METHODS AND MEANS OF ULTRASONIC INSPECTION (USI) OF WELDED JOINTS WITH ACOUSTIC CONTACT LEVEL TRACKING AND EVALUATION OF THE NATURE AND ACTUAL CHARACTERISTICS OF FLAWS

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During the ultrasonic inspection process the measurement sensitivity may significantly vary, for example due to differences in surface roughness and waviness between the calibration sample and a test item, lack of couplant on the scanned surface, presence of corrosion on external or internal surfaces of the weld adjacent area which entail high inaccuracy during the measurements of flaw characteristics. Therefore, acoustic contact level tracking is so important during the measurements.

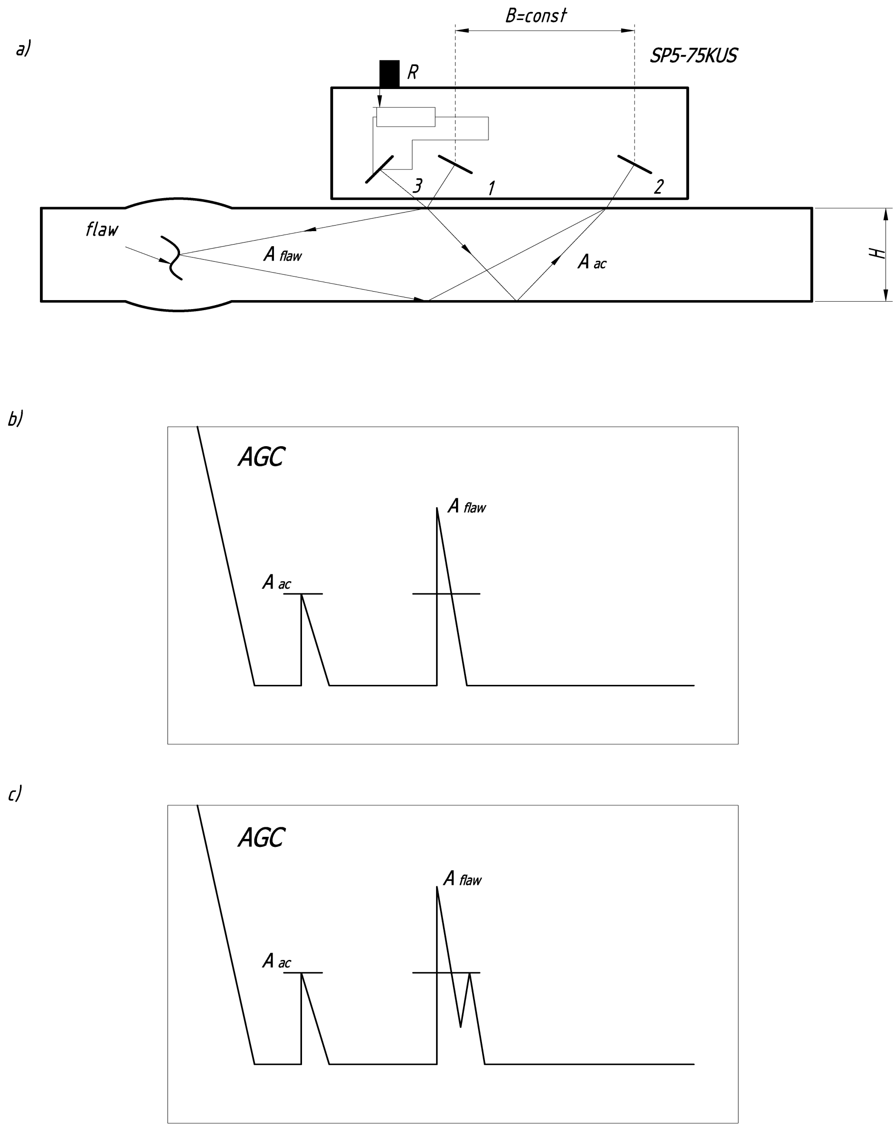


Figure 1

The ultrasonic semi-associated transducer SP5-75 KUS with acoustic contact tracking functionality (figure 1) designed for the inspection of welded joints with the thickness 2.5 – 12 mm helps to achieve this objective. The transducer utilizes semi-associated echo-reflecting scheme of "dual tandem" where measurement transducers (items 1, 2, figure 1a) with the input angle of 75º produced by a wide directional diagram scan the entire section of the seam and the acoustic contact level tracking is performed with the help of acoustic contact pulse generated by the third piezoelectric plate (item 3, figure 1a) located on the prism of the first transducer. The acoustic contact pulse (A_{ac}) travels through the prism of the first transducer, then it goes through the test item (as a transverse wave with oblique incidence) and having reflected from the bottom of the test item and traveled through the prism of the second prism is received by the second (receiver) piezoelectric plate. The parameters of the third piezoelectric plate are set according to the conditions specified in [5] which ensure measurement identity for acoustic contact level and operating sensitivity. As shown on figures 2 and 3, the amplitude of the echo signal A_{ac} changes proportionally to the change in sensitivity level caused by the varying conditions of external or internal surface of the test item. The value $\Delta A = A_0 - A_{ac}$ depends neither on the condition of the test item surfaces nor other factors which contribute to partial loss of the acoustic contact (figures 2d, 3d).

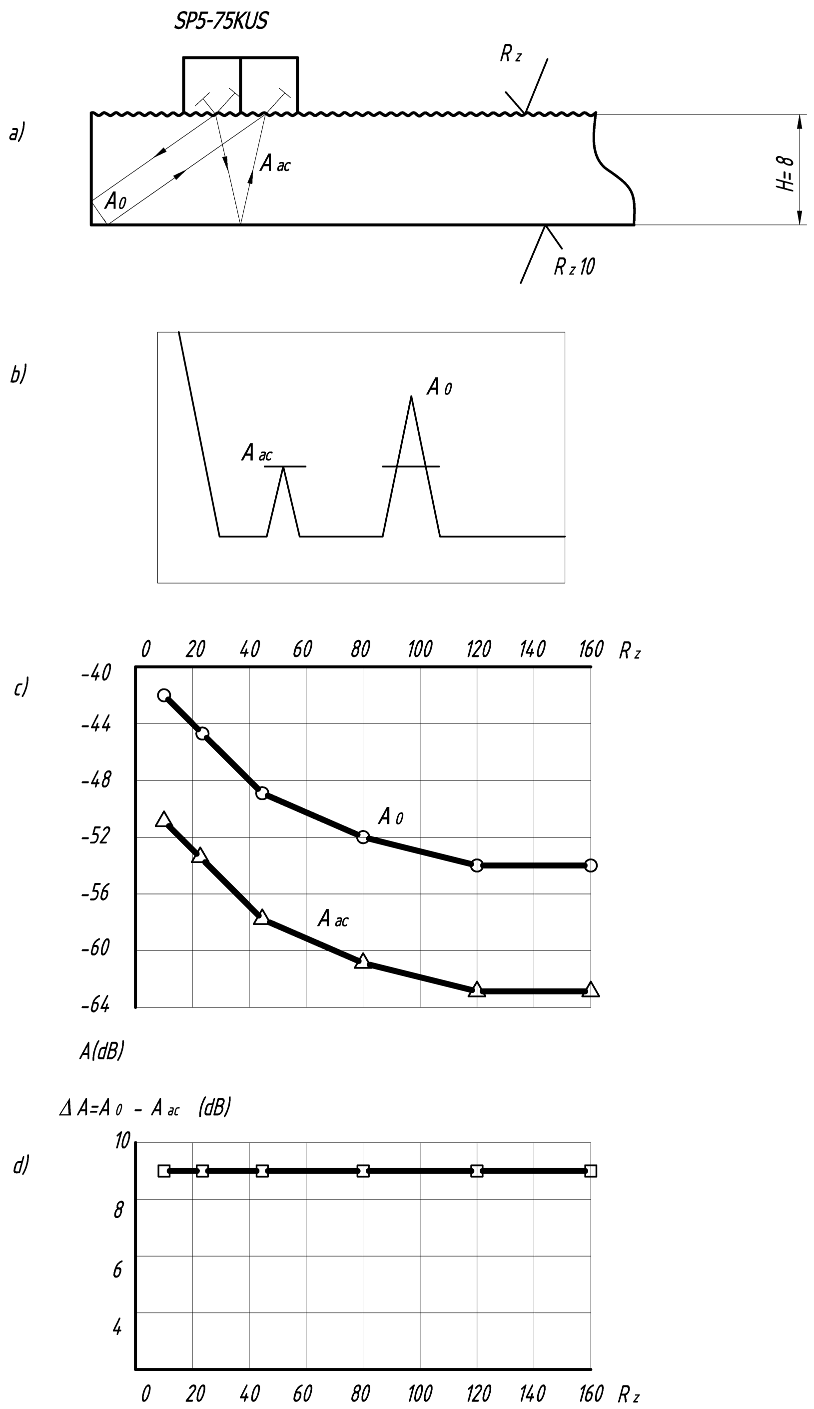


Figure 2

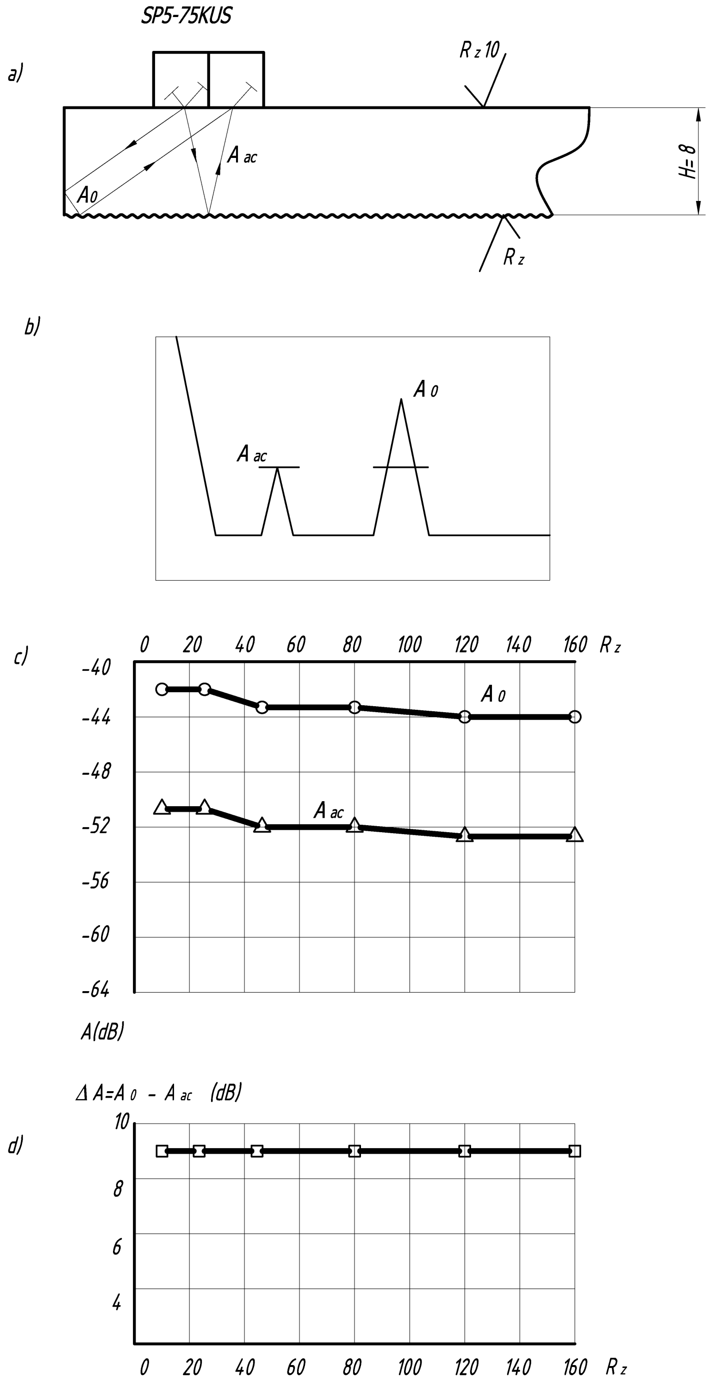


Figure 3

The internal variable resistor "R" (see figure 1a) controls (within 16 dB range) the amplitude of the acoustic contact signal which allows setting the amplitude A_{ac} equal to, for example, defect sensitivity level, and the automatic gain control (AGC) feature of the flaw meter UMA "SCANNER" ensures automatic control of the selected sensitivity level over the acoustic contact pulse gate area. Thus, the acoustic contact level tracking function makes it possible to test welded joints and base metal with set constant sensitivity level taking into account the varying conditions of the test surface including presence of sound-conducting surfaces of the test items: enamels, paint coatings, pipe insulation, etc.

The transducer design with 2 spring-loaded PEP brackets makes it possible to test girth joints of pipelines Ø57 mm and above, and magnetic mount feature ensures additional comfort during testing.

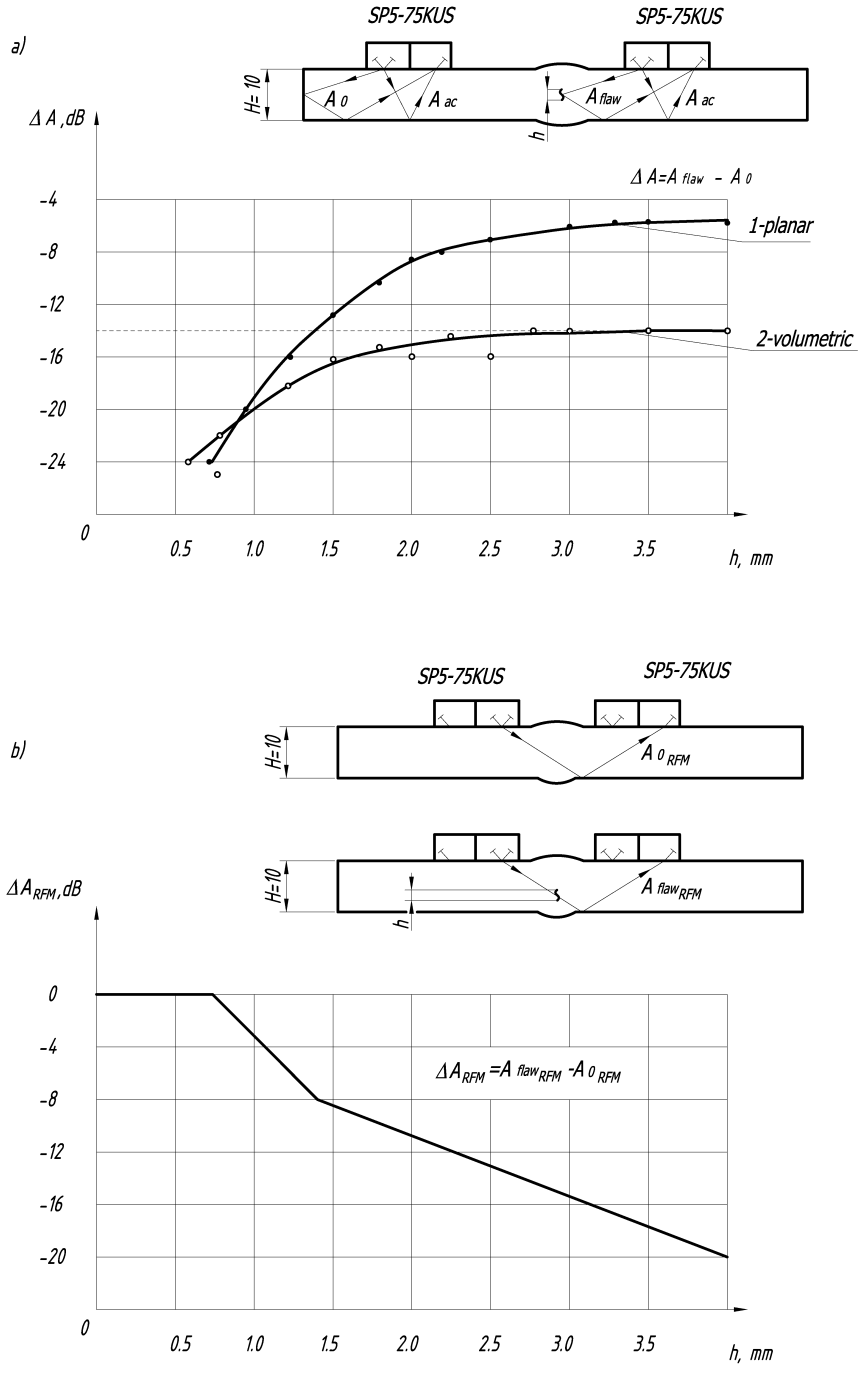
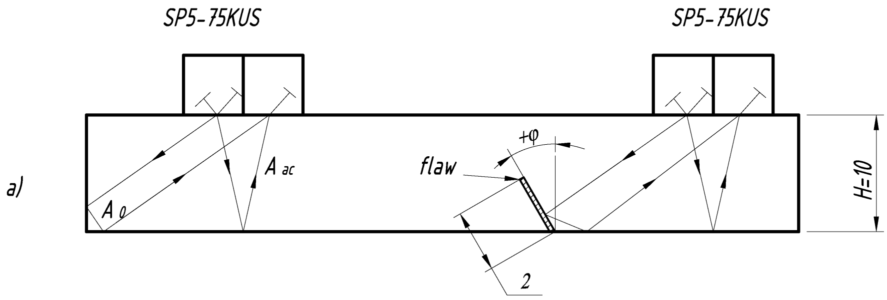


Figure 4

For vertically oriented extensive flaws with plane nature the correlation dependence of the echo signal amplitude versus the height of a plane vertical flaw (penetration depth) shown on figure 4a, item 1 has been provided. The figure 5 shows correlation between amplitude and the plane flaw inclination angle (figure 5b) which indicates that within ±20º deviation from the vertical orientation the amplitude may vary by 6 dB for the height of a plane flaw h = 2 mm = const. By simultaneously using two SP5-75 KUS transducers located on the opposite sides of the welded joint and additional reflecting-shadowing method (RFM) with acoustic contact tracking function under each SP5-75 KUS transducer the correlation dependence has a linear character (for h > 1.5 mm) and is not dependent on the plane flaw orientation (inclination angle) (figure 4b).



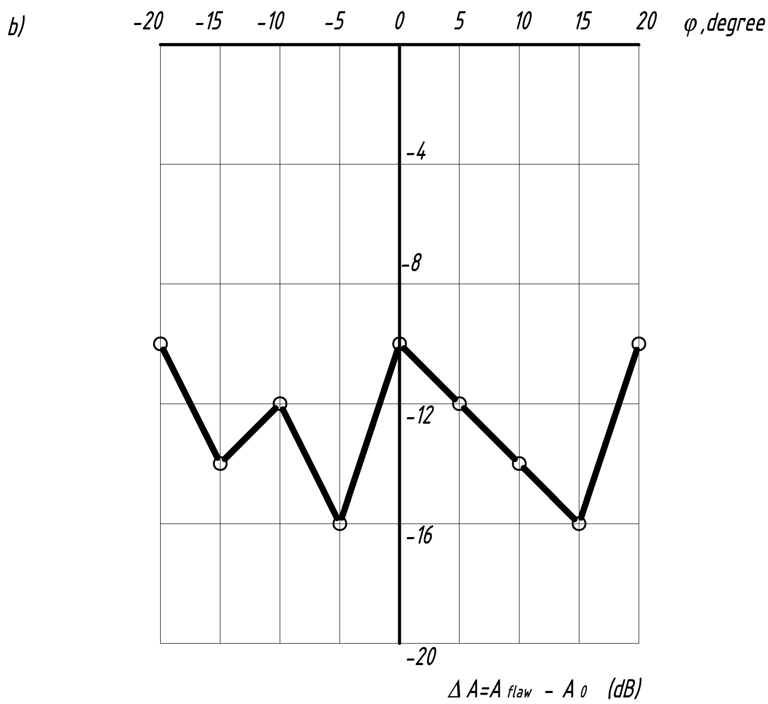


Figure 5

The advantage of high input angles is that such angles ensure uniform sensitivity over the width (“x” coordinate) and the depth (“y” coordinate) of the welded joint which is shown on figure 6.

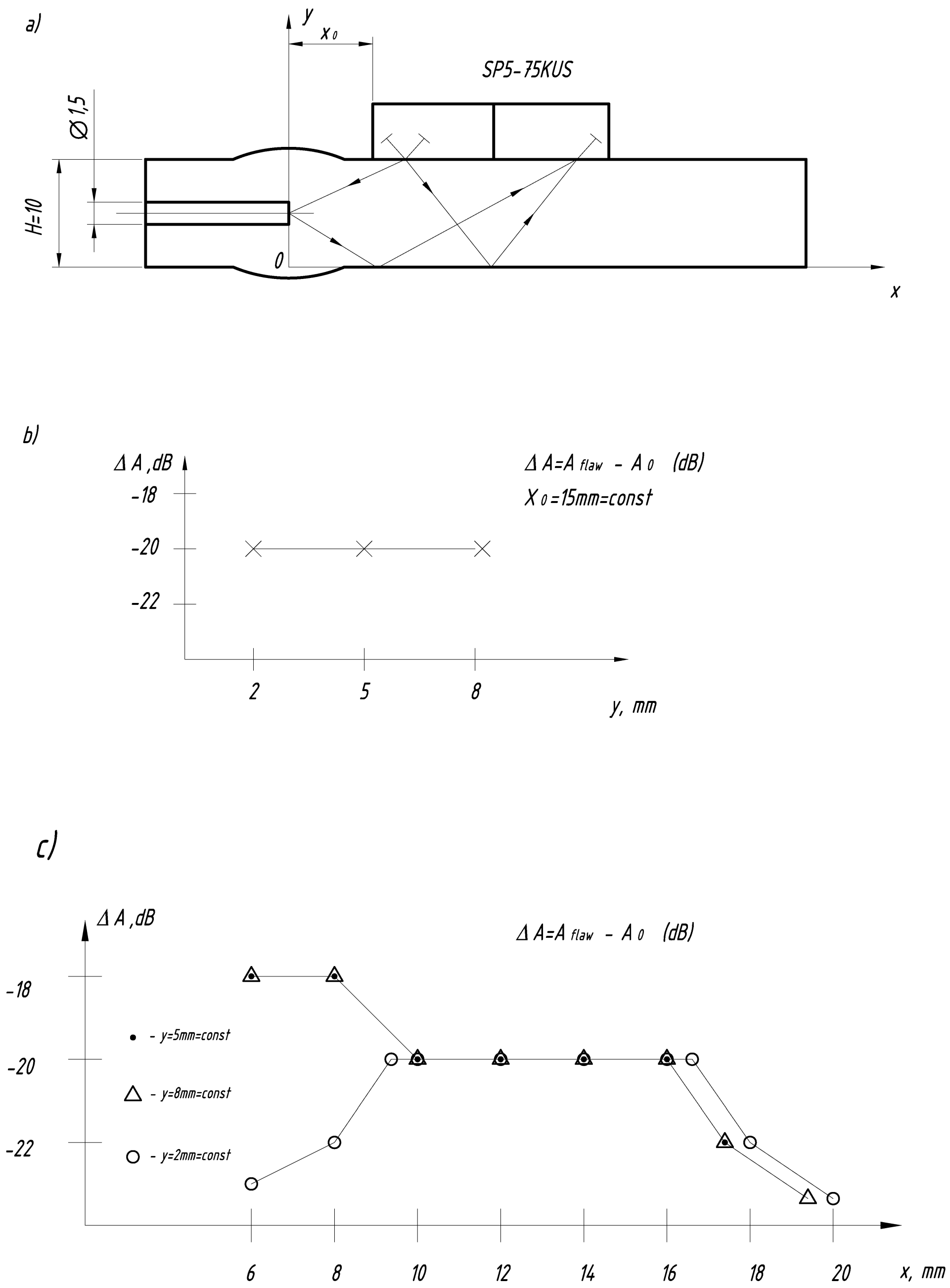


Figure 6

The “dual tandem” scheme not only provides enhanced detection of most critical flaws –of plane nature (figure 4a, item 1) as compared with volume nature (figure 4a, item 2) - but also reduces the interference level caused by weld sag or internal reinforcement bead. The latter is achieved by separating the emission from reception over the fixed distance b = const and application of wide input angles. This technique substantially reduces the level of reflected and diffracted waves through shadowing of a part of the sag surface or the reverse bead [2]. Moreover, small thicknesses (less than the diameter of piezoelectric cell) produce the multiple reflected beams effect which also increases signal-to-noise ratio [3, 6].

The diagram on figure 4a shows that for $\Delta A > -14$ dB the flaw has a plane nature (which corresponds (for the thicknesses H = 4 – 11 mm) to equivalent area Seq > 3 mm^2).

For $\Delta A \leq -14$ dB the distinctive feature of a volume flaw is two or more echo signals with commensurable amplitudes (figure 1c) which are related to direct reflection from such flaw, single mirror reflection and/or multiple re-reflections of transverse and diffracted waves.

The multi-channel ultrasonic inspection system “SKARUCH” [1, 4] is based on the above principle of acoustic contact level tracking and makes it possible to perform flaw detection of welded joints with evaluation of the nature and actual characteristics of detected extensive flaws.

References

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