

U L T R A

**ZAKŁAD BADAN
MATERIALÓW**

53-621 Wrocław, Głogowska 4/55, tel/fax +48 71 3734188
52-404 Wrocław, Harcerska 42, tel. +48 71 3643652
www.ultrasonic.home.pl mobile phone +48 601 710290
e.mail: ultrasonic@home.pl krymos@pwr.wroc.pl
NIP: 897-003-18-44

Ultrasonic examination of welds with small thickness.

Instruction of

Ultrasonic IBUS-TD-06 method

Examination of pipe's welds with thickness 2 to 8 mm

and

Examination of plate's welds with thickness 2 to 8 mm

using ultrasonic probes - Tandem

News

**IBUS-TD instruction contains
non-standard range of weld's
examination (thickness 2-8 mm)**

News

**IBUS-TD method is compability with
PN-EN ISO/IEC 17025 norm
(point 5.4.4.)**

Prepared: Władysław Michnowski
Reference certificate in BN-UT 3
No. 02-003 - 00015

Wrocław 2006

Grounds of method's compability with PN-EN ISO/IEC 17025 standard
is given in Attachment 1.

A. Introduction

This instruction is an important element of general quality system IBUS-NZ. This system assures the highest possible reliability of welds. Independently it can be applied in other quality system. It can be also applied as a procedure of weld's selection.

1. Beggining

Present standards and recommended technics of weld examination are limited. Namely they refer to welds thicker than 8mm. Attachment 2 explains the reasons of that limit. Long-term expiriances of ULTRA insitution and constant co-operate with polish power industry in weld's examination according to IBUS method are described in article (8.3) - Attachment 5. It also contains rules and advantages of IBUS method. Present version of IBUS method is compatible to PN-EN ISO/IEC 17025 standard (point 5.4.4.) and the grounds for that compability are given in Attachment 4. This instruction is complete. It means that instruction containg requirements and informations for weld examination. Especially it descibes:

- The way of execution and range of examination and criterions of weld's acceptation
- Required technical equipment
- Valuation of equipment and its parameters
- Documentation of examinations
- Associate standards

2. Examinations objects

Major examination objects are detecting flaws in welds which don't fulfill criterion of acceptation and their selection. Results of examination and selection can be used in feed-back as control of realization's quality process. IBUS-NZ quality system is used automatically. This fact allows elimination of production's mistakes in almost real time and constant improving reliability of produced welds upto the highest possible reliability.

3. The range of usage

The method IBUS-TD is designed to test welds of butt plates and circumferentail welds of boiler pipes in range of 2..8mm thick. It can be applied to welded elements made of:

- Steel
- Aluminium and its alloys
- Magnesium alloys
- Titan alloys

Examination of elements made of low-carbon and low-alloy steels is unlimited. The examination of elements made of different materials requires the usage of calibration blocks made of identical material to tested element. Geometric limits of examination can appear, for example: weld in washer, welds with different element's thicknesses, etc. ULTRA institution gives free consultations on these cases.

4. Basic rule and assumptions for examination method

The examination according to the IBUS-TD instruction is a comparative one. It compares the indications coming from real flaw to indications of artificial flaw. The artificial flaw is the reference hole situated perpendicularly to the tested surface made in plate or pipe. The diameter of reference hole (**Assumed diameter of reference hole equals 1mm**) was established upon long-term experiences. The DAC curve of reference hole is made for comparison of indications. The raise of acceptance criteria by 3 or 6 dB is allowed, but such situation should be mentioned in examination report.

5. Examination's categories and their conditions

The examinations according to the IBUS-TD were effectively carried out for many years with the hardware available in actual time. Present technological level of hardware gives

possibility to achieve the highest possible reliability of welds through the usage of simple methods. However it requires proceeding in quality system according to IBUS-NZ instruction. It also requires using proper equipment. Instead, in a range of examinations executing with usage of present technological equipment, IBUS-TD-06 instruction can be used for simple examinations (with recommended conditions given below).

5.1. Simple examinations – Bpr

Simple examination means executing examination and immediately selection of examined weld as good or bad. The selection is based only on reliability of operator (usually with no documentation about the base of such decision). Those examinations have the smallest range of conditions and their features are:

- High efficiency
- Possibility of usage any flaw detector (even analog one) having confirmed parameters according to point 6.4.
- Usage of Tandem probes: profiled for pipe's diameter or flat (for flat surfaces)
- Very simplified documentation of executed examinations. It rest on declaring that in described (eventually documented with picture) element of construction – examined according to “IBUS-TD-06 Simple examination” X pieces means all welds with positive result (eventually strictly specified exceptions), including Y pieces that were repaired according to LMN technology and were examined again, only this time with positive result (model of authentication from examinations Bpr – Attachment 6.)

Fault of using simple examinations is that they can be utilize in small level for present control of quality in production process. The reason of that is very simplified documentation.

5.2. Normal examinations – Bne

Normal examination means executing examination with full documentation. Though (similarly to simple examination) immediately weld selection appers. This result and set of additional informations (about whole process of weld execution) are noted and are used in process of quality control. These examinations have bigger range of conditions and their features are:

- A little bit smaller but still high efficiency, however if we have many welds in examined portion than efficiency is similar to efficiency achieved in simple examination Bpr
- Necessary of usage a flaw detector having specified features like: possibility of remembering examination results, possibility of remembering parameter set and DAC curves, possibility of transferring data to other outside carriers or computer (for example through USB, wireless-Bluetooth, etc.). Flaw detector CUD contains all mentioned features.
- Having a flaw detector with tandem probes profiled for pipe's diameter or flat (for flat surfaces)
- Having a computer program (dynamic data base, for example IBUS-NZpr) supervising realization process and quality control of executed welds
- Personnel having technical certificate of reference in a domain of IBUS instructions (course is in ODOK-SIMP Wroclaw)
- Automatically archived full technical documentation of executed examinations. It has to be freely available until it's deleted from archives

5.3. Automated examinations – Bza

Automated examinations – Bza are in advanced stadium of working out. Most important assumed features in realizing project are:

- Integrated, miniaturized set consists: flaw detector pocketCUD – pCUD with microcomputer (embedded PC), communication protocols organized into local

network, micromonitor μM and scanner with STD probe + eventually freely number of freely situated computers

- Set working in real time with monitors of local network and Internet allows real time monitoring on many stations and directly, retrospective valuation and deciding in quality control

Examples: elimination of welder “not in shape”, pointing and elimination of technological mistakes, wrong preparation for welding and pointing who is responsible, etc.

B. Preparations for Bpr and Bne examinations

IBUS-TD-06 instruction contains examination technology in Bpr and Bne categories. Instruction will be completed in Bza category. Examinations Bpr and Bne have obvious similarities. The biggest differences appear in domain of usage of examination results and prepared documentation.

Those examinations are divided into several phases:

- Phase of equipment preparation (DAC curves)
- Phase of examination preparation
- Phase of examination, repetition and comparative examination
- Phase of results archivization

6. Phase of equipment preparation (DAC curves)

6.1. Calibration blocks and probes

Calibration blocks (figures 1 and 2) are used to creating DAC curves (figure 3). DAC curve is used to comparison between readings received from real flaw and readings received from hole in calibration block. It's a reference curve and also a valuation curve.

Two types of calibration blocks are used:

- Simplified calibration block (figures 1 and 2)
- Regular calibration block according to attached figure IBUS-W (Attachment 7)

6.1.1. Simplified calibration blocks

Simplified calibration blocks (figures 1 and 2) can be made ad hoc by examiner through re boring currently examined segment of plate or pipe according to figures 1 and 2 or through re boring segment of platet or pipe that is identical with examined segment. The usage and realization of simplified calibration blocks require implementing conditions given below.

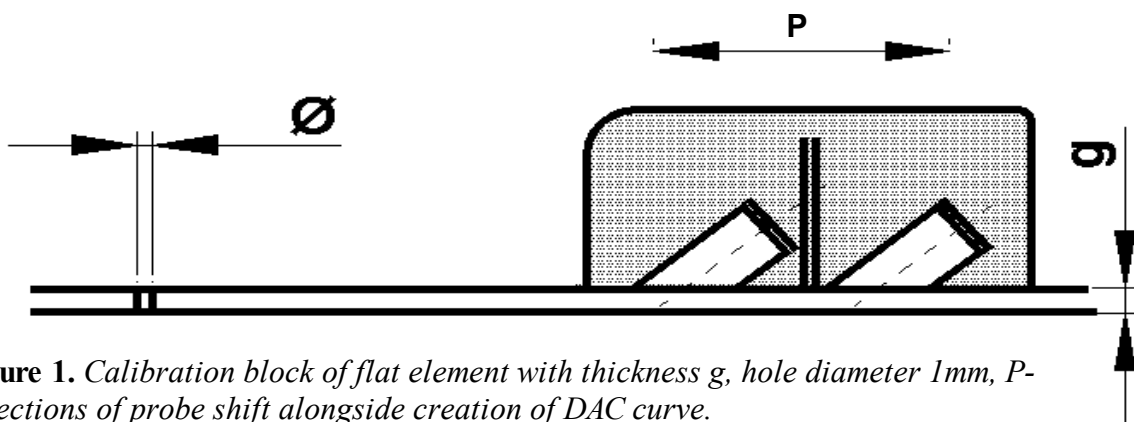


Figure 1. Calibration block of flat element with thickness g , hole diameter 1mm , P -directions of probe shift alongside creation of DAC curve.

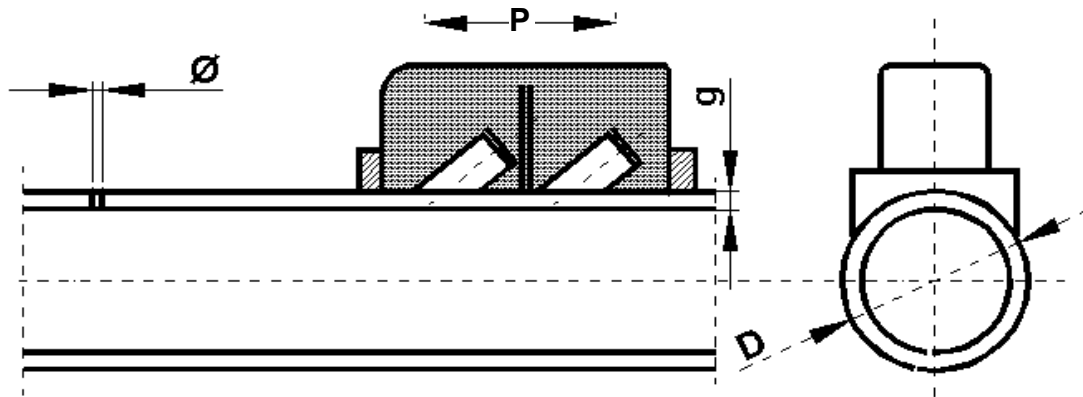


Figure 2. Calibration block used to examination pipe welds with thickness g , diameter D , hole diameter 1mm , P -directions of probe shift alongside creation DAC curve.

Requirements for realization of simplified calibration block.

Important advantage of simplified calibration blocks is their high similarity (almost identity) to segment with examined weld. It's the reason of their reliability. Calibration blocks are made through re boring currently examined segment of plate or pipe according to figures 1 and 2 or through re boring segment of plate or pipe that is identical with examined segment. The conditions for proper realization of simplified calibration blocks are:

- Surface of calibration block must be identical with (or close to) examined segment with weld
- This surface can't have a corrosive, erosive or mechanical damages which limit the surface of probe's contact with examined material (probe is profiled for pipes or flat for flat surfaces)
- Hole in calibration block has to be perpendicular to surface (for flat surfaces) or perpendicular to tangent to a cylindrical surface (for cylindrical surfaces)
- Perpendicularity is good enough if yaw angle doesn't pass 3°
- Hole has to be realized through new, sharp drill having higher hardness than pipe's material, for example hardness equals 25HRC
- Simplified calibration blocks are self prepared, their compatibility with IBUS-TD instruction (according to point 7) is confirmed by an operator who puts proper note in examination protocol

6.1.2. Normal calibration blocks

Normal calibration blocks IBUS-W can be bought in ULTRA institution. They have compatibility certification with IBUS-TD requirements and with attached figure (Attachment 8). IBUS-W calibration blocks can be self prepared and their compatibility with IBUD-TD instruction can be self confirmed if external requirements don't constitute otherwise.

6.2. Creation DAC curve

Creation of DAC curves bases on marking echo amplitude received from hole with standard diameter $\Phi = 1$ in different distances (P) of calibration block from hole (figures 1 and 2). DAC curve is drawn through points of the local highest echo amplitude (figure 3). Shown DAC range of 2-6 cm that is given by marker M (gate) is a typical range. Below 2 cm probe is

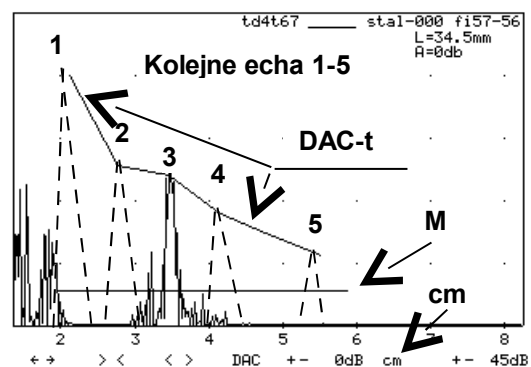


Figure 3. Creation of DAC curve (ex. $g=3$)

above hole Φ , above 6 cm examination sensitivity decreases and examination loses its point.

In a range of 2-6 cm local maximums and minimums can appear. They need to be included on DAC graph. The graph has to be monotonic. In digital flaw detectors (which construction allows for that) DAC curve is remembered in memory of flaw detector according to procedures included in work instruction. For example in flaw detectors CUD point 3.3. In other simple flaw detectors (also analog ones) DAC curve is drawn on a foil which is pasted on screen. This foil can be used many times provided that following datas are marked:

- Informations for identification of graph's position on time base
- Number (id) of probe to which graph refers
- Gain in dB
- Thickness and diameter of calibration block

Warning! Parameters of flaw detector settings for creation of DAC curve must be kept in examination, eventually mistakes in that range cause unacceptable examination mistakes.

In flaw detector CUD (and several other digital ones) DAC curve and associate flaw detector settings are remembered in memory, they can be frequently projected.

Flaw detector settings and curve have own name and informations given above (it provides easy identification). If it's possible in other flaw detectors than datas are remembered in memory of flaw detector. If it's not possible than you can book separate card file of DAC curves or you can create these curves currently.

6.3. Probes

On figures 4 and 5 you can see ultrasonic probes tandem TD profiled to calibration block $\text{Ø}38 \times 3$ mm. These probes are recently made in technology with usage of laser. It assures high repetability of probe's parameters. Each probe has certificate with confirmation of examined parameters as exemplary DAC curve created on calibration block with thicknes equals 4-5 mm.

These curves are created using flaw detector CUD. Probes unprofiled designed to examination of flat surfaces have similar certificates. Example of cetrificate is given in Attachment 8.



Figure 4. *Tandem probe with CE notation, U067 (Ultra No.), DM (big, brazen casing), TD 4T67 7, Ø38, with cosy handle, reference hole has stick inside.*



Figure 5. *Tandem probe with CE notation, U067 (Ultra No.), PM (small, plastic casing), TD 4T67 7, Ø38, height about 10 mm, reference hole has stick inside.*

6.4. Examination equipment

Minimum set of examination equipment for simple examination (Bpr) includes:

- Probes and their DAC curves
- Flaw detector
- Water wetting system
- Diary of realized examinations which is needed for archivization and protocol printouts, usually hand completed, eventually in computer or stamped notebook

Minimum set of examination equipment for normal examination (Bne) includes:

- Probes and their DAC curves
- Water wetting system
- Flaw detector + computer in feed-back like in point 6.4.2.

6.4.1. Flaw detector

Flaw detector used to Bpr examination requires confirmation of its current usable parameters according to PN-EN 12668-1 standard or BN-85/0601-14 standard ("Ultrasonic examinations of metallurgic products – Probes and flaw detector parameters. Requirements and examinations").

6.4.2. Flaw detector + computer

Flaw detector used to Bne examination requires confirmation of its current usable parameters like in point 6.4.1.. Beside if we want main object of normal examinations (weld quality control at production process through usage of examination results in feed-back with production in almost real time) to be realized than we require from flaw detector-computer set following capabilities:

- In co-operate computer must be implemented a computer program that provides remembering examination results and their conversion (for example dynamic data base like IBUS-NZpr)
- Flaw detector has to remember results and parameters of examination: probes parameters and their DAC curves, additional informations like: time and date of examination, welder datas, examination's operator datas, identificational datas of welds and their set, number (id) of next examination, eventually corrections, control examinations after a period of time, etc.
- Beside in flaw detector should be possibility of quick and easy on-line transferring informations to computer (USB, wireless Bluetooth, etc.)

All capabilities given above for example are implemented in flaw detector CUD.

7. Phase of examination preparation

Examination preparation has decisive meaning for effective and reliable execution of examination. Procedures of preparing Bpr and Bne examinations have some similarity and some differences. These differences are marked and they are given below.

7.1. Preparation of simple examinations Bpr

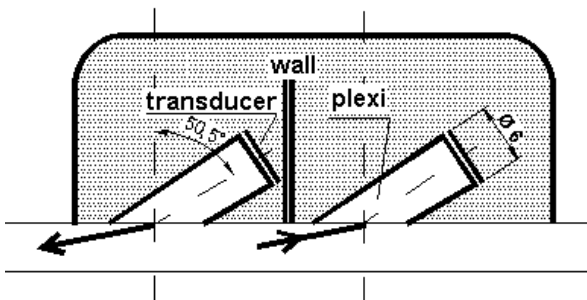
- Preparing description + eventually pictures and schemas of object
- Preparing the range of object examination
- Complementing of equipment and supportive materials
 - Flaw detector
 - TD probes in assortment assuring realizing examination's range according to flat surfaces and range according to profiling to pipe's diameters
 - water wetting system, reserve of detergens and water
 - DAC curves (in digital flaw detector's memory or on foils in case of analog flaw detectors or digital ones without capability of remembering DAC curves)

- Calibration blockss in a necessary range to provide realization of examination's range
- Checking condition of surface of examined object and eventually its correction
- Authorized person's (for example operator or supervisor of examination) decision about proper preperation for examination:
 - Object description and the range of examination
 - Level of object preperation for examination
 - Complementing of equipment
 - Complementing of operators and patrition of the range of examination between them

7.2. Preperation for normal examination Bne

Important differrance in preperation of normal examinationBne in coparision with 7.1. is that all descriptions have to be prepered in electronic form on co-operative computer. Realization of that is achieved through filling sections of data base in a computer program INUS-NZpr.

7.3. Connection of TD probe



TD probe (figure 6) is connected in order to front converter (left transducer one on the figure) worked as transmitter and rear converter worked as receiver. At the same time in flaw detector transmitter has to be disconnected from receiver (similary to probes with double transducer).

Water wetting should be set in order to one drop for about 2 seconds.

Figure 6. Schema of tandem probe.

7.4. Setting flaw detector's parameters

Setting flaw detector's parameters is generally repeating of settings used to creation DAC curve (so they already exist). Differences appear only in correction of gains and position of DAC curves.

7.4.1. Normal settings of flaw detector's parameters

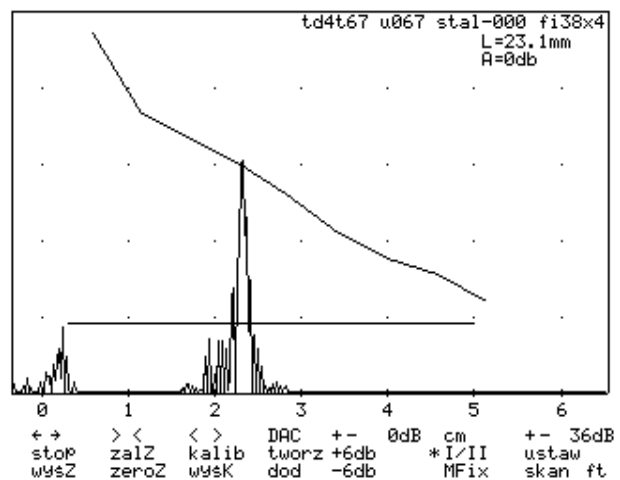
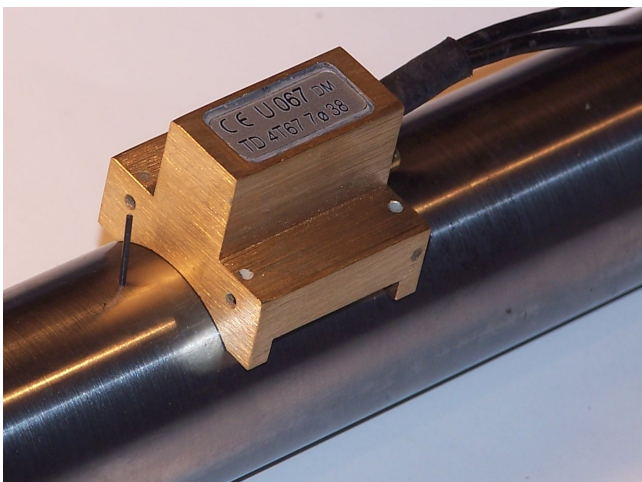


Fig. 7. Setting the probe on calibration block and correctly received echo DAC curve, it should be synchronized in vertical axis 36 dB and horizontal axis too which is done automatically in flaw detectors with memory ex. CUD (curve fi38x4 and probe Nr . u067)

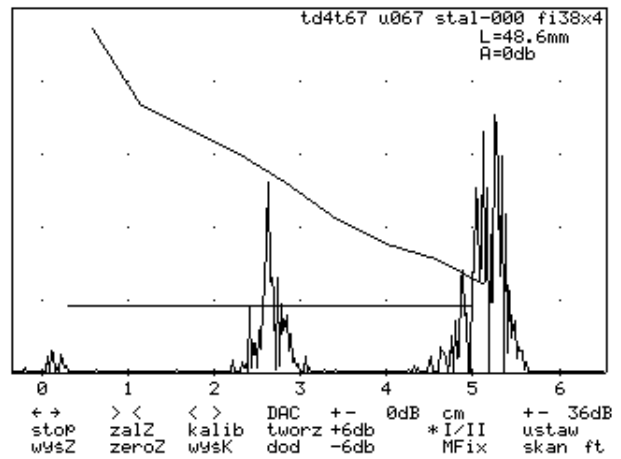
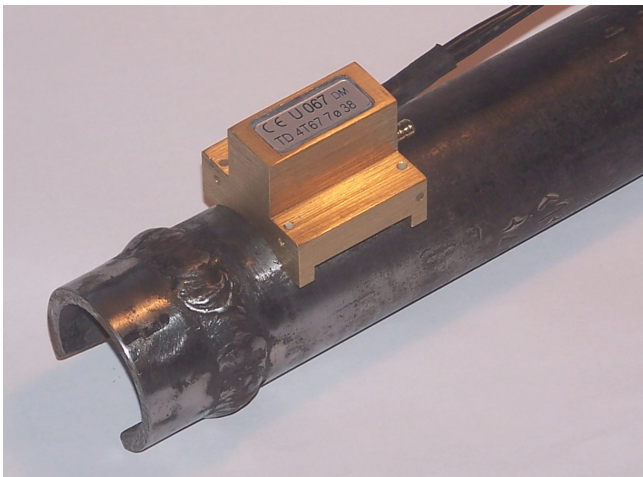


Fig. 8. Setting the probe on examined material, echo received from real flaw 0dB from DAC curve indicates that flaw's size is similar to reference hole

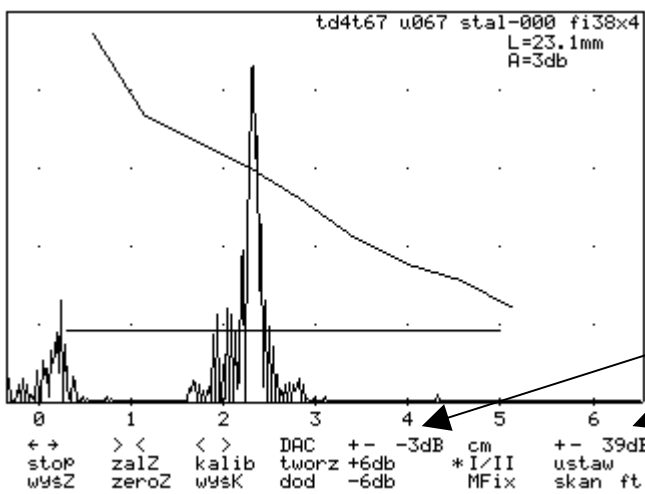


Fig. 9. In relation to fig. 7 gain correction + 3 dB (36+3=39) requires correction of DAC curve position ex. - 3 dB

7.4.2. Correction of flaw detector's parameters and position of DAC curve

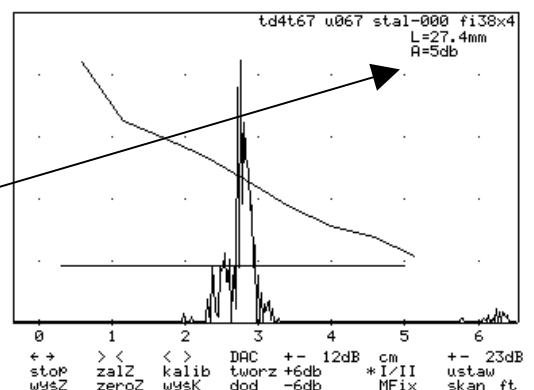
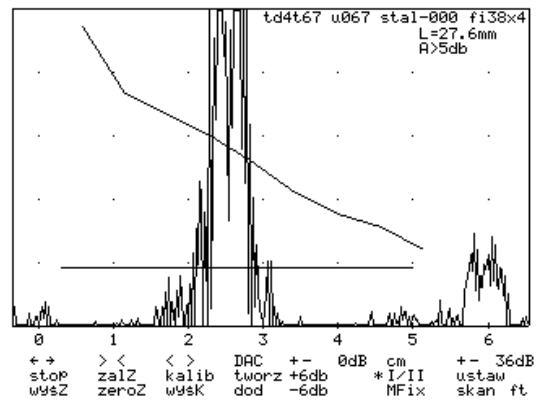
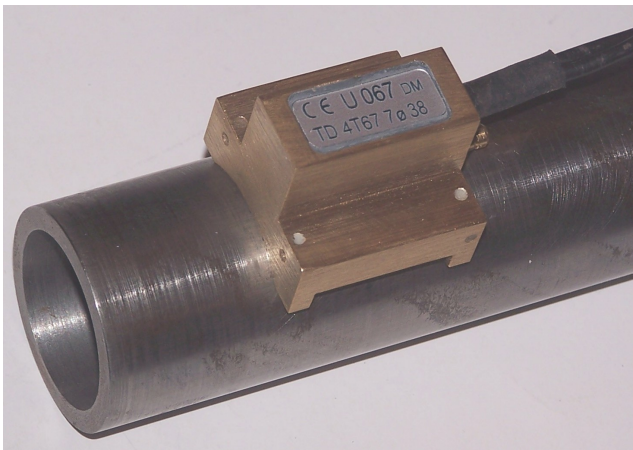


Fig. 10. Measurement of edge echo (above) received from calibration block (fig. 7), this echo is overcontrolled and requires gain correction from 36 dB to 23 dB (13 dB) and also correction of DAC curve position ex. -12dB. Measured difference between edge echo and reference hole echo equals 13dB +5dB=18 dB

C. Realization of examination

7.5. Moving the probe and watching the screen

Both Bpr and Bne examinations base on making sepyfied probe moves next to the weld and watching flaw detector's screen at the same time.

- Probe moves are made along pipe (back and forward several times) and are joined with circular move. These moves can be made quite quick and energrtically but they must be made segmentally so that whole weld size were examined several times
- Watching the screen. At the same time as making probe moves, flaw detector's screen has to be watched and received echos should be valuate according to point 7.6.

7.6. Valuation of welds

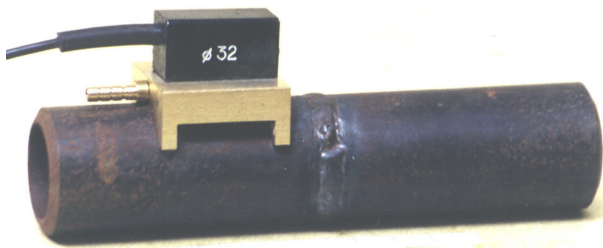


Figure 10. Weld examination $\varnothing 32 \times 4$ mm

- Echo's amplitudes which are below DAC curve are assumed as noises, they aren't flaws, they are acceptable readings
- Echo's amplitudes above DAC curve are assumed as unacceptable flaws, they are unacceptable readings
- Echo's mistake range is allowed and equals ± 3 dB in relation to DAC curve

7.7. Results of examination

Proper usage of examination results is crowning achievement and base of object examination. It forces duty of taking care of 100% examination of all welds in portion and proper usage of examination results on operators executing examination. It concerns both Bpr and Bne examinations. Abandonning 100% weld examination prevents selection of unreliable welds. It always decreases general reliability of device. Customer should be informed and he must give written acceptance (disposition) if there's need for abandonning 100% weld examination. On that case only simple examination Bpr is proceed.

7.7.1. Results of simple examination Bpr

In a domain of simple examinations Bpr the end of examinations are: defining all unacceptable welds and taking care of their repairment, examination of corrected welds and writing out confirmation according to exemplar confirmation from Bpr examinations (Attachment 6). All exeptions means unexamined welds must be unconditionally specified and the reason of unexamination must be motivated. Beside written acceptance of each exeption must be given by customer.

7.7.2. Results from normal examination Bne

In a domain od normal examinations Bne results are on-line transmitted to data base in a computer (IBUS-NZpr computer program). There are three ways of that transmission:

- Directly through computer's keyboard to IBUS-NZpr (eventally using small portions of results)
- Indirectly to assistant that is sitting next to computer with usage of wireless connection (for example: headphone, microphone, wireless network)
- In flaw detectors CUD the result of examination of every weld is transmitted (through wireless connection) after hitting a button

Following informations are given through every way of transmission:

- Number (id) of weld
- Number (id) of welder

- Number (id) of examiner
- Result (good/bad)

Computer program IBUS-NZpr will automatically transform initial datas with examination's results. It provides immediatly displaying or printouts of not only examination's results but also valuation of welder's work, used technology, level of building realization (reperations), etc.. Particular informations in this domain are given in instruction for IBUS-NZpr computer program. Important fact is that access to these datas is not only immediatly but also is possible on any computer (for example supervision's inspector, owner, etc.). Obviously access can be restricted with password.

8. Bibliography

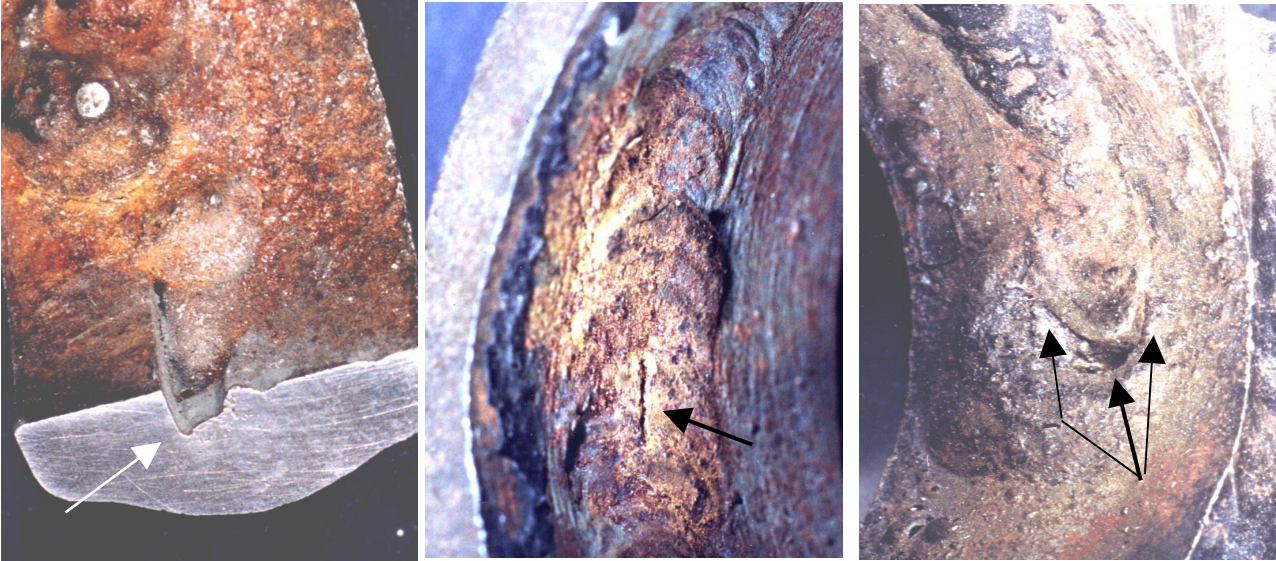
- U. Shlegermann, Badania ultradźwiękowe połączeń spawanych o małej grubości, Seminarium Nieniszczące Badania Materiałów- Zakopane 12-13.03.1998
- Władysław Michnowski, Jarosław Mierzwa, Ultradźwiękowe badania spoin o grubości poniżej 6 mm badania spoin rur kotłowych badania spoin rur kotłowych Seminarium Nieniszczące Badania Materiałów- Zakopane 03.2002
- mgr inż. Janusz Barczyk, mgr inż. Franciszek Leszkowicz (Elektrownia Turów) mgr inż. Władysław Michnowski Zakład ULTRA- System zapewnienia wysokiej niezawodności spoin rur w energetycznych kotłach blokowych..- dozór techniczny 4/1992.
- PN-89/M-70055/02
- PN-EN-1712; PN-EN-1714
- ASME Section V Article 5
- PN-85/M-69775
- PN-EN ISO/IEC 17025

Attachment 1

Need for examination of welds with small thickness

The most important argument for testing of thin welds is fact that resignation often causes a disaster. It took place many times. It concerns a building of pipelines to transport inflammable and explosive materials, a building and renovation of block boilers in power stations and usage of thermal net. The real examples below illustrate the need of testing.

Examples of real weld flaws in pipes, detected in examinations according to IBUS instruction.



There are three types of real flaws. The hardest type to detect is 3-rd one – incomplete fusion (lack of adhesion) deepen in example for crater of rising leak. Incomplete fusion usually rises at the ending or beginning of pipe's circuit weld. It's small flaw that generally occurs in these welds and is the most dangerous (in view of it's fast growing) because it causes frequent failures.

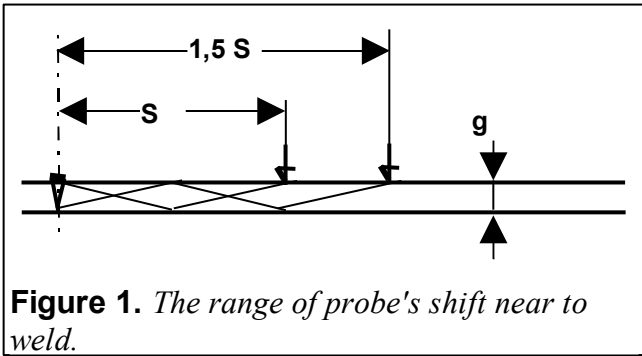
It is hard to detect flaws of that type but it's necessary.

Warning! Usage of examination methods which unsatisfactorily assure detection of that flaw is major technical mistake. Especially radiographic examination is improper because in exposition through two oval walls, probability of flaw's detection is minimal. Instead ultrasonic examination with usage of proper probes and according to IBUS-TD demands gave us better than satisfied results.

Attachment 2

Description of limits in ultrasonic examination of welds with small thickness

Good and unique readings received in weld examination above 12mm limit are no longer unique below that limit (assuming examination with usage of probes with converter 10x10mm). For probes with bigger converter that limit properly increases. Decreasing uniqueness of readings is related to rising geometric noises (leakage, irregularity of weld's root and face) which causes decrease of relation between useful signal and noise level.



1. Geometric limits

Dimensions of probe, used to examination weld with small thickness, require choosing the range of shift as is shown on figure 1 (for example from 1 to 1,5S). Distance between probe and examined weld is increased. Because of that usage of higher gains is required. Natural ultrasonic beam divergence eliminates differences in readings received from flaws in weld's root and face, in case of small thickness it makes these differences even undifferentiate.

2. Increasing of noise level

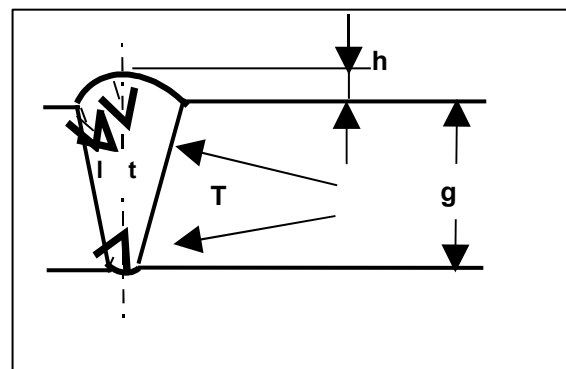
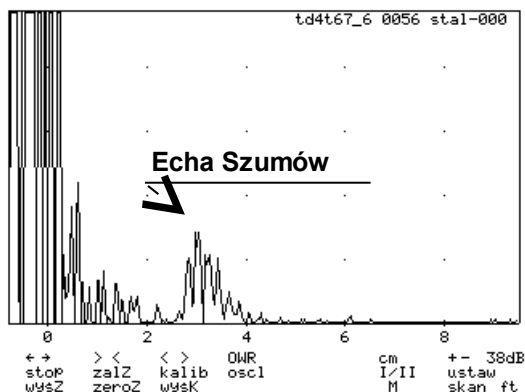


Figure 2. Amplitude of geometric noises in weld examination.

In case of examination of welds with small thickness the reasons of increasing noises level are:

- Change of geomery in thin welds (increasing of relation h/g – figure 2) causes fact that transverse incident wave **T** is more intensively reflected and splited on irregularity of weld's root and face
- Partial reflections (transverse waves **t** and oblong waves **l**) have bigger probability of hitting (as echo) to receiving probe's converter
- For welds in oval pipes geometric diverance of ultrasonic wave's beam on crossing through cylindric surface

Authors of some standards, awarded effects given above, limite the range of their usage to thickness more than 8mm.

3. Conclusions

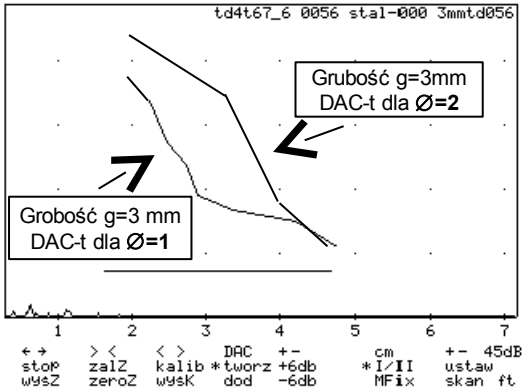
- Significant, distinct reading of weld's examinations (position (weld's root and face) of detected flaw in weld's cut) in case of examination of welds with small thickness stopping to be distinct until disappearing of these readings
- Increasing noise level in case of examination of welds with small thickness gives rise to significant increasing number of welds with unacceptable reading because of incompatibility (flaws) as irregularity of weld's root and face including for example leakages with intensity that is assumed as acceptable
- Conclusions given above cause need for making probes that minimize their negative effects. Such probes are present profiled tandem probes.

Attachment 3

1. Exemplary valuation of readings dynamics of ultrasonic TD probes

Readings dynamics are similar in cases of examinations of flat elements and oval elements (pipes). Examples of these dynamics are given below.

2. Example of dynamics change of readings at changing the reference hole Φ



On the figure are shown two DAC curves created on flat element with thickness equals 3mm and reference hole diameters equal 1mm and 2mm. In examples with oval elements (pipes) similar distribution of DAC-t curves appear.

Figure 1. DAC curves for reference holes 1mm and 2mm.

3. Example of real readings dynamics received from detected flaw in weld.

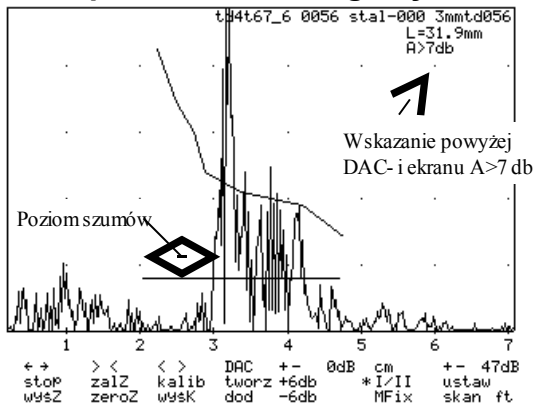


Figure 2. Real reading received from flaw, weld with $g=3mm$, visible in weld's inspection flaw is weld's penetration absence with dimensions of about $3x0,5mm$.

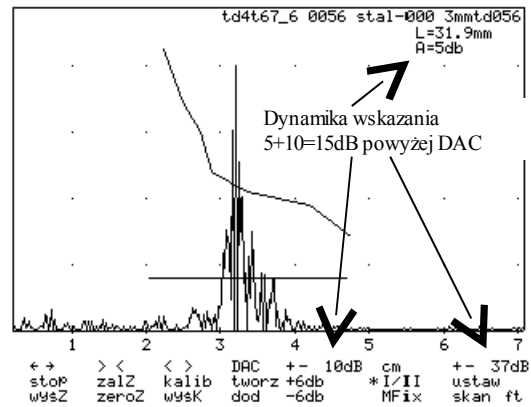


Figure 3. Reading dynamics received from flaw - picture 2 (after correction of gain and DAC position) equals +15dB with minimal noises level.

4. Example of reading dynamics range

In this example, the range of reading dynamics is big and equals 20dB with respect to noises and with respect to DAC curves it equals 23dB (pipe with diameter equals 34mm and thickness equals 2,8mm).

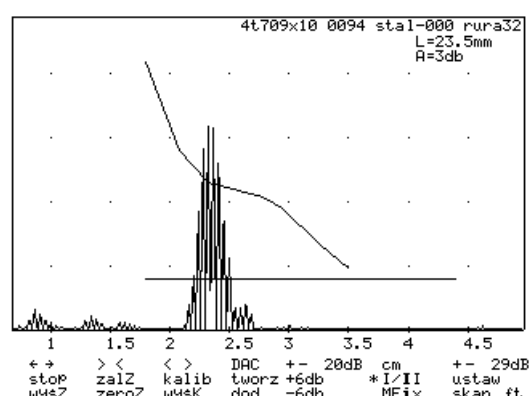
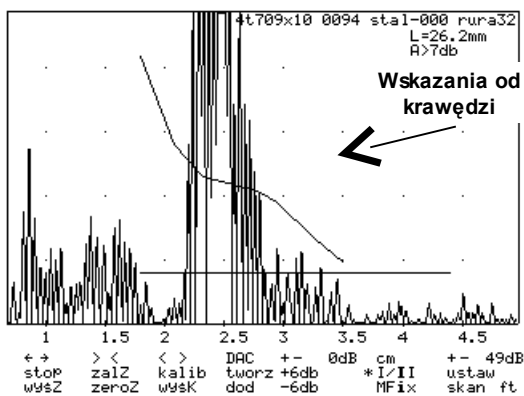


Figure 4. Illustration of reading dynamics range, reading dynamics – 23dB above DAC curve.

Attachment 4

Grounds of ultrasonic IBUS-TD method's compability with PN-EN ISO/IEC 17025 standard

PN-EN ISO/IEC 17025 standard titled: „Generall requirements concern examination competences of examination and model laboratories” in point 5.4.4. formulates requirements for usage of non-standard methods.

Requirements of point 5.4.4. and their explanations are given below:

- a) *proper identification*: **given in title of IBUS-TD Metchod**
- b) *range*: **given in title of IBUS-TD Metchod**
- c) *description of object's type that will be examined or modelled*: **given in title of IBUS-TD Metchod**
- d) *parameters or values and ranges that have to be defined*: **given in title of IBUS-TD Metchod**
- e) *apparatus and equipment together with requirements refered to their technological parameters*: **given in title of IBUS-TD Metchod**
- f) *required reference standards and reference materials*: **given in title of IBUS-TD Metchod**
- g) *required envirinmental conditions and stabilization period if needed*: **given in title of IBUS-TD Metchod**
- h) *procedure's description contains*:
 - *bringing identificational marks, proceeding with objects and their transporting, storage and preperation*: **don't concern IBUS-TD Metchod**
 - *checkings that have to be done before the begginging of works*: **given in title of IBUS-TD Metchod**
 - *checking propriety of equipment work, modeling and regulation of equipment before every use (when it's required)*: **given in title of IBUS-TD Metchod**
 - *the way to observation and writing the results*: **given in title of IBUS-TD Metchod**
 - *all safety rules that have to be observed*: **don't concern IBUS-TD method but general rules of safety work are in force**
- i) *criteria and/or requirements concern acceptance/rejection*: **given in title of IBUS-TD Metchod**
- j) *datas that have to be registered and the way to their analysis and presentation*: **given in title of IBUS-TD Metchod**
- k) *unreliability or procedure to estimate unreliability*: **given in title of IBUS-TD Metchod**

Attachment 5

Article published in „Dozor Techniczny” Nr 4 1992

Master engineer JANUSZ BARCZYK

Power station „Turow”

Master engineer FRANCISZEK LESZKOWICZ

Power station „Turow”

Master engineer WŁADYSŁAW MICHNOWSKI

Institution of material's examinations ULTRA Wroclaw

System of assuring high reliability of pipe's welds in energetical block boilers and present standards (1992) related to ultrasonic examinations of welds

Ultrasonic examinations of welds in Poland have a 30 years all tradition. Presently they are related to standards [1-9] that regulate procedure of examination and classification of examined welds. Some of these standards exist only as an announcement or as a project. Published standards [1-3] contain most of cases of existing needs. Realization of whole publishing program of these standards would cause possibility of unification of examinations and classifications of all welds according to unified, compact system. The advantages of that solution are obvious and it would be the first (in whole 30 years old tradition) as much complex examination (of all welds) arrangement. Despite obvious advantages in usage of single complex system of examination and classification of welds, opinion that this system contains all possible cases in practice is utopian.

Examples that don't strictly fulfill requirements of presently standards are: examinations on automatic devices and also hand examinations of weld in oval pipes in a range of diameters 31-89mm situated in energetical block boilers. In given examples (and in other ones) if it's reasonable than insertion of particular institutional instruction (which is adoption of standards requirements to local conditions) is necessary. The topic of this article is to motivate the way of examination of welds in pipes with diameters 31-89mm on energetical boilers OP 650b in power station „Turow”. This procedure is formulated in IBUS-R 91 instruction which is an adaption of previous IBUS instruction to requirements of standard [1] and standard's project [4].

Motivation of IBUS-R 91 instruction, although bases on example of power station „Turow”, can and even should be taken into consideration in other power stations. During starting and following years of block's work in power station „Turow” (in 60's) leakages appear in a pressure section. They caused tens of emergency stabling of each block (it happened during energetical deficyt). Estimated loses were yearly represented by numbers so big that were noted in nation's budget. This condition stayed for few years and taken attempts of its improvement initially don't give desired effects. Many analyses were executed, for special attention deserves analysis performed by „Energetical Dolnoslaskie District Z.E.O.D. [10 and 11] and by „Energopomiar” in Gliwice.

From analysis in a domain of oval pipe's welds came off: definitely most leakages appear on installation and repair welds, however industrial welds and pressure welds were relatively good, almost always we could separate primary leakages which proclaim the cause of damage from secondary leakages – **in over 50% primary leakages, the reason of damage was: small, sometimes hardly to see hole with shape of: comma, circular or oval. Small dimensions of most appearing leakages declined to obvious conclusion that the flaw in weld (that causes these leakages) also has small dimensions.**

Flaws that fulfill this description are: small, radial crack that is transverse or oblique to weld's axis and mostly appears on the ending of weld. Character and small exploration

dimensions of dangerous weld's flaws in block boilers (and related to these facts very hard detectability) indirectly confirm fact that during modernization of boiler in block 4, **100% welds were radiographically examined in 1 class but it didn't improve welds reliability.** On that solution „Technological District” in Wroclaw together with power station „Turow” elaborated method for assuring high reliability of pipe's welds based on ultrasonic examinations. The usage and implementation of this method and technological improvement of welding caused, in 3 years time, radically improvement in a domain of weld's quality in block boilers. The method's authors were awarded with prize then Energetical Minister [12]. Assuring high weld's reliability in block boilers is a solution of three problems:

- A) Examinations based on IBUS instruction that contains technics of examination and criterions of valuations.** Purpose of these examinations is directly and immediately weld's selection (defining is it good or bad). Any classification is than useless and examinations are simplified and accelerated. Valuation's criterions are fitted on so high level than **not only doubtlessly bad welds are classified as bad but also doubtful ones.** Often charge that part of welds are cut unnecessary is rised. It's just charge but meaningless if we take into consideration largeness of loses related to emergency stabling of block and necessary of detection every (even very little, hard to detect) flaw because each flaw can be dangerous. Problems described in points B) and C) come in limiting the number of doubtful welds to minimum and research executed in Energetical Institute confirms rightness of that attitude.
- B) Equipment.** Examinations are executed with the usage of equipment contains special ultrasonic probes with water wetting and calibration block [12, 13 and 14]. Important difficulty in construction of ultrasonic probes is that (in case of examination of welds in pipes with small diameter) concentration (geometric dispersion) is smaller through crossing pass cylindrical surface. The effect of that dispersion of field „allergy” to circular flaws. It's adverse effect which increases noise level (partial echos) received from irregularity of weld's root and face. However desirable feature of probes used to examination of pipe's welds would be „allergy” to their radial flaws. Performed series of examinations on models of made probes provide setting probe's optimal constructional points as: refraction angle 67 degree, converter dimensions 7x7mm, frequency 4MHz. Beside probes should be precisely profiled and best with water wetting [patent 14]. Their sensitivity and usefulness is constantly controlled on special calibration block.
- C) Co-operation.** Ultrasonic examination operator's tasks don't end on examination of welds and giving results. Their additional responsibilities are: co-operation and valuation of welds, analysis and explanation of examinations with negative results, most important is taking care and control of cutting out and repairment of all welds examined with negative result. System of assuring high reliability of pipe's welds in block boilers is based on examinations executed according to IBUS instruction. In proper version of this instruction IBUS-R 91 included requirements of standard's project [4] and standard [1] however differences given below remain. Weld's valuation in the highest class UI according to standard [1] allows appearing punctual flaws in welds. It would seem like a serious mistake because punctual flaw can be the most dangerous for those welds. Because of that weld's valuation according to IBUS-R 91 doesn't allow any flaws detected above limit of flaw's registration. These limits are arbitrary set (according to standard [4]) as flaw equivalent 0,7mm. This standard [4] doesn't mention about noises means the relation between noise level with setted limit of flaw's registration. IBUS-R 91 instruction set registration limits as sensitive as physically possible meaning at noises level with concurrent constant control of that level (through operator) and possibility of that limit's correction in a range of 6dB.

In sum IBUS-R 91 instruction gives more restricted requirements (in a domain of weld's quality) as it would appear from valuation according to standards [1,4] in UI class. It means that special class-UI is enforced. In this class punctual flaws are unacceptable on level of registering flaws. It seems clear that so restricted quality requirements can cause doubts about possibility of their implementation. In result of that wish to their relaxation appears. Attempts to relaxate this requirements (more or less concious) unfortunately were made and finished negatively. The most drastic example is building (70's) of power station „Dolna Odra” performed by „Energomontaz Enterprise”. During installing boilers in first blocks used 100% ultrasonic examination but according to quite relaxedated criterions. Unfortunately it caused repetition of catastrophic condition of boilers reliabilities (similar to described earlier for power station „Turow”). Only than in installation of boilers in last blocks fully used system of assuring high reliability of welds. It provides immedietaly improvement even so good that failure-free starting of boiler (speaking about welds) was achieved. This condition was achieved at the cost of cutting out more welds (with negative examination result).

However short time of starting and most of all further failure-free boilers work fully recompensed that cost. Each usage of system based on three fundaments: **A – examination, B – equipment (probes), C – co-operate**, has own rythm. Initially examination's speed is relatively slow and number of welds being cut out (with negative result) is big. Little by little system reaches maturity which characteristics are increasing examination's speed and quite considerable decreasing number of welds with negative result. Condition of sustem's maturity is the most advantageus (from weld's reliability point of view). It's obvious that examination's speed and maturity level are achieved through set of activities described as co-operate. Acceleration and increasing system's maturity is the most effective achieved if new created installation team is trained, for example through welding and testing experimental pipes. Training usually isn't necessary in case of stabilized operations.

Instalation's Director of power station „Dolna Odra” said interesting words and this sentence is worth quoting:

„From the beginning I was opponent of enforcing those examinations but they were forced on me. Number of cut out welds and whole confusion confirm me about my prejudice, but achieving reduce of starting for about 90 days proves I was wrong.”

BIBLIOGRAPHY

- [1] PN-89/M-69777 Spawalnictwo. Klasyfikacja wadliwości złączy spawanych na podstawie badań ultradźwiękowych.
- [2] PN-89/M-70055/01 Spawalnictwo. Badania ultradźwiękowe złączy spawanych. Postanowienia ogólne.
- [3] PN-89/M-70055/02 Spawalnictwo. Badania ultradźwiękowe złączy spawanych. Badanie spoin czołowych o grubości 8-30 mm głowicami skośnymi, falami poprzecznymi.
- [4] PN- /M-70055/03 (projekt) Spawalnictwo. Badania ultradźwiękowe złączy spawanych. Badania spoin czołowych o grubości 3-8 mm głowicami skośnymi falami poprzecznymi.
- [5] PN- /M-70055/04 (zapowiedź) Spawalnictwo. Badania głowicami skośnymi złącz spawanych ze spoinami czołowymi o grubości ponad 30 mm ze stali węglowych i niskostopowych.
- [6] PN- /M-70055/05 (zapowiedź) Spawalnictwo. Badanie złączy spawanych ze spoinami czołowymi.
- [7] PN- /M-70055/06 (zapowiedź) Spawalnictwo. Badanie złączy spawanych ze spoinami pachwinowymi.
- [8] PN- /M-70055/07 (zapowiedź) Spawalnictwo. Badanie złączy spawanych z aluminium i

jego stopów. [9] PN- /M-70055/08 (zapowiedź) Spawalnictwo. Badanie złączy ze stali o strukturze silnie tłumiącej i rozpraszającej.

- [10] *R. Bauer*: Analiza przyczyn odstawień i uszkodzeń 7 bloków w Elektrowni Turów za okres 1967. ZEOD 1968 (praca nie publikowana)
- [11] *R. Bauer, E. Rudziński, W. Michnowski, S. Salka, Z. Zawada*: Analiza awaryjności kotłów w Elektrowni Turów w roku 1969. ZEOD 1970 (praca nie publikowana)
- [12] *W. Michnowski, K. Skowroński, F. Leszkiewicz, Z. Strużyński*: Metoda kontroli spoin na rurach kotłowych małych średnic (32-68) przy pomocy specjalnej głowicy ultradźwiękowej - (projekt racjonalizatorski) ZEOD 1974.
- [13] *W. Michnowski*: Niektóre problemy niezawodności kotłów bloków energetycznych. Dozór Techniczny nr 2/1973.
- [14] Patent nr 72214/71 (*W. Michnowski, M. Wiewiórski*)

Attachment 6

Example of authentication from simple examinations IBUS-TD-06 Bpr.

Authentication should include informations as follow:

1. **Examminations executor** :Logo: Full name:
2. Adress: ,Email: Internet: Phone numbers: NIP:
Economic activity's ground Activity's registraction:
3. **EXPERTISE Nr/mm/rrrr**
4. **Name : Ultrasonic examinations of pipe welds according to IBUS-TD-06-Bpr**
5. **Place: „For power station Dolny Wislok in Zagorze”**
6. Nr of contract from day: mark:
7. **Examinations costomer**: Logo: Full name:
8. Adress: ,Email: Internet: Phone numbers: NIP:
9. The owner of examined object: Name
10. Nr of contract from day: mark:
11. **Supervisor of examination team**: Full name, competence certificate according to 473 standard, UT degree, signature
12. Date and place of examination” **Examination was executed from: dd.mm.rrrr. to dd.mm.rrrr.**
13. **Statement's contents**: Place of examination, examined object, general number of welds, number of executed welds, number of examined welds, which weren't examined and why
14. Base of executed examinations and confirmation agreements
15. Equipment used to examinations
16. General result of examinations
17. Giudelines and standards

Example is given below.

U L T R A

**ZAKLAD BADAN
MATERIALOW**

53-621 Wroclaw, Glogowska 4/55, tel/fax +48 71 3734188
52-404 Wroclaw, Harcerska 42, tel. +48 71 3643652
www.ultrasonic.home.pl mobile phone +48 601 710290
e.mail: ultrasonic@home.pl krymos@pwr.wroc.pl
NIP: 897-003-18-44

EXPERTISE Nr/mm/rrrr

For: **ZAKLADOW REMOTOWYCH ENERGETYKI
"Elserwis" S.A.**

ul. Dobra 1
12.345 Pacanów

Ultrasonic examinations of pipe welds according to IBUS-TD-06-Bpr

For power station Dolny Wisłok in Zagorze

18.Nr of contract from day: mark:

**Supervisor of examination team: Full name
competence certificate according to 473 standard
UT degree
signature**

**Examinations for power station Dolny Wisłok in Zagorze
Examinations were executed from: dd.mm.rrrr. to dd.mm.rrrr.**

Zagorze day. dd.mm.rrrr.

Statement's contents:**1. The range of examinations**

Oval welds in pipes were processed by ultrasonic examinations. These welds are in pipes of water heater in boiler K3 on level II. Whole bank of tubes IV is specified and contains:

131 pieces of weld Φ 38 /4, 128 pieces were examined and valuated, 9 of them were corrected.

48 pieces of weld Φ 67 /6, 48 pieces were examined and valuated, 3 of them were corrected.

9 pieces of weld Φ 98 /6, 9 pieces were examined and valuated, none of them was corrected.

All together whole bank IV contains 188 pieces of weld, 185 were examined and 12 of them were corrected. Together it gives 197 welds. 3 welds marked on sketch (attachment) weren't examined because of lack of acces.

Correction of bad welds was made according to MNC technology.

2. Base of executed examinations and confirmation agreements

Based on agreement with examination customer, ultrasonic examinations and valuation of welds were executed according to IBUS-TD-06

3. Equipment used to examinations

- Ultrasonic flaw detector, type: Producer:
- Ultrasonic probes tandem with notation: TD4T67 7 Φ 38, Φ 67, Φ 98 and normal probe 2X2I012.
- Equipment (water wetting system, calibration blocks, power supply).

4. General result of examinations

Examined welds of water heater in boiler K3 on level II say whole bank of tubes IV, sketch (attachment) according to the range given in point 1. 185 welds were examined, 12 of them after correction fulfill requirements of IBUS-TD-06-Bpr instruction, they aren't made correctly.

5. Examinations was executed by:

- Jan Kowalski Competence certificate according to IBUS-TD-06 Nr given by:
- Odyn Zaszczka Competence certificate according to IBUS-TD-06 Nr given by:
- Alfons Grzegorzolka Competence certificate according to IBUS-TD-06 Nr given by:

6. Guidelines and standards

6.1 IBUS-TD

6.2 IBUS-NZ

6.3 .PN-89/M-70055/02

6.4 PN-EN-1712; PN-EN-1714

6.5 PN-85/M-69775

6.6 PN-EN ISO/IEC 17025

Zagorze, dnia dd.mm.rrrr.

Attachment 8

Example of probes certificate.

<b style="font-size: 2em; color: red;">U L T R A ZAKLAD BADAN MATERIALOW	53-621 Wroclaw, Glogowska 4/55, tel/fax +48 71 3734188 52-404 Wroclaw, Harcerska 42, tel. +48 71 3643652 www.ultrasonic.home.pl mobile phone +48 601 710290 e.mail: ultrasonic@home.pl krymos@pwr.wroc.pl <b style="color: red;">NIP: 897-003-18-44
--	---

**AUTHENTICATION Nr. 03/02.2006.
OF REALIZATION AND EXAMINATION
Ultrasonic probes
Tandem**

Based on results of probe examinations performed in 20.02.2006 according to Instruction of Ultrasonic Weld Examination – IBUS-TD and also requirements of standard PN-EN ISO/IEC 17025 – point 5.4.4

ascertained that:

**ultrasonic probes given in Table 1 are accordant to requirements of IBUS-TD
instruction which fulfils requirements of point 5.4.4.
PN-EN ISO/IEC 17025 standard**

This authentication expires in two years time (20.02.2008). After that date probes should be processed into periodic examinations.

Prepared: Jarosław Mierzwa

Verified and approved: Władysław Michnowski
 Expert SIMP ID nr, 1126
 3rd level specialist in domain of non destructive examinations,
 has reference certificate UDT-CERT nr 02-001-00015

Wroclaw 20.02.2006

Authentication is given for :
Enterprise XYZ

**00-411 Scinawka Srednia
ul Gorna 42**

Table 1.

Ip	Probe - symbols	Manufactoring number	Comments
1	TD4T 67 Ø 69 - DM	U6028	
2	TD4T 67 Ø88 - MM	U6031	
3	TD4T 67 Ø120 - DP	U6037	

Attachment 9

Example of calibration block certificate.

U L T R A ZAKLAD BADAN MATERIALOW	53-621 Wroclaw, Glogowska 4/55, tel/fax +48 71 3734188 52-404 Wroclaw, Harcerska 42, tel. +48 71 3643652 www.ultrasonic.home.pl mobile phone +48 601 710290 e.mail: ultrasonic@home.pl krymos@pwr.wroc.pl NIP: 897-003-18-44
--	---

**AUTHENTICATION Nr. 14/07.2005. OF EXAMINATION
OF ULTRASONIC TUBULAR CALIBRATION BLOCK**

Having following symbols: Ø 32/4 U IBUS 04002

Based on results of calibration block examinations performed in 20.02.2006 according to Instruction of Ultrasonic Weld Examination – IBUS-TD and also requirements of standard PN-EN ISO/IEC 17025 – point 5.4.4

ascertained that:

**calibration block has parameters accordant to requirements of IBUS-TD
instruction which fulfils requirements of point 5.4.4.
PN-EN ISO/IEC 17025 standard**

This authentication is without time limit. The usage of calibration block is conditioned by lack of visible mechanical damages including visible corrossion that changes surface and dimentions of calibration block.

Prepared: Jarosław Mierzwa

Verified and approved: Władysław Michnowski
Expert SIMP ID nr, 1126
3rd level specialist in domain of non destructive examinations,
has reference certificate UDT-CERT nr 02-001-00015

Wroclaw 20.02.2006

Authentication is given for :

Enterprise XYZ

**00-123 Plock
ul Dolna 8**

Table of contents

A. Introduction.....	2
1. Begginig	2
2. Examinations objects.....	2
3. The range of usage.....	2
4. Basic rule and assumptions for examination method.....	2
5. Examination's categories and their conditions.....	2
5.1. Simple examinations – Bpr.....	3
5.2. Normal examinations – Bne.....	3
5.3. Automated examinations – Bza	3
B. Preparations for Bpr and Bne examinations.....	4
.....	4
6. Phase of equipment preperation (DAC curves).....	4
6.1. Calibration blocks and probes	4
6.1.1. Simplyfied calibration blocks.....	4
6.1.2. Normal calibration blocks.....	5
6.2. Creation DAC curve	5
6.3. Probes	6
6.4. Examination equipment.....	7
6.4.1. Flaw detector.....	7
6.4.2. Flaw detector + computer.....	7
7. Phase of examinarion preperation	7
7.1. Preperation of simple examinarions Bpr	7
7.2. Preperation for normal examination Bne.....	8
7.3. Connection of TD probe.....	8
7.4. Setting flaw detector's parameters.....	8
7.4.1. Normal settings of flaw detector's parameters.....	8
7.4.2. Correction of flaw detector's parameters and position of DAC curve.....	9
C. Realization of examination.....	10
7.5. Moving the probe and watching the screen.....	10
7.6. Valuation of welds.....	10
7.7. Results of examination.....	10
7.7.1. Results of simple examination Bpr.....	10
7.7.2. Results from normal examination Bne.....	10
8. Bibliography	11
Attachment 1.....	12
Need for examination of welds with small thickness.....	12
Attachment 2.....	13
Description of limits in ultrasonic examination of welds with small thickness.....	13
1 Geometric limits.....	13
2 Increasing of noise level.....	13
3 Conclusions.....	14
Attachment 3.....	15
1 Exemplary valuation of readings dynamics of ultrasonic TD probes.....	15
2 Example of dynamics change of readings at changing the reference hole Φ	15
3 Example of real readings dynamics received from detected flaw in weld.....	15
4 Example of reading dynamics range.....	15
Attachment 4.....	16
Grounds of ultrasonic IBUS-TD method's compability with PN-EN ISO/IEC 17025 standard	16
Attachment 5.....	17
Article publicated in „Dozor Techniczny” Nr 4 1992.....	17
System of assuring high reliability of pipe's welds.....	17

Attachment 6.....	21
Example of authentication from simple examinations IBUS-TD-06 Bpr.....	21
Attachment 7.....	24
Normal calibration block IBUS-W.....	24
Attachment 8.....	25
Example of probes certificate.....	25
Attachment 9.....	26
Example of calibration block certificate.....	26
Table of contents.....	27