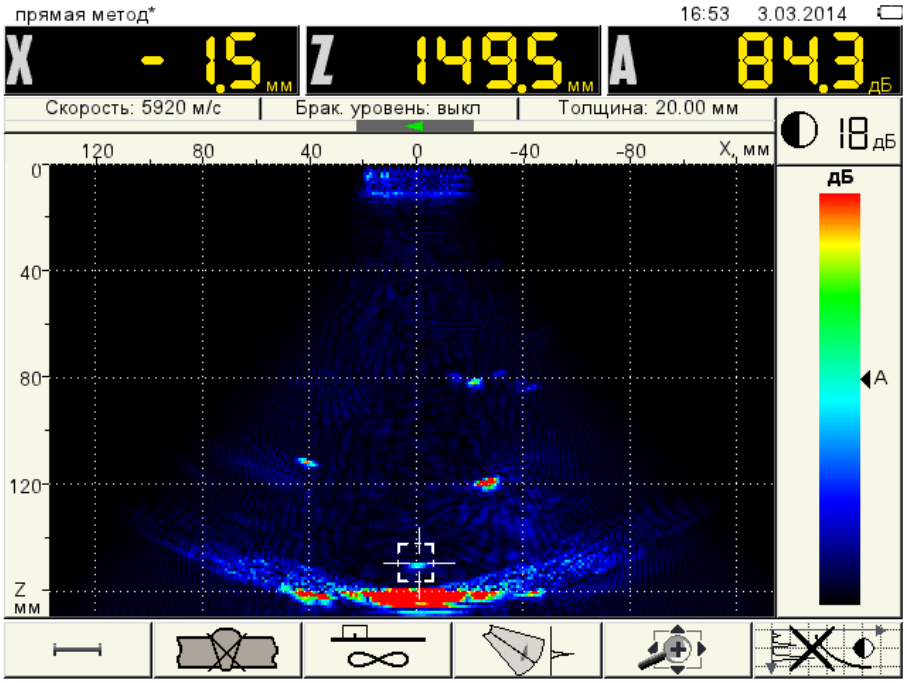


Figure 16 Image RR5. Operation frequency is 2.5 MHz

Amplitude of the image RR5 decreased by 3 dB, use the  key to increase the brightness by 3 dB. We will have an image with a large amount of noise. We conclude that decreasing of the frequency didn't improve the image. Go back to 4 MHz value and set it as a working value.

In the **Excitation pulse** line we set value to 2.0.

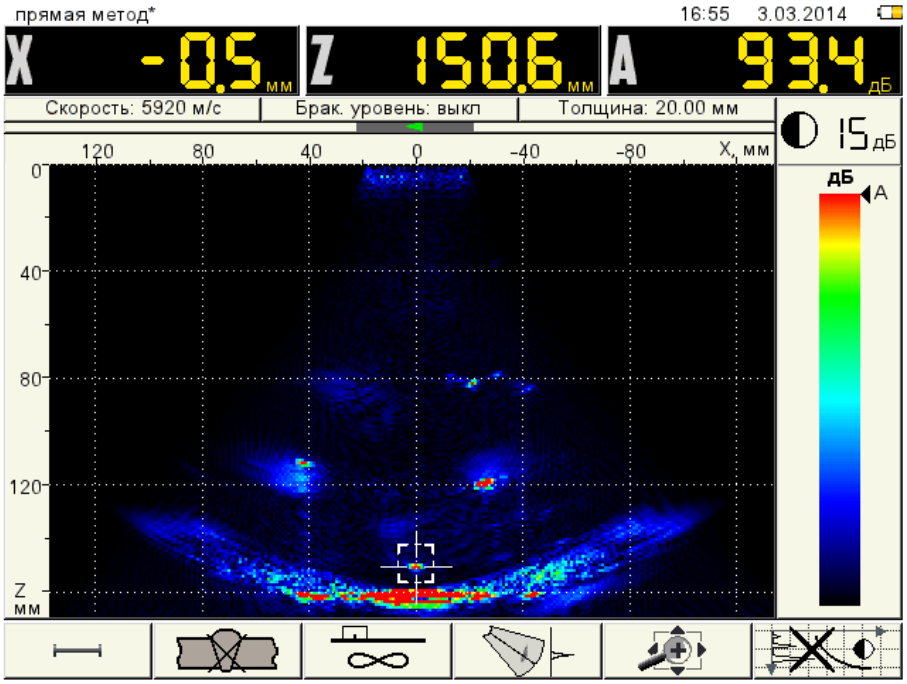


Figure 17 Image RR5. Excitation pulse 2.0 of the period

Amplitude of the image RR5 increased by 6.1 dB. But the amount of noise increased as well. Go back to the initial value 1.0 of the period and set it as a working value.

So, we a back to the initial values of these parameters.

Determine the characteristic value of the analogue TCG using the Formula

$$X = \frac{(A_1 - A_5) * C * 10^{-3}}{2 * (Z_5 - Z_1)}, \text{dB}/\mu\text{s} \quad (1.1)$$

where A_1, A_5 – amplitude of RR images, dB;

Z_1, Z_5 – depth of RR, mm;

C – ultrasonic velocity m/s.

Substitute the values to the Formula (1.1)

$$X = \frac{(102 - 87{,}3) \cdot 5920 * 10^{-3}}{2 * (150{,}3 - 20{,}7)} = 0{,}336 \text{ dB}/\mu\text{s}$$

calculate the delay of analogue TCG using the Formula

$$t_{delay} = \frac{2Z_1 * 10^3}{C}, \mu\text{s} \quad (1.2)$$

Substitute the values to the Formula (1.2)

$$t_{delay} = \frac{2 * 20{,}7 * 10^3}{5920} = 6{,}99 \ \mu\text{s}$$

Press the  key, open the third tab. Set the **Analog TCG** parameter to the 0.34 dB/µs value, and **Delay of Analog TCG** – to 7 µs.

Check amplitudes of the images of all RRs. They should differ from each other no more than by 2 dB.

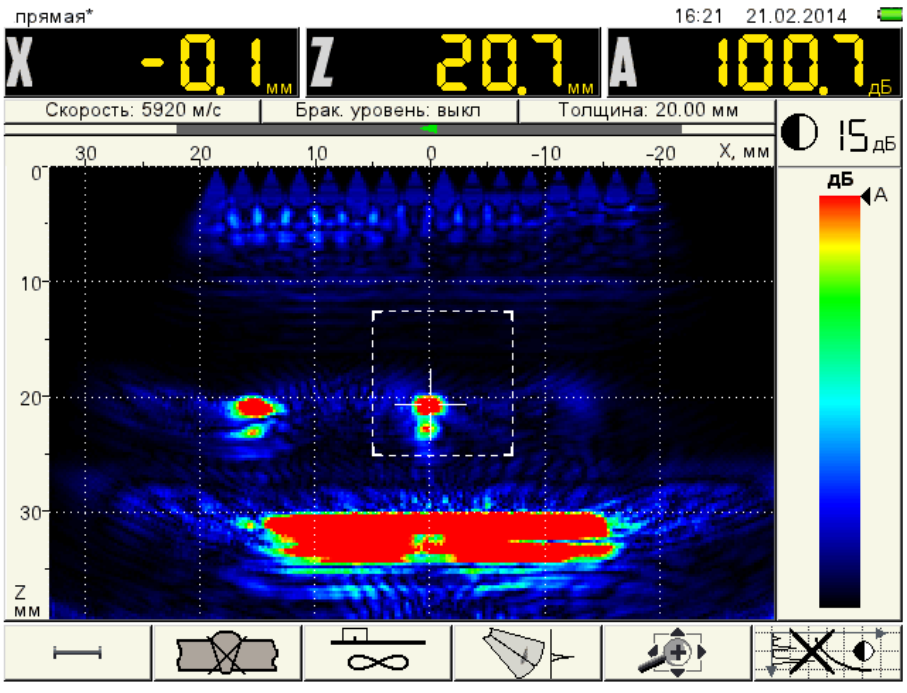


Figure 18 RR1. Depth Z1=20.7 mm, Amplitude A1=100.7 dB

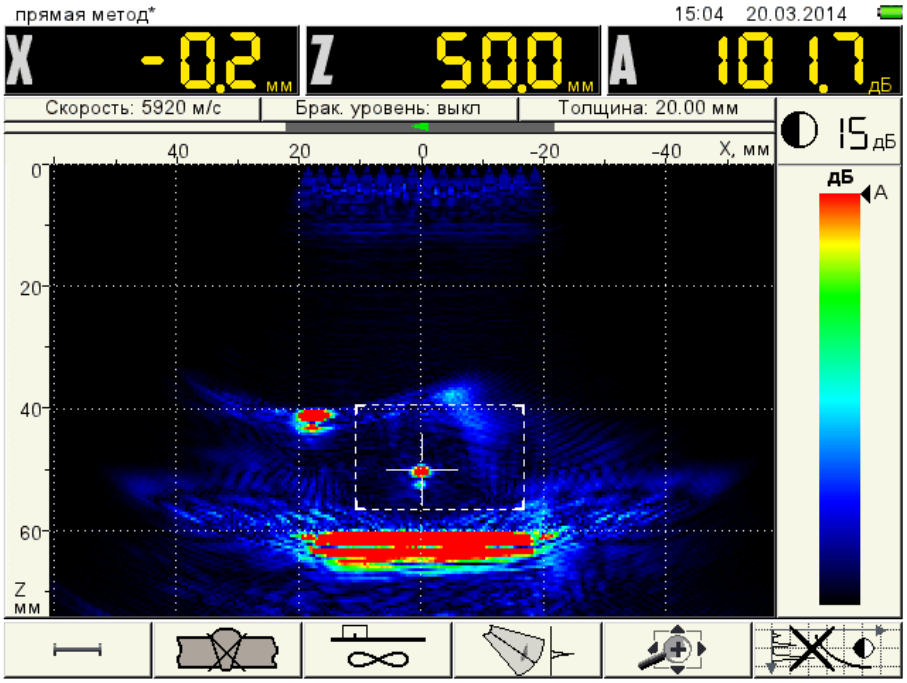


Figure 19 RR2. Depth Z2=50.0 mm, Amplitude A2=101.7 dB

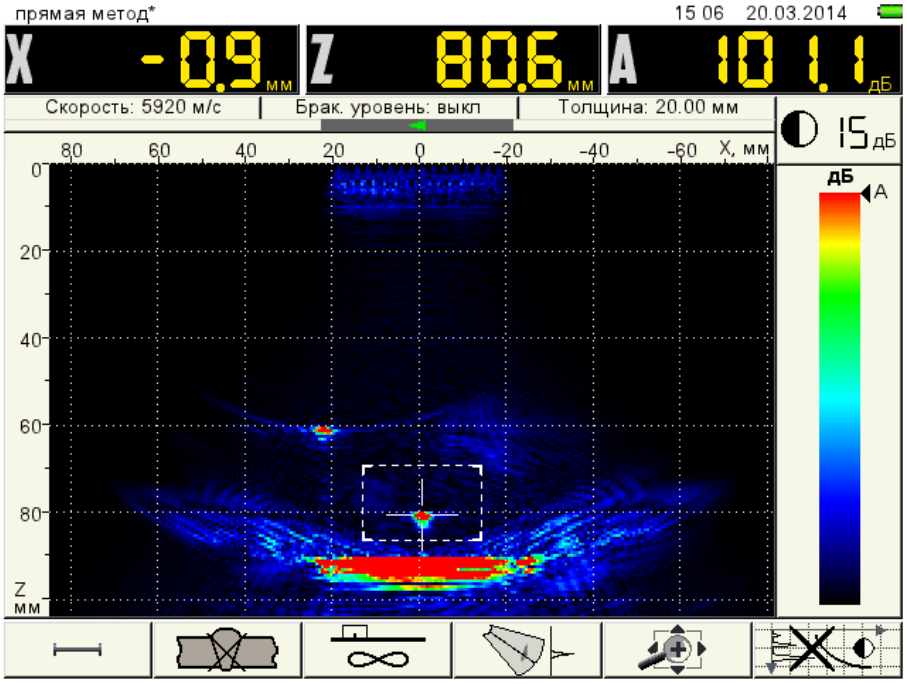


Figure 20 RR3. Depth Z3=80.6 mm, Amplitude A3=101.1 dB

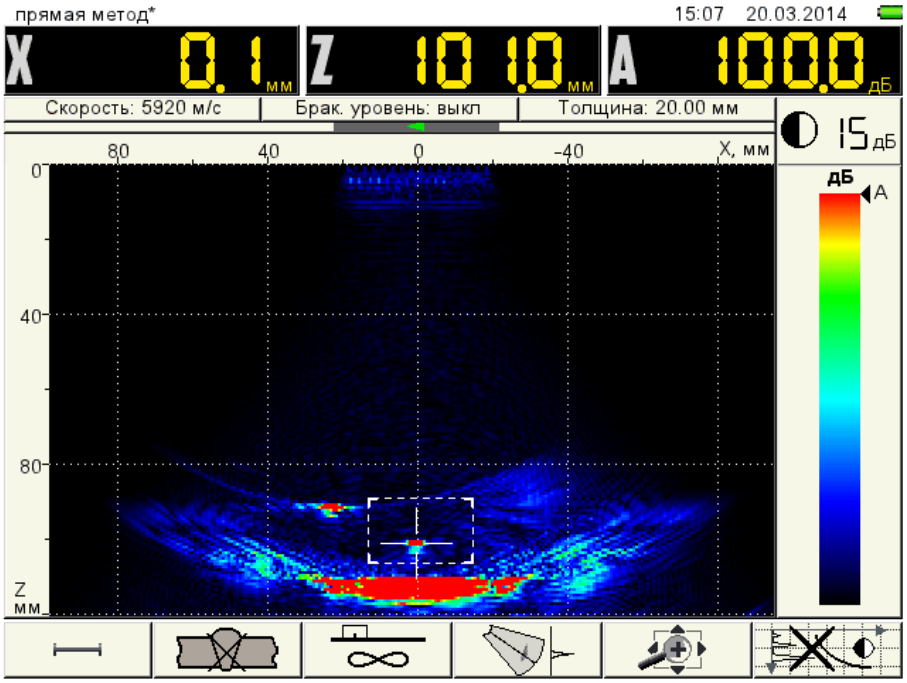


Figure 21 RR4. Depth Z4=101.0 mm, Amplitude A4=100.0 dB

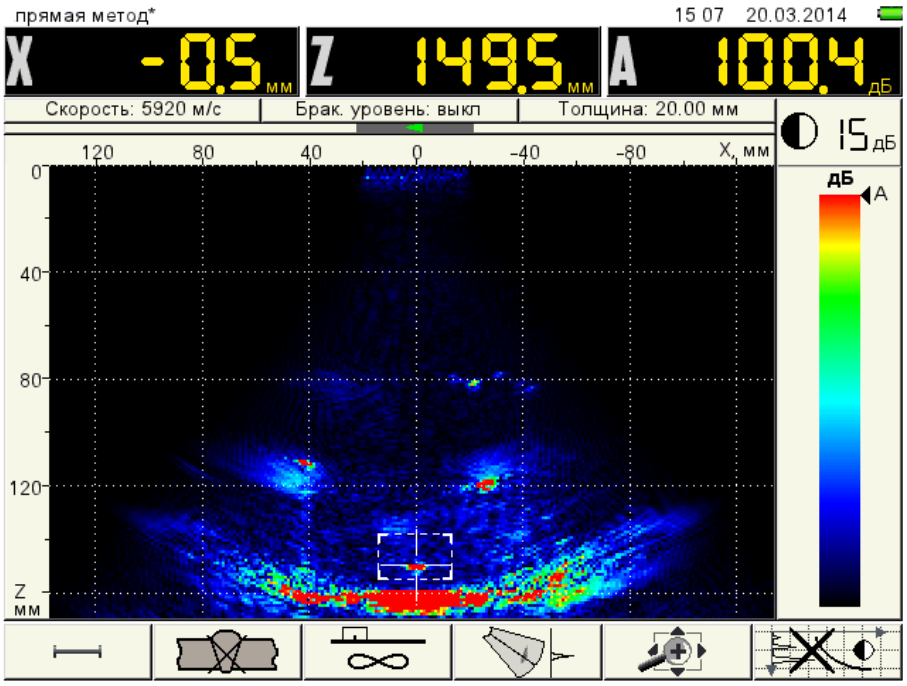


Figure 22 RR5. Depth Z5=149.5 mm, Amplitude A5=100.4 dB.

2.4 Adjustment of the acceptance sensitivity

Determine the average value of the amplitude:

$$A_{av} = \frac{(Z1 + Z2 + Z3 + Z4 + Z5)}{5} = \frac{(100{,}7 + 101{,}7 + 101{,}0 + 100{,}0 + 100{,}4)}{5} = 100{,}4 \text{ dB}$$

This value will be a reference level for calculation of the acceptance level.

Enter the fourth tab of the Configurations mode. Select the **Reference level, dB** line and press the Enter key. An adjustment mode of the reference level is activated. In this mode a cursor is pointed to the

peak signal in the strobe (at the given moment an image from RR5 is in it) and its amplitude will be recorded in the **Reference level** line.

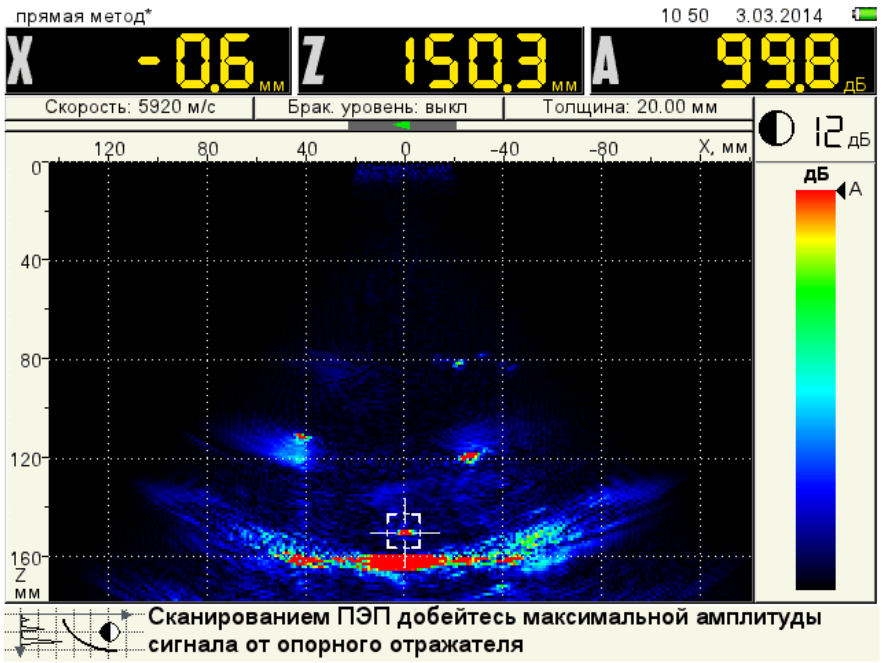


Figure 23 Configurations mode of the reference level

Press the Enter key, and confirm the selected value of the reference level.

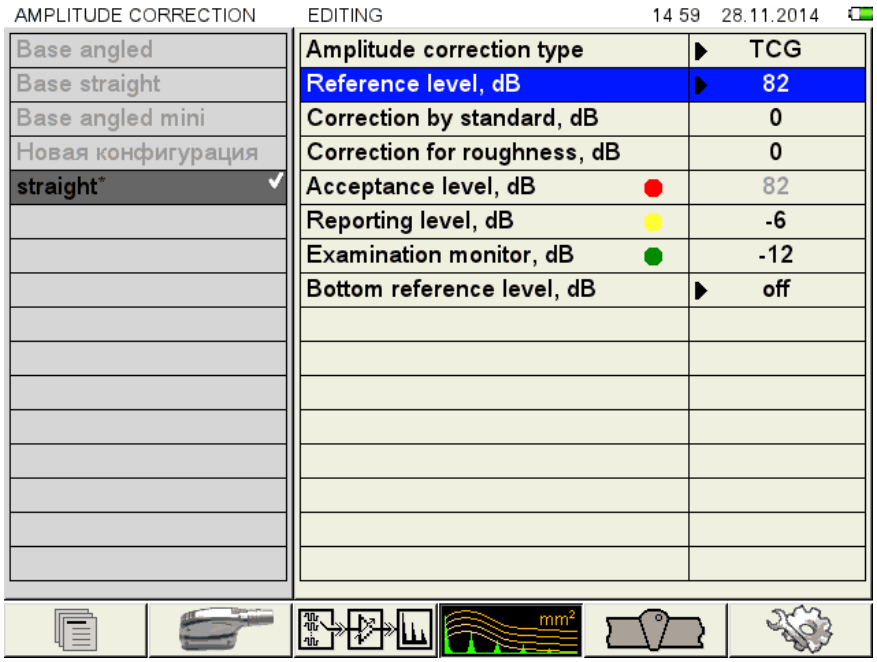


Figure 24 View of the fourth tab at switched on reference level

The following parameters will appear when the reference level is switched on:

Correction by standard, dB – the parameter is different than 0 if adjustment is made with RR which doesn't correspond to your acceptance level (e.g., cylindrical hole Ø 6 mm in CB-2). Corresponding regulatory technical documentation contains tables of corrections to switch to the acceptance level. We will take required value from these tables and set it in this line. We use RRs corresponding to the acceptance level, Hence value of this correction is 0.

Correction for roughness, dB – the parameter is different than 0 if roughness of RR doesn't correspond to roughness of the reference block. To determine the corrections you will need a purpose-specific sensor of roughness and waviness manufactured by CNIITMASH. Set the measured correction value to this line.

Acceptance, dB – an acceptance level. It is equal to the sum of the reference level, sensitivity standard and correction for roughness.

Reporting, dB – a reporting level. The value is set relative to the acceptance level. We set 6 dB value.

Monitor examination, dB – an examination level. It is responsible for operation of the sound and light system of the automatic defect signaling device (Monitor). The value is set relative to the acceptance level. We set 12 dB value.

Bottom reference level, dB – it is used for mirror through transmission method.

Now we shall switch to the operation mode. A color scheme has changed. Signals with amplitude exceeding 100 dB are displayed in red (above the acceptance level), from 94 to 100 dB – are displayed in yellow (from 0 to –6 dB – a reporting level), from 88 to 94 dB – are displayed in green (from –6 to –12 dB – an examination level).

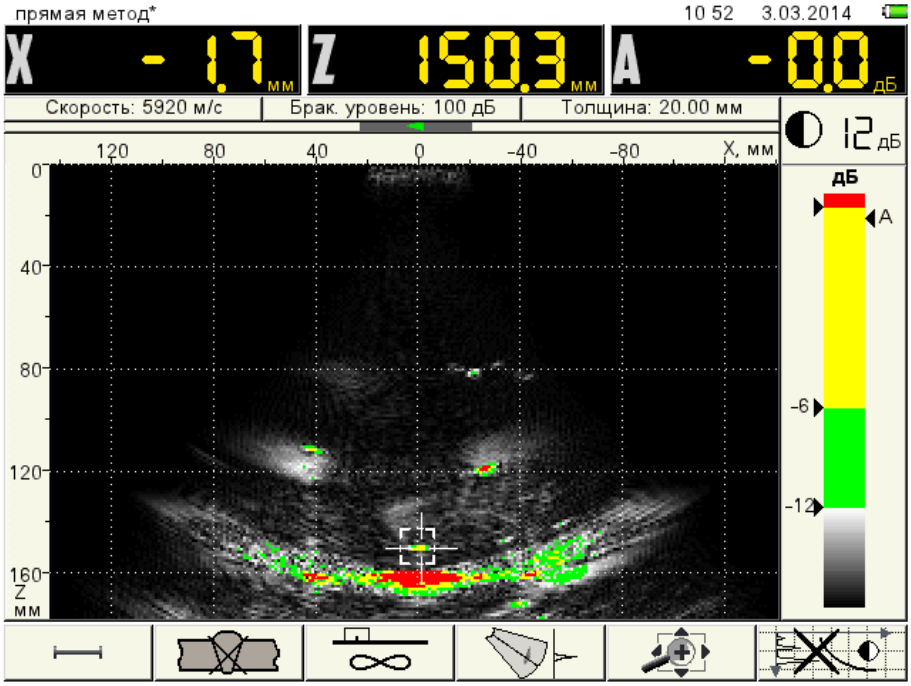


Figure 25 View of the operation mode with switched on reference level

Temporarily switch off the reference level to do further adjustment. To do it, press the **F1**key **F1** followed by the Enter key.

2.5 Checking the depth meter

Depth values we received when checking the TCG:

Z1=20.7 mm; Z2=50.0 mm; Z3=80.6 mm; Z4=101.0 mm; Z5=149.5 mm

Absolute errors are as follows:

ΔZ1= 0.7 mm; ΔZ2= 0.0 mm; ΔZ3= 0.6 mm; ΔZ4= 1.0 mm; ΔZ5= –0.5 mm.

Permissible error is ΔZ≤ ±1.0 mm.

The received errors meet this requirement. The depth meter is adjusted.

If the maximum permissible error is exceeded, in the ADJUSTMENT mode (first tab) we shall change the value of the ultrasound velocity and achieve the result when the error is in the permissible range.

2.6 Adjustment of brightness, measurement of sizes of the reflectors and determination of the permissible front length of the defect

The “TOMOGRAPH” mode enables the user to measure the sizes of the reflectors by their visual images on the screen of the Flaw Detector. Measurement accuracy depends on the following: operation frequency, distance to the reflector, size of the reflector in the wavefront plane of the ultrasonic wave (front length) relative to wavelength.

Conditions at which the sizes measured by the screen, most closely match the real sizes of the reflector , are as follows:

front length of the reflector is longer than two wavelengths;

distance to the reflector is no more than two apertures of the DFA.

Let’s calculate these parameters for our example:

$$\lambda = \frac{C}{f} = \frac{5920}{4 * 10^6} = 1,5 \text{ mm}$$

where C – ultrasonic velocity, m/s;

f – operation frequency of the DFA, Hz.

Two wavelengths 2λ=3 mm.

Two apertures of the DFA M9060=80 mm.

I.e., if the size of the reflector (front length) exceeds 3 mm and distance to it is no more than 80 mm, then the measured sizes of the reflector on the screen will correspond to real sizes of the defect.

In cases where the reflector is at the distance exceeding two apertures, then the front length («blurring») of the image on the screen will be increased. Hence, to measure the sizes within the whole inspection range we have to determine on the reference block the front length of all RRs, which size will be the acceptance size for the given depth of the reflector .

At first for RR1 we set a working brightness level at which the front length measured on the screen of the Flaw Detector will correspond to the real size of RR1.

Change the image scale to 40 mm depth. Find the RR1 image. Measure the front length D of the visual RR1 image.

We do measurement of the front length in the STOP mode. Press the key , move the cursor to the left boundary of the red RR1 image. Press the Enter key and move the cursor to the right boundary of the red image. Front length D=2.4 mm. Actual value of RR1 diameter is 2.0 mm.

Note: actual size of the front length of RR1 is less than two wave lengths. In this case the image will be "blurred" earlier than in two apertures.

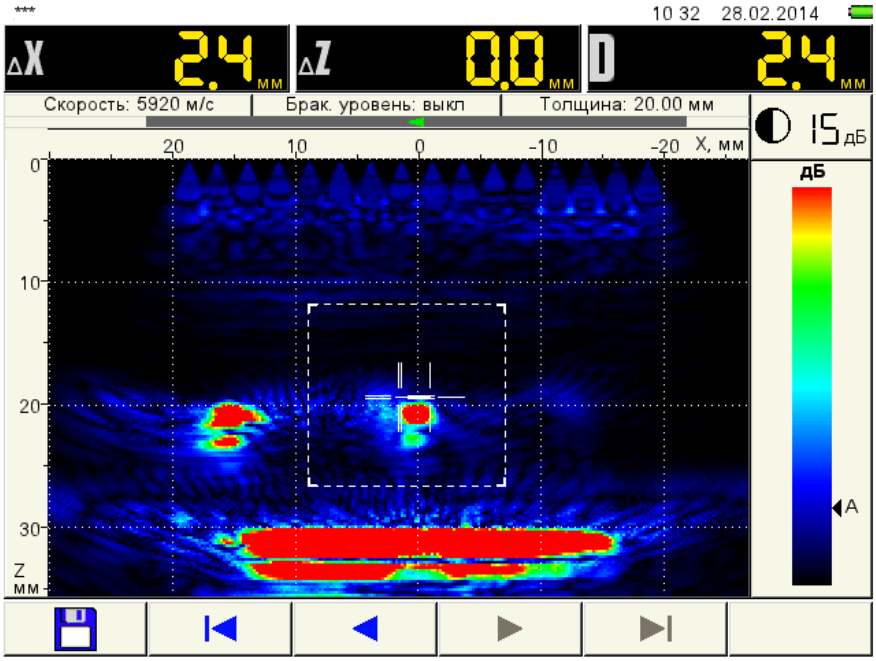


Figure 26 RR1. D=2.4 mm

Use the key to decrease the brightness level to 12 dB. Measure the front length again. We obtain the result D=2.0 mm. It corresponds to real size.

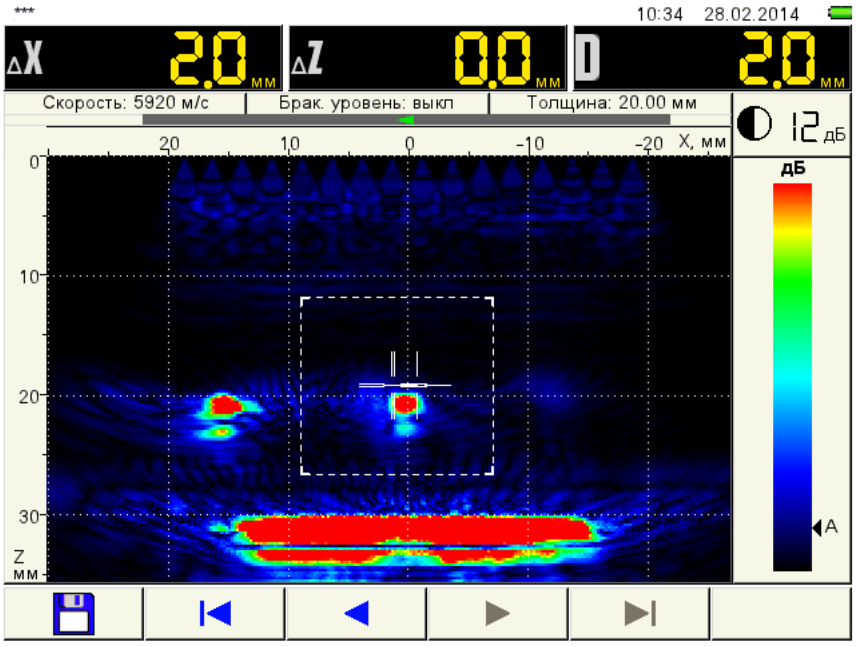


Figure 27 RR1. D =2.0 mm

Move the DFA to RR2. Press the **F5** key. Press and hold the  key up to the moment when RR image is in the center of the screen. Measure D=2.5 mm.

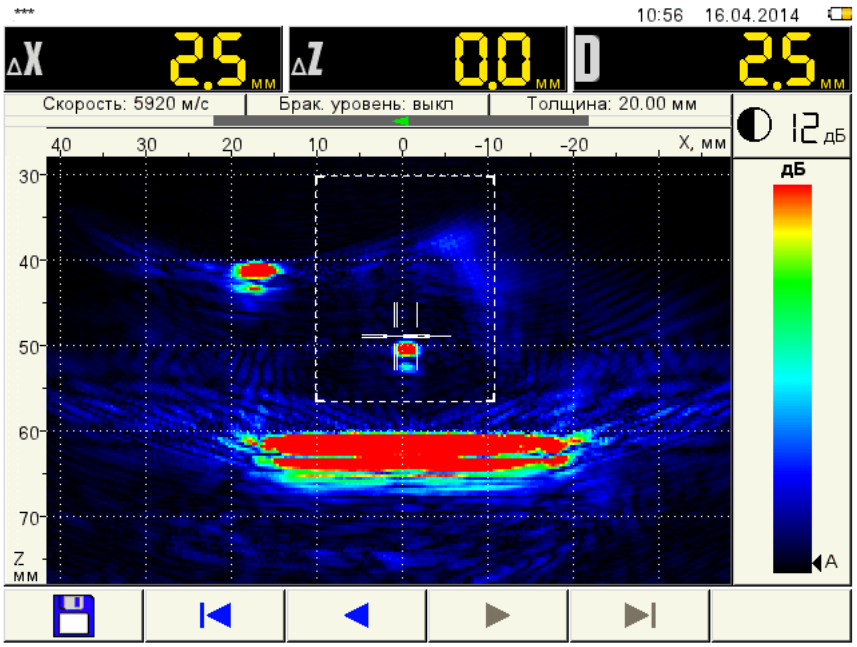


Figure 28 RR2. D=2.5 mm

Move the DFA to RR3. Press the **F5** key**.** Press and hold the key  up to the moment when RR image is in the center of the screen. Measure D=3.8 mm.

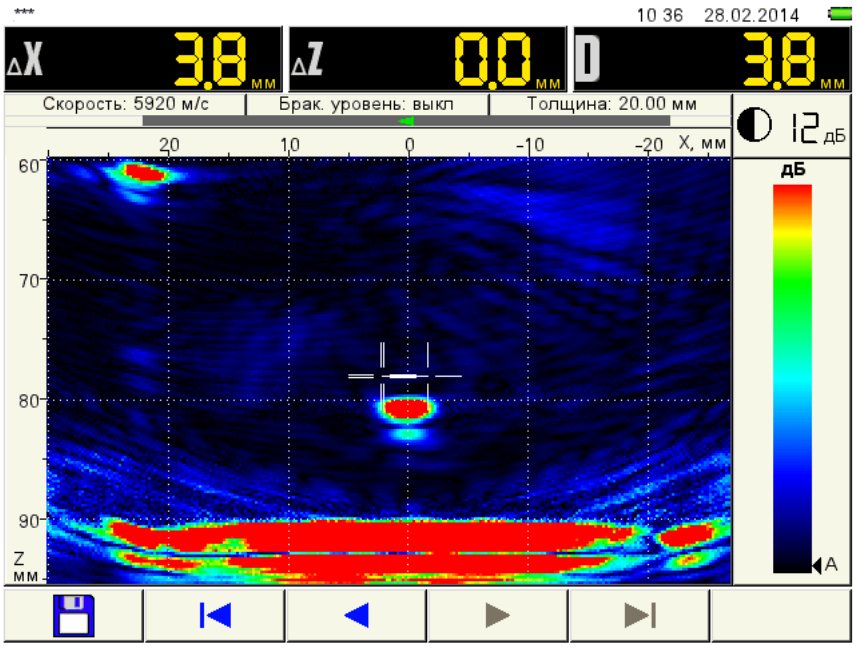


Figure 29 RR3. D=3.8 mm

Move the DFA to RR4. Press the **F5** key**.** Press and hold the  key up to the moment when RR image is in the center of the screen. Measure D=4.0 mm.

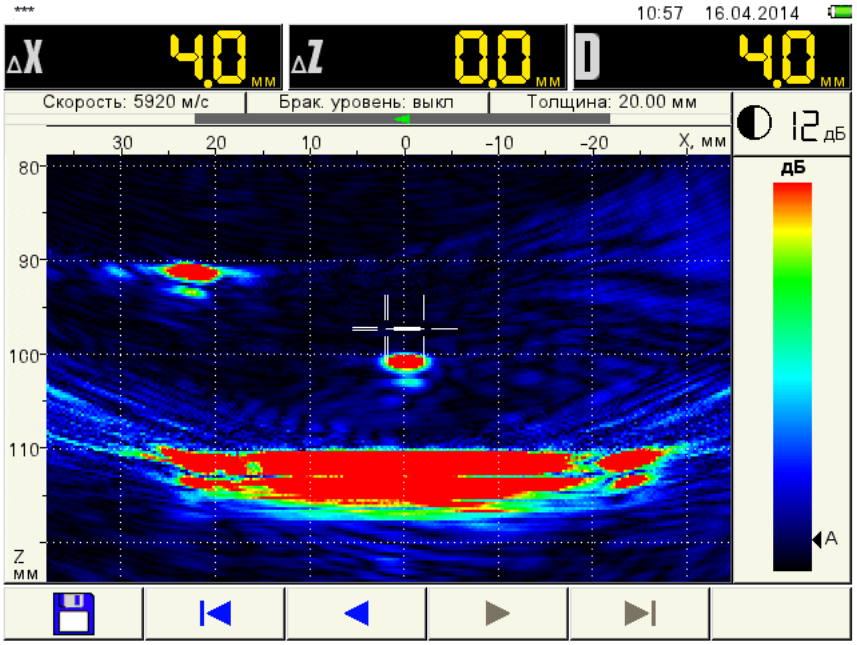


Figure 30 RR4. D =4.0 mm

Move the DFA to RR5. Press the **F5** key**.** Press and hold the key  to the moment when the RR5 image appears. Measure D=5.6 mm.

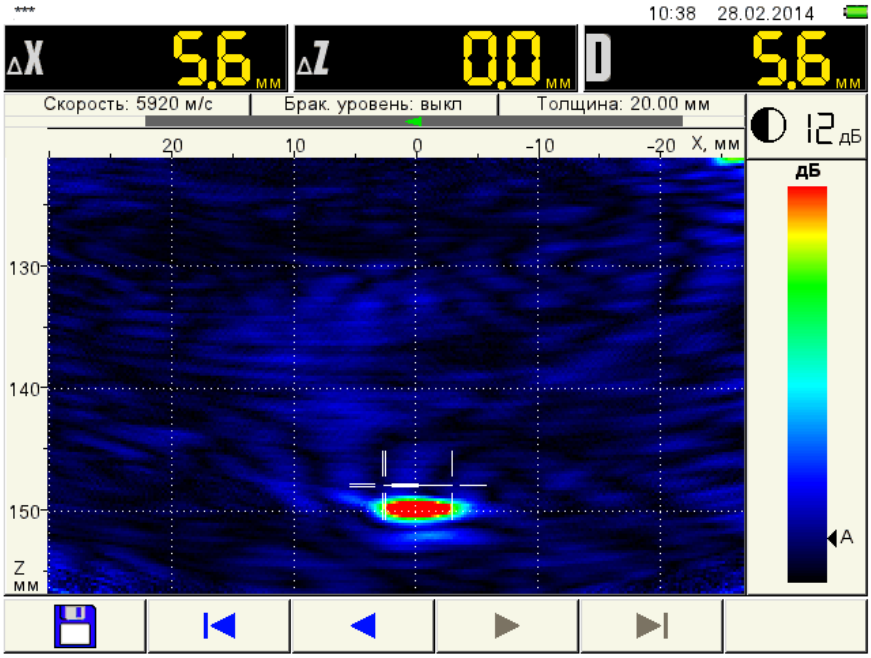


Figure 31 RR5. D=5.6 mm

In such a manner, we determine the maximum permissible front length of the defects D depending on their depth:

D1=2.0 mm for Z1=20 mm;

D2=2.5 mm for Z2=50 mm;

D3=3.8 mm for Z3=80 mm;

D4=4.0 mm for Z4=100 mm;

D5=5.6 mm for Z5=150 mm.

For intermediate values of thickness Z linearly approximate the size D.

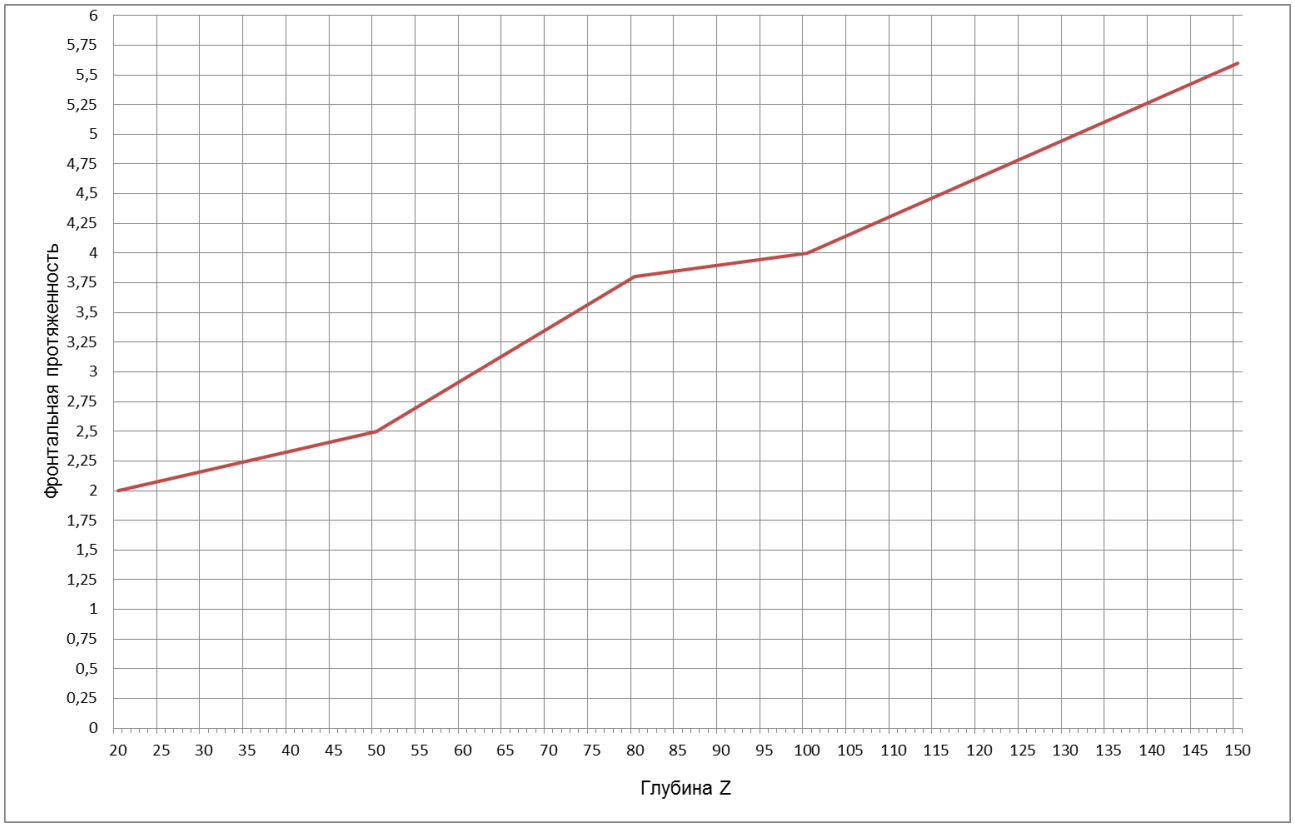
Example: we found a defect, size Dx=5.0 mm at depth Zx=125 mm. Zx is within the interval between Z4 and Z5. Calculate Dmax for depth Zx=125 mm using the Formula:

$$Dmax = D4 + \frac{(D5-D4)*(Zx-Z4)}{(Z5-Z4)} = 4 + \frac{(5{,}6-4{,}0)*(125-100)}{(150-100)} = 4{,}8 \text{ mm}$$

Conclusion: this defect is impermissible by its front length.

For convenience, a graph of dependence of the front length size on its depth can be generated in the MS Excel program and further printed out. In this case we can promptly decide on the admissibility of the defect without calculating according to this criterion.

An example graph generated on the basis of the data received in paragraph 2.6.13.



2.7 Adjustment of the image scale and examination area

Press and hold the **F5** key**,** and simultaneously press the  key; we return the origin of coordinates Z to zero. Press the  key and change the image scale to Z=170 mm depth. Release the key **F5**. Press the key **F1.** Use the arrow keys left-right and up-down to set the boundaries of the examination area. Upper boundary of the examination area Z1=0 mm. During inspection a bottom image at depth 160 mm will be present on the screen, if we set the lower boundary of the examination area at a depth of 160 mm, then the monitor system will constantly response to it. Hence we set the oversized lower boundary for value 158 mm, to avoid this. Left and right boundaries are set by the boundaries of the DFA indicator visible on the screen. X1=22 mm, X2 = –22 mm.

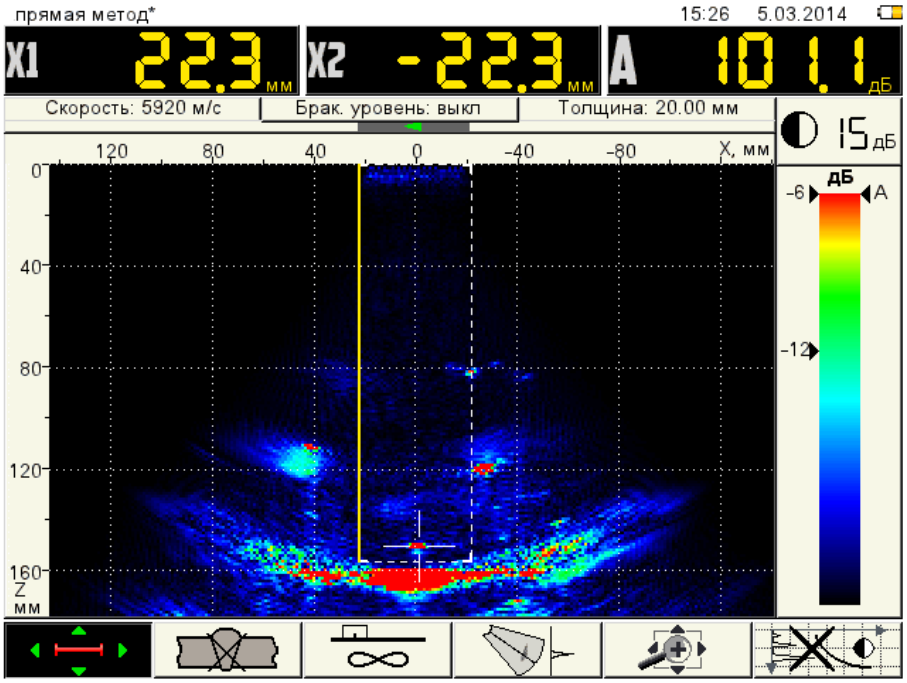


Figure 32 Setting the left boundaries of the examination area

With the **F1** key pressed, press the Enter key. The reference level is switched on.

Save the configuration into the instrument's memory (the procedure is described in the Operation Manual).

The instrument is ready for carrying out the inspection.

2.8 Preparation of the entry and scanning surface

The inspection shall be carried out by the contact method, moving the DFA along the object surface manually.

Prior to inspection of the surface from the side which shall be scanned (entry surface), it must be cleared and has a parameter of the surface roughness Rz ≤ 40 µm.

Scanning can be carried out by means of the ordinary transducer with a pitch, not exceeding a half of the transverse dimension of the DFA.

During scanning care shall be taken to presence of the contact grease and preservation of the acoustic contact costantly pressing the DFA to the surface of the object.

Velocity of linear displacement of the DFA during scanning should not exceed 100 mm/s.

2.9 Detection and measurement of characteristics of the defects

When images appear on the screen in the inspection area and sound and light monitor system responds, stop moving the DFA and find the maximum value of the amplitude of the found image by moving and rotating of the DFA. Make sure that this image belongs to the defect, but not to the false reflector. Sources of the false signals can be cavities, signals from the structural elements and etc.

When the defects with amplitude equal or exceeding the reporting level (recording level) are detected, the following characteristics shall be specified:

– amplitude of echo-a signal from the defect A, dB;

– depth of the defect Z, mm,

– longitudinal lenght of the defect L, mm;

– front length the defect D, mm;

– coordinates from the zero point (scanning start) X, mm and Y, mm;

– quantity of defects on the inspected area Σn.

Coordinate Z – depth of the reflector is indicated in the panel of the measurement results.

Coordinates X, Y determine as a place of location of the defect on the scanning surface.

To classify the defects by the length we have to determine a conventional longitudinal lenght L_o equivalent disk reflector – an effective beam width at depth of the defect.

Classification shall be carried out by comparison of the measured conventional length of the defect L to the effective width of the ultrasonic beam at depth of the detected defect. The defect is considered not extended, if $L \leq L_o$. The defect is considered extended, if $L > L_o$.

Place the DFA over RR1 and move it transversally up to the moment when amplitude of the image increases to–6 dB (the reporting level).

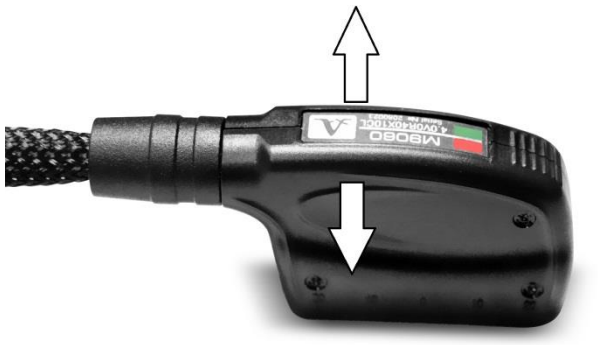


Figure 33 longitudinal movement of the DFA

After that we move it in the opposite direction to the same value. Measure an amount of this displacement with a ruler. This operation is done on all RRs. Record the values into the ultrasonic flaw detection log.

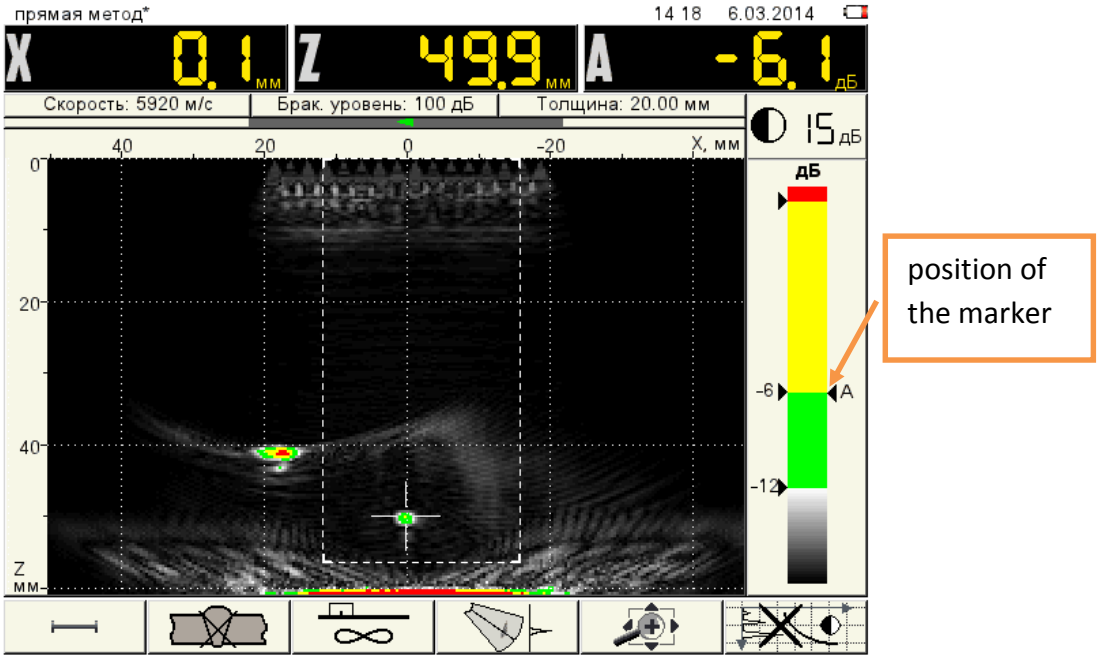


Figure 34 Image RR2 on the recording level -6 dB

L_o(KO1. Z=20 mm)=7 mm;

L_o(KO2. Z=50 mm)=10 mm;

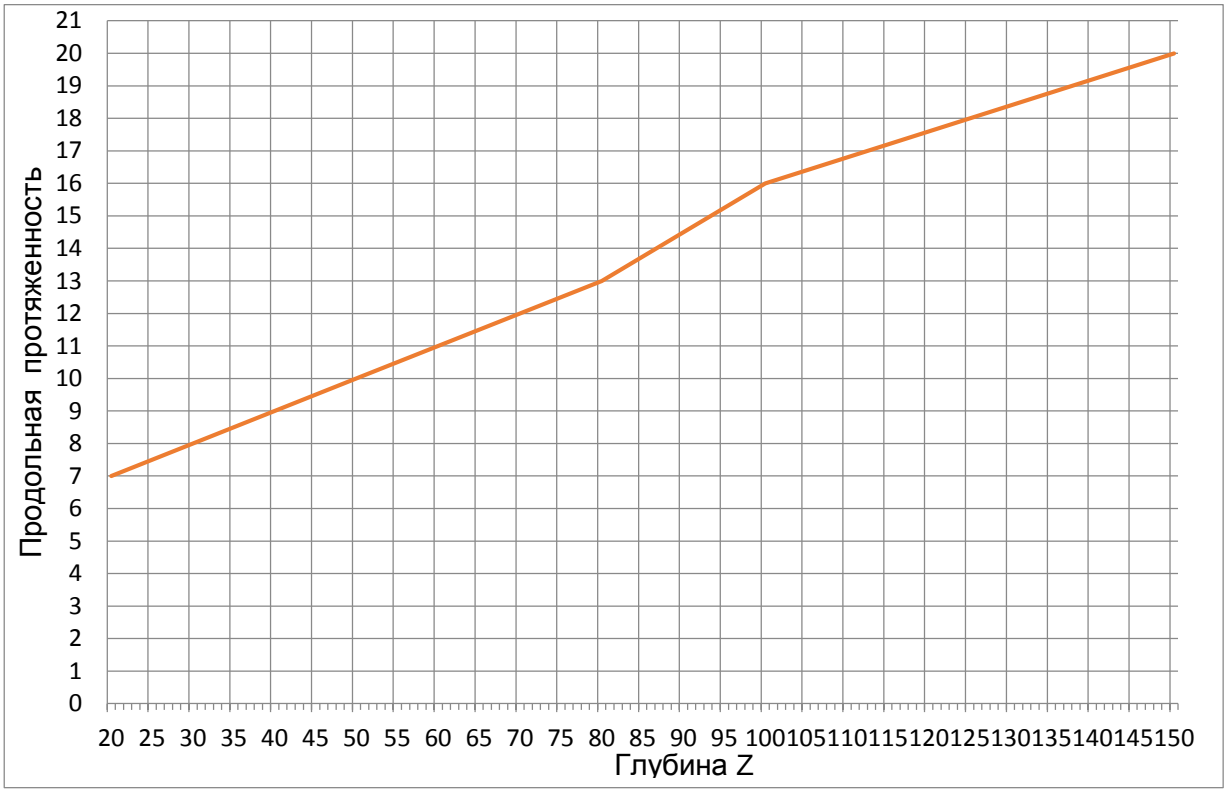
L_o(KO3. Z=75 mm)=13 mm;

L_o(KO4. Z=100 mm)=16 mm;

L_o(RR5. Z=150 mm)=20 mm.

For convenience, a graph of dependence of the longitudinal length on its depth can be generated in the MS Excel program and further printed out. In this case we can promptly decide on the admissibility of the defect without calculating according to this criterion.

An example graph generated on the basis of the data received



The defects with $L>\Delta L_o$ are found, the defects are considered extended.

Let's consider carrying out the inspection using the example of forging 160 mm thick. Place the DFA into the scanning start highlighted by the marker. We will see the following image.

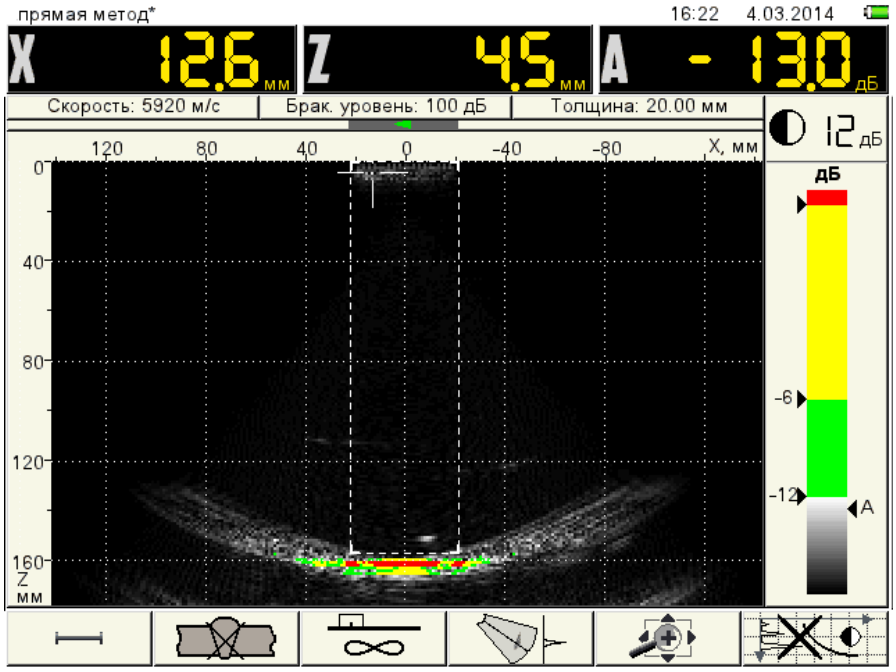


Figure 35 Scanning start

Move the DFA by the selected movement scheme. The monitor system will respond. Find the maximum value of the A=7.8 dB at depth Z=119.1 mm. Measure the coordinates of maximum X and Y relative to the initial point with a ruler. Measure conventional length in four directions. Maximum measured conventional length L=26 mm. This value exceeds the L_o.

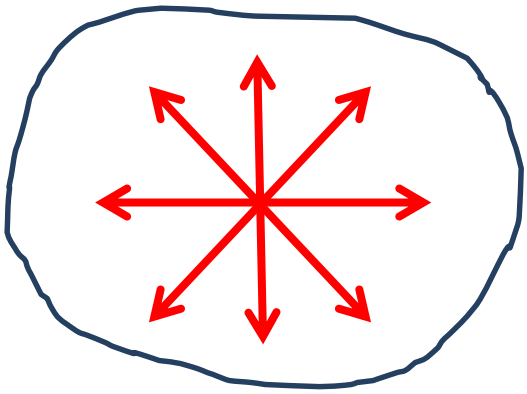


Figure 36 Measurement of the conventional length of defect

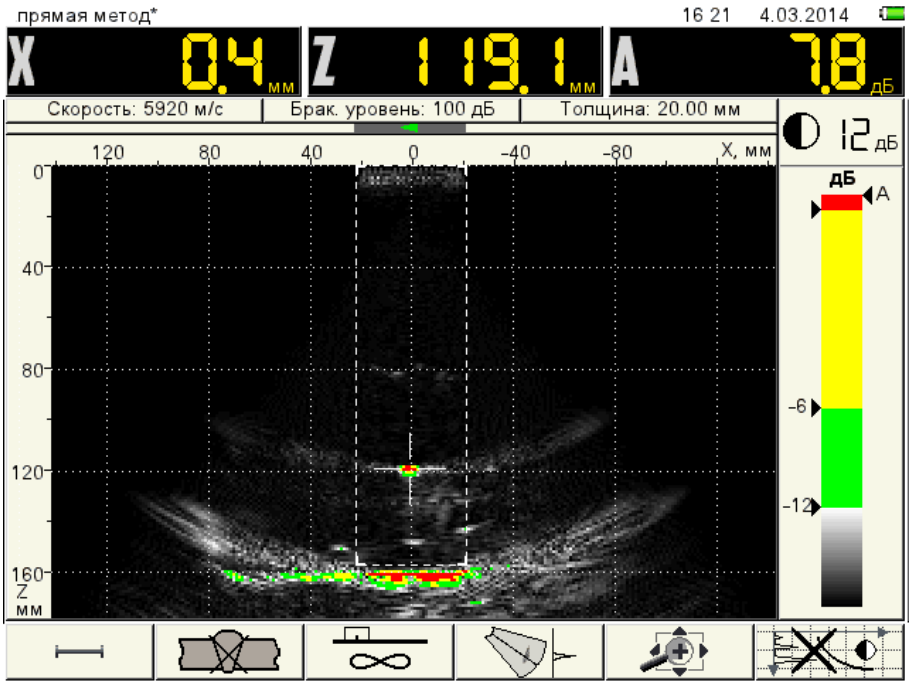


Figure 37 Image of defect at depth Z=119.1 mm

To determine a front length of defect: press the **F5** key, then press and hold the key  up to the moment when depth of defect Z=119 mm is in the screen center. Press the  key and zoom in. Press the **F1** key**,** then press the  key to switch off the reference level. Press the key and measure a front length of the image D=5.7 mm.

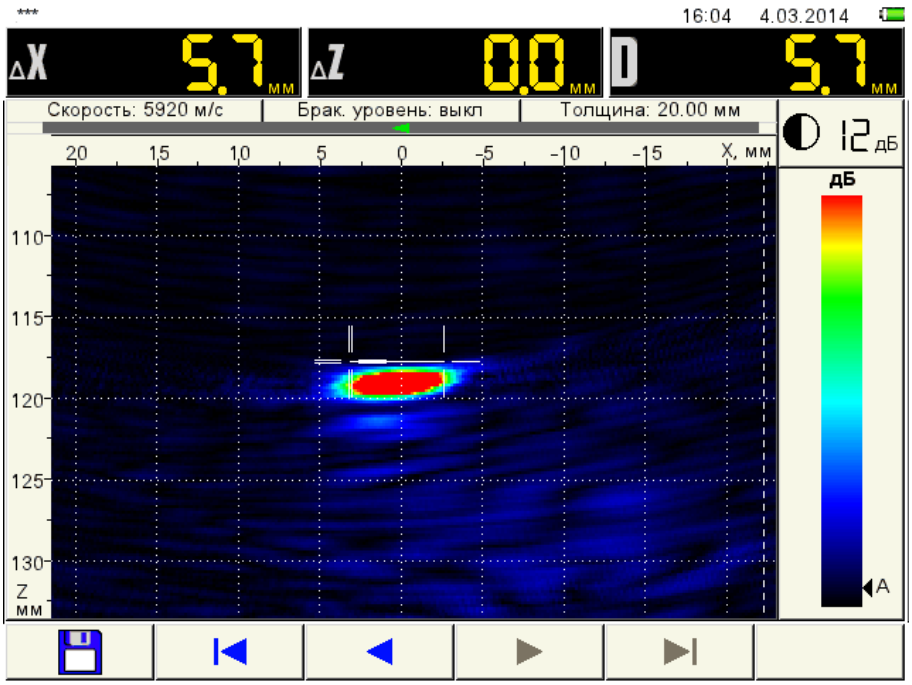


Figure 38 Measurement of the front length of defect

In such a manner, do the following conclusion:

A defect is found with amplitude of the signal above the acceptance level A=+7.8 dB, at depth 119.1 mm;

longitudinally extended defect, L=26 mm exceeds the maximum permissible value at a given depth (a graph in paragraph 2.9.10);

front length D=5.7 mm (a graph in paragraph 2.6.16) doesn't exceed the permissble value;

Coordinates of the defect relative to the initial point X=30 mm, Y=45 mm.

3. Carrying out inspection with an angle DFA M9065

For clarity let's consider adjustment procedure of the instrument and procedure of ultrasonic inspection using the specific examples.

Example: inspection of the welded joint C21 (15 mm thick) according to GOST 5264-80. Steel 20.A reference block 15 mm, notch 3.5×2.0 mm.

3.1 Adjustment of the parameters of the basic configuration

Connect M9065. Insert a large LEMO end fitting to the ARRAY connector, carefully aligning the red marks on both connectors. Insert the red end fitting into the OUT connector, black – into the IN connector.

The DFA can be connected/disconnected with a switched on instrument.

Switch on the instrument. Switch to the "TOMOGRAPH" operation mode as follows:

– Press and hold the Mode key;

– Use the keys to select the operation mode in the opened window listing the modes (Figure 19);

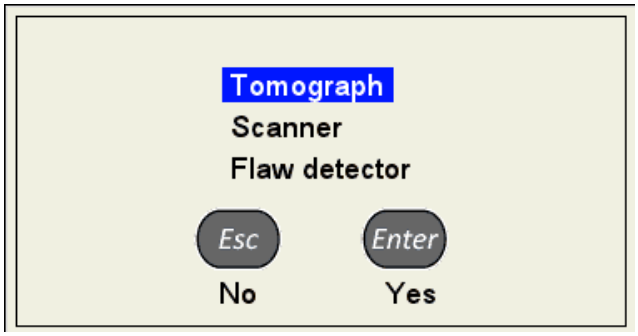


Figure 39 Mode selection window

– press the key to conform the selected option Enter.

Press the key to enter the CONFIGURATIONS-TOMOGRAPH mode. At that the instrument's screen will display an image (Figure 40). Select the **Base angled** option for M9065. Press the Enter key to conform. A sign **√** will appear next to the selected option.

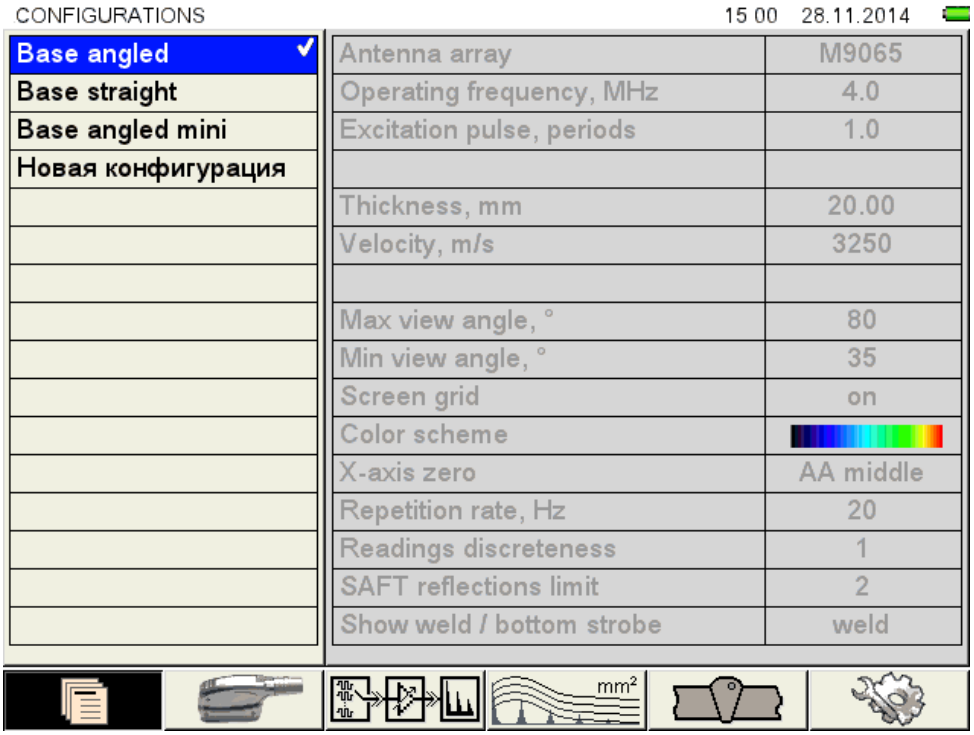


Figure 40 Entry point to the CONFIGURATIONS-TOMOGRAPH mode.

Press the  key to edit the values of the configuration parameters.

First tab – icon  – unites the measurement parameters pack.

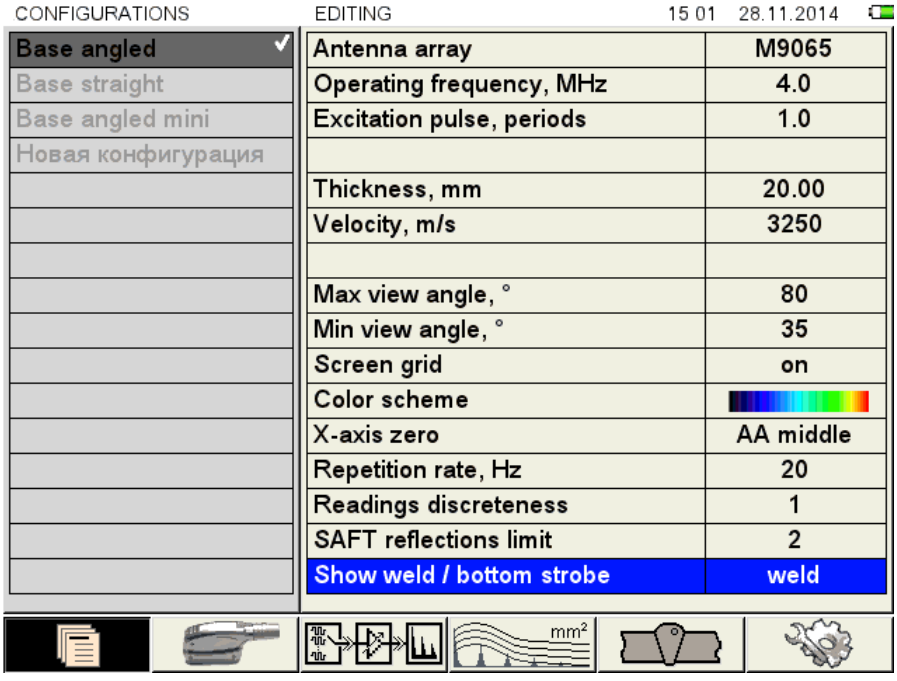


Figure 41 Configurations mode. First tab

Enter the following parameters:

Antenna array – DFA M9065 is set by default. Do not change this option. The second tab  enables creation of the antenna array with different parameters;

Operation frequency, MHz – at this point we do not change the default value of the nominal frequency 4 MHz. Operation within the frequency range from 1 to 10 MHz is possible. Our purpose: in the process of setting select the best frequency at which the amplitude of the signals will be a maximum one; signal-to-noise ratio is optimal and the phantom signals will be missing;

Excitation pulse, periods – at this point we don't change the default value 1.0. It determines the quantity of the oscillation periods in the emission pulse. Our purpose in the process of setting is to select an optimal value at which the amplitude of the signals will be a maximum one; signal-to-noise ratio and sizes of the reflectors will be optimal;

Thickness, mm – a thickness of the object under examination. It is required for correct operation of the reconstruction algorithms of the tomogram, which use the reflections at the opposite boundary of the object under examination. It is the mode of «Subsurface defects», «Plate mode», «Vertical cracks mode» and «Several algorithms mode». It is not used in the «Unknown thickness» mode. During inspection we will use several algorithms, hence we set value to 15 mm.

Figure 42 Tomogram reconstruction modes, F3 key

Ultrasonic velocity, m/s – the default value is 3250 m/s (average propagation velocity of the longitudinal wave in the carbon stee). We don't change it. If the object under examination is manufactured of different material, then set the velocity value for this material listed in the tables or measured according to the methods listed in the books on ultrasonic inspection (e.g., «Reference book. Nondestructive inspection. Volume 3» Under the general editorship of Kluev V.V.);

Max. view angle, ° – the default value is 80°. We don't change it. It determines angular limits of the coverage sector of the antenna array. Increasing of the value will result in visualization of the surface wave (Rayleigh wave), decreasing will result in decreasing of noise, as well as in decreasing of amplitudes of the signals in the remaining coverage sector;

Min. View angle, ° – the default value is 35°. We don't change it. It determines the lower boundary of the view sector of the antenna array. Increasing the value will result in decreasing of noise, as well as result in decreasing of amplitudes of the signals in the remaining coverage sector, decreasing will result in visualization of the longitudinal wave;

Color scheme – select a color scheme of the screen. Select a default one;

X-axis zero – setting of the reference point of the X axis relative to the antenna array. Set the «Antenna array front», i.e. the front end of the antenna array will be the start;

Repetition rate, Hz – frequency setting of the information update displayed on the screen. It considers image persistence. The set value is 20 Hz. We don't change it.

Readings discreteness – setting the category of the value of the parameter being measured in the panel of the measurement results, e.g., 1 or 1.0 mm. We recommend setting the value to 0.1 during adjustment; during inspection – to 1;

SAFT reflections limit – corresponds to number of the considered rereflections at boundaries of the object under examination when the image is being formed (for all reconstruction algorithms of the tomogram, except the «Unknown thickness» mode). The setting range of the values if from 1 to 20. When the value increases , the focus image is improved, but it will result in slowing the repetitions rate. We recommend to set the value within the range from 2 to 5. For thickness up to 10 mm the value should be increased to 5. Value 2 is sufficient for thickness exceeding 10 mm. At this point we set value 2.

Welded seam/bottom strobe – allows drawing the welded seam (butt) on the screen image or enable the bottom strobe (it was described during adjustment direct antenna array M9060. It is not used for angle antenna arrays). Select the «seam».

Second tab – icon  – here the parameters of the antenna arrays are stored. These parameters are displayed in the first line of the first tab.

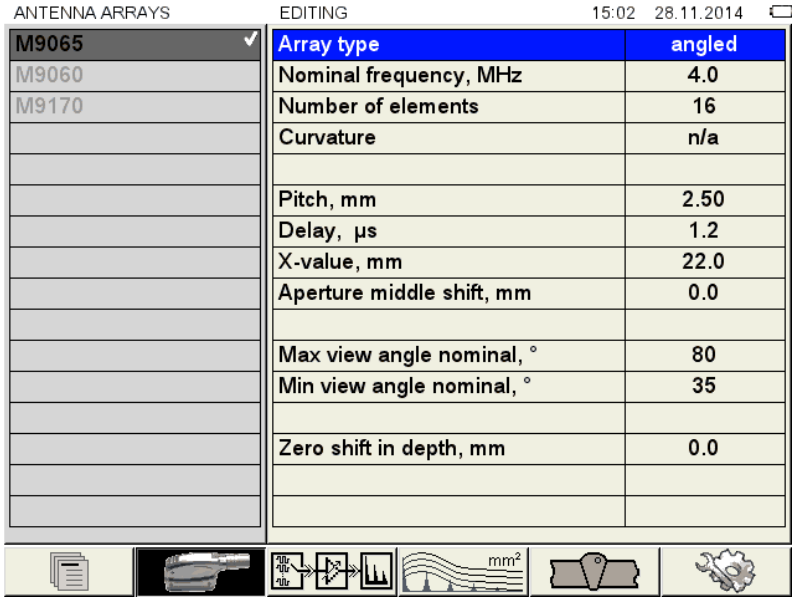


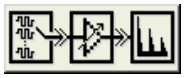
Figure 43 Configurations mode. Second tab

Sign √ flags the antenna array selected in the first line of the first tab. In this case it is M9065.

For experienced users: press and hold the  *key during 2 seconds to switch to adjustment mode of the antenna array parameters. The instrument's screen will display an image represented on Figure 43.*

There is no need to edit the array parameters at this point to fulfill our task. It may be required to change the **X-value** parameter to check the depth meter. This operation will be described later.

The parameters of the second tab are described in the Operation Manual. Value of the antenna array parameters must comply with the certified values.

Third tab – icon  – allows selection of the gain in the instrument's receiver and functionality check of the antenna array. P)rior to selection of the gain, adjust the image scale and examination area in the operation mode.

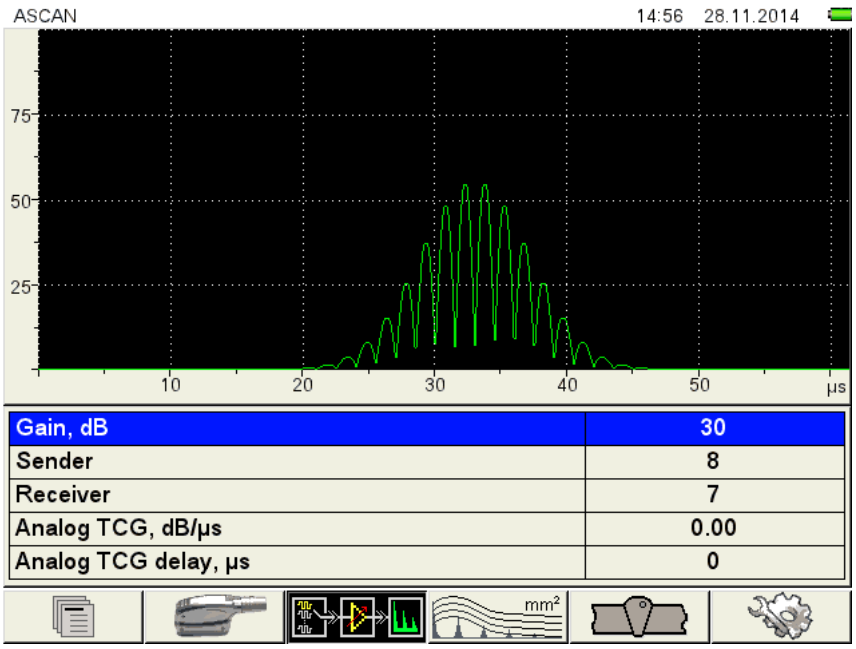


Figure 44 Configurations mode. Third tab

3.2 Adjustment of image scale and examination area

Press the key  to enter the operation mode. In the third icon F3 the “Unknown thickness” tomogram reconstruction algorithm is set by default. This algorithm is set as the main one. Activate the fifth icon **F5** and select a correct scale of the image, In such a manner so that the image depth is up to 30 mm (straight and once reflected beam). Position indicator of the antenna array must be in the right or left part of the tomogram image area (B-Scan). Activate the first icon **F1.** Use the arrow keys left-right and up-down to set the examination area: depth from 0 to 31 mm, width from 0 to 20 mm (width welded joint). Place the antenna array on the reference block and point it to the near reflector.

Now you have to get an image presented on Figure 45.

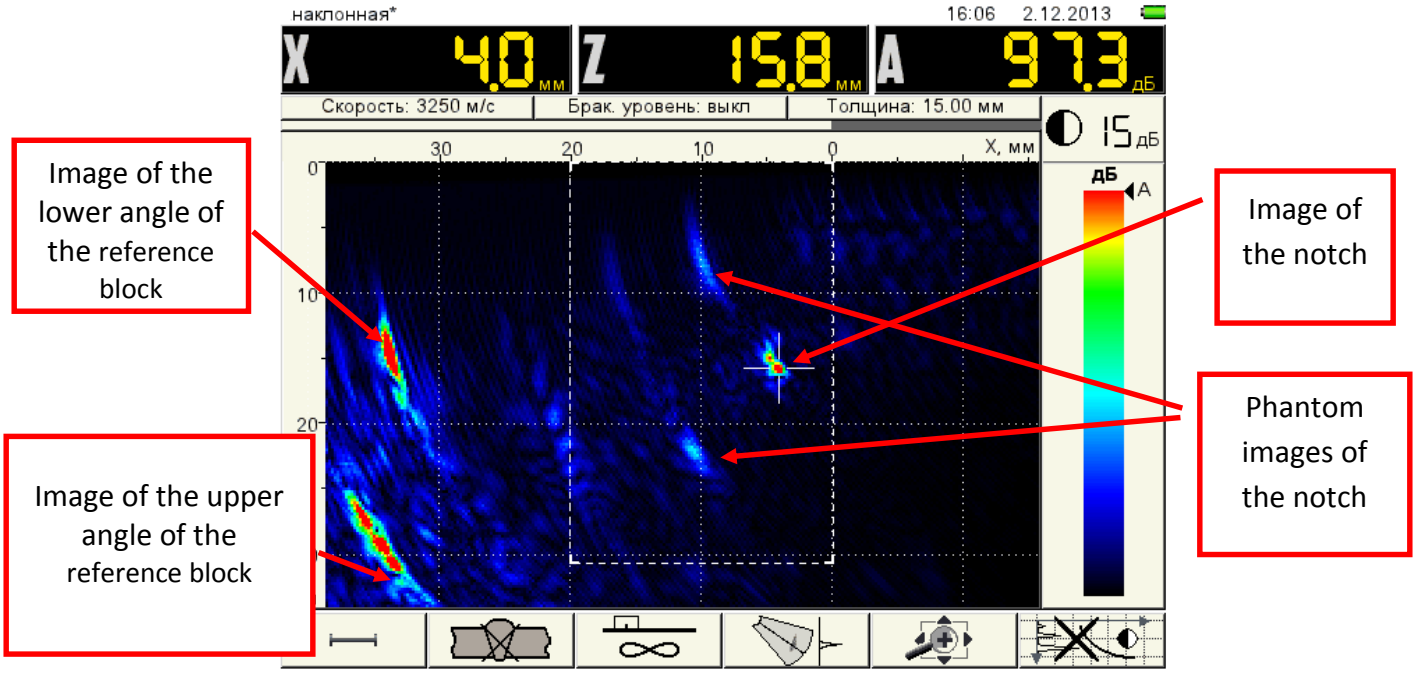


Figure 45 Operation mode. The antenna array is pointed to the near reflector

3.3 Adjustment of amplification of the receiver

Press the  key to open the third tab of the Configurations mode. Now set «Sender – 1», «Receiver – 2» and find on A-Scan the signal peak from the near reflector notch in the 14 µs area (time of double transmission of the wave from the antenna array to the notch and back). The signal exceeds the limits of the screen by height.

Note: functionality (performance) of all 16 elements of the antenna array is checked by sequentially switching the numbers of the Sender and Receiver. Performance criterion is the presence of the emission pulse and reflected signals on the A-Scan.

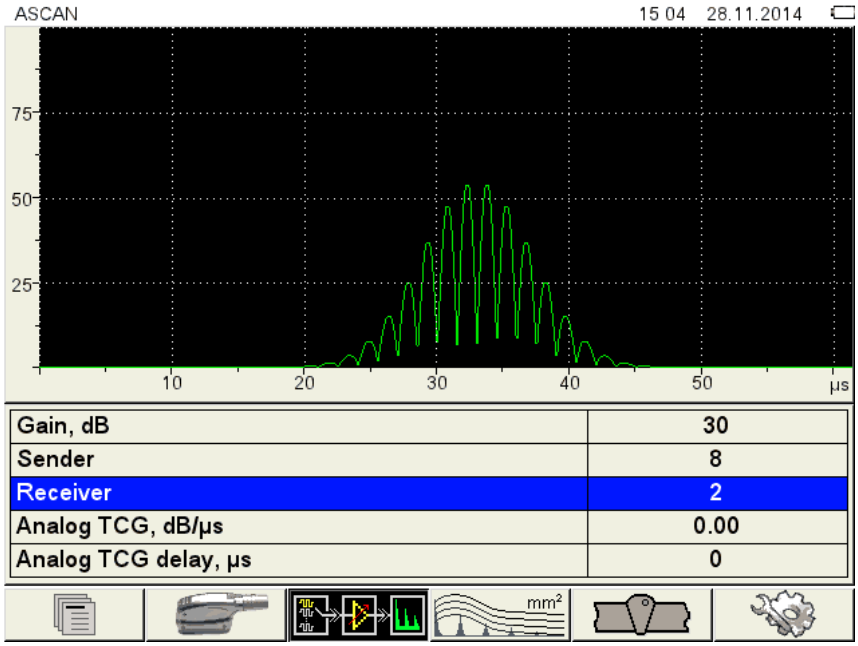


Figure 46 Configurations mode. Third tab.

Decrease Gain to the value at which a signal from the notch will have a height of 50-75% of the screen.

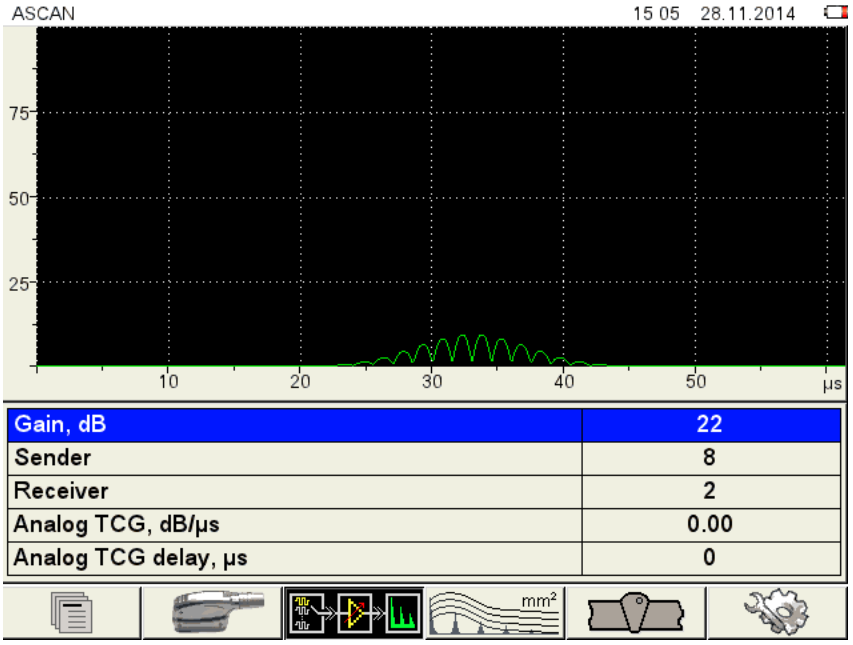


Figure 47 Configurations mode. Third tab

3.4 Adjustment of brightness

Switch to the operation mode.

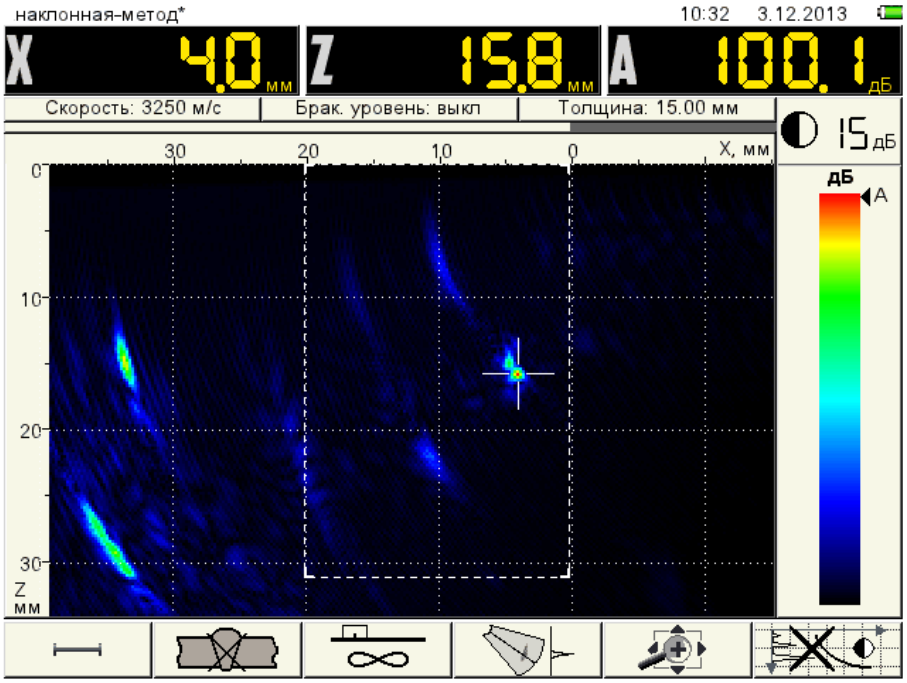


Figure 48 Adjustment of brightness.

Use the key  to increase the brightness the value at which the conventional height of the notch ΔZ will equal to the actual height of the notch .

Measurement of the conventional height can be done in the STOP mode. Press the key , move the cursor to the upper boundary of the red image of the notch , press the key 

and move the cursor to the lower boundary of the red image. Conventional height of the defect ΔZ=1.9 mm. We acept the brightness level 21 dB as a working value.

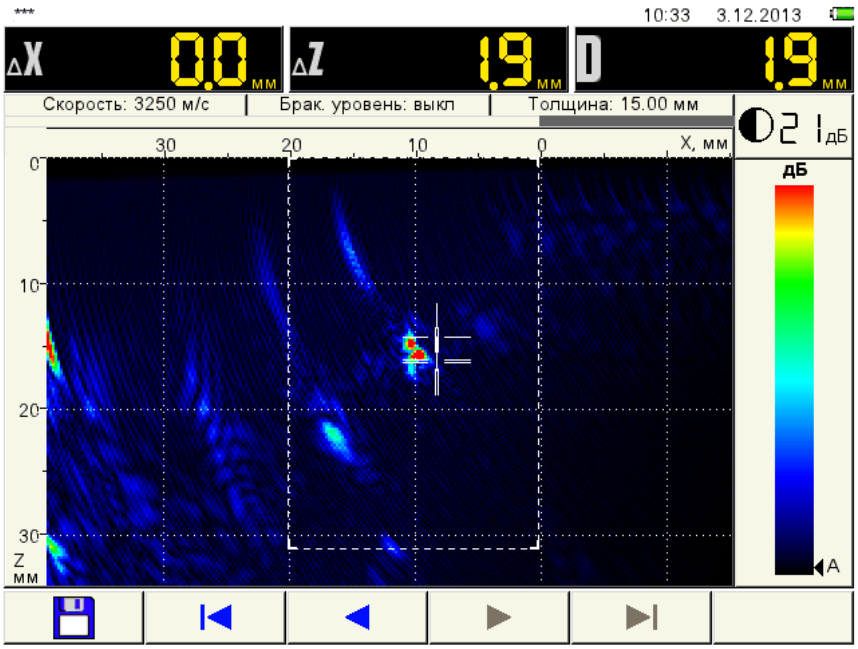


Figure 49 Measurement of the conventional height.

On the screen, except the signals there are phantom images of the notch, amplitude of their signals is by 10-12 dB less than the amplitude of a signal from the notch. During operation they can be above the examination level, hence we shall try to get rid of them.

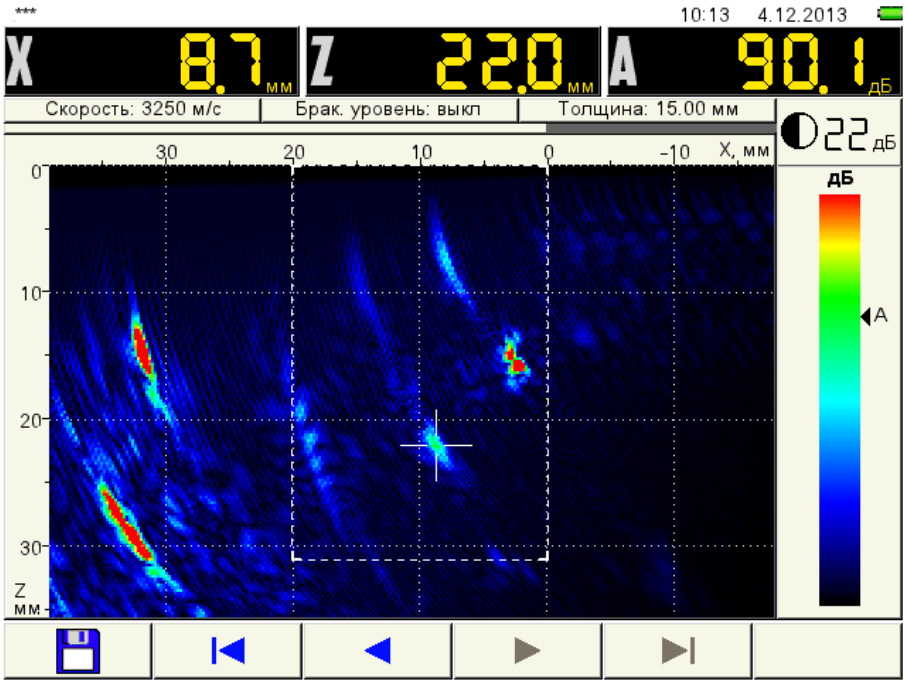


Figure 50 Phantom images.

To do it in the first tab **F1** we set the operating frequency 2.5 MHz. Go to the third tab and adjust Gain according to paragraph 3.3.

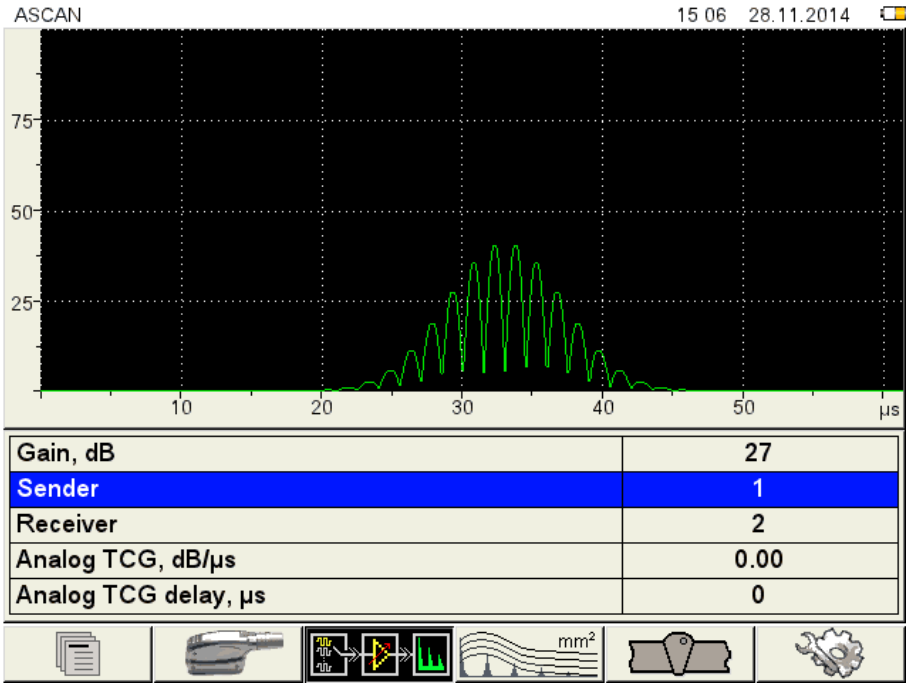


Figure 51 Adjustment of amplification of the 2.5 MHz frequency

Now we switch to the operation mode, phantom images are hardly visible, amplitude of a signal from the notch dicreased by 7.4 dB. But the image sixe increased a little. We accept the 2.5 MHz frequency value as a working value.

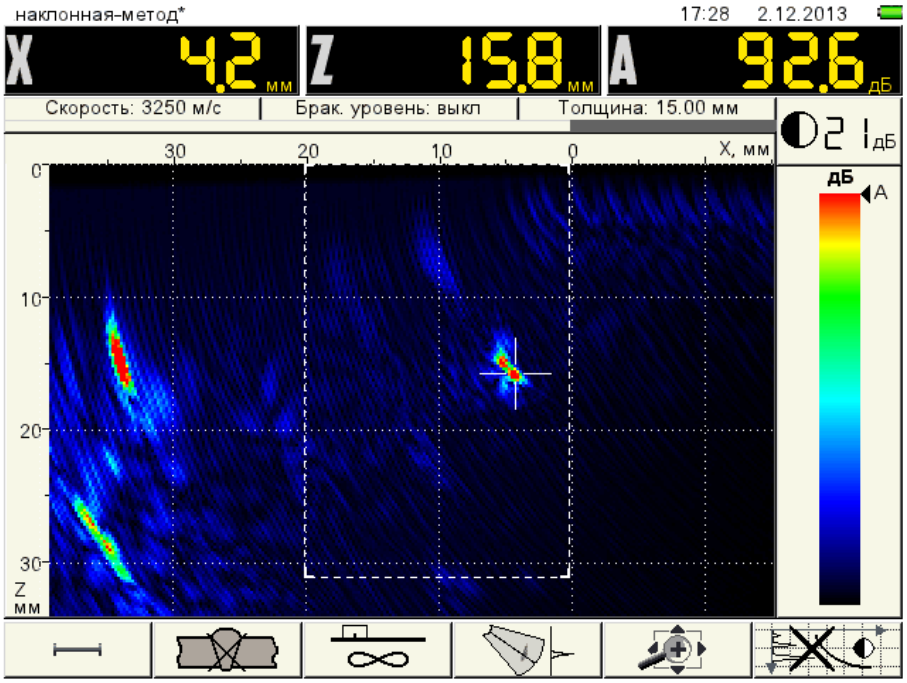


Figure 52 Operation mode. 2.5 MHz frequency

Increase Brightness by 1 dB and measure conventional height of the notch according to the above-described method. Height ΔZ=2.1 mm. We accept the brightness level 22 dB as a working value.

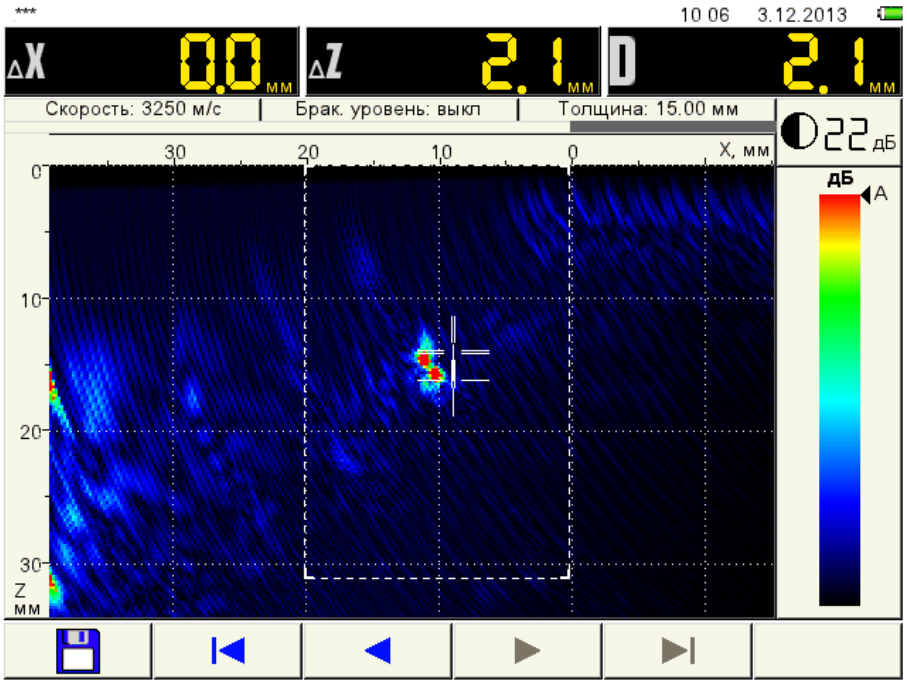


Figure 53 Measurement of the conventional height of the near reflector

Let's check the adjustment of brightness on the distant reflector (upper notch). Conventional height ΔZ=2.0 mm. Brightness level is accepted without changes.

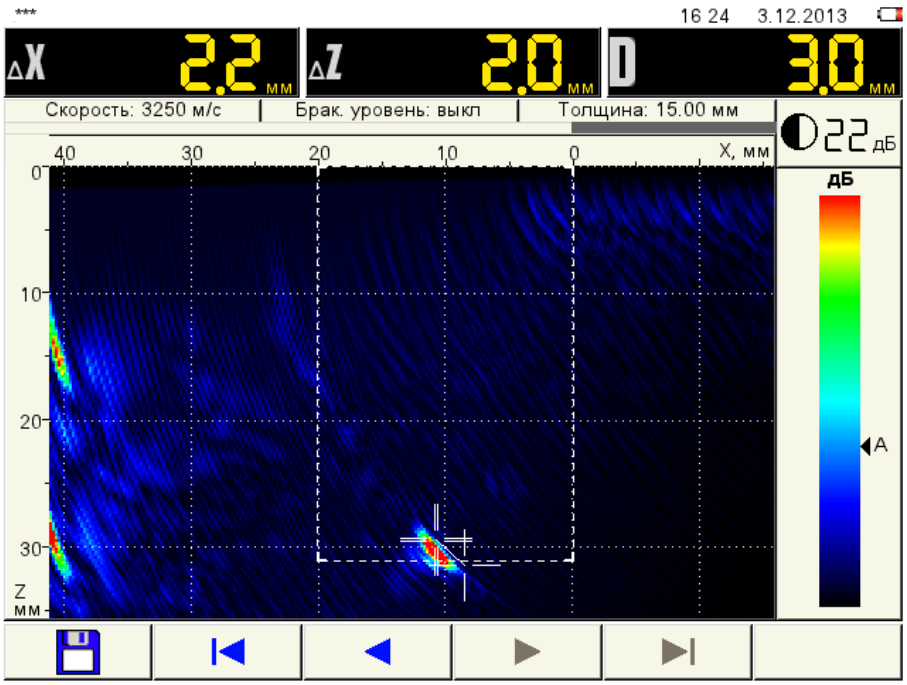


Figure 54 Measurement of conventional height of the distant reflector

3.5 Checking the depth meter

On the reference blocks with «notches» the most convenient way to check the depth meter is by the far reflector. Place the antenna array agaisnt it and check the readings of Coordinates X and Y. Maximum permissible error of the depth meter at which there is no need to change the parameters is ±0.5 mm.

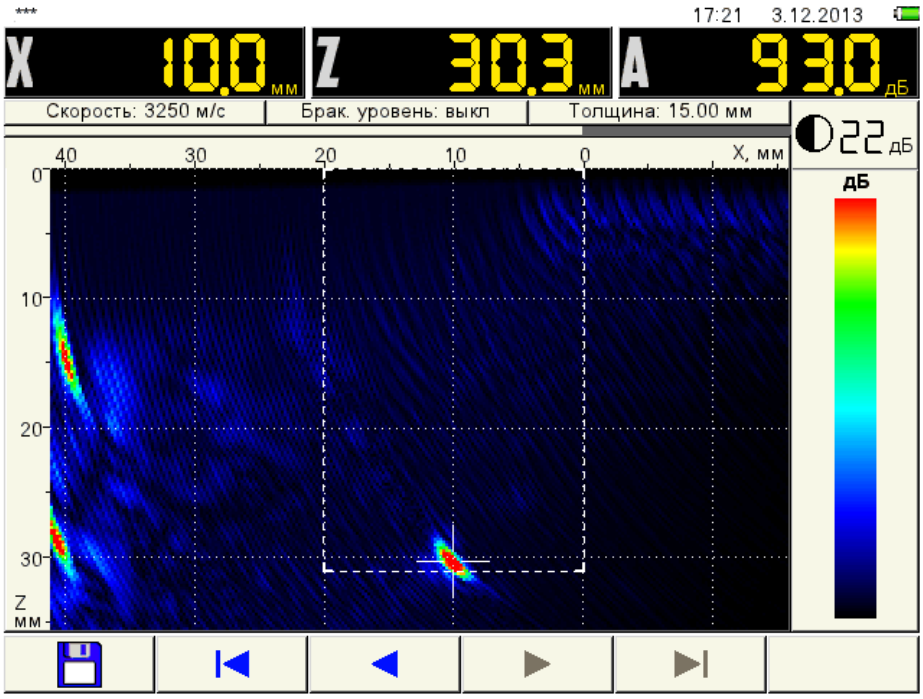


Figure 55 checking the depth meter of the distant reflector

X=10 mm. Use the ruler on the reference block to check the X coordinates. We got 8 mm. The error exceeds the permissible one. To correct it: go to the Configurations mode (the seonc tabe), press an hold the key  during 2 seconds and enter the adjustment mode of 9065. Select the **X-value** line and set value to 24 mm.

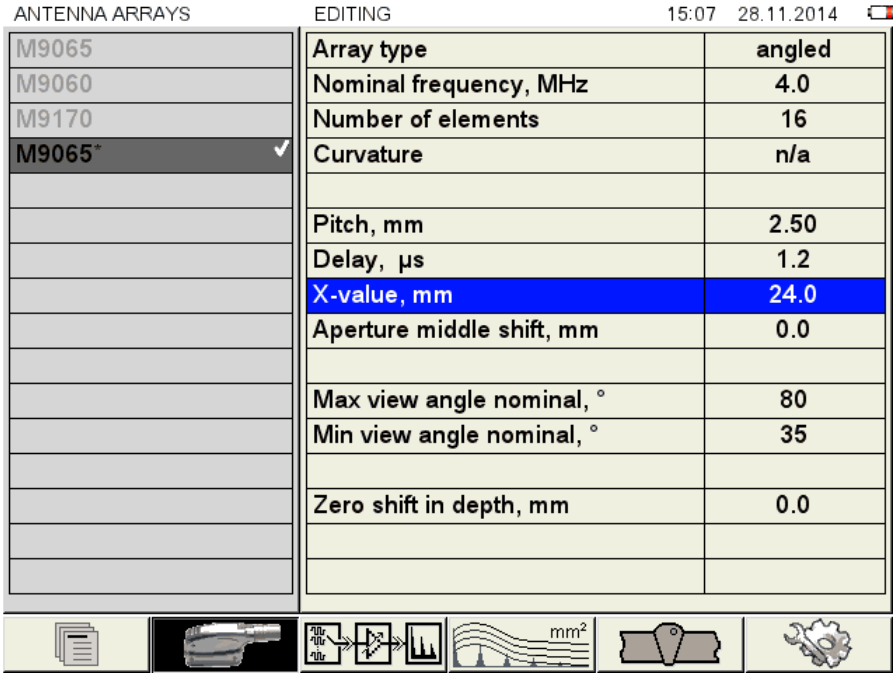


Figure 56 Adjustment of the antenna array X-value.

Press the key , then Enter and save the antenna array configuration under a new name. Return to the operation mode and check the depth meter.

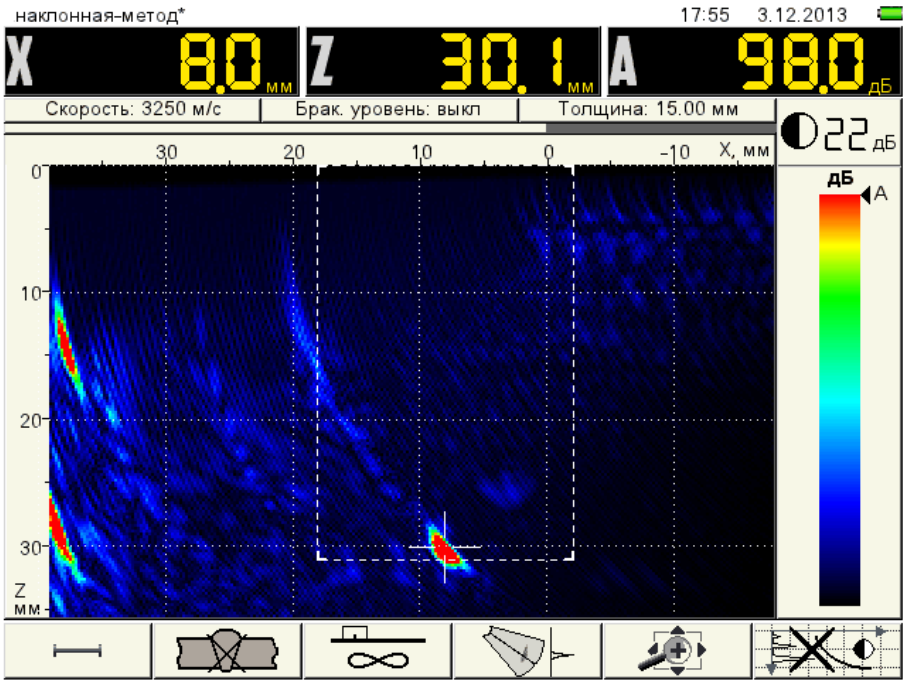


Figure 57 The strobe shifted due to changed X-value of the antenna array

X=8.0 mm, Y=30.1 mm. The depth meter is adjusted. But the inspection area has shifted, use the key to return it to the initial state.

Let's consider the second item in the first tab of the Configurations mode, the **Excitation pulse, periods** to adjust the sensitivity. Now 1 is set. We shall set to 1.5.

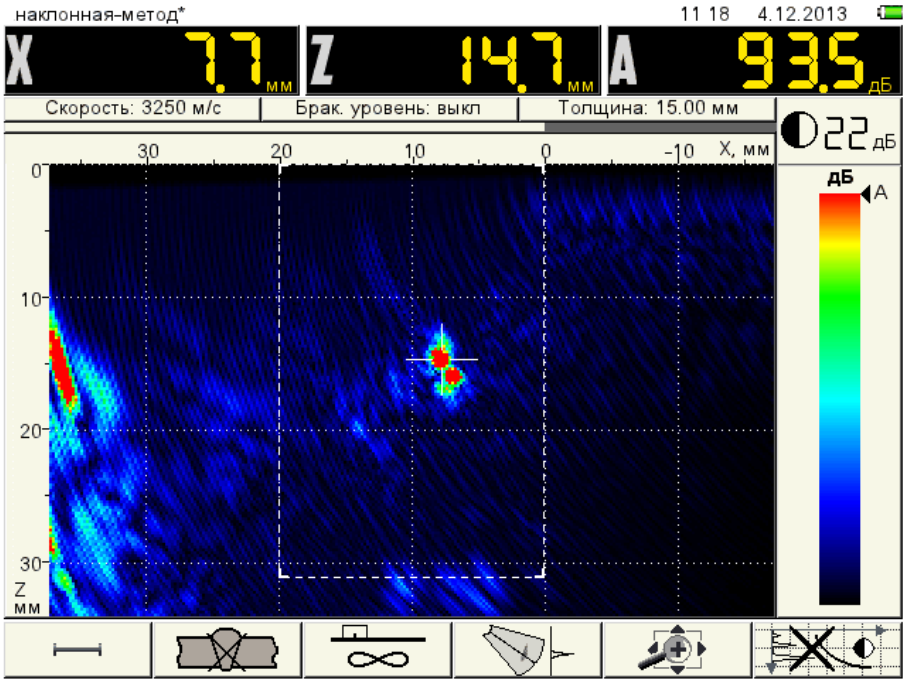


Figure 58 Operation mode. Excitation pulse of 1.5 period

Amplitude a signal from the notch increased by 0.9 dB, amount of noise increased and image of the notch is “thicker”. Measure the conventional height ΔZ=2.6 mm.

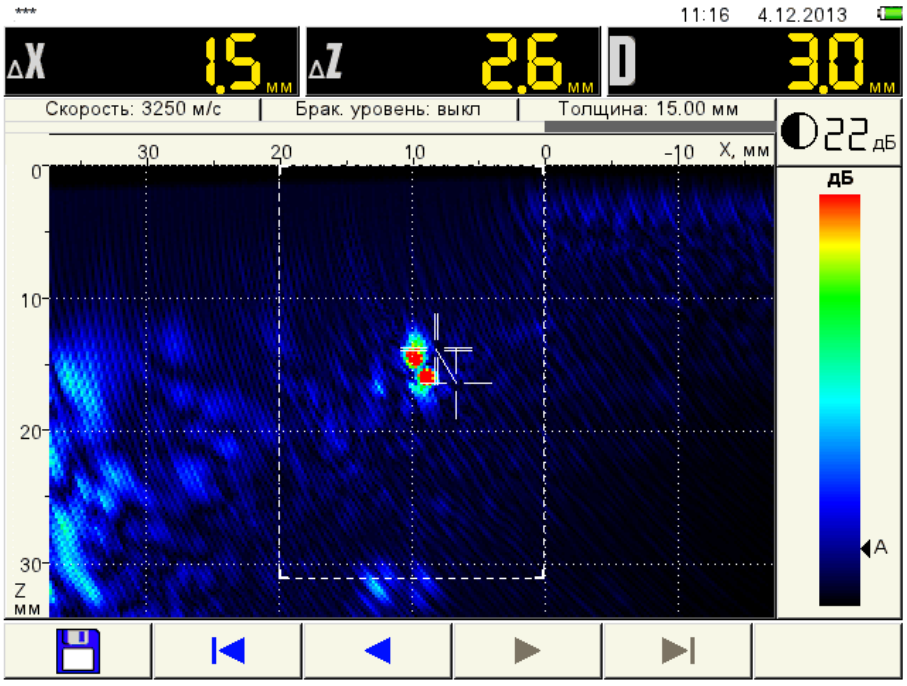


Figure 59 Measurement of the conventional height. Excitation pulse of 1.5 period

Brightness can be reduced, e.g., to 20 dB, and the conventional height can be set to the actual one.

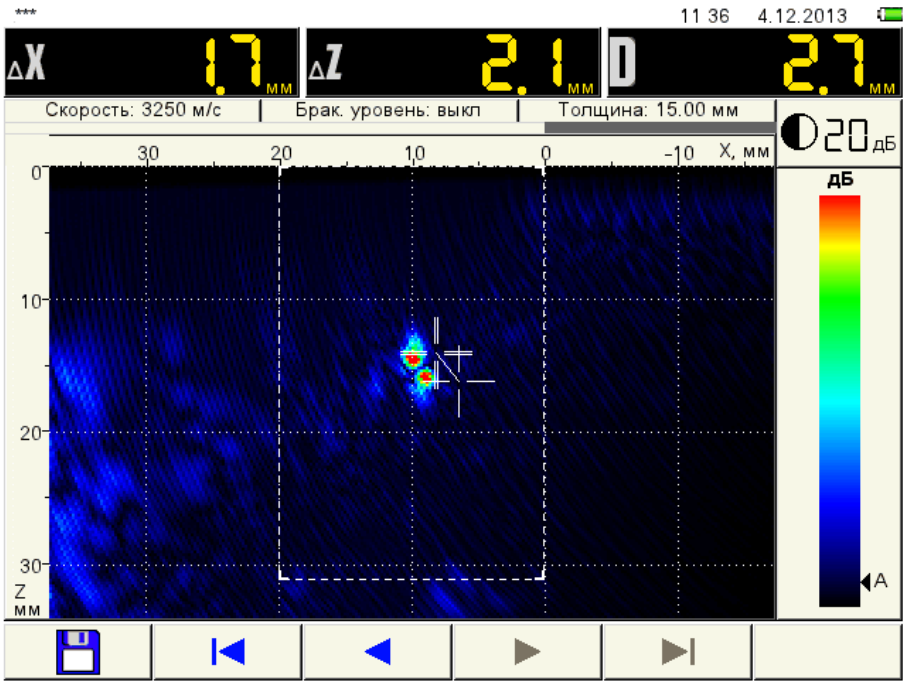


Figure 60 Excitation pulse 1.5 period. Brightness is reduced to 20 dB

The “picture” didn’t improve, theamount of noise increased. Hence go back to the value of the excitation pulse 1 and accept it as a working value.

3.6 Adjustment of TCG “Unknown thickness” mode

The instrument enables two ways of TCG adjustment:

Choice 1 – Analog TCG, which is in the third tab **F3** of the Configurations mode.

We recommend using it for objects under examination thicker than 20 mm during adjustment of TCG on the reference blocks with flat bottom RR or RR of the cylinder holes type.

Adjustment method is similar to adjustment of the direct antenna array. It is described in paragraph 2.3 There is only one difference in the formulas for calculation of the TCG characteristics and delay.

The Formula (1.1) will have the following form

$$X = \frac{(A_1 - A_5) * C * 10^{-3} * \cos\alpha}{2 * (Z_5 - Z_1)}, \text{dB}/\mu\text{s}$$

The Formula (1.2) will have the following form:

$$t_{\text{delay}} = \frac{2Z_1 * 10^3}{C * \cos\alpha}, \mu\text{s}$$

Choice 2 – Spatial TCG, which is in the fourth tab **F4** of the Configurations mode. We recommend using it for objects under examination with thickess up to 20 mm including, during adjustment TCG on the reference blocks with “otches”.

We will adjust TCG according to the choice 2.

Enter the Configurations mode (the fourth tab), select the TCG line and press the key Enter. Place the antenna array opposite to the near reflector and carefully move the antenna array in direction from the near reflector to the near reflector in such a manner to make the accumulated images on the screen to overlap the examination area horizontally.

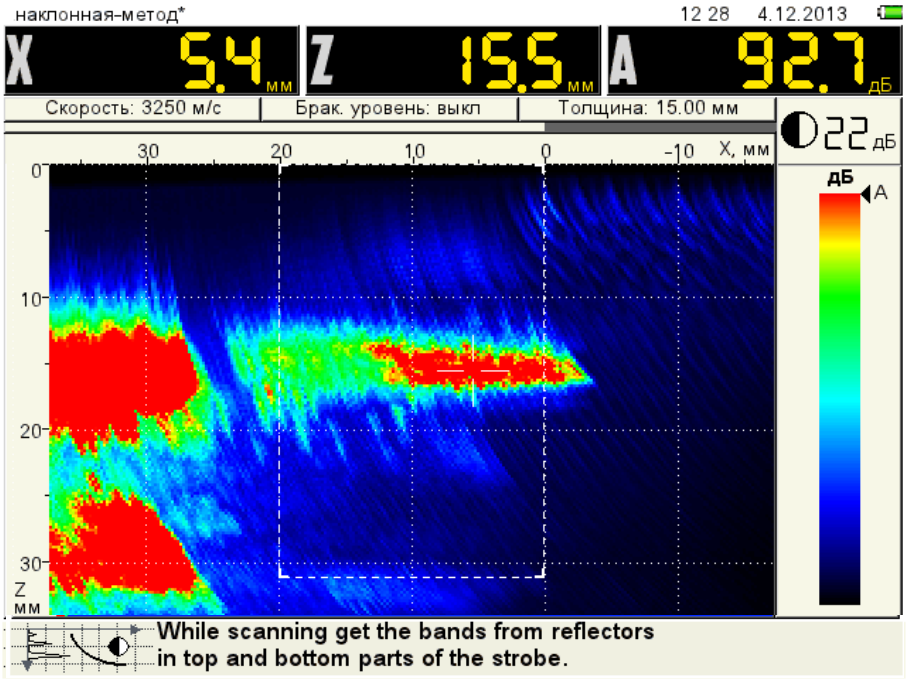


Figure 61 Adjustment of TCG to the near reflector

Rotate the reference block by 180º around a vertical axis and accumulate the images of the distant reflector.

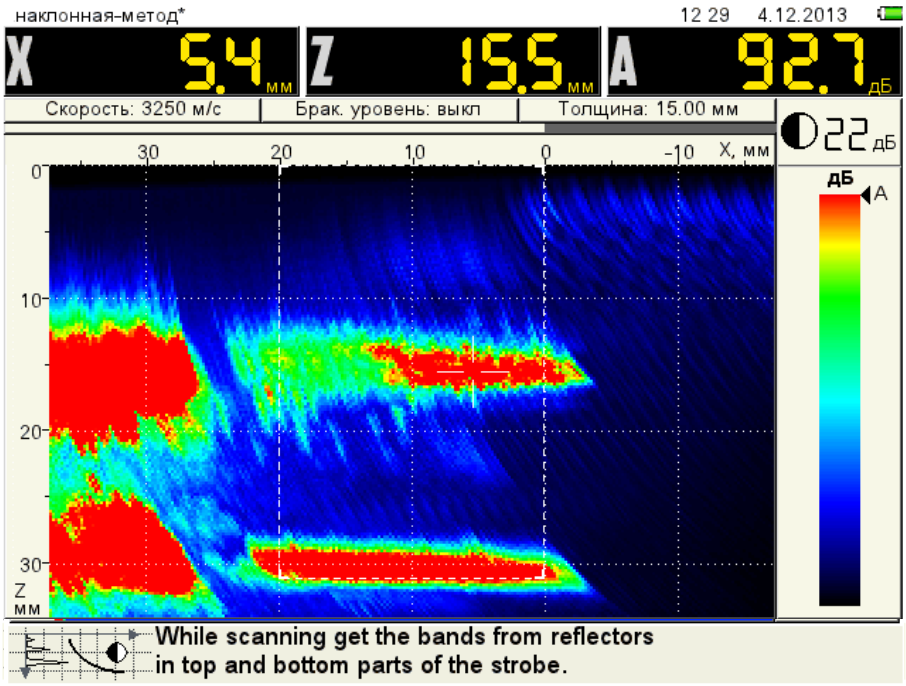


Figure 62 Adjustment of TCG by the distant reflector

Press the key Enter and accept a generated TCG. Switch to the operation mode and check the values of the amplitude of a signal from the near reflector and distant reflector. The scattering of values of the amplitude which can be left unchanged is 2 dB.

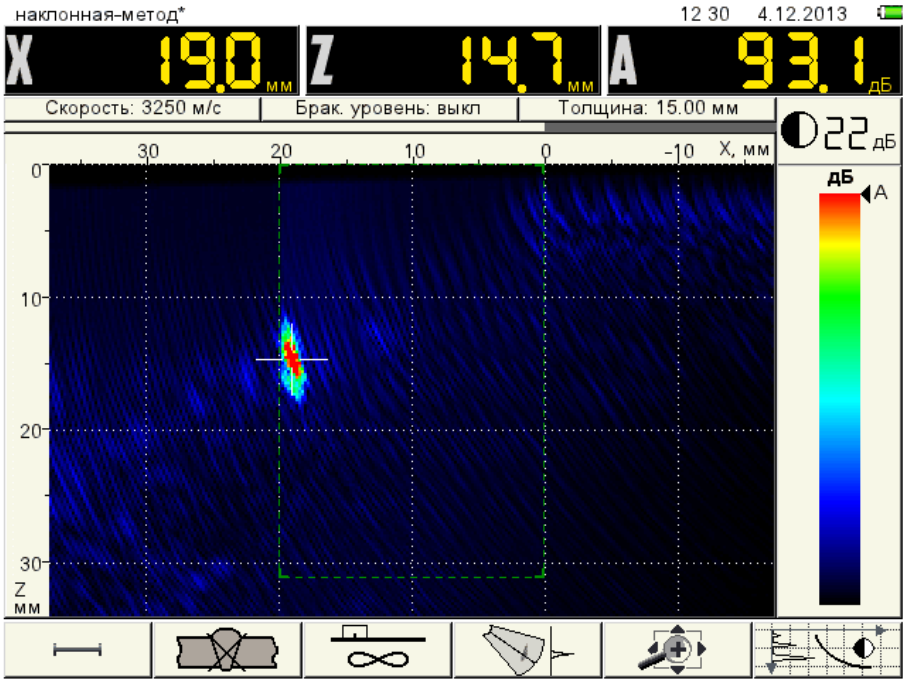


Figure 63 Checking TCG by the near reflector

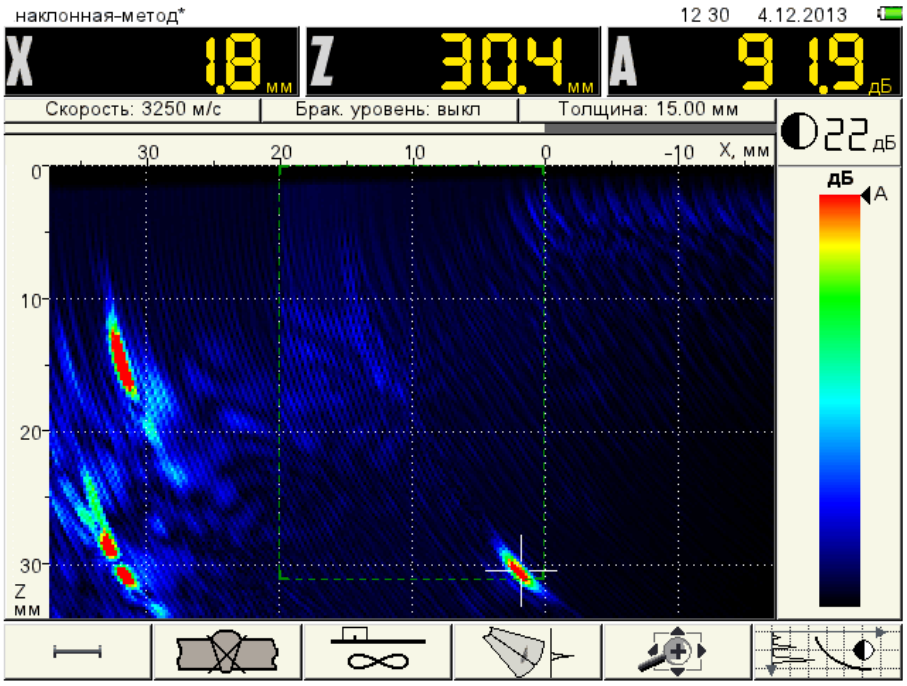


Figure 64 Checking TCG by the distant reflector

Peak signal equals to 93.1 dBfrom the near reflector, minimal signal 91.9 dB from the distant reflector. The scattering of values is 1.2 dB. We accept the generated TCG.

Check the conventional height of the notch of the near reflector and distant reflector once again. If height of the notch is increased, then decrease image brightness.

3.7 Adjustment of the acceptance sensitivity

Return to the fourth tab, select the line **Reference level** and press the key Enter. Place the image of the notch to the center of the examination area (Near reflector or distant reflector) and press the key Enter.

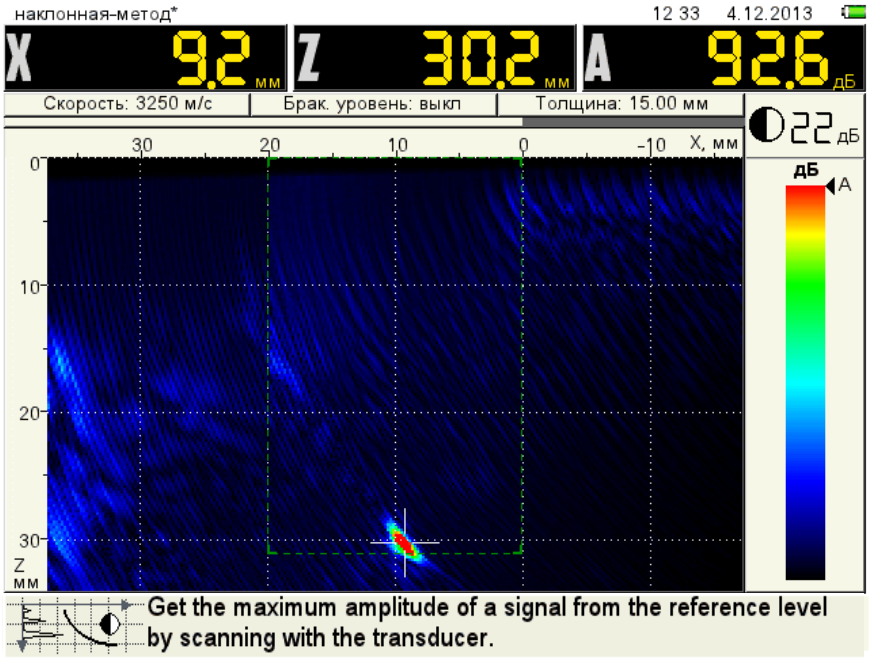


Figure 65 Determination of the reference level

The level 92 dB is set in the **Reference signal** line.

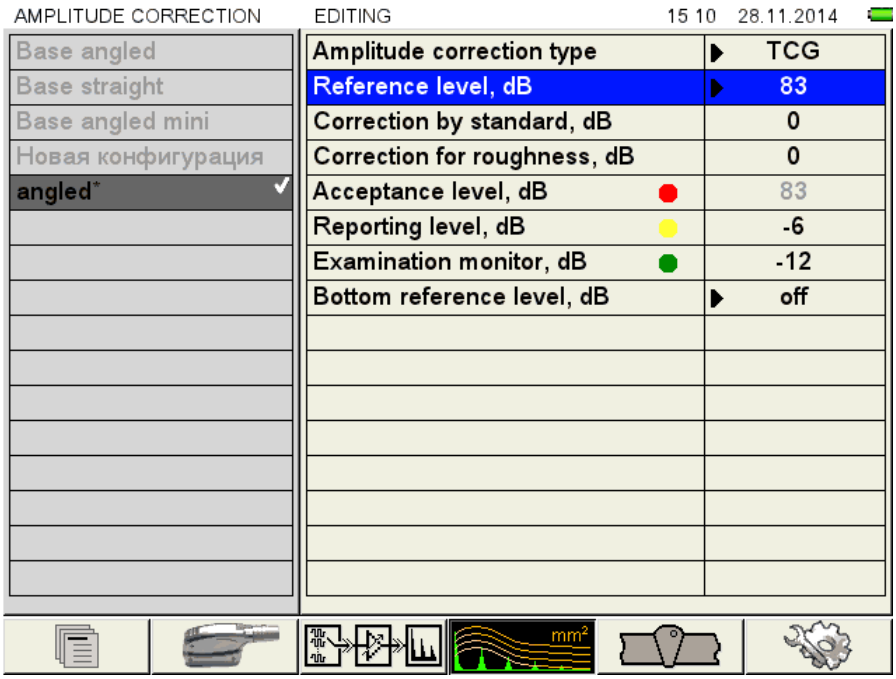


Figure 66 Configurations mode. Fourth tab. Reference level

When the reference level is switched on, the following parameters appear :

Correction by standard, dB – the parameter is different than 0 if adjustment is made with RR which doesn't correspond to your acceptance level (e.g., cylindrical hole Ø 6 mm in RR-2). Corresponding regulatory technical documentation contains tables of corrections to switch to the acceptance level. We will take required value from these tables and set it in this line.

Correction for roughness, dB – the parameter is different than 0 if roughness of the object under examination doesnt correspond to roughness of the reference block. To determine the corrections you will need a purpose-specific sensor of roughness and waviness manufactured by CNIITMASH. Set the measured correction value to this line.

Acceptance, dB – acceptance level. It is equal to the sum of the reference level, sesitivity standard and correction for roughness.

Reporting, dB – a reporting level. The value is set relative to the acceptance level. We set value –6 dB.

Monitor examination, dB – examination level. It is responsible for operation of the sound and light monitor system. The value is set relative to the acceptance level. We set value –12 dB.

Now we shall switch to the operation mode. Color scheme has changed. Signals with amplitude exceeding 92 dB are displayed in red (above the acceptance level), from 86 to 92 dB – yellow (from 0 to –6 dB – a reporting level), from 82 to 86 dB – green (from –6 to –12 dB – an examination level).

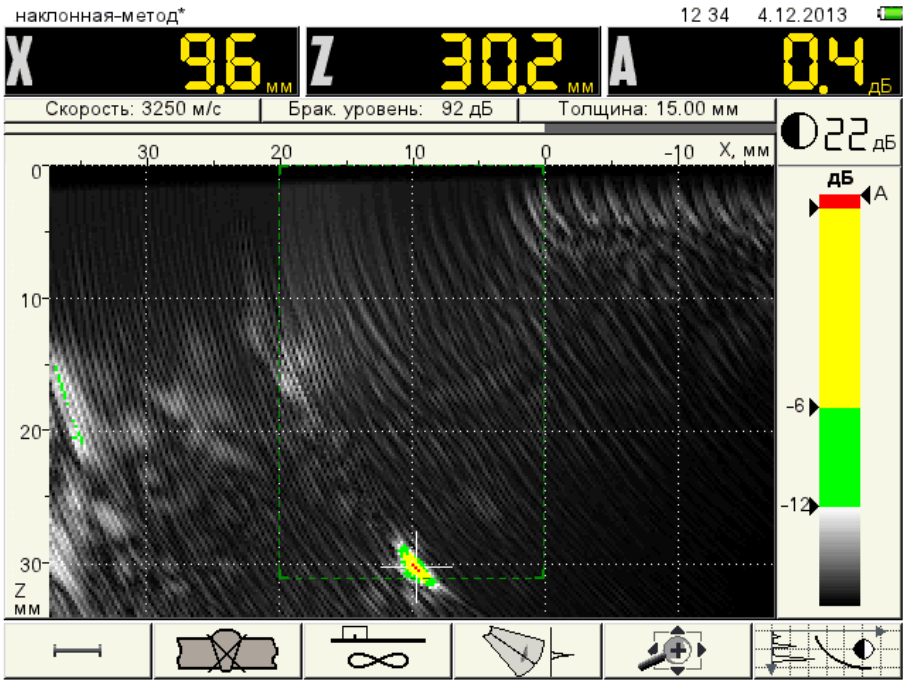


Figure 67 Distant reflector image. Reference level is switched on

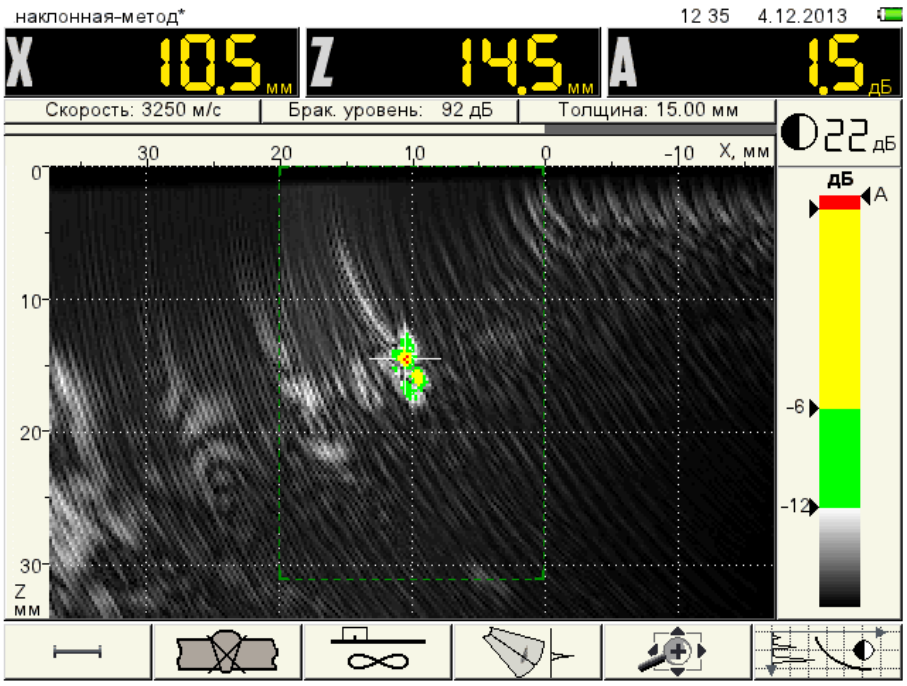


Figure 68 Near reflector image. Reference level is switched on

In this color scheme we can see only images of the reflectors, which amplitude exceeds the examination level. In this mode the monitor system responds – visual (red LEDs) and sound which responds when the amplitude of the signal exceeds the examination level in the strobe.

In this mode the conventional sizes reflectors are distorted. Hence we recommend to perform the measurement of conventional sizes after this mode is switched off. To do it we have to switch off the reference level. Press **F1** key (control over the first strobe) and press the Enter key. To switch off the reference level: press the same keys again.

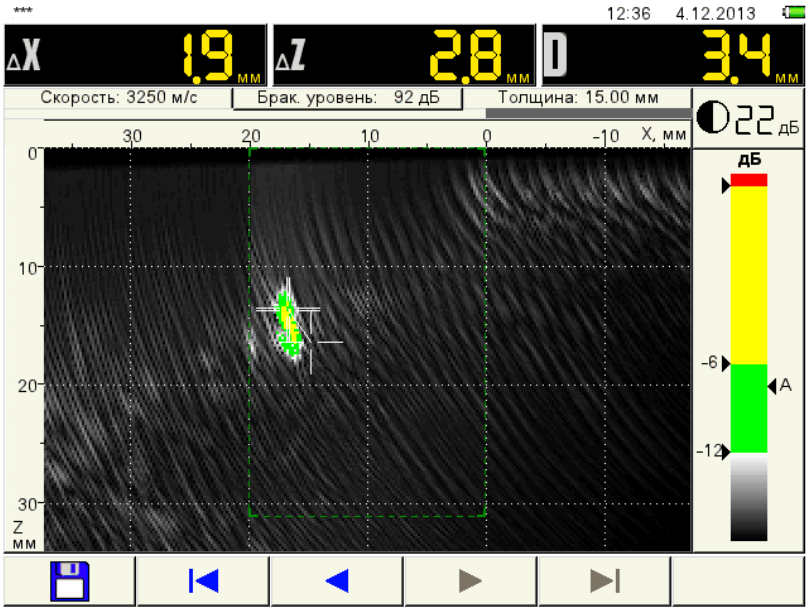


Figure 69 Measurement of the conventional height. Reference level is switched on

3.8 Adjustment of conventional boundaries of the welded seam

The instrument enables display of two boundaries of the welded seam for the butt welded joints of the same thickness on the screen.

Press the **F2** key. An image of the welded seam will be displayed on the screen. Press the Enter key and select required weld view.

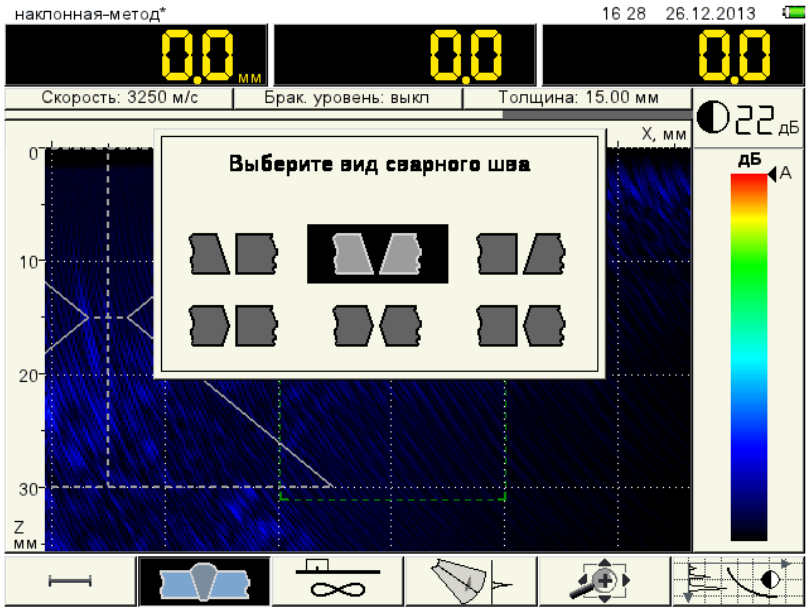


Figure 70 Selecting the welded seam

Press 

to confirm. Set the first parameter X0 (will be yellow highlighted) – actual distance from the antenna array to the welded seam. When the antenna array is placed at the given distance the location of the visible images will be correct.

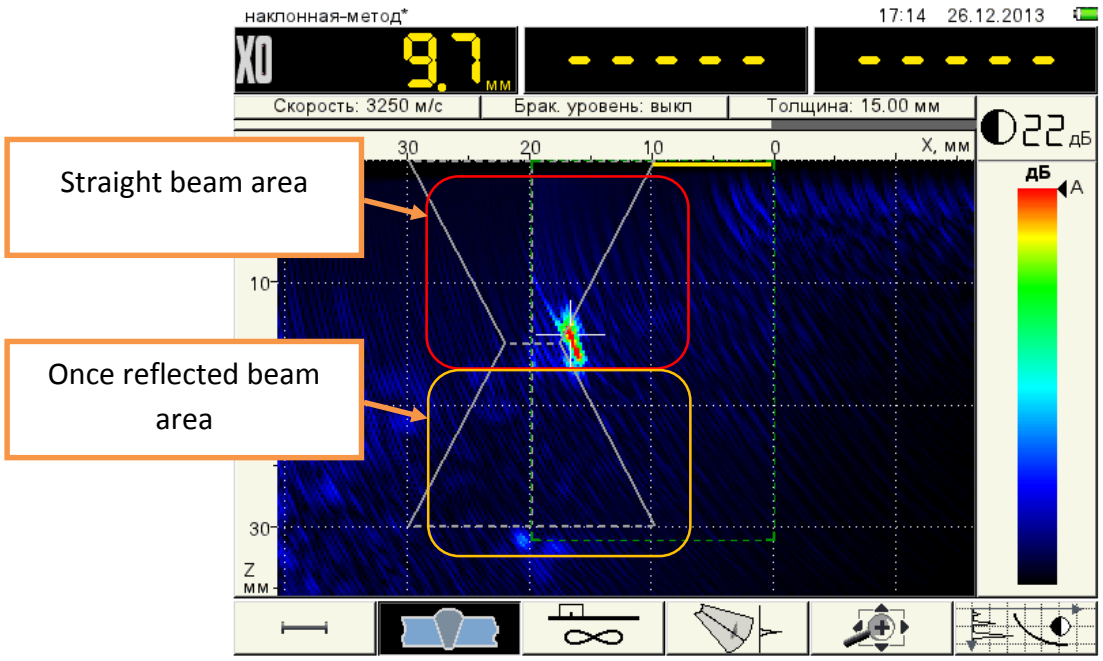


Figure 71 Setting the distance from the antenna array to the welded seam

Use the arrows  to set the value X0=0 mm, i.e. close to the welded seam.

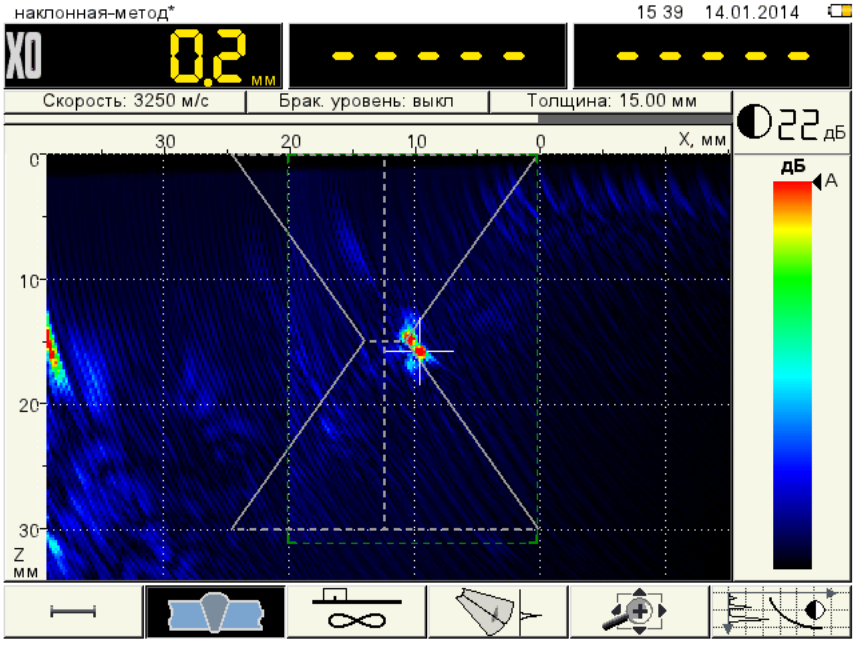


Figure 72 The X0=0 mm value is set

Measure the width of the cap weld (upper width) “e” on the welded seam. We got 20 mm. Press the key  . The “e” parameter is yellow highlighted on the screen. Use the keys  to set this value.

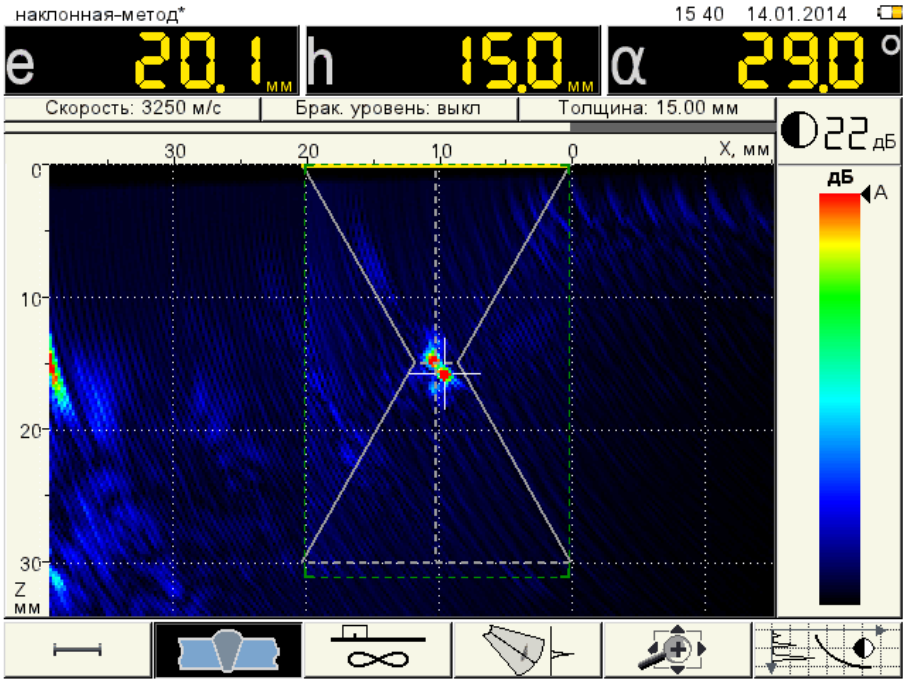


Figure 73 Setting the “e” width

Measure the width of the weld root (lower width) “e1” on the welded seam. We got 5 mm. Press the key  . The “e1” parameter will be yellow highlighted on the screen. Use the keys  to set this value.

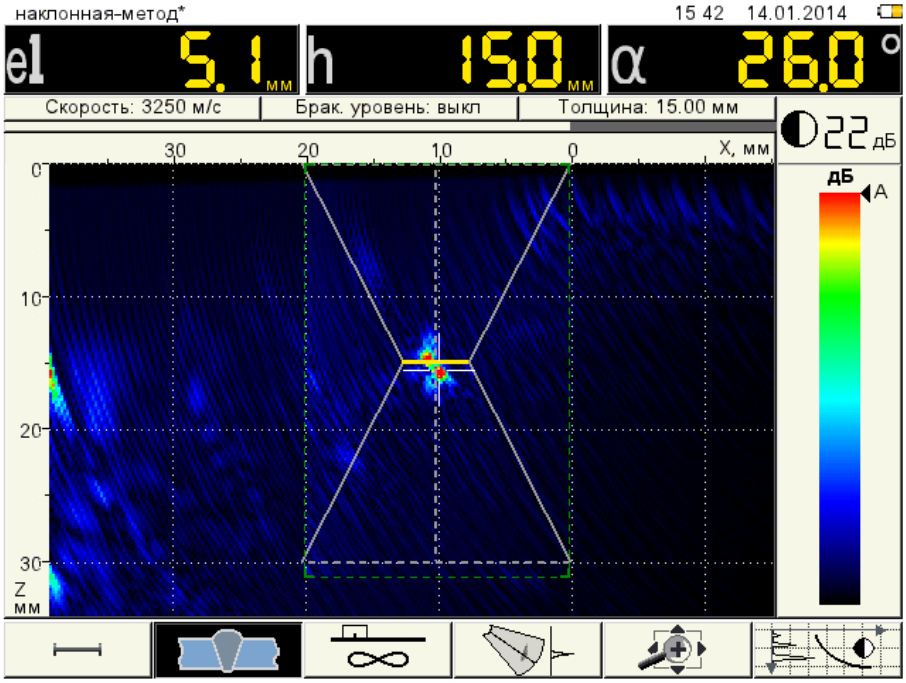


Figure 74 Setting the “e” width1

Parameters h – Height of the edges and α – angle of bevel cannot be edited. They shsll be calculated from the ratio of the parameters e, e1. e2.

Parameter e2 – average width. It appears if the double sided edge is selected. Then the image of the seam will be as follows.

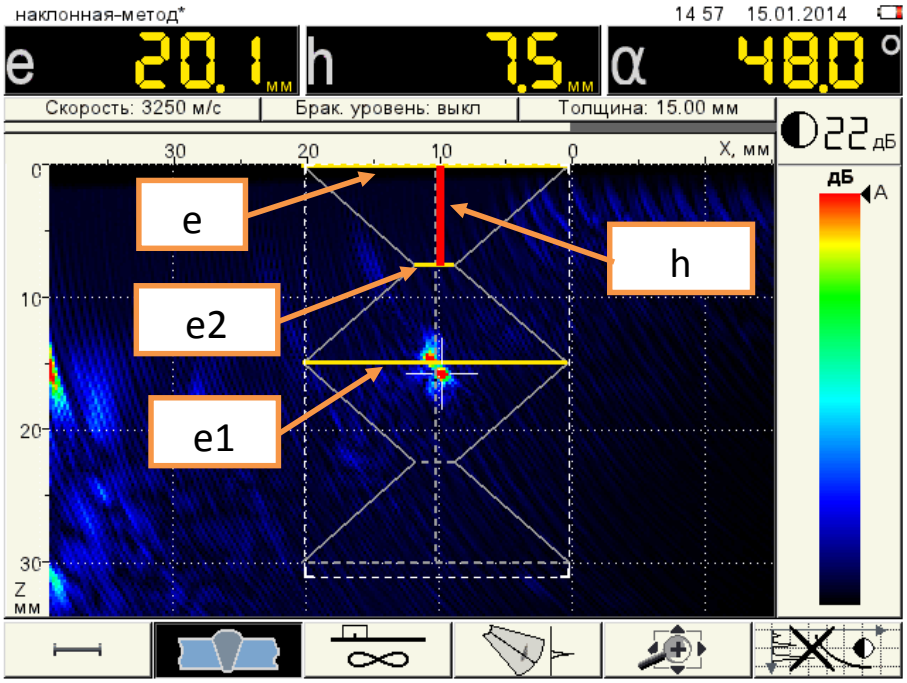


Figure 75 View of the welded seam image boundaries with double side edges and description of the measured parameters.

Record the created configuration into instrument's memory under «C21-15 mm п-п» name (п-п – Unknown thickness).

Now we will create configurations for two visualization modes – «plate mode» and «vertical cracks mode».

Note: these modes are working in the instruments enabling reflection of the ultrasonic wave at the surface parallel to the scanning surface.

3.9 Adjustment of «Plate mode»

Reconstruction mode «Plate» can be the main one when inpecting the butt welded joints.

Advantage – the defects found by the once reflected beam are displayed in correct positions with real depth relative to the scanning surface.

Drawback of this mode – we have no information on the beam which we use to find the defect. It can be important to select the "defect-false reflector" kind.

We recommend using three recostruction types in a complex: main – «Unknown thickness» or «Plate» and additional «Vertical cracks».

After the adjustment of the «Unknown thickness» mode we performed in the «Plate» mode we have to correct the brightness value and adjust TCG for this mode. After that we save the edited configuration under a new name.

Press the key **F3** and use the keys  to sekect «Plate mode». Press  to confirm

Press the key **F1** and decrease the depth of the strobe Z2 to 15 mm. Press the key  and switch off the reference level. Place the antenna array on the reference block. View of the near reflector (the same as in the Unknown thickness mode) consitis of two images. Now they are located at the same depth and their conventional height is 1.1 mm. It is two times less than the actual one. It shows that in this mode measurement

of the conventional height of the planar defects near the boundaries of the welded seam (by depth) results in great error. Hence measurement of the conventional height of the defects shall be carried out in the “Unknown thickness” or “Vertical cracks” mode.

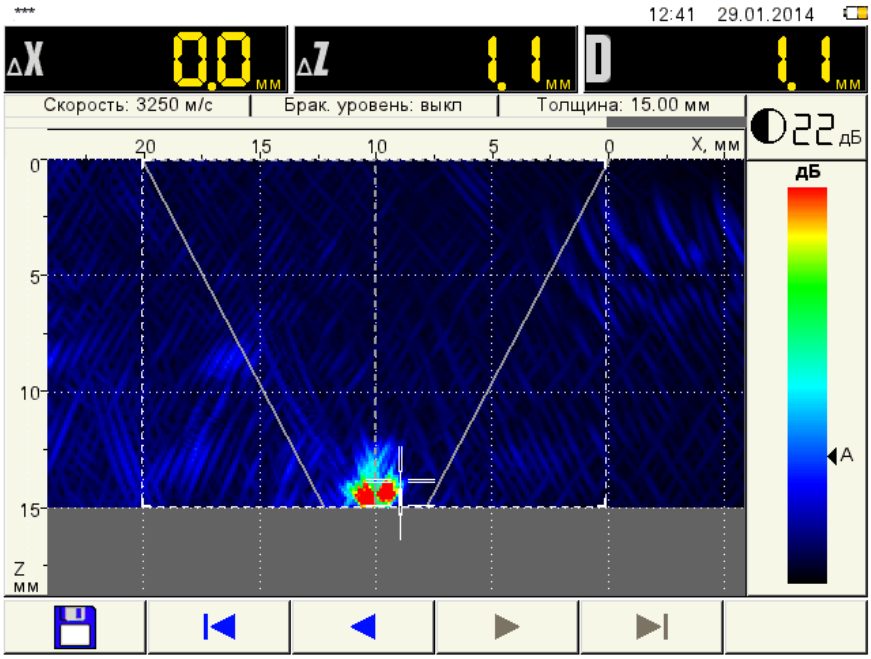


Figure 76 Plate mode. Near reflector image

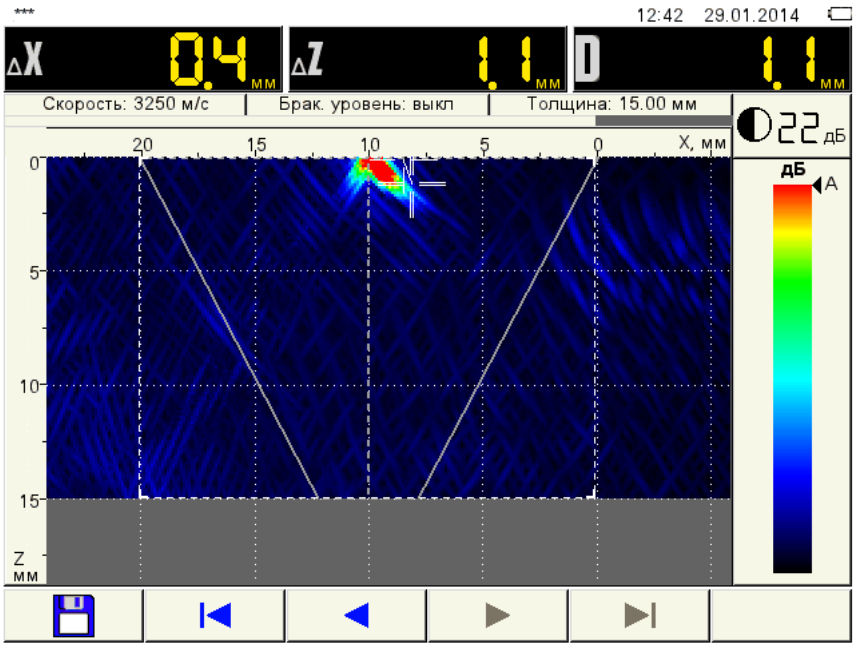


Figure 77 Plate mode. Distant reflector image

Press the key, enter the Configurations mode (the fourth tab), select the TCG line and press the key Enter. Adjsut TCG and the reference level in accordance with paragraph 3.6.

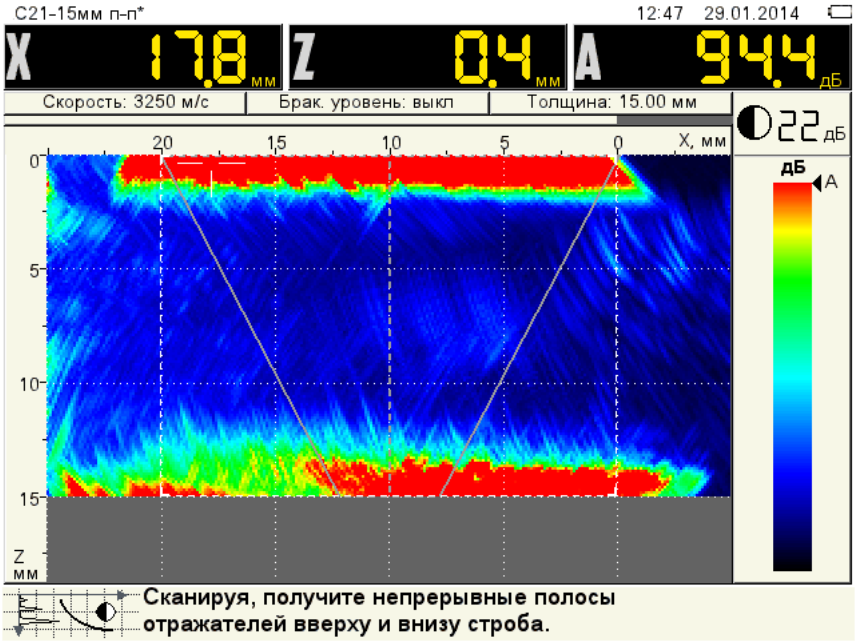


Figure 78 Plate mode. Adjustment of TCG

Check correctness of TCG adjustment. Determine the reference level 93 dB. Adjustment is completed.

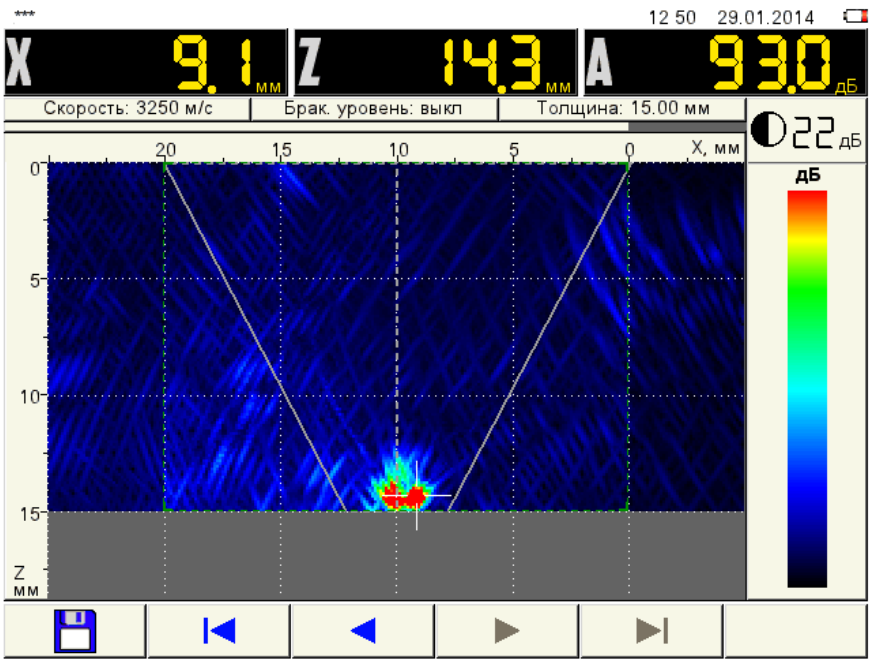


Figure 79 Plate mode. Checking the adjustment of TCG by the near reflector

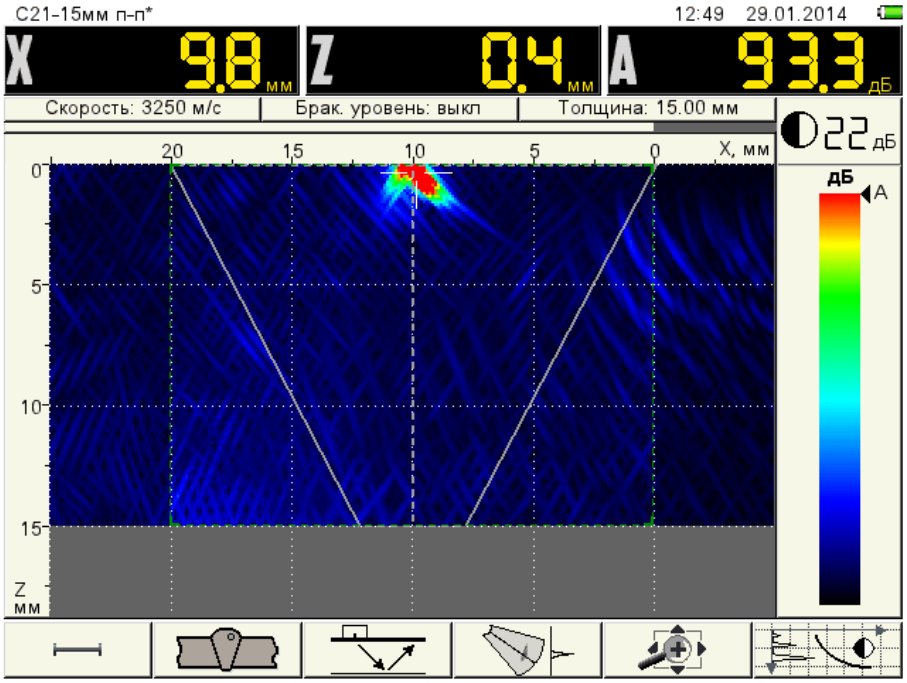
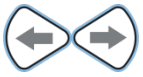


Figure 80 Plate mode. Checking the adjustment of TCG by the distant reflector

Record the created configuration into instrument's memory under «C21-15 mm layer» name.

3.10 Adjustment of "Vertical cracks mode"

This mode is not used to search for the defects. It is designed to clarify the defect type. To be prcise, to find planar vertically oriented defects and measure their conventional height.

Press the key **F3** and use the keys  to select «Vertical cracks mode». Press  to confirm. Adjust brightness. Set the value at whcih vertical size of images ΔZ for the near reflector and distant reflector will correspond to the actual height of the notch. Measurement of the defect heigh is described in paragrph 0.

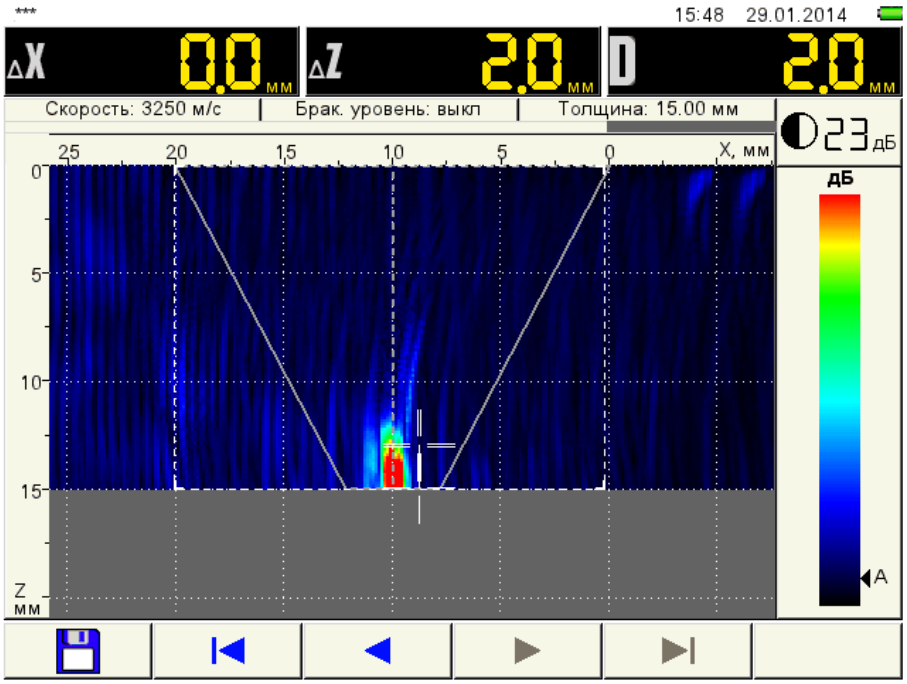


Figure 81 Vertical cracks mode. Measurement of the near reflector size

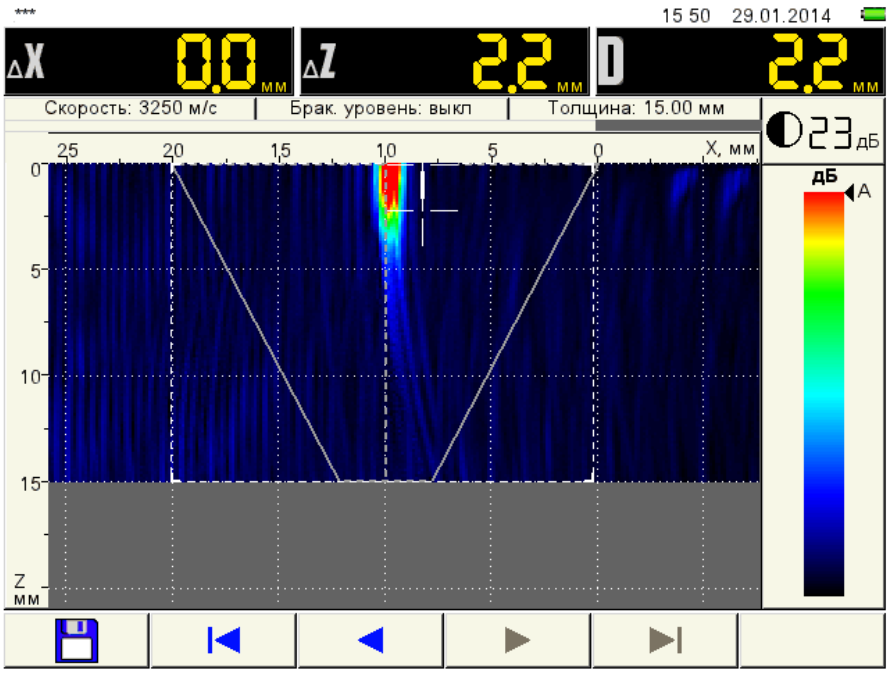


Figure 82 Vertical cracks mode. Measurement of the distant reflector size

Set the working brightness level to 23 dB.

Now we adjust TCG in accordance with paragraph 0. Check correctness of TCG adjustment. We don't set the reference level. Adjustment is completed.

Record the created configuration into instrument's memory under «C21-15 mm crack» name.

3.11 Preparing the entry surface and scanning:

The inspection shall be carried out the contact method, moving the antenna array along the object surface manually.

The inspection of welded joints shall be carried out by scanning (moving) the angle antenna array along the surface of the welded elements in directions and within the areas determined by the nominal thickness of the welded elements.

Scanning to detect the defects shall be carried out by the stanrard (usual) transducer as well by means of transverse-longitudinal scanning (out-in traverse fo the antenna array from seam to seam with sequential shift along the perimeter fo the seam by the pitch not exceeding a half of the transverse dimension of the antenna array Dп/2 as presented in Figure 83. The maximal distance of the antenna array to the Xmax seam and scanning way).

Note: for M9065 and welded seams with thickness from 5 to 10 mm including only the longitudinal displacement of the antenna array along the welded seam can be used. For thickness exceeding 10 mm a transverse-longitudinal scanning shall be used.

Calculate maximal distance of the antenna array to the seam edge using the Formula

$$X_{max} = 2H \cdot tg\alpha + \mathrm{A} + B/2,$$

where H – thickness of the object under examination;

α – slope angle of the central beam fo the antenna array;

A – width of the rmal influence zone;

B – aperture (length of the contact pad of the antenna array).

Scanning is performed on both sides of the welded seam.

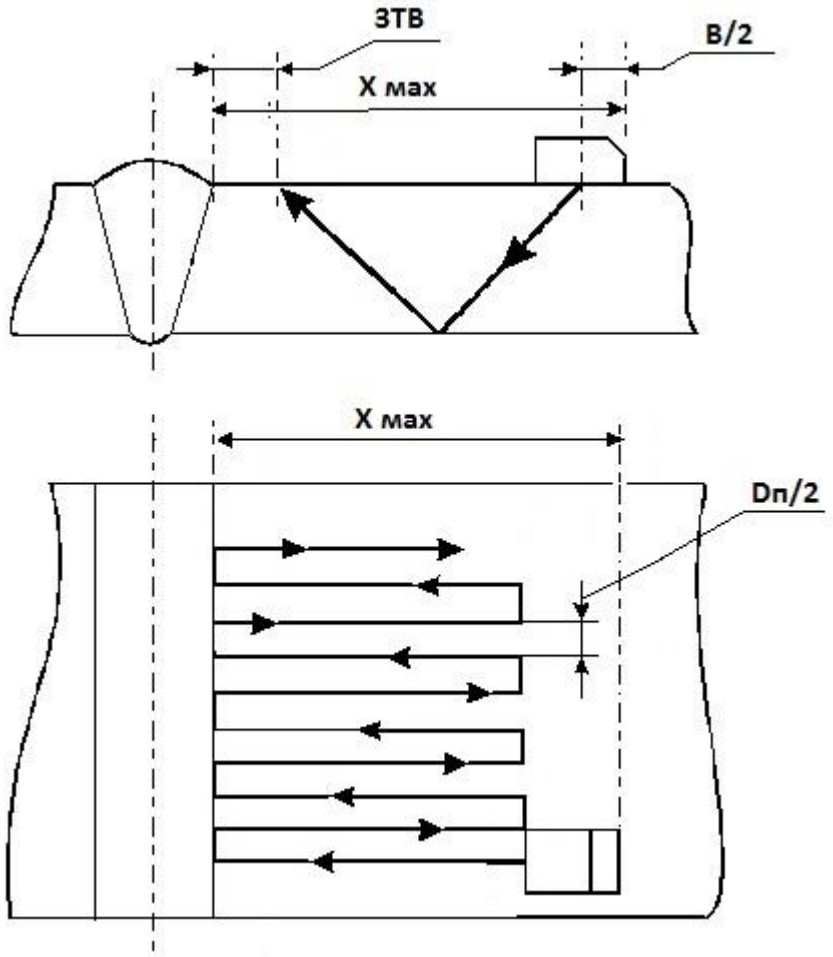


Figure 83 Maximal distance of the antenna array to Xmax seam and scanning way

During scanning care shall be taken to presence of the contact grease and preservation of the acoustic contact costantly pressing the antenna aray to the surface of the object.

Velocity linear displacement of the antenna array during scanning should not exceed 100 mm/s.

Suggestions: clear the transfer area of the antenna array by means of the angle grinders and flap grinding wheels. If lots of stiffened metal splashes present in the area to be cleaned, then we recommend at first delete the splashes by means of the abrasive wheel, and thendo final cleaning by means of the flap grinding wheel.

3.12 Determination of the angle of the central beam α by RR-2

Place the antenna array onto the RR-2 into position I.

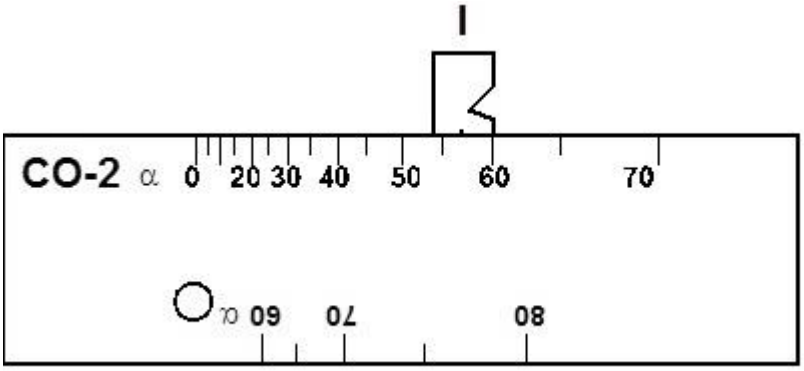


Figure 84 Determination of the angle of the central beam of the antenna array

Identify an image of the ∅6 mm hole among the images didplsyed on the screen of the Flaw Detector. This image shall be seen at 42 mm depth and it must be inside the strobe. Moving the antenna array along the surface of RR-2 find such a position when the amplitude of the impulse is a peak one. In this position zero on the body of the antenna array will indicate a slope angle of the central beam to the marking-out for RR-2.

Note: for M9065 with a contact pad (protector) α=60°, for M9065 with a white contact pad α=50°.

3.13 Detection and measurement of characteristics of the defects

When the images appear on the screen in the inspection area and sound and light monitor system responds, stop moving the antenna array and find the maximum value of the amplitude of the found image by means on moving and ratatinf o the antenna array. Make sure that this image belongs to the defect, but not to the false reflector. Sources of the false signals can be irregularities of the dressing, bulges of the root section of the seam, pad, cavities, structural gaps, offset of the edges and etc.

When the defects with amplitude equal or exceeding the reporting level (recording level) are detected, the following characteristics shall be specified:

- amplitude of echo-a signal from the defect A, dB;
- depth of the defect Z, mm;
- longitudinal length of the defect ΔL, mm;
- conventional height of the defect ΔZ, mm;
- coordinates from the zero point (scanning start) L, mm;
- quantity of defects on the inspected area.

Depth Z of the reflector is indicated in the panel of the measurment results.

L coordinate is defined as a place of location of the defect by length of the welded seam relative to the assumed reference point.

Conventional length ΔL is measured as a distance between the extreme positions of the antenna array when it is moved along the seam axis. The extreme positions of the antenna array are considered those positions at which the amplitude of the signal decreases by 6 dB of the acceptance level, i.e. the measurements are carried out on the recording level of sensitivity.

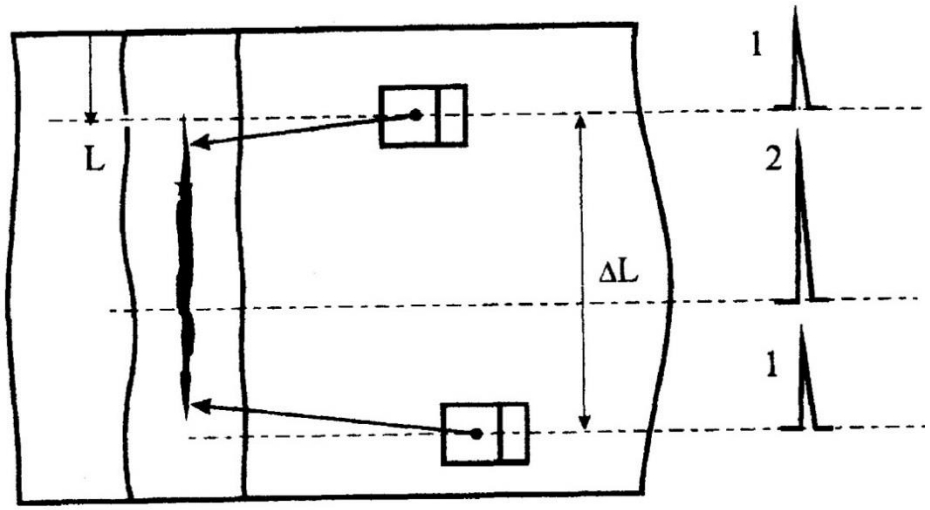


Figure 85 Measurement of coordinates L and conventional length ΔL

Let's consider using the example of inspection of the above specified welded seam.

Welded joint C21 according to GOST 5264-80 (15 mm thick). Upper roller – width e=20 mm, Height g=2 mm, lower roller (bulge of the weld root) – width e2=5 mm, Height g1=1.5 mm. Weld length is 197 mm.

Figure 86

Place the antenna array to the scanning start close to the upper roller. We will see the following image.

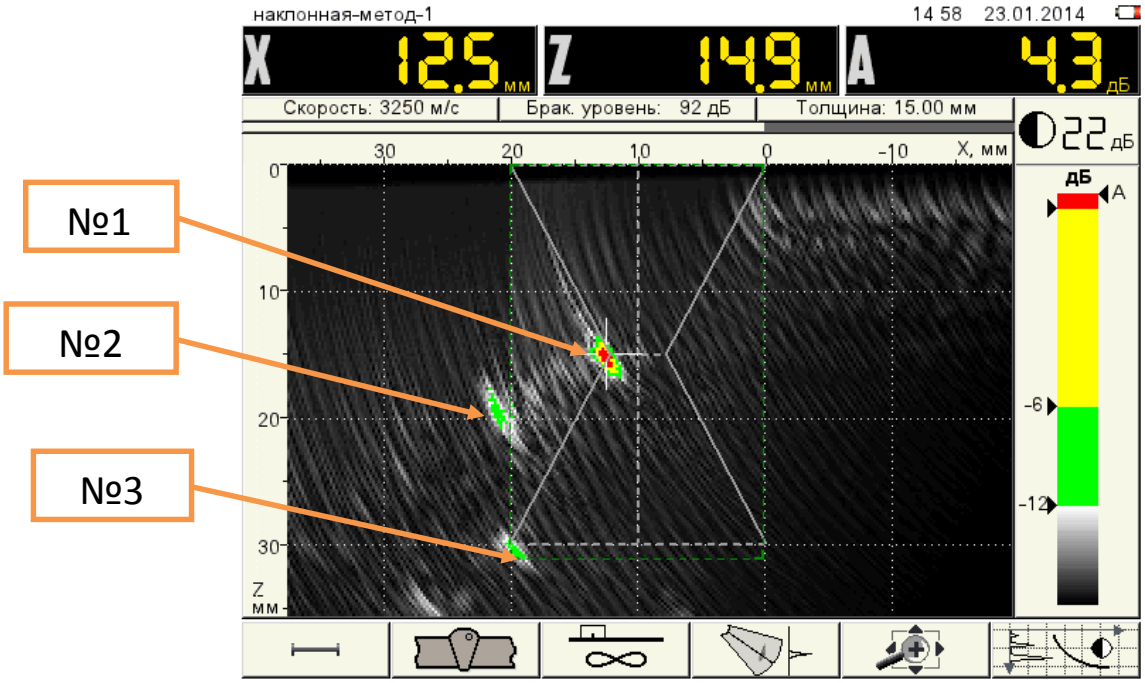


Figure 87 False images

Visible Images in the TOMOGRAPH mode are quite easily determined as images of the false reflectors:

№ 1 – reflection at the left the boundary of the bulge in the root of the seam by the straight beam;

№ 2 – rereflection at the bulge of the weld root;

№ 3 – reflection at the left boundary of the seam dressing by once refelected beam.

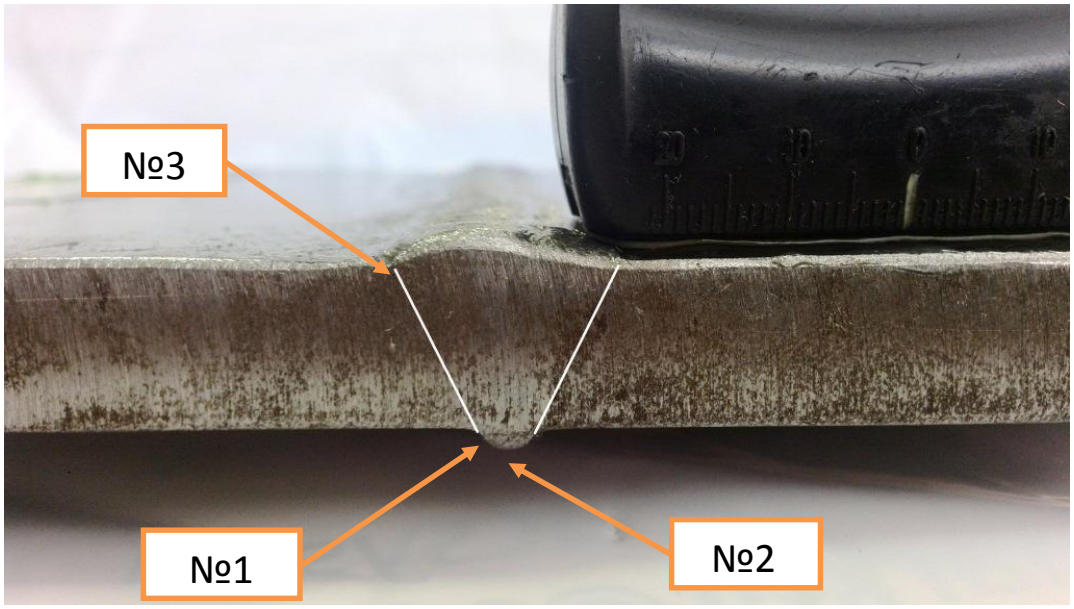


Figure 88

We start scanning the welded seam. The monitor responses. Now we shall stop, and find the maximum value of the amplitude of the given defect and we will see the following image.

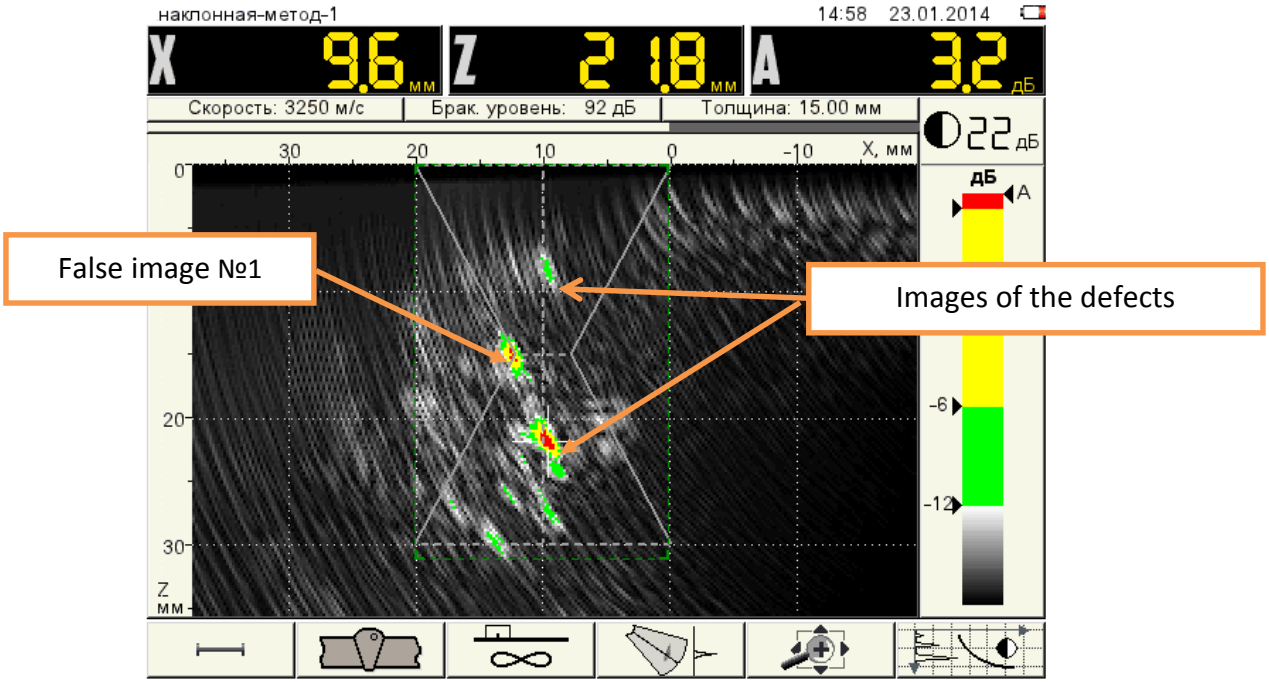


Figure 89 Images of the defect and false images

Several signals of the defects are detected in the center of the welded seam with X=9.6 mm coordinates (space from the edge of the antenna array). Maximum amplitude from the image visible by once reflected beam is at depth Z=2H-Z=30-21.8=8.2 mm, it exceeds the acceptance level by 3.2 dB.

Coordinate L=34 mm.

Determine the conventional length.

Image of the conventional start of the defect (–6 dB to the acceptance level) shall be determined by the marker position on the color-brightness scale:

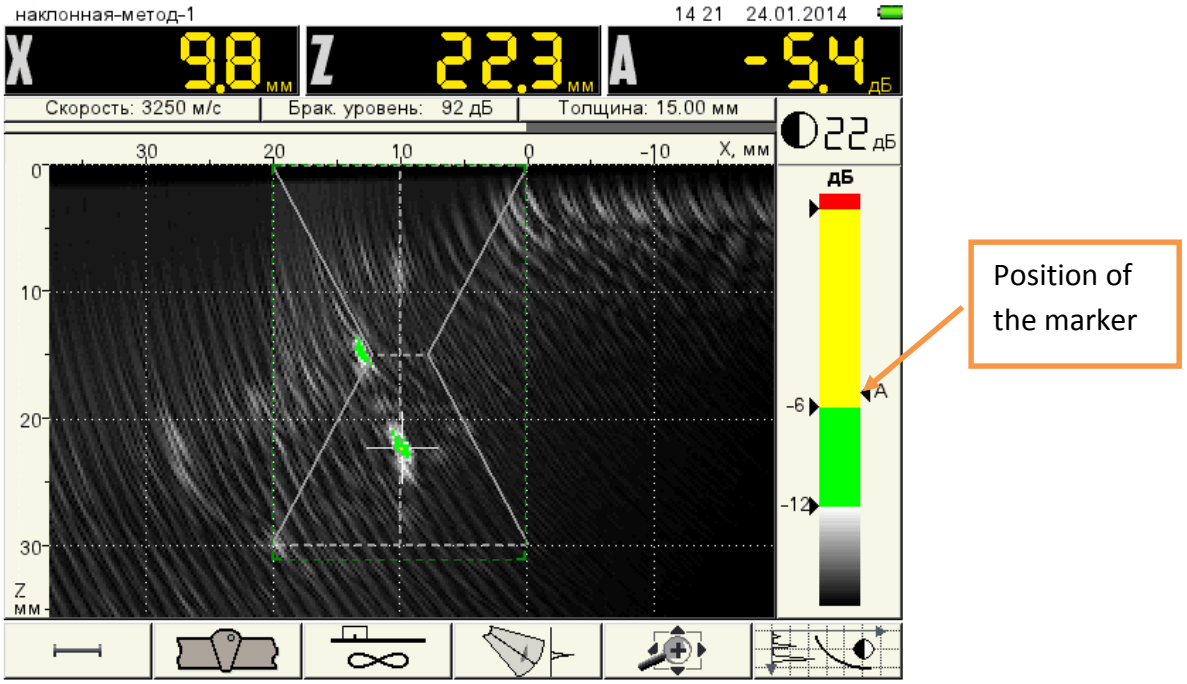


Figure 90 Determination of ΔL

Image of the conventional end of the defect shall be determined in the same manner.

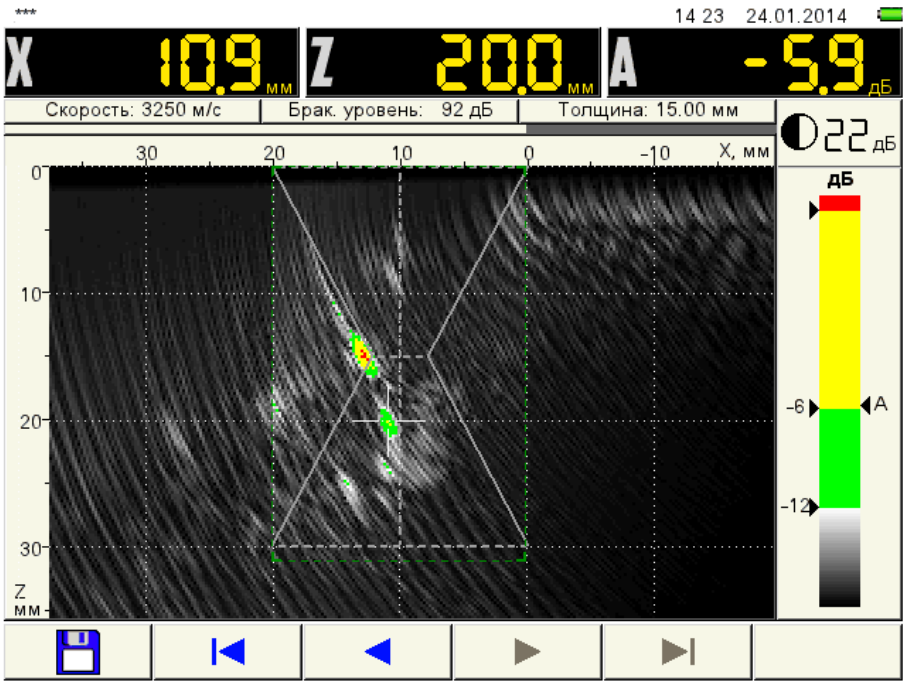


Figure 91 Determination of ΔL

Highlight with the marker the start and end position, and measure the conventional length by means of the ruler. We receive ΔL=20 mm.

Do scanning of this area on the opposite side.

The image in the scanning start position is close to the reinforcing bead. We see a false signal - reflection at the right boundary of the bulge in the root of the seam by the straight beam.

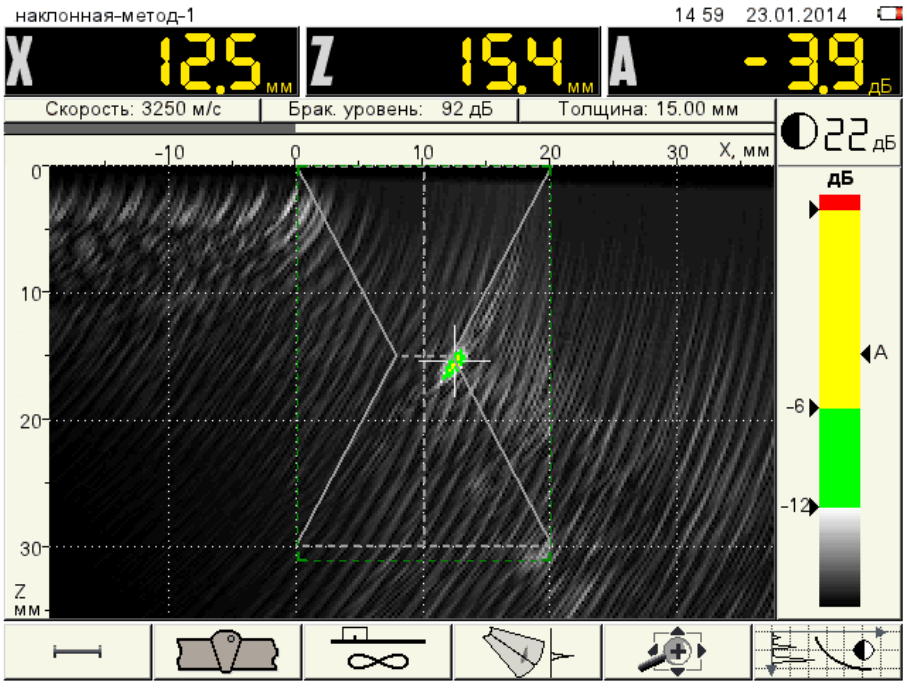


Figure 92 False reflector. The antenna array is placed on the opposite side

We start scanning. The monitor responses. Find the maximum value of A=0.2 dB with a space X=11.1 mm, at depth Z=30-24.7=5.3 mm by once reflected beam. Measure the conventional length ΔL=17 mm.

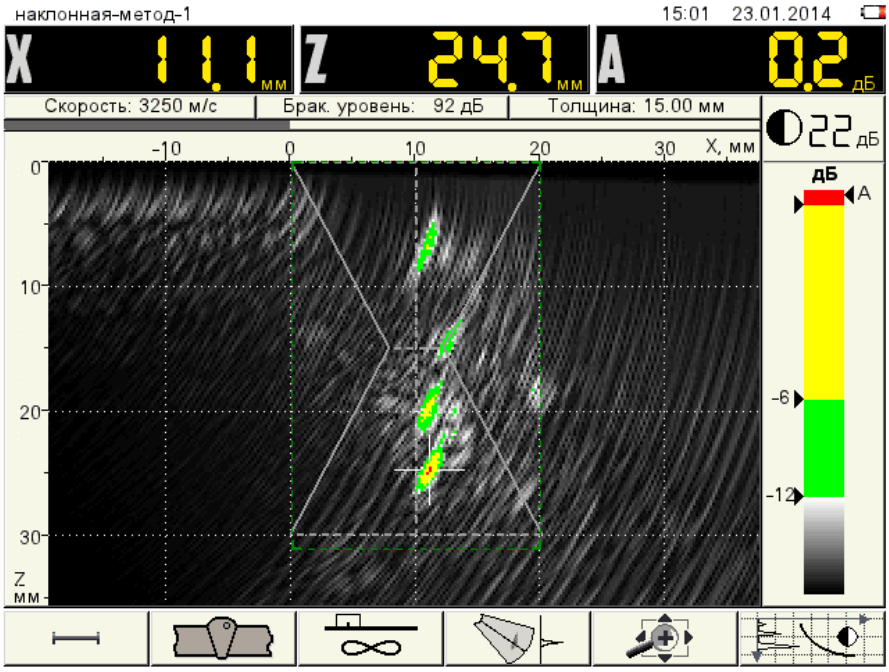


Figure 93 Images of the defects and false reflector

The defects can be searched in the “Plate mode” as well. Press the  key. Select the “C21-15 mm plate” configuration. Place the antenna array to the scanning start. The screen displays the same images of the false reflectors, as in the Unknown thickness mode.

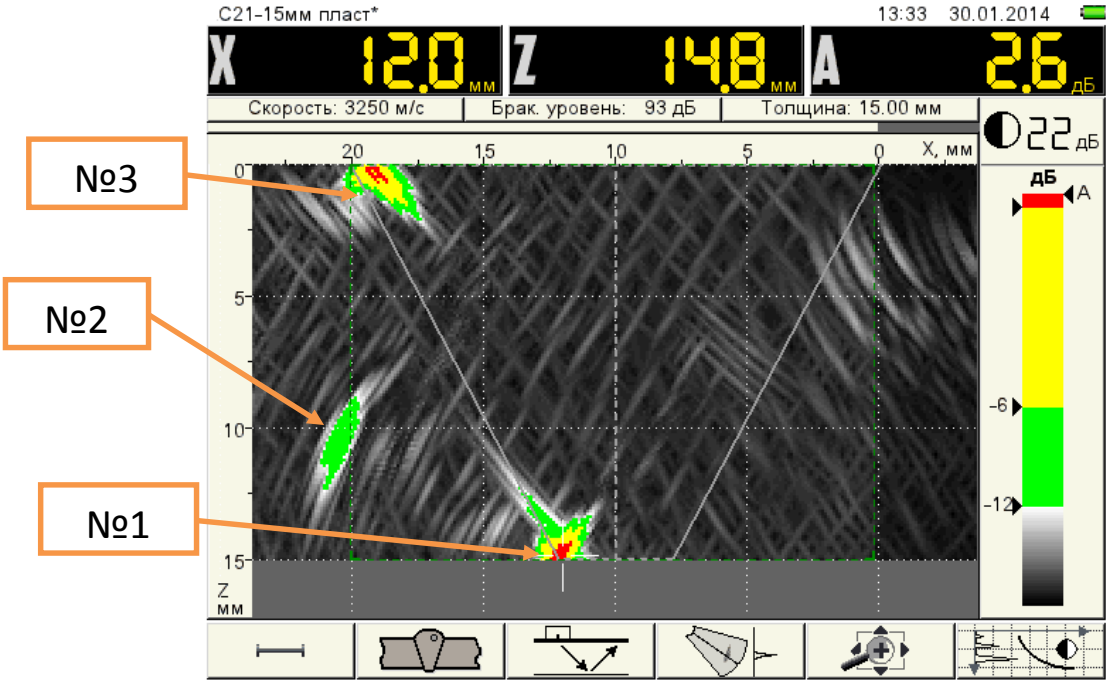


Figure 94 Plate mode. Images of the false reflectors

We start scanning the welded seam. The monitor responses. Now we shall stop, find the maximum value of the amplitude of the given defect, and we will see the following image:

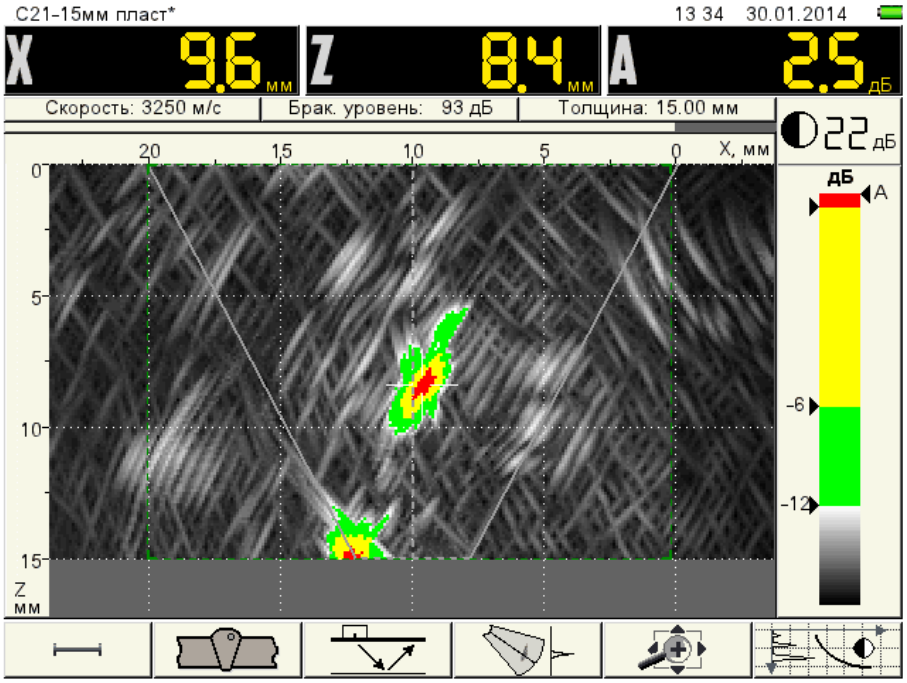


Figure 95 Plate mode. Image of defect and false reflector

An image of a single defect is found in the center of the welded seam with X=9.6 mm coordinate (space from the edge of the antenna array). Maximum amplitude of the image visble by the once reflected bean is at depth Z=2H-Z=30-21.8=8.4 mm, it exceeds the acceptance level by 2.5 dB. Coordinate L=34 mm.

Witn another positon of the antenna array on tehis defect we see two images one above the other. It looks like highlights of the planar reflector.

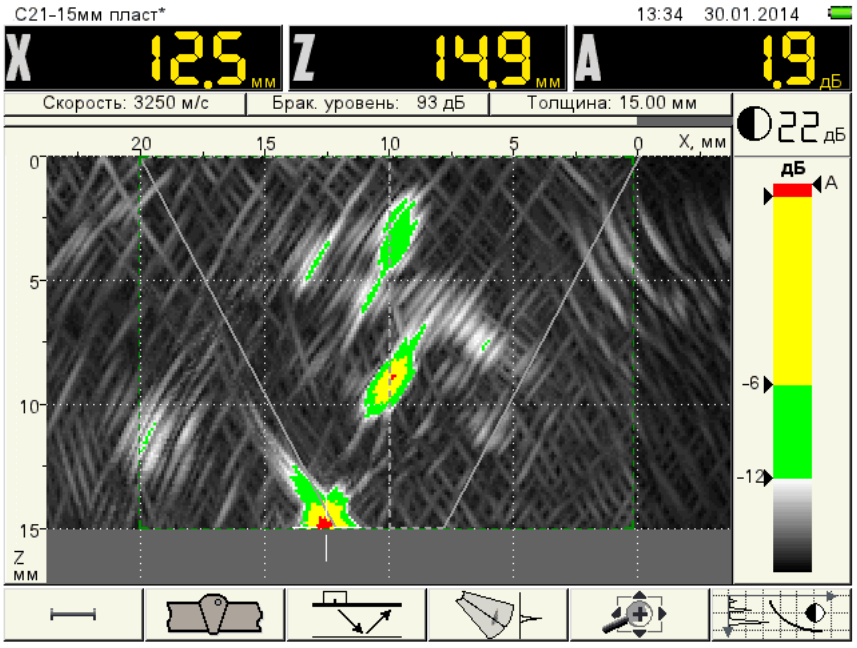


Figure 96 View of the image of the defect and false reflector at another position of the antenna array

Let's scan the found defect on the opposite side. We as well see two images one above the other on the screen.

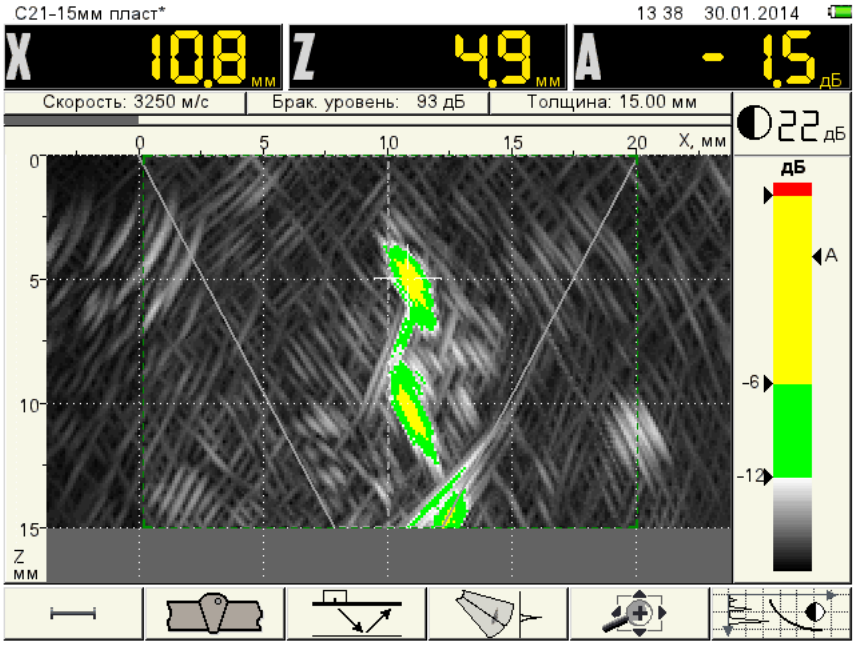


Figure 97 Image of the defect and false reflector on the other side

Switch to “Vertical cracks mode”. Press the  key. Select the “C21-15 mm layer” configuration. Place the antenna array to the scanning start. There are two false reflectors of the upper roller and freespan in the root of the seam.

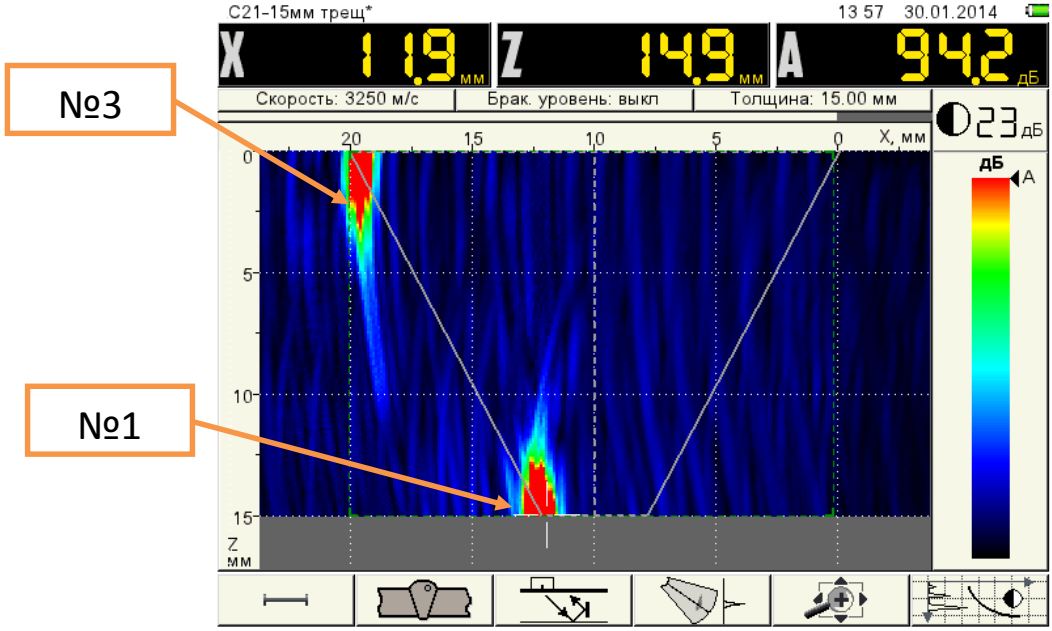


Figure 98 Vertical cracks mode. Images of the false reflectors

We start scanning the welded seam. We can see an image of the defect appearing. Now we shall stop, and find the maximum value of the amplitude and vertical size of this defect.

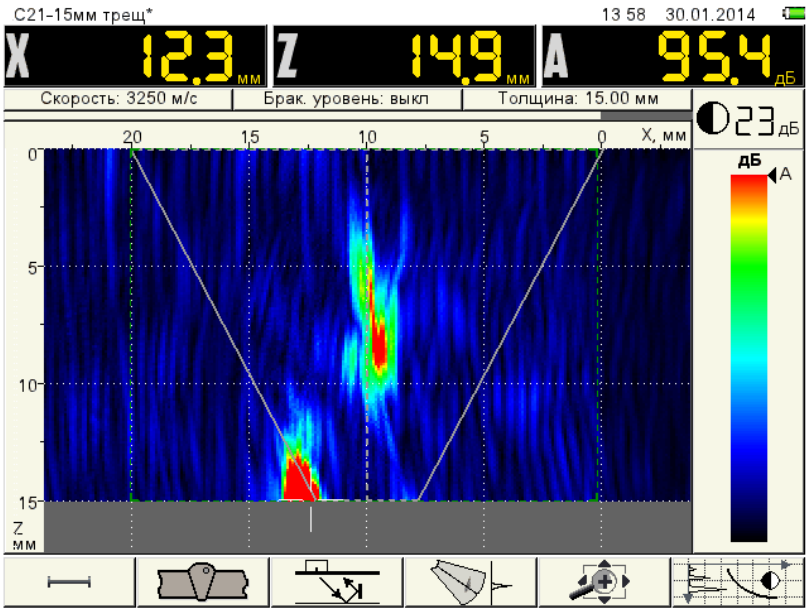


Figure 99 Vertical cracks mode. Image of the defect and false reflector

Press the key  to measure conventional height of the defect. Move the cursor to the upper boundary of the red image, press the  key and move the cursor to the lower boundary of the red image. Conventional height of the defect ΔZ=4.4 mm.

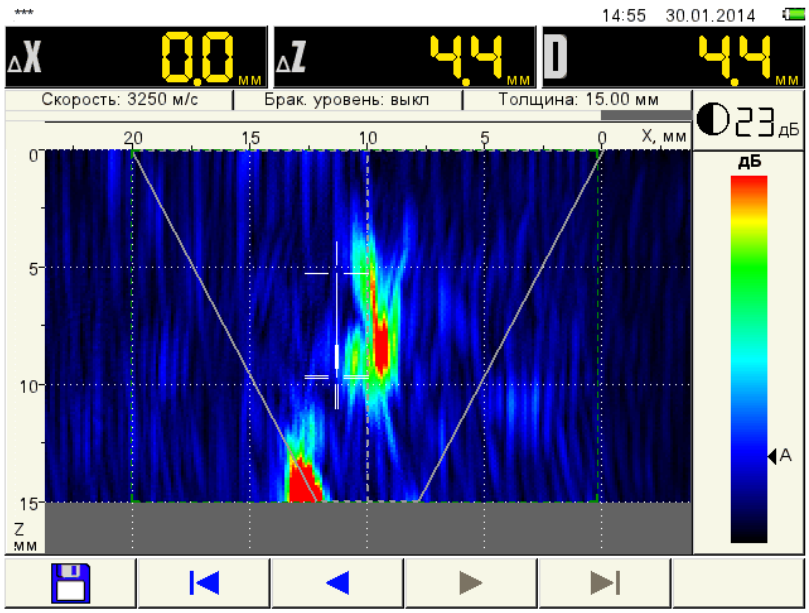


Figure 100 Measurement of the conventional height of the defect

Thus, we make the following conclusion:

– a defect is found with maximum signal amplitude above the acceptance level A=+3.2 dB at depth 8.2 mm;

– with the conventional longitudinal length ΔL=20 mm, possessing the characteristics of a planar flaw (defect);

– conventional height ΔH=4.4 mm;

– origin coordinate L=34 mm.