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Procedures of Ultrasonis testing based on digital techniques

Abstract: In this article new possibilities of portable flow detectors equipped with built-in scanner, universal and objective procedures are presented. These procedures enable the execution of testing according to any standards and technical conditions. The universal procedures automate e.g. size evaluation of detected defects. Objective procedures are applied to testing of e.g. electrical insulators, axles, welded joints according to European Standard EN1712 – EN1714. Each procedure is executed step by step and is inspired, controlled and registered by programs included in flow detector. The programs can be easily changed and exchanged with the host computer. The scanner enables to draw a map of detected defects automatically and to automate evaluations of tested elements

In not very long history of ultrasonic tests normative acts, technical conditions and the directives of these surveys were established, we can say that they create quite big library, which is still growing. Some of these acts are quite complicated, and adapting them may be arduous, so it leads to interpretative differences, or even test's failures. Essential cause of difficulties with proper application of these acts is often their high degree of complication and very low clearance. The reason is that at the time, when these acts were established, only analog or hybrid defectoscopes existed, and these acts are adapted to small potential of these defectoscope. Application of **digital defectoscopes**, the ones which are **controlled by computer**, enables including research procedures based on existing normative acts. Application of defectoscope including these programs- procedures facilitates a lot ultrasonic tests and make them completely reproducible. We can divide the surveys procedures into two groups:

I - UNIVERSAL PROCEDURES

Universal procedures are used in tests of very different objects. Examples of these procedures are, for example, equivalent size of failure estimate procedure (AVG - DGS) strengthening range regulation procedure, time base automation, probes and materials catalogues and so on. Some of the universal procedures are used in object procedures as their part. Examples of universal procedures are given in chapter 2.

II - OBJECT PROCEDURES

Object procedures usually give complete ways of testing definite objects e.g. Welding testing according to definite standard, axle set testing, rail testing, high voltage insulator testing, etc. Among commercially available digital defectoscopes not numerous are equipped with richer set of universal procedures, but there is a complete lack of defectoscopes equipped with object procedures. Results of research on **programming and implementation of some procedures** in digital ultrasonic defectoscopes are shown below.

To begin with digital defectoscope notion is specified**.**

1.Technical requirements concerning digital defectoscope

Usage of defectoscope in mode of definite procedure realization requires it to be a digital defectoscope. The Portable digital defectoscope notion, during recent years has undergone changes and it is still ambiguous so as a digital ultrasonic portable *defectoscope* we understand the one, which simultaneously has:

1.1 At least one **microprocessor,** with essential hardware environment (memory, input and output buffer, analog- digital converter etc. publication cycle 4.1).

1.2 Software that is: system, operating and application programs, but their form is not important, for example they may be blocked or in several parts, they may be written in different languages etc

1.3 Flat display LCD or similar (in stationary systems a monitor is possible)

1.4 Possibility of **active defectoscope with computer communication.**

Even if defectoscope doesn't have one of the listed features, it is a **hybrid** defectoscope, if it doesn't have any of the listed features it is an **analog** defectoscope. According to this

partition a really lot of contemporary constructions are hybrid defectoscopes, however analog defectoscopes are used very oftenEven if defectoscope doesn't have one of the listed features, it is a **hybrid** defectoscope, if it doesn't have any of the listed features it is an **analog** defectoscope.
According to this partition a really lot of contemporary constructions are hybrid defectoscopes, however analog defectoscopes are used very often

2.UNIVERSAL PROCEDURES on examples: estimate of equivalent size of failure according to AVG- DGS diagram, Welding tests- scanner.

2.1 Estimate of equivalent size of failure according to AVG- DGS diagrams

The way of estimate of equivalent size of failure according to AVG- DGS diagrams elaborated already in the sixties in known Krautkramer company is still base of ultrasonic tests and estimates and is still included in many actually existing legal acts. This way is suitable especially to be expressed in procedure which may be included in any digital defectoscope, and this procedure may be fully automated and – for this- very easy and fast in usage. Application of this procedure requires from defectoscope to include catalogued data concerning used probes and their parameters and acoustic parameters of possibly tested materials. Then the defectoscope may automatically announce size of equivalent failure for each chosen echo of the failure. In figure 1 detected failure with equivalent size R=1,8 mm in distance 43,5 mm from the probe with angle beam 70 is in depth 15mm in this case it is a cylindrical hole which is 1,5 mm in diameter.

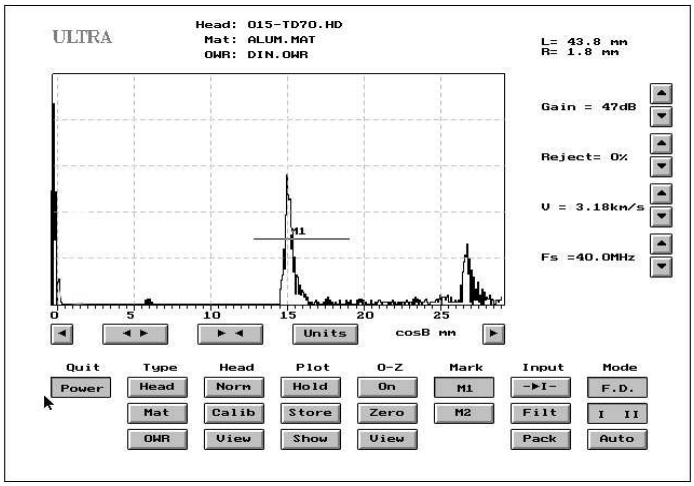


Figure 1. Photo of defectoscope's screen in FD (flaw detector) mod

2.2. Testing of welding – scanner

The scanner elaborated over ten years ago in ULTRA company is used for tests of welds and metal sheets, and also for other purposes. This scanner make use of surface waves for locating position of testing probe on tested surface. In figure (next to the text) the scanner functioning scheme is shown. In this type of scanner ultrasonic surface waves are used for check of place of testing probe position. Ultrasonic surface wave transmitter probe 1 with magnetic holder located at the beginning of the weld in parallel to it sends surface wave impulse. Double probe **2** receives these signal by of two its converters. The run time of these impulses is measure of distance of probes 1 and 2. The second converter of testing probe is standard probe for welding testing e.g. 4T70^{o}9x10C.Two probes distance measurement cycle and testing cycle follow alternately, and measure distance and the result of testing are information about given cut of the welding. Set of these information is processed into **failure maps, welding estimates** etc.

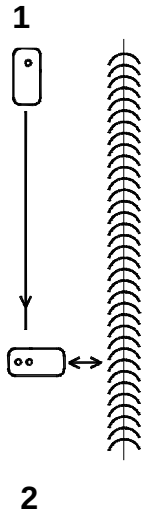
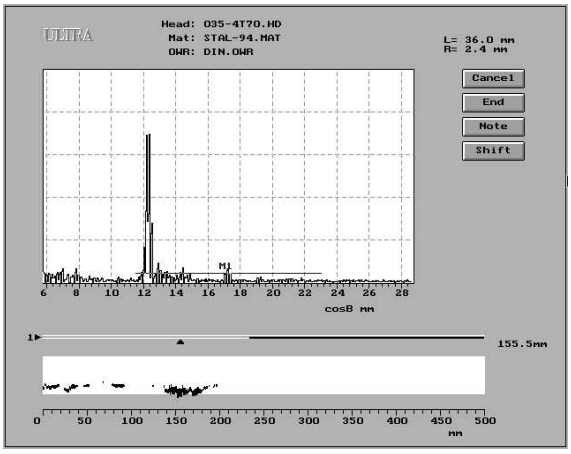


Figure 2 shows screen of defectoscope working in **SK- Scanner** mode.
Figure 3 shows screen of defectoscope working in **DP- Display**, where sonogram and estimate of the welding is shown.



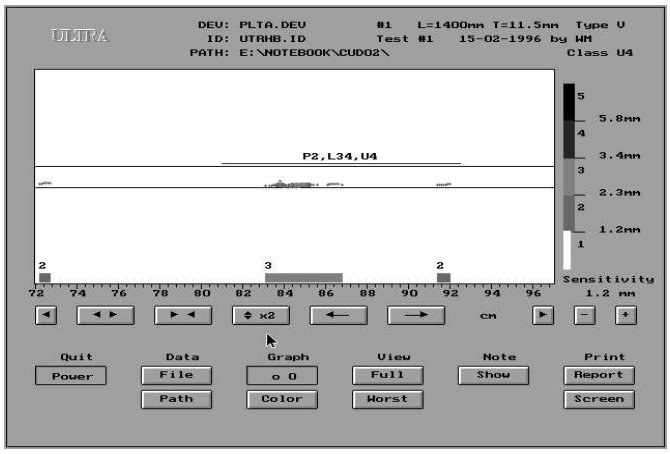


Figure 2 Photo of the defectoscope screen working in SK mode	**Figure 3. Defectoscope screen in DP mode**
All the defectoscope settings and **presentation** and registration of results in this mode of work are executed automatically. The visible echo of failure with equivalent size R=2,4 mm in distance Z=155,5 mm on the depth about 12mm. Lighter rectangle with the map of detected failures drawn.	Visible map of detected failures on welding cut with estimate of the welding executed automatically. Class U= 4 is a welding in class 4 according to PN_ 89/M-697770. Sensitivity of failure registration 1,2 mm of equivalent failure. Key buttons Print activates automatic printout of finished reports.

3. OBJECT PROCEDURES

Improvement, acceleration and increase of repeatability ultrasonic tests may be reached by applying object procedures with following range:

- **initial stage of scaling on models**, concerns only the procedures which demand it-**step-stage realization of the tests** „forced" by the program e.g. after inserting data about the tests, successive activities of the tests, complements to partly automated documentation of the tests, archive and possible printouts, at any moment **access to full information** connected with realized stage of the tests e.g. type of the probe and parameters of the settlements, drawing of geometry of the test, description of this stage activities etc
- **results and estimates,** dependently on requirements of procedure, results automated or decided by operator
- **fully automated calculations,** transforming all the initial data into results, e.g. all the distances, sizes of equivalent failures, probe strokes and identification failure location, exchange time parameter for distances and inversely etc. In near future more complicated calculations e.g. sizes of critical failure according to crack mechanics
- **analyses**

Written ultrasonic test procedures concern existing normative acts. It's obvious that these procedures have to be compatible with requirements of these acts , and it is often connected with resignation of some of already existing higher potentials of digital defectoscopes. The issue of the future is modification of normative acts for them to take into consideration increased digital defectoscope potentials e.g. to take into account in estimate of tested objects requirements connected with mechanics of the strokes.

3.2. An example of the procedure - procedure PROC 01 for axles testing according BN- 75/3518- 02

Procedure for axle sets testing established according to **BN- 75/3518-02** standards assumes course of proceeding the tests is realization of hints printed on the screen. Essence of these hints, taken (based) on the standard are two stages of proceeding.

Stage 1 Defectoscope scaling on comparative model.

The task realized on this stage is inserting into computer memory the data obtained on model made according to the standard. These data will be used later, during the actual tests of axles. This stage consists of three consecutive steps of proceeding. Each of the step of the scaling has a window, appearing on the screen, with description and drawing of test geometry. The purpose of scaling on this comparative model is to catalogue defectoscope settings, e.g. observation ranges, probes number, strengthening etc; after establishing them, they may be automatically used during axle tests. It's enough to perform scaling on the model once, and registered results will be automatically loaded and used on every step of the test. They may be used repeatedly for tests of next axles.

Stage 2 axles test

The task realized in this stage is actual test of axles according to the standard. This stage consists of eight consecutive steps. After pressing the Start button, the computer demands to announce data, e.g. axle number, and wheel set number and text concerning current step of procedure is displayed. The end of procedure is registration of the failure. As a registration we understand saving the defectoscope screen in BMP format on which besides the commentary there are (automatically) number of axle and wheel set number and test date and stage of strengthening. Second element of registration is description of the failure, which appears immediately after remembering the screen. The failures registered during current measurement may be watched and edited. After execution of all the steps the card with spaces to fill in appears. The spaces on this card are automatically rewritten from previous measurement (to reduce to minimum operator expenditure). Finishing testing causes listing data to tests register and obviously they may be remembered**.**

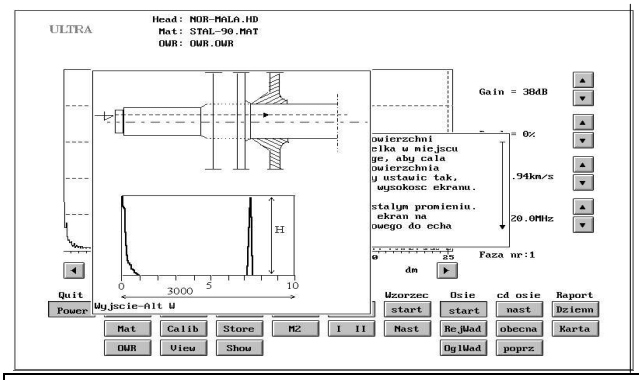


Figure 4. Screen during test with current procedure step displayed

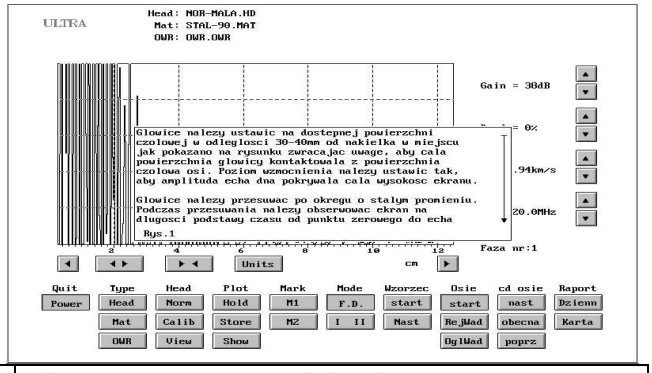


Figure 7 Screen with picture for current step of procedure displayed .

4. Conclusions

Ultrasonic digital defectoscope equipped with test procedures elaborated according to proper standards significantly accelerates tests, making them considerably much repeatable.

5.Publications

(1). W. Michnowski, J.Mierzwa R. Paszszuk Basis of Digital Technique, Harmless Tests (Podstawy Techniki Cyfrowej, Badania Nieniszczące) numbers from 6/7 to 10/11

(2).B.Rojek, A.Korneta, New Digital Ultrasonic Apparatus- Seminar Materials Nowa Cyfrowa Aparatura Ultradźwiękowa- Materiały Semiarium Zakopane 11- 13 marca (March) 1998 p. 91