
British Standard

Ultrasonic examination of welds

Part 1. Methods for manual examination of
fusion welds in ferritic steels

Contrôle des soudures par ultrasons

Partie 1. Méthodes d'examen manuel des soudures par fusion dans les aciers ferritiques

Ultraschallprüfung von Schweißnähten

Teil 1. Verfahren zur manuellen Prüfung von Schmelzschweißnähten an ferritischen Stählen

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Foreword

This Part of BS 3923 has been prepared under the direction of the Welding Standards Committee and supersedes BS 3923 : Part 1 : 1978 and Part 3 : 1972, which are withdrawn.

This Part of BS 3923 forms part of a series dealing with methods for the non-destructive testing of welds. It does not state when this particular type of testing should be employed nor does it give standards of acceptance, as both of these aspects should either be covered in the appropriate application standard or be agreed between the contracting parties.

This Part of BS 3923 is not associated with any particular type of fabrication but has been prepared to cover a wide range of products and as such lays down the broad principles of ultrasonic examination. It may be used to develop test specifications and techniques but does not in itself constitute a test specification.

This Part of BS 3923 differs from the previous edition of BS 3923 : Part 1 in the inclusion of additional, more detailed requirements for the examination of the most common types of welded joint. These requirements are sub-divided into three Examination Levels, applicable to welds of different required levels of integrity, with specific details covering test sensitivity, test coverage and surface finish. A fourth Examination Level is listed, the details of which should be in accordance with the general requirements of this Part of BS 3923 and agreed by the contracting parties. In addition, methods for evaluating and sizing imperfections are presented in a more detailed and formalized manner than before. In order to apply ultrasonic inspection more efficiently, an appendix giving recommendations on the parameters to be defined when setting an acceptance standard for quality control purposes has been also added.

It is emphasized that a satisfactory technique can only be determined after taking into account all the relevant factors regarding the equipment to be used and the characteristics of the weld to be examined.

The use of any method should always be considered in relation to inspection and testing as a whole. The full benefits of this or any other method can only be obtained by considering the results in conjunction with those likely to be obtained from any other method.

Purchasers of ultrasonic examination services to this standard are advised to specify in their purchasing contract that the supplier operates a quality system in compliance with BS 5750 to assure themselves that examinations claimed to comply with BS 3923 : Part 1 consistently achieve the required level of performance.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Methods

1 Scope

This Part of BS 3923 deals with methods of manual ultrasonic examination of fusion welded joints in all forms of ferritic steels having a thickness range of 6 mm to 150 mm and, when in circular form, a minimum outside diameter of 100 mm.

NOTE 1. Some methods of ultrasonic examination which are not necessarily specific to welds have been included in appendices for completeness.

NOTE 2. The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 3923 the following definitions apply. Other definitions are given in BS 499 : Part 1 and BS 3683 : Part 4.

2.1 set-through connection. A form of welded joint between two connecting cylinders in which the smaller diameter cylinder penetrates the full wall thickness of the larger.

2.2 set-on connection. A form of welded joint between two connecting cylinders in which the smaller diameter cylinder sits on the surface of the larger without penetrating its thickness.

2.3 node joint. A form of welded joint between two non-connecting cylinders set either obliquely or at right angles, in which the smaller diameter cylinder sits on the surface of the larger without penetrating its thickness.

2.4 branch weld. A form of welded joint between two connecting cylinders in which the diameter of the smaller cylinder is equal to or greater than half the diameter of the larger.

2.5 nozzle weld. A form of welded joint between two connecting cylinders in which the diameter of the smaller cylinder is less than half the diameter of the larger.

2.6 stub weld. A form of nozzle weld in which the thickness of the smaller cylinder is 12.5 mm or less, and the inside diameter is 120 mm or less.

2.7 sides of weld (or joint). The two sides of a weld are the regions occupied by the two components which are joined by the weld.

2.8 surface of weld (or joint). The whole surface of the welded joint, e.g. in a pipe butt weld the surfaces are the outer surface of the pipe and the inner (bore) surface.

2.9 in-line butt joint. A connection between the edges or ends of two parts that are substantially parallel to each other.

2.10 non-linear joint. Any form of connection between two parts that are not substantially parallel to each other.

2.11 evaluation level. A signal height in relation to the distance/amplitude correction (DAC) level, below which any signal can be disregarded and above which it is further investigated.

2.12 echodynamic pattern. The form of change in signal height and shape on traversing the ultrasonic beam in two mutually perpendicular directions across an imperfection.

2.13 recording level. A signal height in relation to the DAC curve above which the signal is recorded.

2.14 weld body (weld metal). All metal melted during the making of a weld and retained in the weld.

NOTE. See term 10 018 and figure 4 of BS 499 : Part 1 : 1983.

3 Items for agreement

3.1 General requirements

Unless otherwise agreed between the contracting parties, actions shall be either:

- (a) as given in the application standard; or
- (b) as listed in table 1.

NOTE. Where action is agreed between the contracting parties, items 1 to 4 in table 1 should be agreed during the contract negotiations and items 5 to 7 in table 1 prior to the commencement of testing.

3.2 Specific requirements for Examination Level 4

If testing is to be carried out to Examination Level 4, the following additional items to those listed in 3.1 shall be agreed by the contracting parties:

- (a) method of setting test sensitivity and evaluation/recording levels;
- (b) test sensitivity and evaluation/recording levels to be applied;
- (c) details of the scans to be applied and the probes to be used;
- (d) surface condition category of the weld (see 8.2).

NOTE. Where agreement has not been sought on any of the above items, the provisions of Examination Level 2 should be applied.

3.3 Specific requirements for all Examination Levels

In addition to the requirements of 3.1 and 3.2, the following items, which are specified in the clauses referred to, to be agreed between the contracting parties, shall be documented. Both the definitive requirements specified throughout this Part of BS 3923 and the following documented items shall be satisfied before a claim of compliance with the standard can be made and verified:

- (a) where the certification of personnel is not in accordance with a nationally accredited certification scheme, the qualifications of personnel carrying out the examination (see clause 4);
- (b) additional, omitted or modified scans of the weld (see clause 6 and 9.1);
- (c) the weld surface profile category to be applied to the test procedure (see 8.2);
- (d) the manufacturing stage at which testing is to be carried out (see 9.1);
- (e) if the optional scans for transverse defects are to be carried out (see table 6);
- (f) if sizing of imperfections is to be carried out at a range exceeding the half-skip position (see 17.5).

Table 1. Items for agreement or action	
Item	Action
1 Acceptance standard (see note)	Agreement essential (unless an acceptance standard is included in the relevant application standard, when this shall be applied) When fracture mechanics or engineering critical assessment is to be applied, Examination Level 1 shall be used and the result reported
2 Examination Level (see clause 6)	Unless an Examination Level is included in the relevant application standard apply Examination Level 2
3 Manufacturing stage at which examination is to be made	After final heat treatment wherever possible. If the design of the joint makes this not possible, a full ultrasonic examination shall be carried out as late as possible in the manufacturing sequence, and supplemented by whatever examination is possible after final heat treatment
4 Level of operator approval	Appropriate category of nationally accredited certification scheme NOTE. Guidance is given in the note to clause 4.
5 Positional reference data	In accordance with supplier's/manufacture's normal practice
6 Use of special test blocks	In accordance with supplier's/manufacture's normal practice
7 Detailed test procedures (see 7.2)	To be prepared by supplier/manufacture in accordance with the specific requirements and advisory sections of this Part of BS 3923
8 Reporting	Additional report content
NOTE. Wherever possible the acceptance criteria should be written in a form that can be directly related to ultrasonically measurable parameters. Advice on the preparation of acceptance standards for quality control purposes is contained in appendix A.	

4 Personnel

The successful application of manual ultrasonic testing depends on the knowledge and experience of the personnel responsible for producing the test procedures, and the technical competence and ability of the ultrasonic practitioner to carry out the procedural requirements and interpret results.

Unless otherwise agreed between the contracting parties (see 3.3(a)) the appropriate level and category of certification of personnel shall be in terms of those obtained from an agreed nationally accredited certification scheme (such as the Personnel Certification in Non-destructive Testing (PCN) scheme).

NOTE. If the PCN scheme is selected then:

(a) personnel responsible for producing procedures to Examination Level 4 (see clause 6) or procedures differing from this Part of BS 3923 should be either:

(1) PCN level III, or

(2) in a responsible position with technical training and experience to be considered senior to PCN level II;

(b) personnel conducting and interpreting the tests carried out in accordance with this Part of BS 3923 should be PCN level II assisted, if appropriate, by PCN level I personnel.

5 Equipment

5.1 Flaw detector and probes

5.1.1 Presentation. A-scan presentation shall be used. The trace shall be well defined and associated with permanent graticule scale markings covering both range and amplitude.

5.1.2 Test frequency. The equipment shall be capable of working at a test frequency within the range 1 MHz to 6 MHz.

5.1.3 Time base linearity. The linearity of the time base shall be within 2 % over the whole range, i.e. the echoes do not deviate by more than 2 % of the time base range from their true position.

5.1.4 Amplifier linearity

5.1.4.1 Linear. The amplifier shall be linear to an accuracy of ± 1 dB at any point within the range 20 % to 80 % full screen height. The amplifier shall also have a dynamic range up to 80 % full screen height of not less than 24 dB.

5.1.4.2 Logarithmic. The amplifier shall give equally spaced decibel steps throughout the graticule height.

5.1.5 Calibrated gain control. The gain shall be adjustable via a calibrated gain control having steps of not more than 2 dB and an accuracy of not less than 1 dB over any 20 dB range.

5.1.6 Probes. Any internal 'noise' from probes shall not interfere with the interpretation of results at the working sensitivity.

NOTE 1. When a probe is to be used with a flaw detector from another manufacturer, inductive matching may be required to optimize performance.

NOTE 2. Guidance on probe selection is given in appendix C, and guidance on the determination of probe characteristics is given in BS 4331 : Part 3.

5.1.7 Resolution. The resolution of the combined electronic apparatus and probe shall be measured on the A7 test block shown in BS 2704 by the method described in BS 4331 : Part 3.

This test block is suitable for measuring the resolution of compression wave probes and shear wave probes.

Compression wave probes in the range 4 MHz to 6 MHz shall clearly resolve the 3 mm step and the 4 mm step; lower frequency probes (2 MHz to 2.5 MHz) shall resolve the 5 mm step.

Shear wave probes in the range 4 MHz to 6 MHz shall clearly resolve the 2 mm step and the 3 mm step; lower frequency probes (2 MHz to 2.5 MHz) shall resolve the 4 mm step and the 5 mm step.

5.2 Reference and calibration blocks

Calibration blocks for routine calibration and the determination of specific probe characteristics shall be as specified in BS 2704 and BS 4331 : Part 3 respectively.

Reference standards to be used for setting sensitivity by means of the DAC method shall be as described in K.1.

5.3 Coupling

Coupling shall be obtained by either contact or gap scanning, using a liquid, gel or paste medium suitable for the application and compatible with the material under test.

The maximum surface temperature when using conventional probes and couplants shall not exceed 50 °C.

5.4 Calibration

The method of calibration of the flaw detector and probes shall be in accordance with BS 4331 : Parts 1 and 3.

The probes and test block(s) used during calibration shall be maintained at a temperature within ± 15 °C of that of the joint(s) to be examined.

NOTE. With increasing temperature there is a marked increase in attenuation and decrease in ultrasonic velocity in the material from which the angle probe wedges are manufactured. This leads to a reduction in probe sensitivity and an increase in beam angle.

6 Examination Level

The purpose of these specific examination requirements is to enable a consistent level of examination, to a defined standard, to be achieved by different contractors on the main types of welded joint. Since the application for which the joints are to be employed will vary, three different levels of examination have been defined wherever applicable.

The requirements of Examination Levels 1, 2 and 3 for different categories of welds are contained in tables 3 to 28 which detail the surface condition category, the number and extent of the scans, the type of probe (i.e. normal or angle beam), and the surfaces from which scanning shall be carried out. These tables shall be used in conjunction with clauses 10 and 17 which give the required scanning sensitivity and recording/investigation levels, and the parameters to be measured for the principal types of imperfection.

The tables give the requirements for welds having unrestricted access for scanning (see appendix D). Where the strict requirements of the tables cannot be met due to inherent features of the joint or associated components, the scanning requirements shall be modified to give at least an equal level of coverage. If this is not obtainable, the particular Examination Level cannot be met.

The Examination Levels have been written with the following applications in mind, although their use may be specified, as required.

(a) **Examination Level 1:** High integrity examination where the highest practical level of inspection is required.

(b) **Examination Level 2:** Medium integrity examination where a rigorous level of examination for quality control purposes is required whilst ensuring that, within the normal limits of ultrasonic examination, all unacceptable likely imperfections are detected and sized.

This level has been sub-divided into Examination Level 2A for fully dressed welds and Examination Level 2B for welds normally examined in the undressed condition.

(c) **Examination Level 3:** An economical level of examination for quality and process control. This is not recommended for 'fitness for purpose' applications.

NOTE. It should be noted that where, in the interests of economy a more limited inspection to Examination Level 3 is chosen there may be reduced probability of detecting and correctly rejecting all structurally significant imperfections.

(d) **Examination Level 4:** The requirements of this Examination Level are not defined, but shall be agreed by the contracting parties in order to cover those applications not covered by Examination Levels 1, 2 or 3.

The details contained in tables 3 to 28 represent the basic requirements for Examination Levels 1, 2 and 3.

In addition, except where specifically overruled by the requirements of the tables, the general requirements of clause 9 shall be met.

Specific beam angles and probe frequencies are not listed in the tables as these will depend on the weld profile, type of welding and weld thickness. In general, at least one beam angle shall be chosen to be as near normal to the weld fusion face(s) as practicable. Further details on the choice of probes are given in appendix C.

NOTE. Where considered necessary, additional scans may be specified by agreement between the contracting parties. Such an occasion may arise for example where there is a risk of chevron cracking. Similarly, certain scans may be omitted or substituted, if agreed between the contracting parties, where limited access or other features of the joint prevent one or more of the listed scans from being carried out (see 3.3(b)). The access requirements for unrestricted examination of the welds are contained in table 32.

In the event of a non-standard condition being encountered at the time of testing, details of any modification to the requirements listed in the tables shall be included in the operator's report.

Where Examination Level 4 is to be applied, the items to be agreed by the contracting parties are listed in clause 3. In this case, as for Examination Levels 1, 2 and 3, the general requirements of this Part of BS 3923 shall be met.

7 Requirements to be met prior to scanning

7.1 Provision of datum points

In order to enable the position of possible imperfections to be permanently and accurately identified within the weld cross section and along its length, either datum points shall be marked on the component or details of an agreed method of referencing based on inherent features of the joint or associated components shall be provided for the operator.

Wherever considered applicable by the purchaser, extra reference datum points relative to the weld root shall be marked on the surface of the material prior to the commencement of welding. Where the nature of the material and its service conditions render scribing undesirable, other suitable means of marking shall be used (see also appendix E).

The weld shall be clearly identified and cross-referenced to the engineering drawing.

7.2 Detailed test procedure

A test procedure shall be prepared for the particular weld or class of welds to be examined.

The following information and instructions shall either be included in the test procedure or be given to the operator through other relevant documentation:

- (a) Examination Level;
- (b) type(s) of ferritic parent material and form (i.e. cast, forged or rolled, etc.);
- (c) manufacturing stage at which examination is to be made, and post-weld heat treatment if any;
- (d) joint preparation and dimensions;
- (e) welding procedure;
- (f) surface condition category (see 8.2);
- (g) couplant;
- (h) type of ultrasonic flaw detector;
- (i) details of scans and probes to be employed;
- (j) method of sensitivity setting (see clause 10), and scanning and evaluation levels to be applied;
- (k) design and use of special test blocks, if any;
- (l) method to be used for referencing positions of imperfections, if found;
- (m) reporting requirements;
- (n) acceptance standard;
- (o) operator qualification.

7.3 Additional information

Immediately prior to examination, the operator shall be informed of any local deviations from joint preparation drawn in the welding procedure, and shall be given details of any repairs already made.

7.4 Preparation of cross-sectional drawings

In the event that it is not otherwise provided, the operator shall prepare a cross-sectional drawing of the joint showing the fusion faces as designed, the actual surface contour, and the weld and parent metal thicknesses after checking ultrasonically.

A pin profile gauge shall be used to record surface contour of welds where testing conditions are changing continuously due to changing geometry. Where the joint geometry is variable around the circumference of the joint, e.g. branch and nozzle joints, at least two cross-sectional drawings shall be made, namely longitudinal and transverse with respect to the axis of the larger diameter component.

NOTE. Cross-sectional drawings at intermediate positions may also be necessary for accurate location of imperfections.

8 Surface condition, counterboring and access for scanning

8.1 Surface finish

The level of testing that can be achieved is dependent on the surface condition of the weld and adjacent parent material.

All scanning surfaces shall be free from loose scale and weld spatter and shall be of sufficiently uniform contour and smoothness that satisfactory acoustic coupling can be maintained. The surface finish (i.e. fine-scale roughness) of all surfaces from which scanning is carried out shall be not rougher than $6.3 \mu\text{m } R_a$. (See BS 1134.)

NOTE. An appropriate surface comparator should be used for estimating the surface finish.

8.2 Weld surface category

The requirements for the weld surface finish categories SP1 to SP6 specified in tables 3 to 28 are as follows:

appendix B, which also includes details of the test coverage and standard of testing that can be achieved with each category.

NOTE. The weld surface category necessary to meet the requirements of Examination Levels 1, 2 and 3 is given in clauses 11 to 16 which deal with specific examination requirements.

Where unspecified, the weld surface category shall be agreed between the contracting parties and included in any detailed testing procedure (see 3.3(c)).

8.3 Counterboring and access for scanning

Advice on the limitations imposed by counterboring, and the requirements with regard to both counterboring and access for scanning necessary for unrestricted examination of the weld are contained in appendix D.

9 Test coverage: general requirements

9.1 General

A complete weld examination shall be sub-divided into the following inspection operations:

- (a) examination of the parent materials (see 9.2);
- (b) location of the weld root where necessary by any one of the methods given in appendix E;
- (c) examination of the weld root (where applicable) (see 9.3);
- (d) weld scan with normal probes (where specified) (see 9.4);
- (e) weld scan for longitudinal imperfections (see 9.5);
- (f) weld scan for transverse imperfections (where specified) (see 9.6);
- (g) other special scans, e.g. for chevron cracking (to be agreed by the contracting parties) (see 3.3(b)) and 9.7).

NOTE. Where the existence of lamellar tearing is suspected, additional scans using an appropriate angle beam probe having the best angle of incidence, taking into account the orientation of the imperfections, may need to be carried out.

This clause details the methods that shall be used for operations (a) to (f), whether the examination is being carried out in accordance with Examination Level 1, 2 or 3, or to a procedure agreed by the contracting parties under the provisions of Examination Level 4.

The manufacturing stage at which testing is carried out shall be by agreement between the contracting parties (see 3.3(d)).

NOTE 1. Materials that are subject to reheat cracking (e.g. creep resisting steels of the CrMoV or 2¼ Cr type), irrespective of any intermediate testing, should be finally examined after stress relief heat treatment. Electroslag welds may have to be normalized prior to conducting a critical ultrasonic examination.

The examination of the weld shall be carried out by manual scanning using an A-scan presentation. The equipment, test blocks and calibration procedures shall meet the requirements of clause 5.

NOTE 2. Additional guidance on the selection of probes for inspection operations (c) to (f) is contained in appendix C. Methods for evaluating and sizing imperfections are detailed in appendices M and N.

9.2 Parent metal examination

9.2.1 General. Whether or not the parent metal has been ultrasonically tested previously, an examination shall be made after welding:

- (a) to locate any imperfections, such as laminations or tears, in the material through which the ultrasonic beam will pass during examination of the weld;
- (b) to establish the material thickness in order to enable the actual beam path lengths to be determined.

Where imperfections are found, their influence on the degree of inspection possible in the vicinity of the weld shall be assessed and the technique for scanning during subsequent weld inspection adjusted to ensure the maximum possible local coverage of the full cross section of the weld.

During preliminary examination, the operator shall note variations in the attenuation of the material and the influence of surface condition on coupling in order to determine the practicability of performing an effective test.

9.2.2 Method. The material shall be examined manually by the pulse echo technique using a compressional single or twin crystal normal probe capable of good near surface resolution (see BS 5996 and C.7).

The nominal probe frequency shall be not less than 2 MHz.

NOTE. In view of the requirement to note possible variations in attenuation in the material, probes in the range 4 MHz to 6 MHz are preferable. Where a single crystal probe does not give the necessary near surface resolution on material less than 25 mm thick, a twin crystal probe is preferable. Similarly, on thicker sections where the detection of small imperfections close to the test surface is important, a twin crystal probe should be used for this area in addition to a single crystal probe for the main body of the material.

The time base shall be calibrated using a suitable block by the method described in BS 4331 : Part 1 so that a minimum of two back wall echoes from the parent material are displayed on the screen.

During scanning it is essential that particular attention is paid to sudden apparent changes in material thickness as these may be caused by major imperfections lying close to the back wall.

The test sensitivity shall be set according to 10.2.1, i.e. such that the second back wall echo is at full screen height on an imperfection-free area of the material. When the instrument sensitivity has to be locally increased to maintain this level, it shall be established whether the reduction in back wall echo is due to surface roughness or contour, increased material attenuation or parent metal imperfections, particularly those lying at an angle to the surface of the material.

9.2.3 Test coverage. The parent material shall be tested along the full length of the weld, for a distance back from the weld equal to the maximum scanning distance to be used for the subsequent angle probe examination.

In order to give complete coverage, the pitch between adjacent scan lines shall not exceed 0.8 times the diameter of the transducer. The speed of probe movement shall not exceed 150 mm/s.

9.3 Examination of weld root

9.3.1 Single-sided welds. On single-sided welds with an undressed root, wherever possible, a separate scan shall be carried out from both sides of the weld, in order to distinguish between echoes from normal features of the weld, such as the root bead, and echoes from root cracks or incomplete root penetration. In addition, where the weld cap is dressed sufficiently flat (SP2, SP3 or SP4), a normal probe shall be used to measure the depth of bead penetration or root concavity, or to confirm fusion on to the backing material, if used (see 9.4).

9.3.2 Double-sided welds. The methods used to detect and measure the extent of the unfused root face will depend on the joint configuration and material thickness. Since imperfections of this type behave as specular reflectors, particularly as their size increases, it is very important to achieve the optimum angles for reflection.

9.3.3 Method. The method of examination of the weld root shall be one of those given in appendix F.

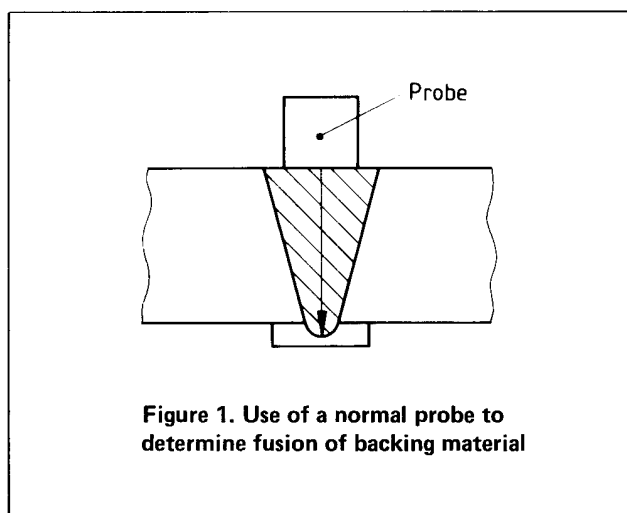
9.4 Weld scan with normal probes

9.4.1 General. Where this technique is to be applied, the weld cap shall be dressed flush to surface condition categories SP3 or SP4 for in-line butt welds, or SP7 for non-linear welds (see appendix B).

A normal probe shall be scanned over the surface of the weld in order to perform the following functions as appropriate to the type of weld under examination:

- (a) measure the depth of any excessive root penetration or root concavity;
- (b) determine the presence and extent of any lack of fusion into the backing material, where fitted (see figure 1);
- (c) detect any lack of inter-run or root fusion, or other favourably oriented imperfections in the weld.

9.4.2 Method. The method of examination shall be that given in appendix G.



9.5 Weld scan for longitudinal imperfections

9.5.1 General. The methods covered by 9.5 are intended to detect all linear and non-linear imperfections which are predominately longitudinal with respect to the weld axis.

The most critical part of the examination is that for imperfections lying along the fusion faces, such as lack of side wall fusion or heat-affected zone (HAZ) cracking. Since these imperfections often behave as near-specular reflectors, the probe angle(s) shall be chosen such that the beam axis strikes the fusion face as near to the normal as possible.

NOTE. Other imperfections in the body of the weld, such as cracks, slag inclusions, etc., tend to have a more random orientation and, in general for higher examination levels, require one or more additional probe angles to ensure reliable detection.

In the case of non-linear welds, such as branch connections, T-joints and nodes, etc., a number of different probe angles and scanning surfaces may be required to give complete coverage, and the tables and figures in clauses 12 to 16 provide guidance.

Particular attention should be paid, when selecting probe angles for branch and node welds, to the marked changes in weld geometry at different positions around the circumference.

Calibration of the probes and time base of the flaw detector shall be in accordance with clause 5. If not otherwise agreed between the contracting parties the sensitivity shall be set in accordance with 10.2.2..

Guidance on the choice of probes is given in appendix C. The maximum test range shall not exceed 200 mm for 4 MHz to 5 MHz probes. For greater ranges, probes of 2 MHz to 3 MHz shall be used.

9.5.2 Method. The method of examination shall be one of those given in appendix H.

9.6 Weld scan for transverse imperfections

9.6.1 General. Certain materials are prone to the development of transverse imperfections, which may be:

- (a) isolated and small, or
- (b) very frequent and across the whole weld, or
- (c) predominantly near the surface, or
- (d) of extensive depth almost to the root.

NOTE. Imperfections near the test surface may sometimes mask the existence of others lying deeper in the material.

Generally, but not exclusively, transverse imperfections are orientated perpendicularly with respect to the weld surface and, as they are usually planar and therefore behave as near-specular reflectors, the choice of beam angle is particularly important.

On circumferential welds in cylindrical components, the angle of the beam with respect to the radial plane changes with depth in the material, and for each probe angle there is only one depth at which the beam strikes a radial imperfection normal to its surface (see figure 2). This depth is also the limiting value for coverage of weld thickness.

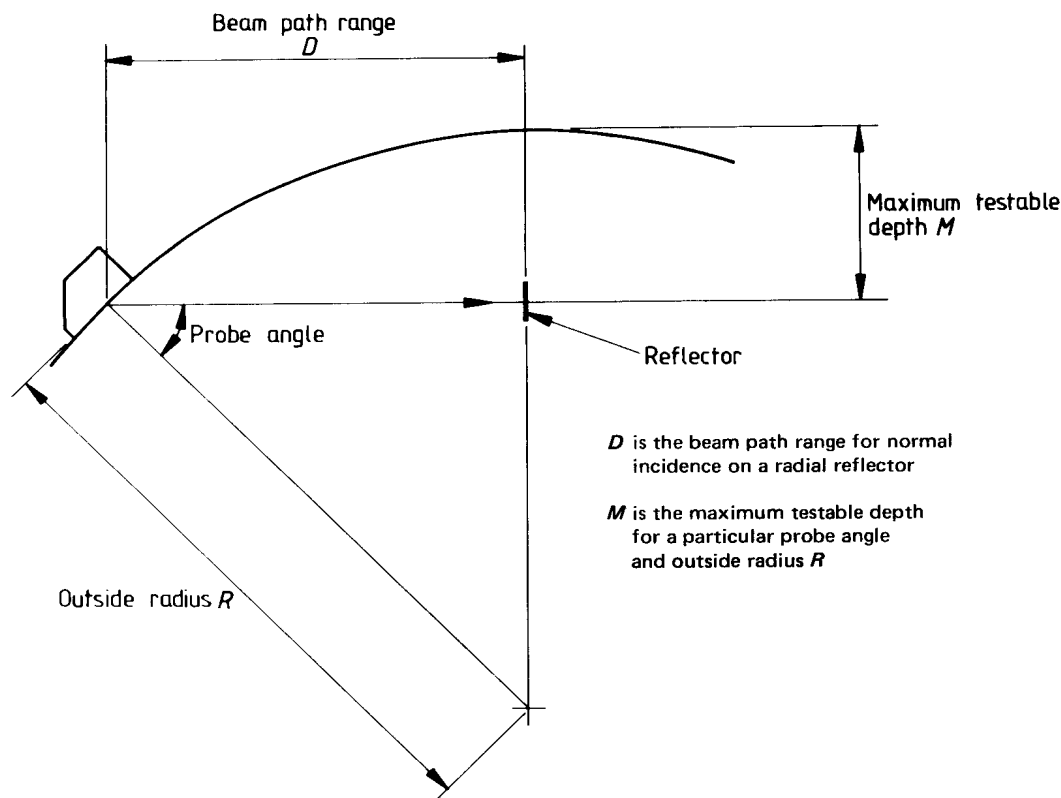
For a critical examination it is essential that the weld cap is dressed flat and flush with the parent material on either side to a minimum standard of SP3.

9.6.2 Method. The method of examination shall be one of those given in appendix J.

NOTE. The examination for transverse imperfections is generally confined to in-line butt welds as only a very limited degree of inspection is possible on non-linear welds due to their unfavourable geometry.

9.7 Other special scans

Scanning directions intermediate between transverse and longitudinal shall be carried out, as necessary, when imperfections of other orientations (e.g. chevron cracking) form part of the acceptance criteria.



D is the beam path range for normal incidence on a radial reflector

M is the maximum testable depth for a particular probe angle and outside radius R

Probe angle	Maximum testable depth, M	Beam path range, D
70°	0.06 R	0.34 R
60°	0.13 R	0.50 R
50°	0.24 R	0.64 R
45°	0.30 R	0.70 R
38°	0.38 R	0.79 R

NOTE. The maximum testable depth, and beam path range to maximum testable depth, are given in terms of outside radius R , for different probe angles.

Figure 2. Effect of curvature on incident angle and maximum testable depth

10 Sensitivity

10.1 General

For Examination Levels 1, 2 and 3, sensitivity setting for the weld examination shall be referenced to a distance/amplitude correction (DAC) curve (see appendix K) for a series of 3 mm diameter side-drilled holes in a suitable test block. The curve shall be corrected where necessary for differences between the attenuation and surface condition of the material under test and the test block.

The design of the test block, method of plotting the DAC curve, and the application of correction factors are described in appendix K. If forms of test block are used where more convenient for 'on-the-job' setting, the sensitivity shall always be relatable to the 3 mm DAC curve for the probe in use.

NOTE. For Examination Level 4, other methods, including the distance/gain/size (DGS) system may be used by agreement between the contracting parties.

10.2 Scanning sensitivity

10.2.1 General. The initial scanning sensitivity shall be sufficiently high to give a reasonable assurance that all significant discontinuities are detected, irrespective of type or orientation. It shall be set as described in **10.2.2** and **10.2.3** and checked at intervals during inspection.

NOTE. Alternative methods for setting sensitivity may be used provided they are referenced to the 3 mm side-drilled hole block.

10.2.2 Parent metal examination (normal probes).

The scanning sensitivity shall be set on the parent material in an area free from imperfections such that the second back wall echo is displayed at full screen height.

In the absence of a back wall echo due to non-parallel surfaces, the scanning sensitivity shall be set as above using a separate parallel-sided plate with the same thickness and attenuation characteristics.

10.2.3 Weld examination (normal and angle probes).

The minimum scanning sensitivity to be used for the weld examination will depend on the Examination Level to be

applied, and the type of scan to be employed, i.e. whether using normal or angle probes and, if the latter, whether searching for longitudinal or transverse imperfections.

For Examination Level 1, the minimum scanning sensitivity shall be set to show evidence of 'grass' up to the maximum testing range. This sensitivity shall be referenced to the DAC curve for 3 mm diameter side-drilled holes corrected for material attenuation or coupling losses, and shall be not less than the appropriate value shown in table 2.

For Examination Levels 2 and 3, the minimum scanning sensitivity shall be set by adjustment of the instrument gain to the value at which the corrected DAC curve was plotted. The gain shall then be further increased by the appropriate decibel value shown in table 2.

For Examination Level 4, the minimum scanning sensitivity shall be by agreement.

NOTE. No maximum scanning sensitivity is specified. However, even when not a specific requirement, it is recommended that a low level of 'grass', i.e. 2 mm to 3 mm above the baseline, should be visible up to the maximum testing range since this allows the operator visually to monitor the probe/workpiece coupling during scanning.

If an extended dead zone or excessive 'grass' prevents the clear identification of possible imperfection echoes close to the probe at the minimum scanning sensitivity specified above, the full testing range shall be scanned in two parts, the sensitivity being set separately for each part.

11 Specific requirements for in-line butt welds in plate and pipe

Tables 3 to 6 give the requirements for substantially in-line full penetration welds, welded from either one or two sides. They are sub-divided into four thickness ranges for Examination Levels 1 and 2, and into three thickness ranges for Examination Level 3. Examination Level 2 has been further sub-divided into Examination Level 2A for fully dressed welds, and Examination Level 2B for welds normally examined in the undressed condition.

Table 2. Minimum scanning sensitivity levels

Examination Level	1	2	3	4
Normal beam scans	DAC + 14 dB	DAC + 8 dB	DAC + 8 dB	Method and level by agreement
Scans for longitudinal imperfections	DAC + 14 dB	DAC + 14 dB	DAC + 8 dB	
Scans for transverse imperfections	DAC + 20 dB	DAC + 14 dB	DAC + 8 dB*	

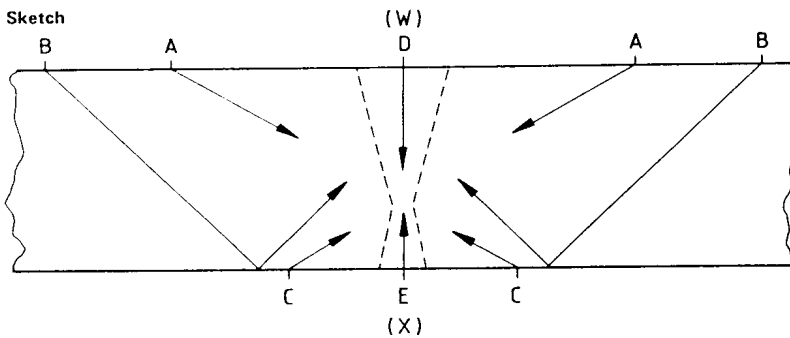
*When requested by the purchaser (see **3.3(e)**).

NOTE 1. Where excessive grass is experienced at the minimum sensitivity settings quoted, a lower frequency probe is recommended. Where excessive grass is still experienced with a lower frequency probe, it is recommended that testing should only continue by agreement between the contracting parties.

NOTE 2. + means more sensitive.



Table 3. Butt welds in plate and pipe: Examination Level 1



NOTE. The letters in the table identify the scans shown here.

Access and surface condition

(a) Double-sided welds, and single-sided welds meeting the following conditions:

Both surfaces dressed to SP4. Surfaces over which defect sizing has to be carried out shall be locally dressed to SP5 (see appendix B)

(b) Single-sided welds:

As for (a) but upper surface only. Root bead to be dressed off where possible

Plate/pipe 6 mm to 15 mm thick	Double/single-sided welds (see access and surface condition (a))		Single-sided welds (see access and surface condition (b))
Scans from both sides of weld	Upper surface	Lower surface	Upper surface
Longitudinal defects	A to B 0—1 skip 1 angle	—	A to B 0—1 skip 1 angle
Transverse defects	(W) 0—1 skip 1 angle (W) Near surface 1 angle	—	(W) 0—1 skip 1 angle (W) Near surface 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	D Near surface and full section 1 probe	—	D Near surface and full section 1 probe
Plate/pipe 15 mm to 50 mm thick*			
Longitudinal defects	A 0—½ skip 2 angles A Near surface 1 angle	C 0—½ skip 2 angles C Near surface 1 angle	A to B 0—1 skip 2 angles A Near surface 1 angle
Transverse defects	(W) 0—½ skip 2 angles (W) Near surface 1 angle	(X) 0—½ skip 2 angles (X) Near surface 1 angle	(W) 0—1 skip 2 angles (W) Near surface 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	D Near surface and full section 1 probe	—	D Near surface and full section 1 probe
Plate/pipe 50 mm to 100 mm thick			
Longitudinal defects	A 0—½ skip 2 angles A Near surface 1 angle	C 0—½ skip 2 angles C Near surface 1 angle	A 0—½ skip 2 angles A Near surface 1 angle
Transverse defects	(W) 0—½ skip 2 angles (W) Near surface 1 angle	(X) 0—½ skip 2 angles (X) Near surface 1 angle	(W) 0—½ skip 2 angles (W) Near surface 1 angle
Separate root scan (see note 1)	See note 1(b) (if applicable)	—	A 1 angle (see note 2)
Normal beam scan	D Near surface 1 probe D Full section 1 probe	E Near surface 1 probe	D Near surface 1 probe D Full section 1 probe
Plate/pipe 100 mm to 150 mm thick			
Longitudinal defects	A 0—½ skip 2 angles A Near surface 1 angle	C 0—½ skip 2 angles C Near surface 1 angle	Not applicable
Transverse defects	(W) 0—½ skip 2 angles (W) Near surface 1 angle	(X) 0—½ skip 2 angles (X) Near surface 1 angle	
Separate root scan (see note 1)	See note 1(b) (if applicable)	—	
Normal beam scan	D Near surface 1 probe D Full section	E Near surface 1 probe E Full section 1 probe	

*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 not more than 20° from the perpendicular to the root plane, either as part of the general weld examination or, if necessary, as an additional scan. If the weld root before welding exceeds 3 mm, there are two acceptable alternatives, as follows:

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

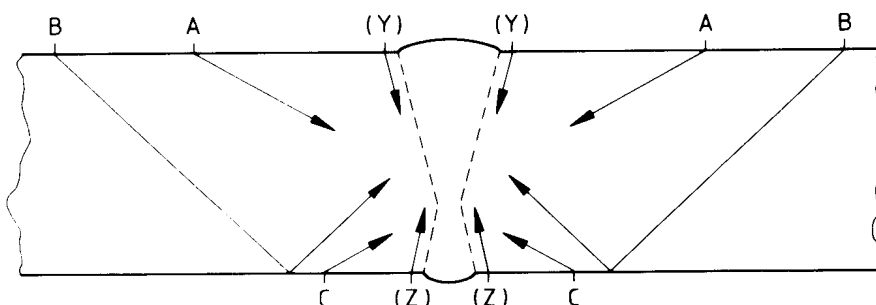
NOTE 2. In the case of single-sided welds, the root should be scanned with a 45° 4 MHz to 5 MHz probe where possible. A 70° probe may be used on welds below 20 mm thick, and a 2 MHz to 2½ MHz probe on welds over 100 mm thick, provided the probe has good range resolution.

Table 4. Butt welds in plate and pipe: Examination Level 2A

Sketch NOTE. The letters in the table identify the scans shown here.			Access and surface condition (a) Double-sided welds, and single-sided welds meeting the following conditions: Both surfaces dressed to SP3 (see appendix B). Surfaces over which defect sizing has to be carried out shall be locally dressed to SP5 (b) Single-sided welds: As for (a) but upper surface only	
Plate/pipe 6 mm to 15 mm thick	Double/single-sided welds (see access and surface condition (a))		Single-sided welds (see access and surface condition (b))	
Scans from both sides of weld	Upper surface	Lower surface	Upper surface	
Longitudinal defects	A to B 0—1 skip 1 angle	—	A to B 0—1 skip 1 angle	
Transverse defects	(W) 0—1 skip 1 angle	—	(W) 0—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	D Near surface and full section 1 probe	—	D Near surface and full section 1 probe	
Plate/pipe 15 mm to 50 mm thick				
Longitudinal defects	A to B 0—1 skip 2 angles		A to B 0—1 skip 2 angles	
Transverse defects	(W) 0—1 skip 2 angles		(W) 0—1 skip 2 angles	
Separate root scan (see note 1)	See note 1 (a) or (b) (if applicable)	1	A 1 angle (see note 2)	
Normal beam scan	D Near surface and full section 1 probe	—	D Near surface and full section 1 probe	
Plate/pipe 50 mm to 100 mm thick				
Longitudinal defects	A 0—½ skip 2 angles A Near surface 1 angle	C 0—½ skip 2 angles	A 0—½ skip 2 angles A Near surface 1 angle	
Transverse defects	(W) 0—½ skip 2 angles (W) Near surface 1 angle	C 0—½ skip 2 angles	(W) 0—½ skip 2 angles (W) Near surface 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	D Near surface 1 probe D Full section 1 probe	—	D Near surface 1 probe D Full section 1 probe	
Plate/pipe 100 mm to 150 mm thick				
Longitudinal defects	A 0—½ skip 2 angles A Near surface 1 angle	C 0—½ skip 2 angles C Near surface 1 angle	Not applicable	
Transverse defects	(W) 0—½ skip 2 angles (W) Near surface 1 angle	(X) 0—½ skip 2 angles (X) Near surface 1 angle		
Separate root scan (see note 1)	See note 1(b) (if applicable)	—		
Normal beam scan	D Near surface 1 probe D Full section 1 probe	E Near surface 1 probe		
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 not more than 20° from the perpendicular to the root plane, either as part of the general weld examination or, if necessary, as an additional scan. If the weld root before welding exceeds 3 mm, there are two acceptable alternatives, as follows: (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 to 5 MHz probe where possible. A 70° probe may be used on welds below 20 mm thick, and a 2 MHz to 2½ MHz probe on welds over 100 mm thick, provided the probe has good range resolution.				

Table 5. Butt welds in plate and pipe: Examination Level 2B

Sketch



Surface condition

SP1. Weld dressing not required, except where necessary to remove the source of confusing echoes

NOTE. The letters in the table identify the scans shown here.

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	—	A to B 0—1 skip 1 angle
Transverse defects		(Y) 0—1 skip 1 angle for diameters greater than 250 mm	—	(Y) 0—1 skip 1 angle for diameters greater than 250 mm
Separate root scan (see note 1)		See note 1 (a) (if applicable)	—	A 1 angle (see note 2)
Normal beam scan		—	—	—
Plate/pipe 15 mm to 50 mm thick*				
Longitudinal defects		A 0—½ skip 2 angles	0—½ skip 2 angles	A to B 0—1 skip 2 angles
Transverse defects		(Y) 0—½ skip 2 angles	0—½ skip 2 angles	(Y) 0—1 skip 2 angles
Separate root scan (see note 1)		See note 1 (a) (if applicable)	—	A 1 angle (see note 2)
Normal beam scan		—	—	—
Plate/pipe 50 mm to 100 mm thick				
Longitudinal defects		A 0—½ skip 2 angles	C 0—½ skip 2 angles	A 0—½ skip 2 angles B ½—1 skip 1 angle
Transverse defects		(Y) 0—½ skip 2 angles	(Z) 0—½ skip 2 angles	(Y) 0—½ skip 2 angles (Y) ½—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		—	—	—
Plate/pipe 100 mm to 150 mm thick				
Longitudinal defects		A 0—½ skip 2 angles	C 0—½ skip 2 angles	Not applicable
Transverse defects		(Y) 0—½ skip 2 angles	(Z) 0—½ 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.

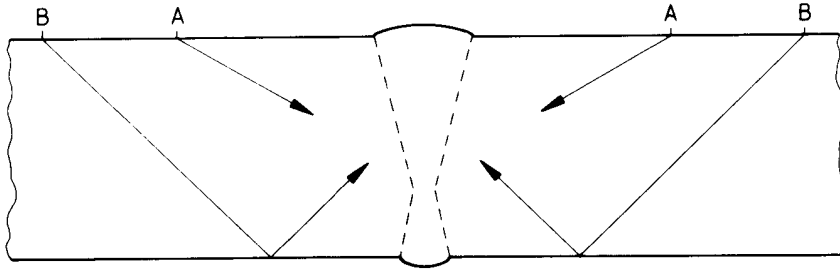
NOTE 1. In the case of double-sided welds, where the depth of the weld root before welding does not exceed 3 mm, the root shall be scanned at not more than 20° from the perpendicular to the root plane, either as part of the general weld examination or, if necessary, as an additional scan.

If the weld root before welding exceeds 3 mm, there are two acceptable alternatives, as follows:

- (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 to 5 MHz probe where possible. A 70° probe may be used on welds below 20 mm thick, and a 2 MHz to 2½ MHz probe on welds over 100 mm thick, provided the probe has good range resolution.

Table 6. Butt welds in plate and pipe: Examination Level 3

Sketch			Surface condition SP1. Weld dressing not required, except where necessary to remove the source of confusing echoes
			
NOTE. The letters in the table identify the scans shown here.			
Plate/pipe 10 mm to 50 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—½ skip 1 angle		0—1 skip 1 angle
Transverse defects	0—1 skip 2 angles*	—	0—1 skip 2 angles*
Separate root scan (see note 1)	See note 1 (a) (if applicable)	—	A 1 angle (see note 2)
Normal beam scan	—	—	—
Plate/pipe 50 mm to 100 mm thick			
Longitudinal defects	A 0—½ skip 1 angle B ½—1 skip 1 angle	—	A 0—½ skip 1 angle B ½—1 skip 1 angle
Transverse defects	0—½ skip 2 angles* ½—1 skip 1 angle*	—	0—½ skip 2 angles* ½—1 skip 1 angle*
Separate root scan (see note 1)	See note 1 (a) or (b)	—	A 1 angle (see note 2)
Normal beam scan	—	—	—
Plate/pipe 100 mm to 150 mm thick			
Longitudinal defects	A 0—½ skip 2 angles B ½—1 skip 1 angle	—	Not applicable
Transverse defects	0—½ skip 2 angles*	0—½ skip 2 angles*	
Separate root scan (see note 1)	See note 1 (a) or (b) (if applicable)	—	
Normal beam scan	—	—	
*When requested by the purchaser (see 3.3(e)).			
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 not more than 20° from the perpendicular to the root plane, either as part of the general weld examination or, if necessary, as an additional scan.			
If the weld root before welding exceeds 3 mm, there are two acceptable alternatives, as follows:			
(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 to 5 MHz probe where possible. A 70° probe may be used on welds below 20 mm thick, and a 2 MHz to 2½ MHz probe on welds over 100 mm thick, provided the probe has good range resolution.			

12 Specific requirements for set-on connections

Tables 7 to 14 give the requirements for substantially radial full penetration welds. They are sub-divided into branch welds, nozzle welds and stub welds, as defined in clause 2, according to the relative diameters of the two parent components, or in the case of stubs welds to their small diameter and thickness. Branch and nozzle welds have been sub-divided into two thickness ranges; stub welds fall into a single thickness range.

Examination Level 1 is not considered achievable on stub welds due to the inaccessibility for inspection from the bore.

Table 7. Set-on connections. Branch welds: Examination Level 1			
Sketch Surface condition: SP7. Root bead removed			
Branch 15 mm to 50 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surfaces of branch	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles	Examination Level 1 not achievable
Branch bore	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 1 angle	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 1 angle	
Inner/outer surfaces of component B	Scan S3 from bore 1 probe Scan R2 from outer surface 1 angle	Scan R2 from outer surface 1 angle	
Weld fillet	—	Scan F1, 1 angle* Scan F3, 1 probe*	
Separate root scan	—	—	
Scans for transverse defects	Scan T from weld fillet* 1 angle Scan U from bore 1 angle	Scan T from weld fillet* 1 angle Scan U from bore 1 angle	
Branch > 50 mm thick			
Outer surfaces of branch	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle Scan Q1 (0–½ skip) 1 angle	
Branch bore	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 1 angle Scan P3, 1 probe	Scan P1 (0–½ skip) 2 angles Scan P2 (0–½ skip) 2 angles Scan P3, 1 probe	
Inner/outer surface of component B	Scan S3 from bore 1 probe Scan R2 from outer surface 1 angle	Scan R2 from outer surface 1 angle	
Weld fillet	Scan F1, 1 angle Scan F3, 1 probe	Scan F1, 1 angle Scan F3, 1 probe	—
Separate root scan	—	—	—
Scan for transverse defects	Scan T from fillet 1 angle Scan U from bore 1 angle	Scan T from fillet 1 angle Scan U from bore 1 angle	—
*Where weld fillet is sufficiently wide.			

Table 8. Set-on connections. Branch welds: Examination Level 2

Sketch 		Surface condition: (a) Bore A accessible: SP6. Root bead removed (b) Neither bore accessible: SP7	
Branch 15 mm to 50 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of branch	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles Scan Q1 (0–½ skip) 1 angle
Branch bore	Scan P2 (0–½ skip) 1 angle	Scan P2 (0–½ skip) 1 angle Scan P1 (0–½ skip) 1 angle	—
Inner/outer surface of component B	Scan S3 from bore 1 probe	Scan R2 from outer surface 1 angle	Scan R2 from outer surface 1 probe
Weld fillet	—	—	Scan F1, 2 angles* Scan F3, 1 probe*
Separate root scan	—	—	Scan Q1, 1 angle
Branch > 50 mm thick			
Outer surface of branch	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 2 angles Scan Q1 (0–½ skip) 1 angle
Branch bore	Scan P2 (0–½ skip) 1 angle Scan P1 (0–½ skip) 1 angle	Scan P2 (0–½ skip) 2 angles Scan P1 (0–½ skip) 1 angle	—
Inner/outer surface of component B	Scan S3 from bore 1 probe	Scan R2 from outer surface 1 angle	Scan R2 from outer surface 1 angle
Weld fillet	—	—	Scan F1, 2 angles Scan F3, 1 probe
Separate root scan	—	—	Scan Q1, 1 angle
*Where weld fillet is sufficiently wide.			

Table 9. Set-on connections. Branch welds: Examination Level 3

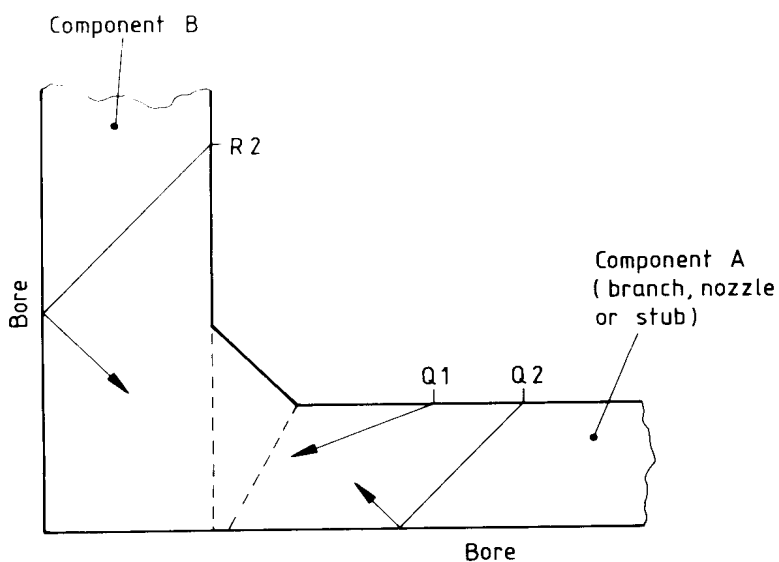
Sketch 		Surface condition: SP6. If root bead is removed the separate root scan can be omitted	
Branch > 15 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of branch	Scan Q1 to Q2 (0—1 skip) 1 angle Scan Q2 (½—1 skip) 1 angle	Scan Q1 to Q2 (0—1 skip) 1 angle Scan Q2 (½—1 skip) 1 angle	Scan Q1 to Q2 (0—1 skip) 1 angle Scan Q2 (½—1 skip) 1 angle
Branch bore	—	—	—
Inner/outer surface of component B	Scan R2 from outer surface 1 angle (for thicknesses above 50 mm only)	Scan R2 from outer surface 1 angle (for thicknesses above 50 mm only)	Scan R2 from outer surface 1 angle (for thicknesses above 50 mm only)
Weld fillet	—	—	—
Separate root scan (only if bead not removed)	Scan Q1, 1 angle	Scan Q1, 1 angle	Scan Q1, 1 angle

Table 10. Set-on connections. Nozzle welds: Examination Level 1

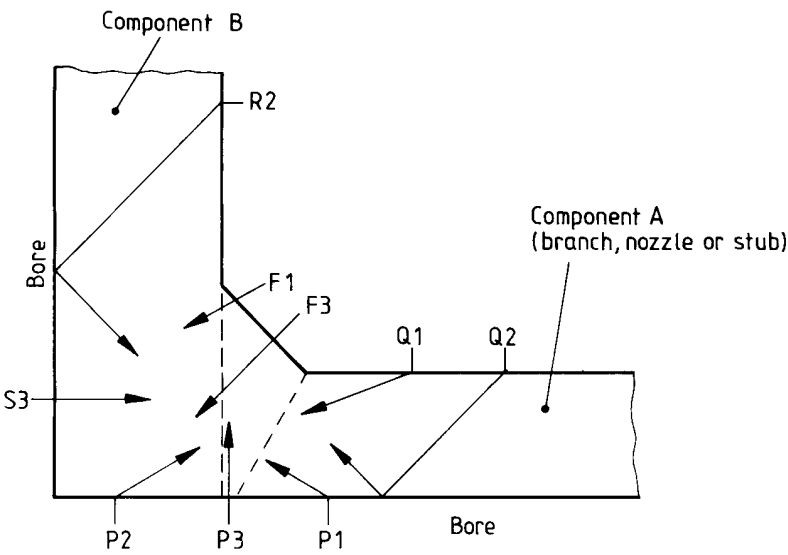
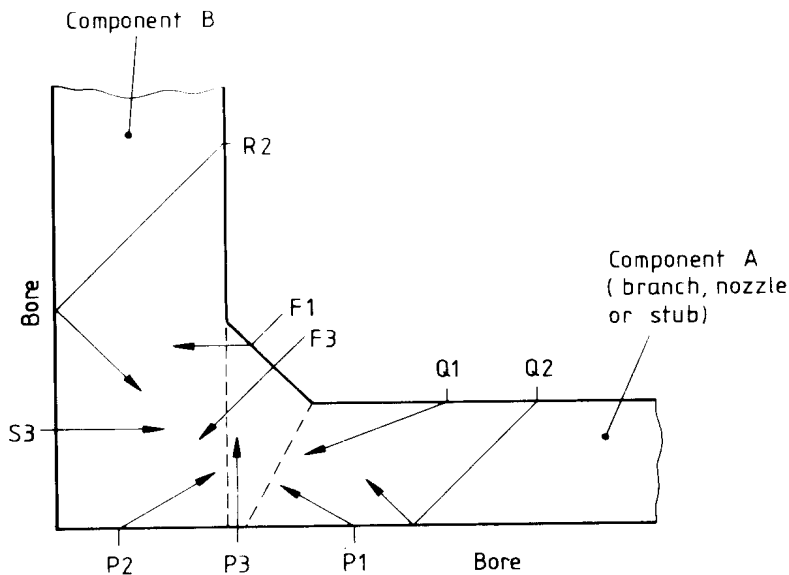
Table 10. Set-on connections. Nozzle welds: Examination Level 1			
Sketch 		Surface condition: Nozzle thickness 15 mm to 50 mm: SP6. Root bead removed Nozzle thickness over 50 mm: SP7. Root bead removed	
Nozzle 15 mm to 50 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of nozzle	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles	Examination Level 1 not achievable
Nozzle bore	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 1 angle	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 2 angles	
Inner/outer surfaces of component B	Scan S3 from bore 1 probe Scan R2 from outer surface 1 angle	Scan R2 from outer surface 1 angle	
Weld fillet	—	—	
Separate root scan	—	—	
Nozzle > 50 mm thick			
Outer surface of nozzle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle Scan Q1 (0–½ skip) 1 angle	Examination Level 1 not achievable
Nozzle bore	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 1 angle Scan P3, 1 probe	Scan P1 (0–½ skip) 2 angles Scan P2 (0–½ skip) 2 angles Scan P3, 1 probe	
Inner/outer surfaces of component B	Scan S3 from bore 1 probe Scan R2 from outer surface 1 angle	Scan R2 from outer surface 1 angle	
Weld fillet	Scan F1, 1 angle Scan F3, 1 probe	Scan F1, 1 angle Scan F3, 1 probe	
Separate root scan	—	—	

Table 11. Set-on connections. Nozzle welds: Examination Level 2

Sketch



Surface condition:

Where bore of B is accessible: SP6.

Where bore of B is not accessible: SP7.

Root bead to be removed where bore A is accessible

Nozzle 15 mm to 50 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of nozzle	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles Scan Q1 (0–½ skip) 1 angle
Nozzle bore	--	Scan P2 (0–½ skip) 1 angle	(See note)
Inner/outer surfaces of component B	Scan S3 from bore 1 probe	—	Scan R2 from outer surface 1 angle
Weld fillet	—	—	—
Separate root scan	—	—	Scan Q1, 1 angle
Nozzle > 50 mm thick			
Outer surface of nozzle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 2 angles Scan Q1 (0–½ skip) 1 angle
Nozzle bore	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 1 angle	Scan P1 (0–½ skip) 1 angle Scan P2 (0–½ skip) 2 angles	(See note)
Inner/outer surface of component B	Scan S3 from bore 1 probe	—	Scan R2 from outer surface 1 angle
Weld fillet	—	Scan F1, 1 angle	Scan F1, 1 angle Scan F3, 1 angle
Separate root scan	—	—	Scan Q1, 1 angle
NOTE. In the absence of access to either bore the level of examination will be reduced. In particular, for nozzle thicknesses above 50 mm the detectability of defects along the B-side wall will be significantly reduced.			

Table 12. Set-on connections. Nozzle welds: Examination Level 3

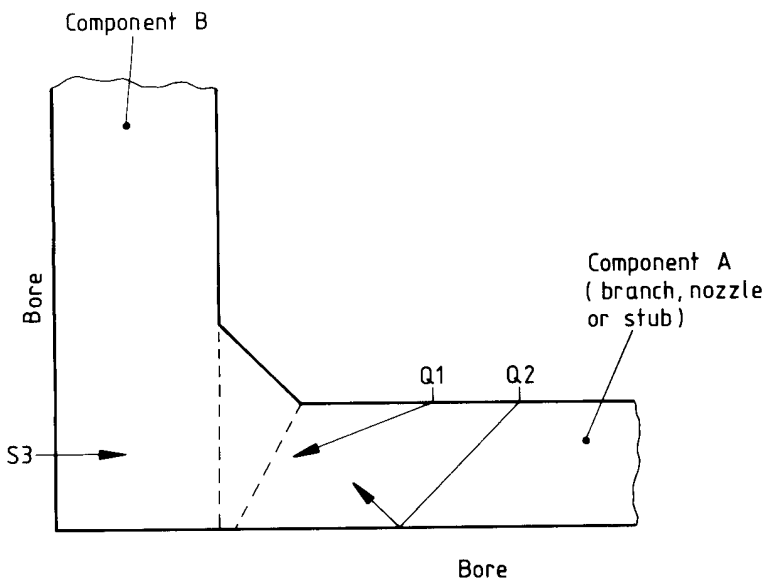
Sketch 		Surface condition: SP6. If root bead is removed the separate root scan can be omitted	
Nozzle > 15 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of nozzle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle Scan Q2 (½–1 skip) 1 angle
Nozzle bore	—	—	—
Inner/outer surface of component B	Scan S3 from bore 1 probe (for thicknesses above 50 mm only)	—	—
Weld fillet	—	—	—
Separate root scan (only if bead not removed)	Scan Q1, 1 angle	Scan Q1, 1 angle	Scan Q1, 1 angle

Table 13. Set-on connections. Stub welds: Examination Level 2

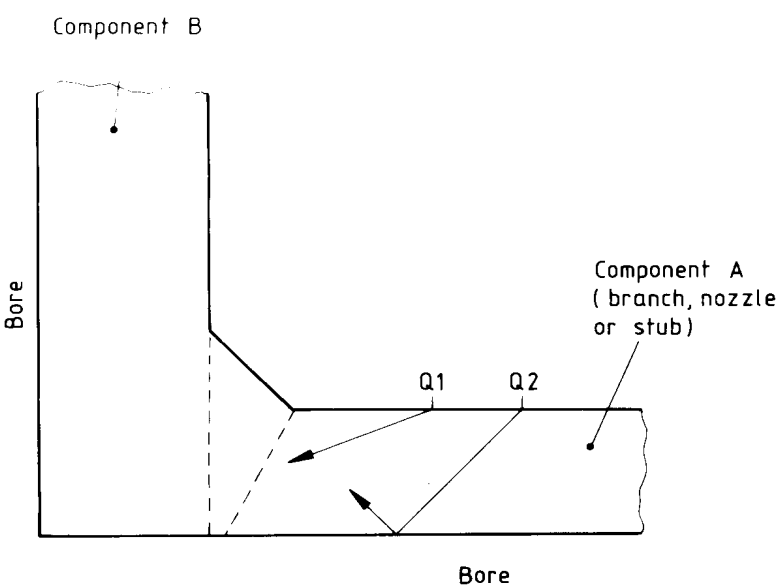
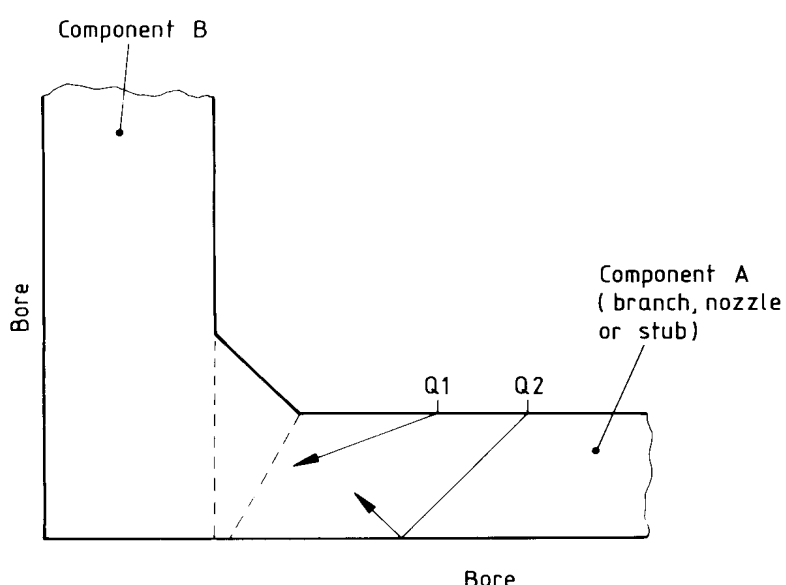
Sketch 		Surface condition: SP6. If root bead is removed the separate root scan can be omitted	
Stub 5 mm to 15 mm thick	Bores of A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of stub	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles	Scan Q1 to Q2 (0–1 skip) 2 angles
Separate root scan	Scan Q1, 1 angle	Scan Q1, 1 angle	Scan Q1, 1 angle

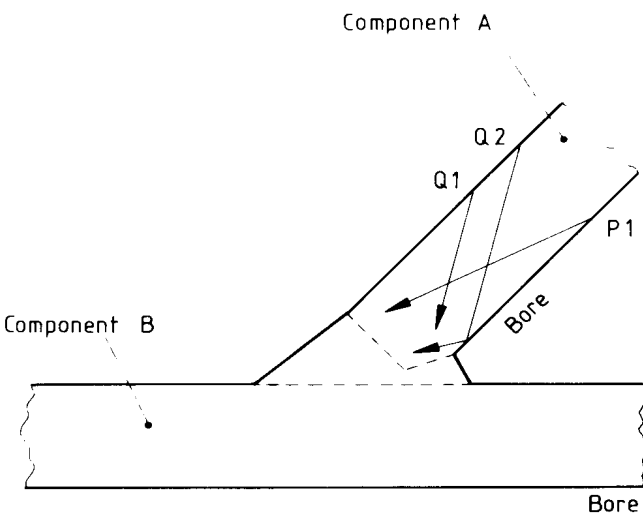
Table 14. Set-on connections. Stub welds: Examination Level 3

Sketch 		Surface condition: SP6. If root bead is removed the separate root scan can be omitted	
Stub 5 mm to 15 mm thick	Bores A and B accessible	Bore of A only accessible	Neither bore accessible
Outer surface of stub	Scan Q1 to Q2 (0–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle	Scan Q1 to Q2 (0–1 skip) 1 angle
Separate root scan	Scan Q1, 1 angle	Scan Q1, 1 angle	Scan Q1, 1 angle

13 Specific requirements for node joints

Tables 15 and 16 give the requirements for full penetration welds of node joints (see 2.3) set at up to substantially non-radial angles in one thickness range. Examination Level 1 is not considered applicable to their class of construction for reasons of geometry.

Table 15. Node joints: Examination Level 2	
Sketch	Surface condition: SP6
Material 15 mm to 100 mm thick	
Component A	Scan Q1 (0—½ skip) 3 angles Scan P1 (0—½ skip) 3 angles if bore of A is accessible; otherwise scan Q2 (½—1 skip) 2 angles
Component B	Scan S3, 1 probe Scan S1, 1 angle Scan S2, 1 angle
NOTE. Examination Level 1 is not normally applicable to this type of construction unless there has been special preparation. If the bore of the component B is not accessible for scanning, Examination Level 2 cannot be achieved.	

Table 16. Node joints: Examination Level 3	
Sketch 	Surface condition: SP6
Material 15 mm to 100 mm thick	
Component A	Scan Q1 (0—½ skip) 3 angles Scan P1 (0—½ skip) 3 angles if bore of A is accessible; otherwise scan Q2 (½—1 skip) 2 angles
Component B	—

14 Specific requirements for set-through nozzle joints

Tables 17 to 22 give the requirements for substantially radial full or partial penetration welds in one thickness range. They are sub-divided into single- or double-sided welds.

Table 17. Set-through nozzle welds. Single-sided: Examination Level 1		
Sketch		Surface condition: (a) Thicknesses up to 50 mm or with access to bore A: SP6. Root bead removed (b) Thicknesses over 50 mm and without access to bore A: SP7. Root bead removed
Nozzle 15 mm to 100 mm thick	Bore A accessible	Bore A not accessible
Nozzle surface	Scan Q2, 1 angle (or scan P1, 1 angle)	Scan Q2, 1 angle
Nozzle bore	Scan P1, 1 angle (or scan Q2, 1 angle) Scan P3, 1 probe	—
Inner/outer surface of component B	Scan S1 (0—½ skip) 2 angles, or scan R1 to R2 (0—1 skip) 2 angles if thickness of B is less than 50 mm	Scan R1 (0—½ skip) 1 angle Scan S1 (0—½ skip) 2 angles (or R2 (½—1 skip) 2 angles if thickness of B is less than 50 mm)
Weld fillet surface (where thickness > 50 mm)	—	Scan F2, 1 angle Scan F3, 1 probe

Table 18. Set-through nozzle welds. Single-sided: Examination Level 2

Sketch Surface condition: SP6. Root bead removed		
Nozzle 15 mm to 100 mm thick	Bore A accessible	Bore A not accessible
Nozzle surface	Scan Q2, 1 angle (or scan P1, 1 angle)	Scan Q2, 1 angle
Nozzle bore	Scan P1, 1 angle (or scan Q2, 1 angle) Scan P3, 1 probe	—
Inner/outer surfaces of component B	Scan S1 (0—½ skip) 1 angle, or scan R1 to R2 (0—1 skip) 1 angle	Scan S1 (0—½ skip) 2 angles, or scan R1 to R2 (0—1 skip) 2 angles

Table 19. Set-through nozzle welds. Single-sided: Examination Level 3

Sketch		Surface condition: SP6. If root bead is removed separate root scan can be omitted
Nozzle 15 mm to 100 mm thick	Bore A accessible	Bore A not accessible
Nozzle surface	—	—
Nozzle bore	Scan P3, 1 probe	—
Inner/outer surfaces of component B	Scan S1 (0—½ skip) 1 angle, or scan R1 to R2 (0—1 skip) 1 angle	Scan S1 (0—½ skip) 2 angles, or scan R1 to R2 (0—1 skip) 1 angle and scan R1 (0—½ skip) 1 angle
Separate root scan	Scan R1, 1 angle	Scan R1, 1 angle