

**Certification Services Division  
Midsummer House, Riverside Way  
Bedford Road, Northampton, NN1 5NX  
United Kingdom**

Tel: +44(0)1604-438-300.  
Fax: +44(0)1604-438-301.  
E-mail: [pcn@bindt.org](mailto:pcn@bindt.org)



## **PCN/GEN APPENDIX C1 ISSUE 9 DATED 1ST JULY 2016 ULTRASONIC TESTING OF WELDS**

**IMPLEMENTATION DATE: 1<sup>ST</sup> AUGUST 2016**

### **CERTIFICATION OF PERSONNEL FOR ULTRASONIC TESTING OF WELDS**

#### **ASSOCIATED DOCUMENTS:**

Appendix Z1 to PCN/GEN (examination syllabus compendium)

Appendix Z2 to PCN/GEN (example examination questions)

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The British Institute of Non-Destructive Testing is an accredited certification body offering personnel and quality management systems assessment and certification against criteria set out in international and European standards through the PCN Certification Scheme.

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# ULTRASONIC TESTING OF WELDS

## 1. SCOPE

1.1 This document prescribes the specific requirements and procedures by which personnel may be examined and, if successful, certified competent for the ultrasonic testing of welds. Requirements contained in this document are supplementary to those contained in the current edition of the PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing.

1.2 Candidates are encouraged to bring their own equipment, including probes, but examination centre equipment may be hired or provided subject to availability. Additional time will be allowed in the practical examination for candidates using examination centre provided equipment, the additional time allowed is only to calibrate equipment, producing DAC curves, checking beam spread and main beam angles not for testing samples.

## 2. EXAMINATION CONTENT

General information on examination content and time allowed for each written part is described in PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing. This Appendix amplifies the provisions of that document only where necessary.

### 2.1 Level 1

Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt an examination comprised of the following parts:

2.1.1 General Theory of the Ultrasonic Method.

2.1.2 Sector Specific Theory of the application of the ultrasonic method in the testing of welds including basic weld production processes and associated defects.

2.1.3 Sector Specific Practical examination comprising:

- (i) calibration of test equipment.

*NOTE. This part of the examination will involve the setting up of the equipment followed by a calibration exercise to check flaw detector and probe performance. At the discretion of the examiner, this part may include oral questions. In addition, a conventional beam spread diagram for a Test Centre probe will be plotted. The candidate will then be required to examine a parent metal sample and report on the condition of the material with particular reference to laminations and inclusions, this will enable the 'P' category to be awarded. If this part of the test is satisfactory the candidate may proceed to the remainder. If not, this exercise may be repeated once but, if it is still unsatisfactory, the test will be discontinued.*

- (ii) testing butt welds in two plate specimens from group 3.1 (see 3.2.1.1). testing butt welds in three pipe specimens from group 3.2 (see 3.2.1.2) an additional 7.5 hours will be allowed for this.

Note 1 to attempt the 3.2 pipe samples the candidate must have attended a further 40 hours pre-approval training at an ATO.

- (iii) reporting the results in a prescribed manner in accordance with the NDT instructions provided.

The total time allowed for the practical examination is 6 hours for the plate only category, candidates attempting both the plate and pipe categories will be allowed 13.5 hours. The minimum pass mark for the practical part is 70% in each sample tested

### 2.2 Level 2

Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt an examination comprised of the following parts:

2.2.1 General Theory of the Ultrasonic Method.

2.2.2 Sector specific theory of the application of the ultrasonic method covering the testing of all configuration(s) of welded joint (regardless of the groups for which certification is sought), and including all basic weld production processes and associated defects.

2.2.3 Sector specific practical examination comprising:

- (i) calibration of test equipment as defined for level 1.  
*NOTE. Level 2 candidates holding current valid level 1 ultrasonic testing of welds certification will be exempt examination part 2.2.3 (i) above.*
- (ii) testing samples covering one or more groups of weld described in Clause 3, depending on the certification applied for (N.B. candidates holding current level 1 certificates for UT of welds 3.1 and who are seeking Level 2 certification for group 3.1, will be required to attempt one specimen from that group, those holding a current Level 1 in groups 3.1 and 3.2 will be required to attempt one specimen from group 3.1 and two from group 3.2). NDT instructions, including information on sensitivity levels and reporting thresholds, will be provided to all candidates.
- (iii) reporting the results of tests on forms provided, indicating the location, type and size of flaws detected in the weld.  
*NOTE. There is no maximum imposed on the number of samples that candidates may attempt on any one visit to the test centre.*
- (iv) for initial level 2 candidates in the ultrasonic testing of welds, the preparation of a detailed NDT instruction suitable for level 1 certificate holders to follow covering the testing of one butt weld in a plate specimen to a provided code, standard or specification, and to prove the instruction by testing.

The total maximum time allowed for the practical examination is calculated by adding 2½ hours per sample tested, 1 hour for calibration of the test equipment and 1 hour for drafting the NDT instruction. The minimum pass mark for the practical part is 70% in each sample tested.

### **2.3 Level 3**

Except where exemptions apply (refer to PCN General Requirements), all candidates will be required to attempt an examination comprising a Basic examination and a Main Method examination.

Information on the content and grading of PCN Level 3 examinations is provided in PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing.

Level 3 candidates who do not hold PCN level 2 certification for the ultrasonic testing of welds will be required to successfully complete the examination described in Clause 2.2.3 (excepting sub-clause (iv))

## **3. CERTIFICATION AVAILABLE**

### **3.1 Level 1**

Practical weld samples are chosen from Group 3.1 and 3.2 if appropriate a further 40 hours of training has been completed as described below. Two samples must be successfully attempted.

### **3.2 Level 2**

3.2.1 Practical weld samples are available in 11 different categories of weld joint geometry sub-divided into five groups. Candidates may apply for examination in one or more of the following groups:

- a) Group 3.1 Butt welds in plate\* (two samples selected from three categories)
- b) Group 3.2 Butt welds in pipe (three samples selected from three categories)
- c) Group 3.7 Constructional T joints (two samples selected from two categories)
- d) Group 3.8 Nozzles and variable configuration welds (two samples selected from two categories)
- e) Group 3.9 Nodes (one sample from one category)

*\* Level 2 candidates who are holders of a level 1 certificate will attempt one sample from Group 3.1. and two samples from Group 3.2 if appropriate.*

3.2.1.1 Group 3.1 Butt welds in plate (two samples to be attempted). This group is sub-divided according to thickness and type of weld into the following categories:

Category	Thickness (mm)	Type of weld
3.1.2	6-15 (inclusive)	Deposited from one side of plate
3.1.3	Over 15	Deposited from both sides of plate
3.1.4	Over 15	Deposited from one side of plate

Group 3.1 also covers pipe welds of 500 mm outside diameter and above.

To obtain a certificate for butt welds in plate, success must be achieved in two categories. The selection of specific categories in this group will be by test centre staff.

3.2.1.2 Group 3.2 Circumferential butt welds in pipe and tube (three samples to be attempted). This group is sub-divided according to wall thickness and outside diameter into the following categories:

Category	Outside diameter (mm)	Wall thickness (mm)
3.2.1	50 - 105	6 - 15
3.2.5	Over 105	6 - 15
3.2.7	Over 105	Over 15

#### NOTES.

- i) *All welds are deposited from outside the pipe without backing strips. Certification on such welds covers welds deposited from both outside and inside of the pipe.*
- ii) *Candidates for certification in pipe 3.2, will be required to complete examinations on three categories of sample, 3.2.1, 3.2.5 and 3.2.7. To obtain a certificate all three categories must be successfully examined.*

3.2.1.3 Group 3.7 Constructional T joints (two samples to be attempted). This group is sub-divided into two categories: 3.3.2 Full penetration T joints and 3.4.2 Partial penetration T joints. Candidates concerned with constructional steelwork will be examined on a full penetration T joint and a partial penetration T joint. Success must be achieved in both samples and in 3.1 butt welds in plate to obtain a certificate for this group. Candidates successful in Group 3.8 are exempt Group 3.7 and this will be awarded automatically.

3.2.1.4 Group 3.8 Nozzles and variable configuration welds (two samples to be attempted). This group comprises two categories: 3.3.1 Full penetration nozzles and 3.4.1 Partial penetration nozzles, and covers welds in branches and stubs as well as nozzles. Successful completion of this group provides exemption from Group 3.7 Constructional T joints. Candidates seeking certification in this group will be examined on one full penetration 3.3.1 and one partial penetration joint 3.4.1 of this type, both of which will be of variable geometry. Success must be achieved in both samples and in Group 3.1 and/or Group 3.2 to obtain a certificate for this group.

3.2.1.5 Group 3.9 Nodes (one sample to be attempted). This group covers full penetration node joints. Success must be achieved in one sample and in 3.1 and/or 3.2 to obtain a certificate for this group.

### 3.3 Level 3

Candidates may obtain level 3 certificates by successful completion of the examination described in Clause 2.3, but they must hold appropriate level 2 certification for ultrasonic testing of welds issued under PCN requirements, or an equivalent approval recognised by PCN. Otherwise they must successfully complete a practical examination equivalent to PCN level 2 Group 3.1.

Candidates who achieve an overall score of 80% or more for Level 1, 2 and 3 examinations shall be awarded with the distinction level 'D' *excluding ISO 20807 certificates* (refer to PCN GEN – Grading of Examinations).

#### **4. RENEWAL AND RECERTIFICATION**

4.1 The general rules for level 1 and level 2 renewals and recertification are fully described in PCN document CP16, and the rules for level 3 renewals and recertification are detailed in PCN document CP17.

4.2 Level 1 certificate holders seeking recertification will be required to undertake a practical examination involving the testing of one butt welded plate sample and if certification covering butt welded pipe is held one pipe sample and reporting the results in a prescribed manner in accordance with the NDT instruction provided. The time allowed will be 2½ hours. The minimum pass mark for the practical part is 70% in each sample tested.

4.3 Level 2 certificate holders seeking recertification will be required to undertake a practical recertification examination involving the writing of a satisfactory NDT instruction on the testing of a butt welded plate sample suitable for level 1 personnel to follow, and the practical testing of one welded sample from each group for which certification was issued, interpreting codes, standards or specifications as required, and reporting the results in a prescribed manner in accordance with instructions provided. The time allowed will be 2½ hours per sample tested, plus 1 hour for drafting the NDT instruction. The minimum pass mark for the practical part is 70% in each sample tested.

4.4 The minimum pass mark for recertification in any category is 70%, the minimum mark for each individual element of the examination is 70%. Level 2 candidates must pass the NDT instruction writing part in order to recertify.

4.5 A level 2 candidate seeking to recertify in multiple categories who is not successful in all categories may be issued certification covering those categories in which success was achieved. However, level 2 candidates for recertification who fail all butt welded specimens (plate and pipe), but who are successful in the NDT instruction writing part and one or more variable weld configuration specimens (nozzle or node) will have the variable configuration group(s) held over pending the one allowable retest, success in which will result in the issue of a PCN certificate that includes the previously passed variable configuration group as well as the group successfully tested during the retest examination. Failure in the one allowed retest will result in the individual concerned being considered an initial candidate for certification in the sector, method and level concerned.

4.6 All candidates will need to undertake a practical examination of a parent material sample and report on the condition of the material with particular reference to lamination and inclusions to enable the 'P' category to be maintained. Pass mark 70%, one allowable retest. If after the allowable retest the candidate is still unsuccessful the weld categories will be held for a period of 6 months from the last test date allowing the candidate to attempt and pass the whole initial ISO 20807 plate tester examination. If the candidate is still unsuccessful after 6 months the weld categories will be lost.

#### **5. SUPPLEMENTARY EXAMINATION CONTENT**

5.1 PCN Level 1 ultrasonic testing of welds certificate holders wishing to upgrade to level 2 are required to be successful in all level 2 written examination parts detailed in Clause 2.2 above, and test samples appropriate to the certification sought (see Clause 3.2). Existing PCN Level 1 Plate weld certificate holders, certified in accordance with PCN/GEN Appendix C1, who apply to be certified for the Ultrasonic Testing of Pipe welds will be required to attend a further 40 hour pre-approval training and to pass a practical examination of 3 Pipe welds see 3.2.1.2.

5.2 Existing PCN level 2 certificate holders, certificated in accordance with PCN/GEN Appendix C1, who apply to be certificated for the ultrasonic testing of additional weld groups, will be required to pass a further practical examination comprising the testing of samples from the group in which certification is sought (see Clause 3.2 above).

#### **6. GRADING**

General information on the grading of examinations will be as specified in the current edition of PCN General Requirements for Certification of Personnel engaged in Non-Destructive Testing, and information on the grading of practical examinations is provided in PCN document CP22.

## REFERENCE LITERATURE

### Essential Reading

- ❑ BS EN 1330-2 Non-destructive testing – Terminology – Part 2: Terms common to the non-destructive testing methods
- ❑ BS EN 1330-1 Non-destructive testing-Terminology – Part 1 List of general terms
- ❑ BS EN 1330-4 Glossary of terms used in non-destructive testing. Ultrasonic flaw detection
- ❑ BS EN 12668-1 Non-destructive testing – Characterisation and verification of ultrasonic examination equipment – Part 1: Instruments
- ❑ BS EN 12668-2 Non-destructive testing. Characterisation and verification of ultrasonic examination equipment. Probes
- ❑ BS EN 12668-3 Non-destructive testing – Characterisation and verification of ultrasonic examination equipment – Part 3 combined equipment
- ❑ BS EN 583-1 Non-destructive testing –Ultrasonic examination – Part 1: General principles
- ❑ BS EN 583-3 Non-destructive testing –Ultrasonic examination – Part 3: Transmission technique
- ❑ BS EN 583-5 Non-destructive testing –Ultrasonic examination – Part 5: Characterisation and sizing of discontinuities
- ❑ BS EN 12223 Calibration block No.1 for ultrasonic examination
- ❑ BS EN ISO 11666:2010 Non-destructive testing of welds - Ultrasonic Testing Acceptance levels
- ❑ BS EN ISO 23279:2010 Non-destructive testing of welds - Ultrasonic Testing Characterisation of indications in welds
- ❑ BS EN ISO 17640:2010 Non-destructive testing of welds - Ultrasonic Testing Techniques, Testing Levels and Assessments
- ❑ BS EN 27963 Calibration block No.2 for ultrasonic examination of welds
- ❑ BS EN 12062 Non-destructive examination of welds – General rules for metallic materials
- ❑ BS 499-1 Welding terms and symbols - Part 1 : Glossary for welding, brazing and thermal cutting.
- ❑ BS EN ISO 9000 Series, Quality Management Systems
- ❑ Product Technology Classroom Training Handbook – The British Institute of Non-Destructive Testing.
- ❑ Training Course Notes. PCN requires candidates to have attended an approved course of training. Accredited Training Establishments are required to provide trainees with an up-to-date set of training course notes. These are considered essential reading.

### Recommended Reading

- ❑ Procedures and 'Recommendations for Ultrasonic Testing of Butt Welds' 2<sup>nd</sup> edition. The Welding Institute
- ❑ 'Ultrasonic Flaw Detection for technicians' by J C Drury. Obtainable from the British Institute of Non-Destructive Testing
- ❑ Mathematics and formulae in NDT. Edited by Dr. R Halmshaw. Obtainable from the British Institute of Non-Destructive Testing
- ❑ ASNT Classroom Training Handbook originally published by General Dynamics
- ❑ ASNT Question and Answer Book
- ❑ ASNT Level II and III Study Guides.
- ❑ NDT Handbook, second edition, volume 7.
- ❑ ASNT Student Package.
- ❑ ASNT Instructor Package (overheads for training).

NOTE. Some of the above are available only in reference libraries. For information on sources of the above recommended reading contact The British Institute of Non-Destructive Testing, Midsummer House, Riverside Way, Bedford Road, Northampton, NN1 5NX, United Kingdom.

# CRITICAL ASSESSMENT OF WELD DEFECTS

## 1. GENERAL

1.1 In most weld inspections, defects are accepted or rejected in accordance with a quality or 'workmanship' standard. These standards are arbitrary in the sense that setting the level of acceptable defects takes no account of the ability of the component or structure to tolerate such a level of defects in service. In most cases this results in over conservatism with the level of acceptable defects being much lower than the structure could actually tolerate.

1.2 Techniques are now available to quantify the tolerable levels of defects for a given structure with reasonable certainty. Such techniques, called fitness-for-purpose assessments or engineering critical assessments, are being increasingly applied, particularly in circumstances where weld repair would be very costly or unacceptably time consuming. The power generation and oil/gas production industries are making extensive use of fitness-for-purpose assessments.

1.3 The application of fitness-for-purpose assessments requires a greater accuracy of defect sizing than is usually necessary with workmanship standards. Ultrasonic testing is capable of the required accuracy and, with appropriate training, conventional ultrasonic testing practitioners can be capable of achieving the required accuracy for fitness-for-purpose assessments. This document outlines the requirements for an examination to test this ability.

## 2. COMPLIANCE

### 2.1 Scope

2.1.1 The objective of this critical assessment examination is to demonstrate, independently and objectively, that an operator is capable of sizing defects to within a tolerance commensurate with the capability of the ultrasonic method, with particular reference to the location and dimension in the through thickness direction.

2.1.2 The examination does not test the ability of the operator to calibrate the equipment, scan the specimen and detect defects. That is assumed to have been demonstrated in the standard PCN test, which is a pre-requisite for this examination.

### 2.2 Eligibility for Examination

To be eligible for the examination, candidates must have held a PCN Level 2 Ultrasonic Practitioner (Welds) certificate in at least two groups for a minimum of six months prior to the Critical Assessment examination. Candidates holding level 2 in Welds UT under any qualifying ISO 9712 certification who wishes to gain PCN certificate for critical sizing must sit a 2 part practical examination covering welds, plate and pipe (3.1/3.2) in order to gain a basis. Once the practical for 3.1/3.2 has been passed, the candidate may then be eligible to sit the critical sizing examination resulting in the candidate gaining PCN qualifications for Welds UT plate/pipe (3.1/3.2) and critical sizing by proof of PSL49 by other recognised certification.

### 2.3 Equipment

Candidates must supply their own equipment. It is the responsibility of the candidate to ensure that equipment is calibrated and maintained in accordance with requirements given in Annex 1 Section 7. It is recommended that the candidate carries out the checks outlined in Annex 1 Section 7.3 and produces a DAC in accordance with Section 8.2 before arrival at the examination centre.

### 2.4 Examination Procedure

2.4.1 Practical examination specimens will consist of plate and pipe butt welds with thicknesses between 20 mm and 110 mm. Each candidate will be given at least one double sided weld in plate and two single sided welds in pipe.

2.4.2 Candidate are required to size 6 weld defects. At least one will be a transverse defect in a pipe weld, one a root defect in a single sided weld and one a near surface defect.

2.4.3 Candidates will be informed of the position of the defects to be evaluated, to within +/- 50 mm in the 'along weld' direction.

## **2.5 Examination Content**

2.5.1 The examination content is specified in detail in Annex 1. However, it should be noted that the candidate is still required to exercise judgment on matters concerned with sizing, in particular:

- a) the probe angles used for sizing;
- b) selection and use of the defect sizing and characterisation methods described in BS EN ISO 11666 and BS EN ISO 23279

## **2.6 Time Allowed**

A maximum time of 7½ hours is allowed for completion of the test.

## **2.7 Reporting**

The items to be reported, for each defect, are given in Annex 2, which also includes standard reporting forms.

## **2.8 Assessment of Results**

The operator's results will be assessed against pre-determined tolerances. These tolerances are chosen to be consistent with the declared aim of demonstrating that the defects can be sized to within a tolerance commensurate with the capability of the method.

## **2.9 Results**

Results for individual defects will not be revealed.

## **2.10 Retests**

Candidates who fail the examination must wait 30 days before applying again and will return to initial candidate status.

## **3. CERTIFICATION AVAILABLE**

On successful completion of the examination, the candidate will be issued with certification for critical assessment of weld defects.

## **4. VALIDITY**

The critical assessment certification is valid for five years from the date of successful completion of the examination only if the holder possesses and maintains a current valid PCN level 2 certificate for ultrasonic testing of at least two configurations of welded joint as detailed in PCN/GEN Appendix C1.

## **5. REVALIDATION**

Renewal and recertification do not apply to this certification. The certificate expires five years from success in an examination, and further certification is conditional upon the success in the full initial examination described in Annex 1.



# EXAMINATION PROCEDURE FOR CRITICAL ASSESSMENT OF WELD DEFECTS

## 1. SCOPE

1.1 This document details the procedure to be used for the location sizing and characterisation of ultrasonic indications in plate or pipe butt welds. The thickness will be in the range 20 mm to 110 mm and the pipe outside diameter will be in the range 100 mm to 600 mm.

1.2 Each candidate will be required to size 6 defects located in pipe or plate welds.

1.3 Particular attention will be paid to the candidate's ability to locate and size defects in the through-thickness dimension.

1.4 The scanning will be restricted to one surface only, with the weld caps removed.

1.5 There will be no requirement to perform attenuation measurements and corrections.

1.6 The area containing the defect to be located and sized will be clearly marked. Only this area need be examined.

## 2. SAFETY

All work shall be carried out in accordance with the test centre's safety regulations.

## 3. REFERENCES

- ❑ BS EN ISO 11666 Non-destructive testing of welds—Ultrasonic testing—Acceptance levels
- ❑ BS EN ISO 23279 Non-destructive testing of welds—Ultrasonic testing—Characterization of indications in welds
- ❑ BS EN ISO 17640 Non-destructive testing of welds—Ultrasonic testing—Techniques, testing levels, and assessment
- ❑ BS EN 12668-2 Non-destructive testing. Characterisation and verification of ultrasonic examination equipment. Probes

## 4. DATUM AND WELD IDENTIFICATION

The following is permanently marked on the test surface:

- a) reference number
- b) reference line
- c) weld centre line
- d) one side marked A and one side marked B

## 5. COMPONENT SURFACE FINISH

The test surface is ground flat and flush to a maximum error of form 0.5 mm in 50 mm and a surface finish of better than 3.2µm Ra.

## 6. EQUIPMENT

6.1 Equipment to be supplied by the candidate:

6.1.1 Calibrated portable flaw detector.

6.1.2 Probes:

- 0° 10 mm diameter single and twin crystal 4-5 MHz compression wave.
- 38°, 45°, 60° and 70° 10 mm diameter 4-5 MHz single/twin crystal shear wave.
- 2-2.5 MHz 15 mm diameter single crystal shear wave probes may be used on the thick section welds, i.e. 80-110 mm, if the candidate considers it necessary.
- Shear wave probes capable of locating reflectors to within 3 mm of the test surface at the test sensitivity shall be used (where necessary twin crystal probes shall be used to supplement the single crystal probes to achieve this capability).

6.1.3 Calibration blocks .

6.2 Equipment to be supplied by the test centre.

6.2.1 Couplant - any commercially available.

6.2.2 DAC Calibration blocks – 3 mm side-drilled hole DAC block conforming with the requirements of BS EN ISO 17640. This is for the candidate's reference purposes only. The candidate should have produced the DAC curves for each probe prior to attending the test centre.

6.3 Equipment checks prior to the start of inspection.

6.3.1 Flaw detector calibration certificates must be submitted to the examiner prior to the commencement of the test.

6.3.2 Probes shall meet the appropriate ESI standards. Documentation is not required providing the manufacturer and probe type are specified in the equipment check sheet (Figure 1).

6.3.3 The ultrasonic equipment checks specified in Figure 1 shall be carried out prior to attending the test centre and the information reported on the sheet.

6.3.4 The test sensitivities for each ultrasonic probe shall be determined and recorded on the report sheet shown in Figure 2 prior to attending the test centre.

## **7. INSPECTION PROCEDURE**

### 7.1 Pre-inspection Checks

Check reference number and reference marks as described in Section 5 of this Annex.

### 7.2 Scanning Sensitivity

The scanning sensitivity for all probes shall be 20 dB in excess of the sensitivity used to construct the DAC curve.

*If the grass level is in excess of the DAC at this sensitivity the equipment shall not be used to conduct the test.*

#### **NOTES:**

- 1) The working range of the DAC curve shall be between 80% and 20% FSH.
- 2) If the DAC curve falls below 20% FSH, then a further curve for the defect assessment at longer ranges shall be constructed. The scanning sensitivity will still be DAC curve + 20 dB.
- 3) Where excessive near surface noise prevents evaluation of defect signals in the range 0-40 mm then an additional curve covering this range shall be established. The scanning sensitivity will still be DAC curve + 20 dB.
- 4) For the purpose of this examination 'point reflectors' need not be assessed. 'Point reflectors' may be regarded as any reflectors of length and through thickness less than 5 mm in both directions.

### 7.3 Scanning

The specified area shall be examined as follows:

7.3.1 The thickness of the parent metal and of the weld shall be measured using a 0° compression probe.

7.3.2 Shear wave and 0° compression wave probes shall be used as necessary to locate the defect in this area.

7.3.3 All signals above the DAC curve from any probe at the scanning sensitivity shall be investigated.

## **8. DEFECT ASSESSMENT**

### 8.1 Signal Recognition

Any defect signal(s) shall be classified as either planar or volumetric in the through-thickness direction.

### 8.2 Evaluation

### 8.2.1. Sensitivity

#### i) Half Amplitude Technique :

The sensitivity shall be set such that the maximum response from the defect is between 80% and 100% of Full Screen Height (FSH).

#### ii) Maximum amplitude and 20 dB drop technique:

The sensitivity shall be set to the scanning sensitivity. If the defect response exceeds full screen height, the defect shall in addition be investigated at a reduced sensitivity such that the peak response is between 80% and 100% FSH.

### 8.2.2. Method

i) Defects shall be sized using a probe movement method and positioned in accordance with methods described in BS EN ISO 17640

ii) In general the last significant defect echo shall be taken to be that in excess of the DAC curve at the scanning sensitivity. In certain instances, echoes which are part of the main echo envelope may be found to peak below the DAC curve. In this case, this echo shall be regarded as the last significant response for defect evaluation.

iii) Defects shall be sized by at least two shear wave angles and, where a response is obtained, by a 0° compression wave probe (see Annex 2 for more detail).

**NOTE:** When testing curved components the length and position of the defects shall be measured on the surface.

### 8.3 Interpretation of the Results

In many instances the use of more than one probe angle (and where performed, more than one sizing technique), will give a variation in the size plotted. Annex 2 gives some guidance on selecting the value that best represents the defect.

## 9. REPORTING

i) Summarise the results of the ultrasonic equipment checks on the report sheet shown in Figure 1.

ii) Summarise the results of the test sensitivities on the report sheet shown in Figure 2.

iii) Report for each defect the maximum size and position relative to the reference line on the appropriate test log sheet (Figure 3 or Figure 4) showing the extent of the defect in plan and cross-sectional views.

iv) The following information must be recorded on the test log sheet.

a) Operator, employer and date.

b) Test piece reference number.

c) Defect number and probe angles used to determine size.

d) Sizing method used and echo pattern (planar or volumetric) in the through-thickness direction.

e) "b" depth from surface to the top of the defect.

f) "d" through-thickness extent of defect.

g) "L" length of defect.

h) "P" distance from reference line axis to start of defect.

i) "S" distance from weld centre line to top of defect, i.e. A + Smm or B + Smm. (Longitudinal defects only).

j) "W" distance from weld centre line to centre of defect, i.e. A + Wmm or B + Wmm (Transverse defects only).

k) "T" weld thickness.

**REPORT FORMS**

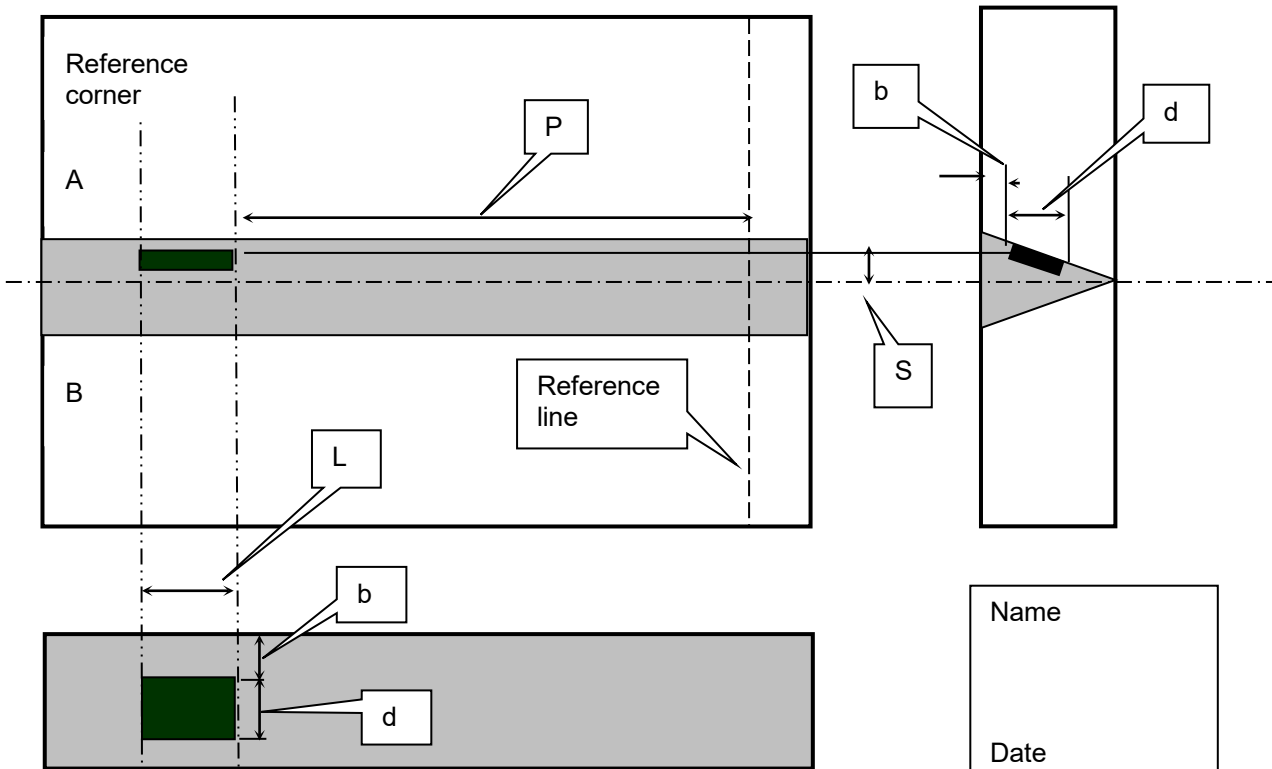
**FIGURE 1 – ULTRASONIC EQUIPMENT CHECKS**

OPERATOR				DATE	
FLAW DETECTOR TYPE			SERIAL NUMBER		
AMPLIFIER LINEARITY			TIMEBASE LINEARITY		
SHEAR PROBE TYPE/SERIAL No	BEAM ANGLE	BEAM WIDTH BS EN 12668-1	PROBE WEAR ESI 98/2 (82 & 83)	RESOLUTION BS EN 12668-2	
COMPRESSION PROBE TYPE/SERIAL No		VISUAL CHECK ESI 98/7 (7.1)	FLATNESS ESI 98/7 (7.2)		
ENGINEER'S SIGNATURE				DATE	

**FIGURE 2 – ULTRASONIC DATA SHEET**

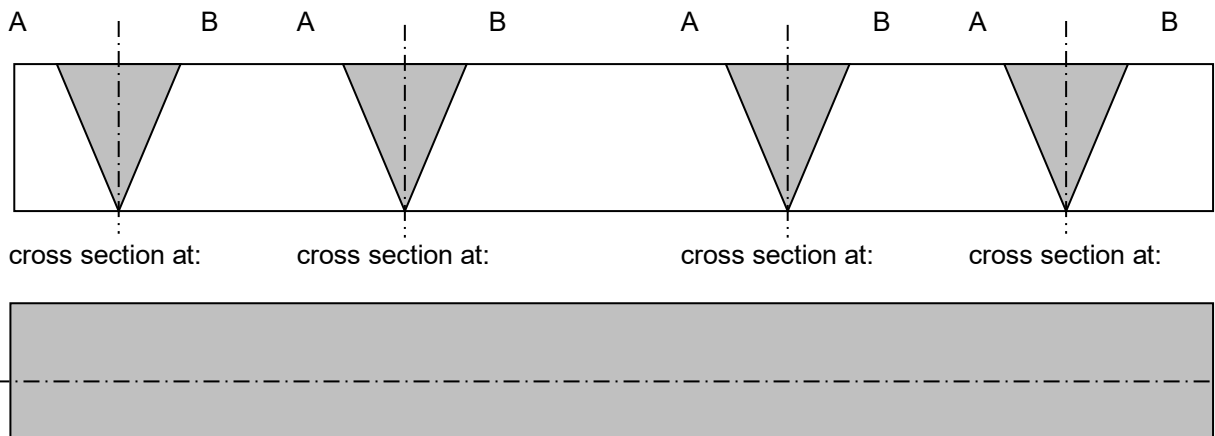
OPERATOR						DATE						
FLAW DETECTOR TYPE						SERIAL NUMBER						
PROBE ANGLE & SERIAL NUMBER	SINGLE CRYSTAL			CHECK			TWIN CRYSTAL			CHECK		
	MHz	A	dB Range	Index	Angle	Pulse	MHz	A	dB Range	Index	Angle	Pulse
<p><b>'A' is calibrated gain control setting (dB) for 3mm SDH to DAC curve (range in mm) for normal and shear wave probes</b></p> <p><b>TEST SENSITIVITY</b></p>												
'A' dB from above			'A' + 20 dB			A' dB from above			'A' + 20 dB			
= dB for 45°						= dB for 38°						
= dB for 60°						= dB for 0° single						
= dB for 70°						= dB for 45° twin						

**FIGURE 3 – WELD DATUMS AND DEFECT PARAMETERS FOR LONGITUDINAL DEFECTS**



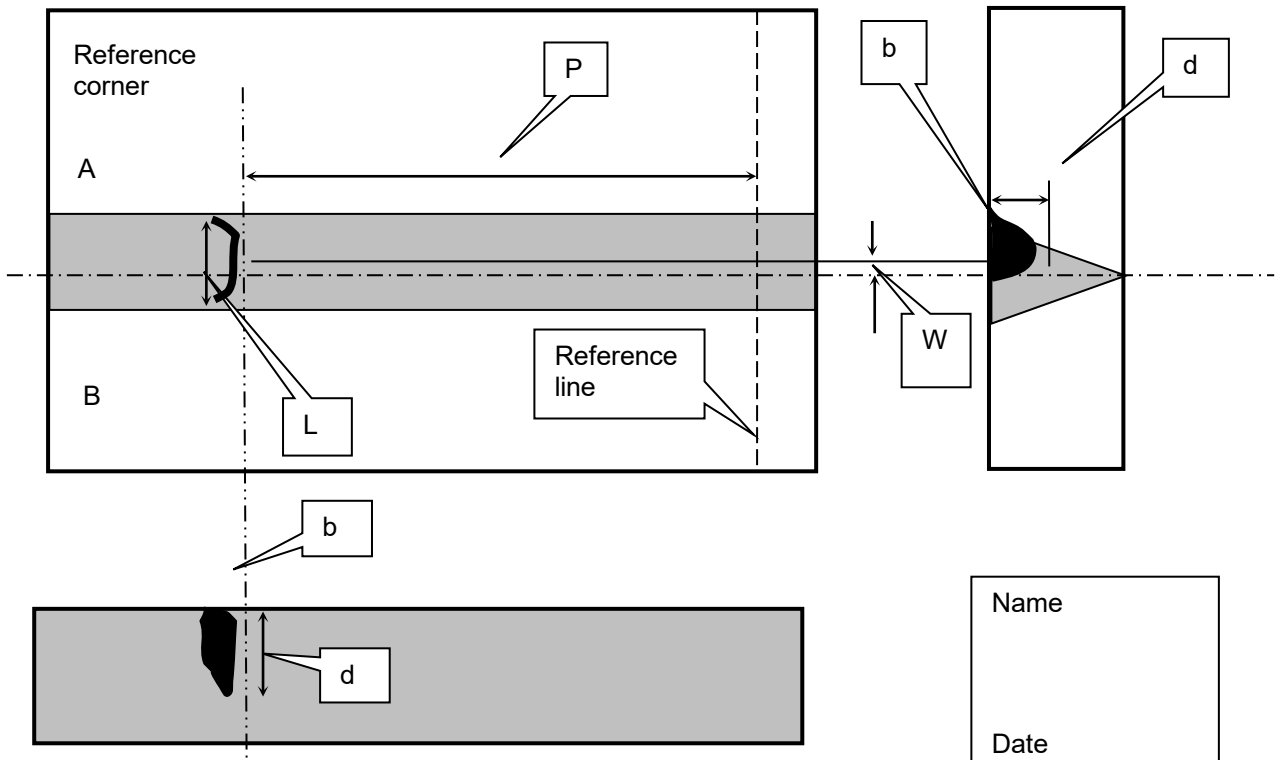
- PAT Pattern type for scan in through thickness direction
- b depth from surface to top of defect
- d defect depth measured at right angles to the surface
- L total length of defect
- P distance from reference line to start of defect
- S distance from weld centre-line to top of defect, stating side A or B
- T weld thickness

defect number	through thickness sizing		defect information						
	Method	probes used	PAT	b	d	L	P	S	T



Plan view

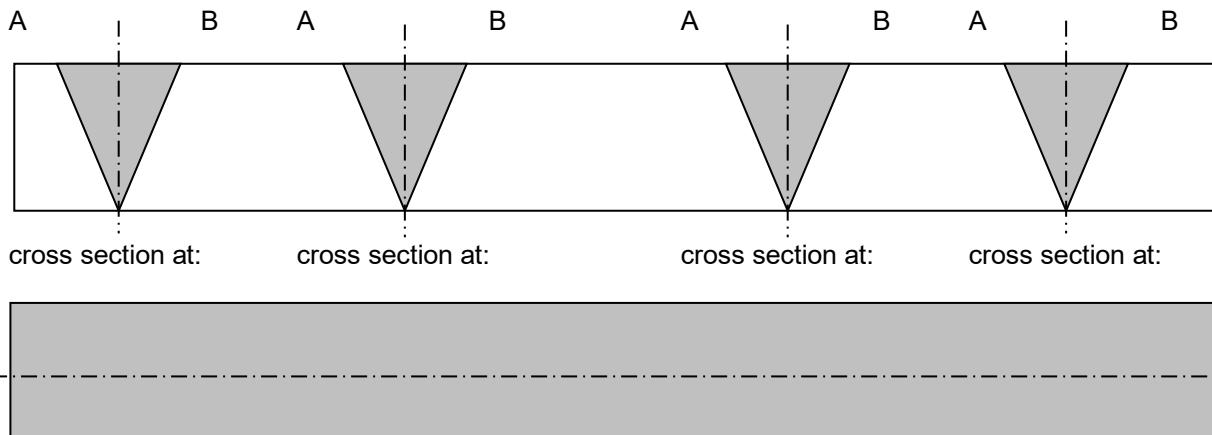
**FIGURE 4 – WELD DATUMS AND DEFECT PARAMETERS FOR TRANSVERSE DEFECTS**



- PAT Pattern type for scan in through thickness direction
- b depth from surface to top of defect
- d defect depth measured at right angles to the surface
- L total length of defect
- P distance from reference line to top of defect
- W distance from weld centre-line to centre of defect, stating side A or B
- T weld thickness

Name
Date

defect number	through thickness sizing		defect information						
	method	probes used	PAT	b	d	L	P	W	T



Plan view

## **GUIDANCE ON THE DEFECT SIZE TO BE REPORTED**

In order to have reliable detection and sizing of defects, it is necessary to scan a weld from two or more directions, or within two or more probe beam angles.

It is in general unlikely that confident detection or accurate sizing can be obtained from the results of any one scan. Therefore it is necessary to critically examine the results of all probes used and to arrive at an interpretation which is consistent with them all. This will involve the operator building in his mind a mental picture or 'model' of the nature, size and orientation of the defect which gives a self-consistent interpretation of the information learned from using each probe and scan. This information will involve the echo amplitudes, the echo patterns and a consideration of the effects of geometrical features of the component on each response.

Preference shall be given to sizes obtained at oblique incidence, particularly if:

- a) these are between 15° and 30° from normal incidence and
- b) normal incidence produces a large amplitude response, (of the order of 12 dB or more in excess of the 3 mm side-drilled hole DAC).

**NOTE:** Care must be taken in assessing whether a very low amplitude response from the bottom extremity of the defect is the tip response or a response from the edge of the sound beam hitting the defect at normal incidence. This is particularly relevant when the oblique incidence is less than 20°.

In certain cases the top and bottom of the defect may only be positioned accurately by superimposing the results from the various scans and recording the maximum dimension.

# GUIDANCE ON PRACTICAL EXAMINATIONS FOR UT WELDS

## 1. SCOPE

This document describes the procedures by which personnel may be examined and graded in the PCN practical examination for the ultrasonic testing of welds. Information contained in this document relates to:

- Specific Requirements for the Certification of Personnel in Ultrasonic Testing of Welds, and
- Specific Requirements for the Certification of Personnel engaged in the Critical Assessment of Weld Defects by Ultrasonic Testing.

## 2. THE 'NORMAL' EXAMINATION

(for levels 1 and 2 as detailed in PCN/GEN Appendix C1).

### 2.1 Specimens

2.1.1 The specimens used in the practical test for PCN ultrasonic (welds) certification are welded steel samples of various geometries and thicknesses. The thickness range is 6 mm to 100 mm.

2.1.2 PCN test centres produce a master report file for each examination specimen which gives full details of the actual defects in the specimen. This information is obtained from a wide range of sources: knowledge of the manufacturing techniques and requirements, ultrasonic tests by qualified operators and radiographs.

2.1.3 The marking masters are based on ultrasonic test data and are independently validated by qualified and experienced practitioners appointed by PCN. In addition, different candidates' results obtained from the same specimen are continuously compared so that any peculiarities become evident and remedial action is taken if required.

2.1.4 The strength of the system is demonstrated by the fact that peculiarities of a significant nature have, to date, not become evident.

2.1.5 Users of the examination can therefore have complete confidence in the fairness of the practical samples.

### 2.2 Assessment of Candidates' Results

2.2.1 Candidates' results are compared with the marking master and eight separate attributes are examined:

- (i) defect detection
- (ii) location of defect(s) in relation to depth and centreline of weld
- (iii) longitudinal or circumferential location of defect(s)
- (iv) length of defect(s)
- (v) through thickness size of defect(s)
- (vi) defect type
- (vii) examination and reporting on parent plate thickness and condition
- (viii) general standard of reporting.

Other factors involved in the practical examination, e.g., setting up equipment and the general approach to testing, are also taken into account.

2.2.2 Weighting factors are applied to the above attributes. Attributes (1), (2) and (3) are regarded as much more important (two to three times) than the others.

2.2.3 The objective of the examination is to show that the operator can carry out inspections intended to demonstrate the quality of workmanship in welding and this explains why detection and location are much more important.

2.2.4 Attributes (4) and (5) are the dominant areas in the critical sizing examination covered in document PCN/GEN Appendix C1.4.



2.2.5 Attributes will be assessed as described below with nominally equal marks being allocated to each defect.

#### **Attribute (i) - Detection**

If a candidate misses a major defect, failure will result. Missing or misreporting small, innocuous defects may not result in a failure. A major defect is regarded as one that was deliberately intended. Small inclusions and pores which can always be found in normal welds are not regarded as major defects for examination purposes. Reporting defects that do not exist can also result in failure.

#### **Attributes (ii) and (iii) - Positioning**

If the candidate has positioned the defect correctly full marks would be awarded. If one of the defects was given at completely the wrong position, e.g. in the bottom instead of the top of the weld, no marks would be awarded for that defect. The closer to the actual position, the more marks awarded.

#### **Attribute (iv) - Length**

Examination defects vary in length from about 10 mm to about 150 mm. To get full marks candidates are expected to achieve an accuracy of length measurement in accordance with Table 1.

#### **Attribute (v) - Through-thickness**

The weighting factor for through-thickness is low. The separate examination on critical sizing described in the second part of this document is available if a candidate's through-thickness sizing ability is required to be thoroughly assessed. For the normal examination, results within +/- 2mm of the true defect size would get full marks. It must be borne in mind that typical examination defects, which are intended to represent real welding defects, usually have a small through-thickness extent.

#### **Attribute (vi) - Defect Type**

Full marks if the result is correct, no marks if it is incorrect or the defect type is not reported. Again, the weighting factor is low.

#### **Attribute (vii) - Parent Plate**

Even though candidates are specifically asked to report on the parent plate more than 50% of them do not do so and therefore receive no marks. An indication of the plate thickness and a reasonable comment about its condition will get full marks.

#### **Attribute (viii) - Standard of Reporting**

This is a judgment based on the clarity and thoroughness of reporting.

### **3. THE CRITICAL SIZING EXAMINATION**

For level 2 candidates as detailed in PCN/GEN Appendix C1.

#### **3.1 Specimens**

3.1.1 The specimens used in the critical sizing test have been specially designed to give a wide range of defect size and echo envelope types.

3.1.2 The validation procedure for specimens is exactly the same as that used for specimens used in the normal examination.

3.1.3 The thickness range is 20 mm to 110 mm.

### 3.2 Assessment of Candidates' Results

3.2.1 The purpose of this examination is to assess the candidate's ability to size and locate defects. Detection is not part of the examination: the candidate is directed to inspect only that part of the specimen in which the defect is located.

3.2.2 The candidate must meet the tolerances for each of the six defects tested as shown in Table 2.

3.2.3 Any result outside these tolerances for the d or b measurement will result in a failure.

3.2.4 More than 1 (one) result outside these tolerances for the L, P and S or W measurement will result in a failure.

3.2.5 The candidate must meet the average tolerances in Table 3 where the average is the mean absolute deviation over all six defects.

3.2.6 Any result outside these tolerances will result in a failure.

#### **EXAMPLE:**

The average deviation for any parameter is calculated as the mean of the absolute value of the deviations over all six defects. For example, if the deviations for parameter 'b' (in mm), i.e., the difference between the candidate's reported value and the master value, are:

+1, -1, -3, -2, +3 and -3

then the average deviation is:

$$\frac{(1 + 1 + 3 + 2 + 3 + 3)}{6} = 2.2$$

and the candidate would fail because this is outside the maximum value allowed (see Table 3).

<b>ACTUAL</b>	<b>TOLERANCE</b>
=<15 mm	+/- 6 mm
15 to 50 mm	+/- 9 mm
=> 50 mm	+/- 12 mm

**TABLE 1**

<b>REPORTED PARAMETER</b>	<b>MAX MEAN DEVIATION</b>
<b>b</b> - Depth of top edge	2 mm
<b>d</b> Through thickness dimension	3 mm
<b>L</b> Total length	6 mm

**TABLE 3**

<b>REPORTED CODE</b>	<b>PARAMETER</b>	<b>MAXIMUM DEVIATION FROM MASTER RESULT</b>
<b>b</b>	Depth of top edge	+/- 4 mm
<b>d</b>	Through thickness dimension	+/- 5 mm
<b>L</b>	Total length	+/- 10 mm
<b>P</b>	Start position	+/- 10 mm
<b>S</b>	Position of top edge across weld	+/- 5 mm (for longitudinal defect)
<b>W</b>	Position of defect centre across weld	+/- 8 mm (for transverse defect)

**TABLE 2**

# ULTRASONIC TEST PROCEDURE FOR USE IN PCN WELD TESTING EXAMINATIONS

## 1. SCOPE

The following procedure specifies manual ultrasonic test requirements for the examination of fusion welded joints in ferritic steel by PCN Authorised Qualifying Bodies staff (mastering examination samples) and candidates attempting PCN ultrasonic weld testing examinations.

Testing techniques specified are compliant with and detailed in BS EN ISO 17640 (Examination level D). Where required, supplementary information has been included to satisfy the general requirements of this standard and examination level.

Where defined by this procedure, defect characterisation and sizing shall be carried out in accordance with EN 583 Part 5.

## 2. REFERENCES

- |                         |   |
|-------------------------|---|
| BS EN ISO<br>11666:2010 | Non destructive testing of welds, Ultrasonic testing - Acceptance levels  |
| BS EN ISO<br>23279:2010 | Non destructive testing of welds Ultrasonic testing - Characterisation of indications in welds                                      |
| BS EN ISO<br>17640:2010 | Non destructive testing of welds Ultrasonic testing – Techniques, testing levels and assessments                                    |
| EN 583 Part 1           | Non destructive testing - Ultrasonic examination Part 1 - General principles  |
| EN 583 Part 2           | Non destructive testing - Ultrasonic examination Part 2 - Sensitivity and range setting   |
| EN 583 Part 3           | Non destructive testing - Ultrasonic examination Part 3 - Transmission technique  |
| EN 583 Part 4           | Non destructive testing - Ultrasonic examination Part 4 - Examination for imperfections perpendicular to the surface                |
| EN 583 Part 5           | Non destructive testing - Ultrasonic examination Part 5 - Characterising and sizing of discontinuities                              |
| BS EN ISO<br>17635:2010 | Non destructive testing of welds - general rules for metallic materials   |
| EN 1330 Part 4          | Non destructive testing – Part 4 - Terms used in ultrasonic testing   |
| BS EN 5817              | Welding. Fusion welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections |

## 3. HEALTH AND SAFETY

Persons using this procedure shall familiarise themselves with and observe national (statutory) and local health and safety requirements, including:

Health and Safety at Work Act (1999)

COSHH regulations

Use of hard hats, ear defenders, safety shoes and any other protective apparel

Designated fire assembly points

First aid points

## 4. PERSONNEL

Persons using this procedure shall hold the following minimum qualifications:

**Mastering of Samples:** Current PCN level 2 certification in the appropriate method and sector.

**Initial Examination Candidates:** Shall meet the minimum training and experience requirements defined by PCN/GEN or its relevant Appendix for the level, method and sector of examination to be attempted.

## 5. EQUIPMENT

Shall be suitable for the application and compliant with the requirements of relevant European standard (BS EN 1714 Clause 6.2).

## 6. EXAMINATION VOLUME

Shall include the entire weld volume and at least 10 mm of the parent material each side of the weld. Precise details of the examination volume are contained in BS EN 1714 (Clause 7) and Appendices A to H of this procedure.

## 7. PREPARATION OF SCANNING SURFACES

Scanning surfaces shall be compliant with BS EN ISO 17640 (Clause 8).

## 8. PARENT METAL EXAMINATION

Parent material adjacent to the weld that will be used as a scanning surface for further probes shall be tested for lamination with a 0° compression probe in accordance with BS EN ISO 17640 (Clause 9).

## 9. RANGE AND SENSITIVITY SETTINGS

### 9.1 Minimum Sensitivity Levels

Normal beam scans	DAC + 8 dB
Longitudinal shear wave scans	DAC + 14dB
Transverse shear wave scans	DAC + 14dB

### 9.2 Sensitivity and Range Correction

Regular checks shall be carried out to confirm sensitivity and range settings in accordance with Clause 10.1 and Table 2 of BS EN ISO 17640

### 9.3 Transfer Correction

Differences in attenuation between the DAC reference block and parent plate of the weld to be tested shall, where possible, be corrected in accordance with BS EN 583-2 and Clause 10.4 of BS EN ISO 17640. Where it is not possible or practical to do so, the test shall not continue.

### 9.4 Signal to Noise Ratio

During testing the noise level ignoring spurious surface indications shall remain at least 12 dB below the evaluation level.

### 9.5 Reference Levels

The following reference levels shall be established using Method 1 from BS EN ISO 17640 using a DAC curve constructed from 3 mm diameter side drilled holes at ranges appropriate to the scans required for the weld to be tested.

Transverse shear wave scans	DAC
Longitudinal shear wave scans	DAC
Normal Compression wave scans	DAC

## **10. EXAMINATION LEVEL**

Information detailed in this procedure is applicable to Examination Level D in BS EN ISO 17640 and is additional to other information defined by this standard. It is essential that this procedure be used in conjunction with the standards referenced.

## **11. EXAMINATION TECHNIQUE**

Testing shall be carried out in accordance with Clause 12 of BS EN ISO 17640 and the relevant Appendix to this procedure (A to H).

## **12. LOCATION OF INDICATIONS**

The location of indications shall be defined by reference to a co-ordinate system as described in Clause 12.4 of BS EN ISO 17640

## **13. EVALUATION OF INDICATIONS**

All indications that equal or exceed the reference level (at test sensitivity) shall be evaluated in accordance with BS EN 583-5. This shall include determination of the approximate length and width of discontinuities using probe movement techniques and for discontinuities other than point reflectors, characterisation using the defined signal pattern recognition techniques.

## **14. REPORTING**

Reporting shall conform with the requirements of BS EN ISO 17640 Clause 13. The approximate dimensions, relative position and type of all discontinuities  $\geq 5$  mm in length that exceed the evaluation level shall be reported.

15. APPENDIX A

BUTT WELDS IN PLATE AND PIPE

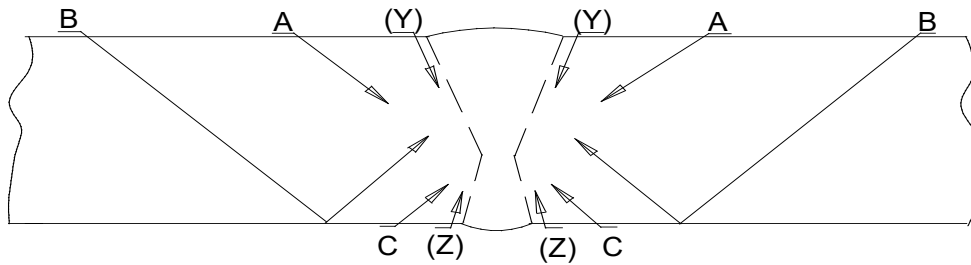


Plate / Pipe 6 mm to 15 mm thick	Double-Sided Welds		Single Sided Welds
Scans from both sides of weld	Upper surface	Lower surface	Upper surface
Longitudinal defects	A to B 0 -1 skip 1 angle	-	
Transverse defects	(Y) 0-1 skip 1 angle for diameters > 250 mm	-	(Y) 0-1 skip 1 angle for diameters > 250 mm
Separate root scan (see note 1)	See note 1(a) if applicable	-	A 1 angle (see note 2)
Normal beam scan	-	-	-
<b>Plate / Pipe 15 mm to 50 mm thick*</b>			
Longitudinal defects	A 0 - 1/2 skip 2 angles	0 - 1/2 skip 2 angles	A to B 0-1 skip 2 angles
Transverse defects	(Y) 0 - 1/2 skip 2 angles	0 - 1/2 skip 2 angles	(Y) 0 - 1/2 skip 2 angles
Separate root scan (see note 1)	See note 1(a) if applicable	-	A 1 angle (see note 2)
Normal beam scan	-	-	-
<b>Plate / Pipe 50 mm to 100 mm thick</b>			
Longitudinal defects	A 0 - 1/2 skip 2 angles	C 0 - 1/2 skip 2 angles	A 0 - 1/2 skip 2 angles B 1/2 - 1 skip 1 angle
Transverse defects	(Y) 0 - 1/2 skip 2 angles	(Z) 0 - 1/2 skip 2 angles	(Y) 0 - 1 skip 2 angles (Y) 1/2 - 1 skip 1 angle
Separate root scan (see note 1)	See note 1(a) or (b) if applicable	-	A 1 angle (see note 2)
Normal beam scan	-	-	
<b>Plate / Pipe 100 mm to 150 mm thick</b>			
Longitudinal defects	A 0 - 1/2 skip 2 angles	C 0 - 1/2 skip 2 angles	Not applicable
Transverse defects	(Y) 0 - 1/2 skip 2 angles	(Z) 0 - 1/2 skip 2 angles	
Separate root scan (see note 1)	See note 1 (b) if applicable	-	
Normal beam scan	-	-	

\*On thicknesses less than 35 mm scanning from the lower surface is not required

**Note 1.** In the case of double sided welds, where the depth of the weld root, before welding does not exceed 3 mm, the root shall be scanned at no more than 20° from a perpendicular to the root plane, either as part of the general weld examination or, if necessary, as an additional scan.

If the weld root exceeds 3 mm before welding, either of the following alternatives are acceptable

- (a) scan root at not more than 10° to the perpendicular, or
- (b) use a tandem technique with two 45° probes

**Note 2.** In the case of single sided welds, the root should be scanned with a 45°, 4 MHz or 5 MHz probe where possible. A 70° probe may be used on welds below 20 mm thick, and a 2 MHz or 2.5 MHz probe on welds over 100 mm thick, provided the probe has good range resolution.