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Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate and universal sections—Test methods and quality classification



This Australian Standard® was prepared by Committee MT-007, Non-destructive Testing of Metals and Materials. It was approved on behalf of the Council of Standards Australia on 8 December 2006.

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 - Australasian Aerospace Non-destructive Testing Committee
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 - Australian Institute for Non-Destructive Testing
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 - Australian Pipeline Association
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-

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Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through public comment period.

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Australian Standard[®]

Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate and universal sections—Test methods and quality classification

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standard New Zealand Committee MT-007, Non-destructive Testing of Metals and Materials, at the request of industry. This Standard supersedes AS 1710—1986, *Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate—Test methods and quality classification*.

After consultation with shareholders in both countries, Standards Australian and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this edition is to introduce new methods and procedures for ultrasonic testing of steels and to specify a method for examining universal beams.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA

Australian Standard

Non-destructive testing—Ultrasonic testing of carbon and low alloy steel plate and universal sections—Test methods and quality classification

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies the methods for the ultrasonic manual testing of carbon and low alloy wrought steel plate of uniform thickness, in the range 5 mm to 180 mm inclusive, and universal sections using A-scan presentation. It also classifies plate quality and defines one quality for universal sections (Level 1) in determining freedom from discontinuities.

NOTE: For guidance for the information to be supplied with the enquiry and order, refer to Appendix A.

1.2 APPLICATION

This Standard applies to the testing of steel plate and universal sections for general internal quality, using methods which specify scanning to a designated scanning system. The procedures described in this Standard enable the test operator to detect ‘laminar’ and ‘inclusion cluster’ type discontinuities. It also defines universal sections in terms of freedom from discontinuities. Section 5 allows the specifications of three quality levels for the body of the plate and one quality level for the edge zone.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard.

AS	
1929	Non-destructive testing—Glossary of terms
2083	Calibration blocks and their methods of use in ultrasonic testing
3998	Non-destructive testing—Qualification and certification of personnel
4635	Non-destructive testing—Qualification of personnel for limited applications of non-destructive testing

1.4 DEFINITIONS

For the purpose of this Standard, the definitions given in AS 1929 and the following apply:

1.4.1 Discontinuity indications

The appearance of an echo on the flaw detector screen (using ‘A’ scan presentation) between the surface position and the back echo position or a reduction of the original back echo.

1.4.2 Inclusion cluster

At the evaluation sensitivity levels specified in Clause 3.5, a discontinuity is termed an inclusion cluster if individual discontinuity echoes are at least 50 percent of the reduced back echo, or cause at least 50 percent reduction in the back echo obtained from a discontinuity free area of the plate.

1.4.3 Inclusion stringers

A discontinuity producing a linear indication of the inclusion cluster type for which any movement of the probe transverse to the direction of rolling causes a loss of indication.

1.4.4 Lamination

At the sensitivity levels specified in Clause 3.5, any discontinuity causing total reflection of acoustic energy for a probe movement of 5 mm or greater in a direction transverse to the major dimension of discontinuity.

1.4.5 Significant discontinuity

At the evaluation sensitivity levels specified in Clause 3.5, any lamination or inclusion cluster type discontinuity (see Clauses 1.4.4 and 1.4.2) with an estimated area equal to or greater than that specified in Tables 5.2 and 5.3 for the applicable quality level.

SECTION 2 EQUIPMENT

2.1 GENERAL

The ultrasonic testing system shall be capable of displaying the presence of discontinuities described in this Standard and of delineation of boundary contours of discontinuities of the plane of the plate, or web or flange of the universal section.

2.2 PROBES**2.2.1 General**

Normal compression probes designed to operate at frequencies nominally within the range of 2 MHz to 5 MHz shall be used. For scanning and evaluation, the probes shall be either twin or single crystal as specified in Table 2.1.

TABLE 2.1
TYPES OF PROBES USED FOR TESTING

Material thickness mm	Probe type and frequency
$\geq 5 \leq 15$	Twin 4 MHz to 5 MHz
$> 15 \leq 40$	Twin or single 2 MHz to 4 MHz
$> 40 \leq 180$	Single 2 MHz to 3 MHz

2.2.2 Protective diaphragms

Single probes used for contact testing may be fitted with a protective diaphragm, provided that adequate sensitivity and resolution are retained.

2.2.3 Probe size

Areas of individual transmitters or receivers shall be—

- (a) $> 50 \text{ mm}^2 < 350 \text{ mm}^2$ for twin probes; and
- (b) $> 300 \text{ mm}^2 < 650 \text{ mm}^2$ for single probes.

2.3 PRESENTATION

A scan presentation shall be used.

2.4 GAIN CONTROL

A gain control calibrated in steps not exceeding 2 dB shall be used for measuring the ratios of ultrasonic amplitudes. Suppression should not be used. If used, its effect on vertical and horizontal linearity shall be known and recorded.

2.5 COUPLANT

A couplant with good wetting characteristics and compatible with the steel under test shall be used.

2.6 EQUIPMENT CHECKS

The equipment parameters in Table 2.2 shall be checked in accordance with AS 2083.

TABLE 2.2
EQUIPMENT CHECKS

Equipment parameter	Requirement or acceptable variation
Horizontal linearity	±2% deviation over full screen width
Vertical linearity	±2 dB between 30% and 100% graticule height
Resolution	Echoes resolved from 4 mm step, (refer Clause 7.3 of AS 2083—2005)
Overall system gain	20 dB minimum

SECTION 3 PROCEDURE

3.1 SURFACE CONDITION

The surface condition of the material under test shall be such that uniform coupling is achieved over the scanned area.

3.2 SENSITIVITY

Reference sensitivity shall be at least equal to the evaluation sensitivity required for the plate thickness range being tested. Scanning sensitivity shall be reference sensitivity plus at least 6 dB.

3.3 SCANNING METHODS FOR PLATE**3.3.1 Direction scanning**

Scanning shall be transverse to the rolling direction of the plate.

NOTES:

- 1 Longitudinal scanning may be performed by agreement. (See Paragraph A2 of Appendix A).
- 2 When the direction of plate rolling is not known, scanning should be carried out in two directions mutually perpendicular at intervals specified in Clause 3.3.2.

3.3.2 Scans transverse to plate rolling direction

Scanning shall be carried out at intervals appropriate to the quality grading as follows:

- (a) Level 1—at 75 mm centres.
- (b) Level 2—at 100 mm centres.
- (c) Level 3—at 150 mm centres.

3.3.3 Scans longitudinal to plate rolling direction

When required, scanning shall be carried out at intervals appropriate to the quality grading as follows:

NOTE: For information to be supplied when ordering refer to Appendix A, Paragraph A2.

- (a) Levels 1 and 2—at 50 mm centres.
- (b) Level 3—at 100 mm centres.

3.3.4 Plate edges**3.3.4.1 Trimmed edges (*sheared, slit or gas cut*)**

For all quality levels, scanning along the plate edges shall be in a continuous band within 25 mm of the trimmed edges.

3.3.4.2 Untrimmed edges (*universal or mill edge*)

Where plates are ordered with untrimmed edges (universal or mill edge), supplementary edge scanning may still be carried out. The first 25 mm from the untrimmed edge or half the plate thickness up to a maximum of 50 mm would not be certified. The next 25 mm would be tested as specified in Clause 3.3.4.1.

3.4 SCANNING METHOD FOR UNIVERSAL SECTIONS

3.4.1 Extent of scanning

Testing shall be carried out on the outer faces of the two flanges and from one face of the web. Testing of the web flange junction from the web face is not practical due to the size of the root radius between the web and the flange.

3.4.2 Scans

Scanning shall be full width traverses, perpendicular to the direction of rolling, at each end of the universal section. The centre-line of the end scan shall be less than $2t$ from the end of the universal section and then at 150 mm intervals on the web and flanges for a minimum distance of 1200 mm, from each end of the universal section, refer to Figure 3.1. In addition a full longitudinal scan of both web/flange junctions shall be made along the flange faces for a minimum distance of 1200 mm from each end.

The detection of limited discontinuities in the web shall not include the zone within one half of the probe face dimensions from the commencement of the radius. Scanning shall extend to the edges of the universal section. However, the detection of limiting discontinuities in the universal section shall not include the edge zone within one half of the probe face dimension.

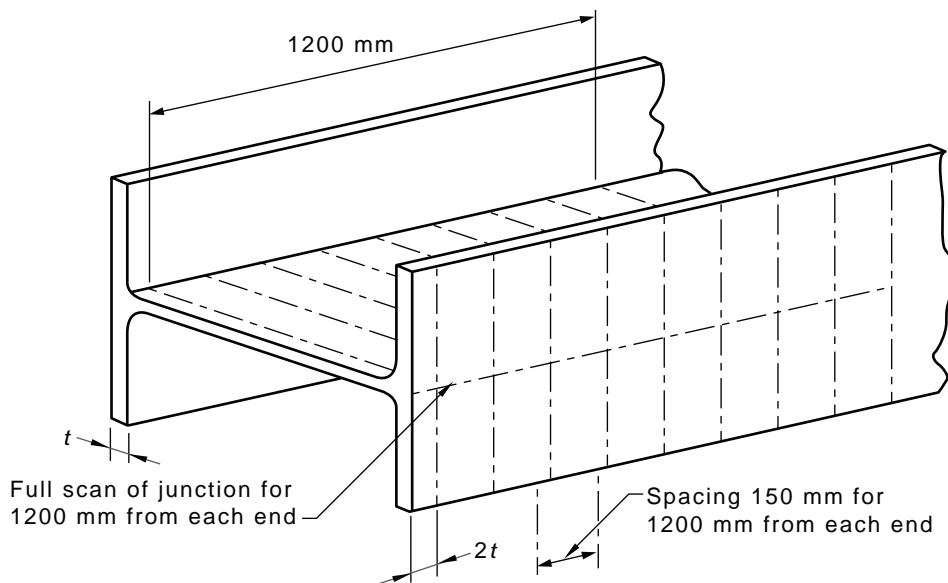


FIGURE 3.1 SCANNING PATTERN

3.5 EVALUATION—SENSITIVITY LEVELS

3.5.1 General

Classification of discontinuities and the delineation of their boundaries shall be performed at the sensitivity levels specified for the relevant plate thickness ranges in Clauses 3.5.2, 3.5.3 and 3.5.4. Sensitivity levels shall be set at a discontinuity free area of the plate or universal section under test.

3.5.2 Material thickness $\geq 5 \text{ mm} \leq 15 \text{ mm}$

For material thickness $5 \leq t \leq 15 \text{ mm}$, the gain required to bring the first back echo to full graticule height shall be used. For laminations (see Clause 1.4.4), each area over which a total loss of back echo occurs shall be determined in accordance with Section 4.

For inclusion clusters (see Clause 1.4.2), each area over which the echo amplitude exceeds 50 percent of the first back echo or reduced back echo shall be determined in accordance with Section 4. This determination shall be made when the discontinuity echo and the back echo are displayed simultaneously (see Figure 3.2).

3.5.3 Material thickness >15 mm ≤40 mm

For plate thickness $15 \leq t \leq 40$ mm, the gain required to bring the second back echo to full graticule height shall be used.

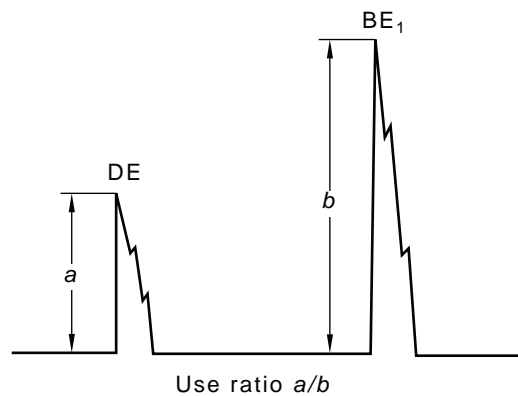
For laminations, each area over which a total loss of back echo occurs shall be determined in accordance with Section 4.

For inclusion clusters, each area over which the echo amplitude exceeds 50 percent of the second back echo or reduced back echo shall be determined in accordance with Section 4. This determination shall be made when the discontinuity echo and the back echo are simultaneously displayed (see Figure 3.3).

3.5.4 Material thickness >40 mm ≤180 mm

For plate thickness $40 \leq t \leq 180$ mm, the gain required to bring the first back echo to full graticule height shall be used. For laminations, each area over which a total loss of back echo occurs shall be determined in accordance with Section 4.

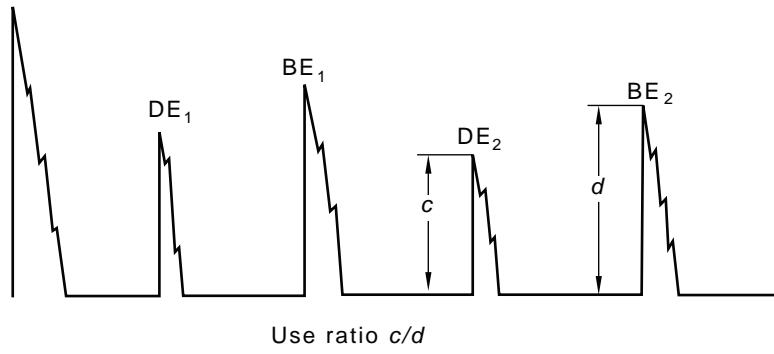
For inclusion clusters, each area over which the echo amplitude exceeds 50 percent of the first back echo or reduced back echo shall be determined in accordance with Section 4. This determination shall be made when the discontinuity echo and the back echo are simultaneously displayed. (See Figure 3.4).



LEGEND:
 DE = Discontinuity echo
 BE = Black echo

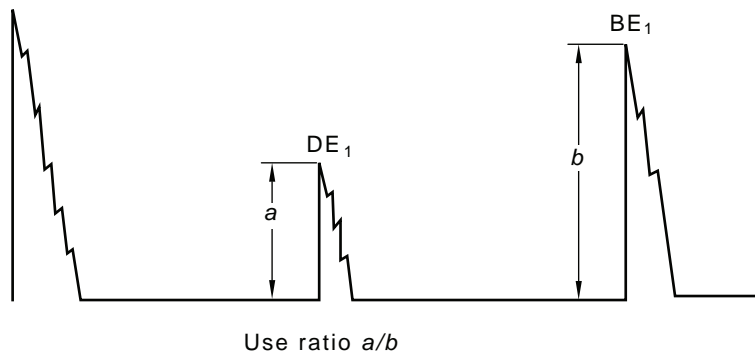
FIGURE 3.2 DISPLAY FOR $5 \text{ mm} \leq 15 \text{ mm}$ MATERIAL
 (TWIN PROBE PRESENTATION)

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LEGEND:
 DE = Discontinuity echo
 BE = Black echo

FIGURE 3.3 DISPLAY FOR >15 mm ≤40 mm MATERIAL
 (SINGLE PROBE PRESENTATION)



LEGEND:
 DE = Discontinuity echo
 BE = Black echo

FIGURE 3.4 DISPLAY FOR >40 mm ≤180 mm MATERIAL
 (SINGLE PROBE PRESENTATION)

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SECTION 4 SIZING OF DISCONTINUITIES

4.1 LAMINATIONS

The area of laminations shall be determined by the ‘6 dB drop’ method in accordance with Appendix B.

When the twin crystal probes are used for delineating areas of laminations, the acoustics separation barrier shall be at right angles to the discontinuity boundary.

4.2 INCLUSION CLUSTERS

The area of inclusion clusters shall be determined by the ‘last significant echo’ method in accordance with Appendix B.

4.3 INCLUSION STRINGERS

The length of the inclusion stringers shall be determined by the ‘6 dB drop’ method in accordance with Appendix B.

SECTION 5 QUALITY GRADING

5.1 QUALITY GRADING OF PLATES

5.1.1 Limit of discontinuities for plate

Discontinuities in steel plate supplied to comply with this Standard shall be limited to the requirements shown in Tables 5.2 and 5.3.

5.1.2 Designation of quality grades for plate

Quality grades shall be designated in accordance with Tables 5.1, 5.2 and 5.3.

TABLE 5.1
QUALITY GRADES

Quality grade	Limits of discontinuities
AS 1710 Level 1	Table 5.2 Level 1
AS 1710 Level 2	Table 5.2 Level 2
AS 1710 Level 3	Table 5.2 Level 3
AS 1710 Edge scan	Table 5.3 Level E

Where an edge is an additional requirement, it shall be designated as Level 1E, Level 2E or Level 3E, as appropriate.

TABLE 5.2
QUALITY GRADES—MAIN BODY OF PLATE

Quality level	millimetres squared					Maximum average inclusion cluster area per square metre of entire plate surface
	Maximum area of non-relevant discontinuity considered*		Maximum area of any individual laminar discontinuity	Maximum total area of discontinuity in any area of 1 m × 1 m		
	Lamination	Inclusion cluster		Lamination	Inclusion cluster	
Level 1	500	2000	1000	3000	5000	1500
Level 2	500	2000	3000	10000	16000	6000
Level 3	1000	5000	6000	20000	40000	15000

* Individual discontinuities areas below these sizes are not included in the assessment of quality grade.

TABLE 5.3
QUALITY GRADES—PLATE EDGES (TRIMMED EDGES ONLY)

Quality level	Maximum area of non-relevant discontinuity considered*	Maximum length discontinuity	Maximum area of individual discontinuity	Maximum total length of discontinuity in any 1 m edge length	Maximum average length of discontinuity per metre of edge length
	mm ²	mm	mm ²	mm	mm
Level E	300	50	500	100	50

* Individual discontinuities areas below these sizes are not included in the assessment of quality grade.

NOTE: Both laminar and inclusion cluster type discontinuities are included in the assessment of the edges.

5.2 QUALITY GRADING FOR UNIVERSAL SECTIONS—LEVEL 1 REQUIREMENTS

5.2.1 Laminar discontinuities

To comply with Level 1 requirements, the universal section shall be free from laminar discontinuities for a distance of 450 mm from each end. The remaining length shall not contain laminar discontinuities 250 mm² or greater in area. In addition, where a laminar type discontinuity is detected in the web and extends into the flange area (where proper assessment of its area cannot be carried out) the area of the universal section affected with the lamination shall not comply with Level 1.

5.2.2 Inclusion discontinuities

For inclusion discontinuities, the universal section shall be assessed over the length tested.

The area of inclusion stringers shall be its measured length (in millimetres) multiplied by 2 mm.

Only inclusion clusters and stringers in excess of 600 mm² area shall be considered.

5.2.3 Level 1 requirements

The total discontinuity area shall be the sum of—

- (a) laminar discontinuities less than 250 mm²; and
- (b) inclusion discontinuities exceeding 600 mm².

The total area of discontinuities to area tested ratio shall not exceed 1:80 for each flange face and web face.

SECTION 6 QUALIFICATION OF NON-DESTRUCTIVE EXAMINATION PERSONNEL

Ultrasonic examination, interpretation, evaluation for compliance, and report shall be made by personnel having qualifications and experience for their job function acceptable to the testing body, the manufacturer and where required by the purchaser.

Operators shall have the qualifications detailed below or shall carry out their duties under the supervision of persons responsible for examination.

Qualifications normally acceptable for the examination of components include the following:

- (a) Certification by the Australian Institute for Non-Destructive Testing (AINDT Certification Board) in accordance with AS 3998 or AS 4635 for ultrasonic thickness testing.
- (b) Equivalent qualifications.

SECTION 7 PRESENTATION OF TEST DATA

7.1 RECORD OF TEST

A record of results shall be made, and shall provide the following information:

- (a) Name of laboratory or testing authority.
- (b) Identification of the plate or universal section and job reference.
- (c) Plate or universal section identification and product standard.
- (d) Material designation according to relevant material specification.
- (e) Surface condition.
- (f) Number of this Australian Standard, i.e. AS 1710, and the scanning pattern used and evaluation level (see Clauses 3.3, 3.4 and 3.5).
- (g) Equipment, probe type and couplant.
- (h) Extent and location of nominated areas inspected.
- (i) Where recordable discontinuities are detected, a plan view showing location, outline area and identification of discontinuities, plus the test datum point.
- (j) Date and place of test.
- (k) Report number and date of issue.
- (l) Any other information specified and agreed between supplier and purchaser.
- (m) Name of certified operator.

7.2 TEST REPORT

Test reports shall contain the following information:

- (a) Name of the laboratory or testing authority.
- (b) Identification of the plate or universal section and job reference number.
- (c) Plate or universal section identification and product standard.
- (d) Material designation according to relevant material specification.
- (e) Surface condition.
- (f) Number of this Australian Standard, i.e. AS 1710, and scanning pattern used and evaluation level (see Clause 3.3, 3.4 and 3.5).
- (g) Where recordable discontinuities are detected, a plan view showing location, outline area and identification of discontinuities, plus the test datum point.
- (h) Date and place of test.
- (i) Report number and date of issue.
- (j) Any other information specified and agreed between supplier and purchaser.
- (k) Name of certified operator.

APPENDIX A
INFORMATION TO BE SUPPLIED WITH THE ENQUIRY AND ORDER
(Informative)

A1 GENERAL

This Appendix contains advice, and recommendations on the information to be supplied by the purchaser at the time of enquiry or order.

A2 INFORMATION TO BE SUPPLIED WHEN ORDERING PLATE

The purchaser should supply the following information with inquiry and order of plate.

- (a) The number of this Australian Standard, i.e. AS 1710 and the quality grade to be achieved for main body of plate and edges (see Clause 5.1).
- (b) Identification of plate, to include:
 - (i) Serial number (where available).
 - (ii) Plate dimensions (nominal ordered).
 - (iii) Edge condition (mill edge, universal edge, or trimmed edge).
 - (iv) Material specification.
- (c) Whether a longitudinal scan is required (see Clause 3.3.3).
- (d) Any departure from test method outlined in this Standard.
- (e) Whether a test report is required (see Clause 7.2).

A3 DIRECTION OF SCANNING

This Standard requires the scanning of plate to be carried out in a directions transverse to the direction of rolling.

Scanning in a longitudinal direction, i.e. parallel to the direction of rolling may only be carried out by agreement between the manufacturer and the purchaser, and must be agreed on at the time of placing the order.

When the direction of rolling is not known, scanning must be carried out in both direction to ensure that at least one direction of scan is transverse to the rolling direction.

A4 REFEREE TESTING

Where disputes arise between the purchaser and the supplier regarding the compliance of the product with this Standard and the need for referee testing becomes apparent; the purchaser and supplier should agree on a testing procedure. The probes that should be used for referee testing are listed as follows:

Material thickness, mm	Probe type and frequency
$\geq 5 \leq 15$	Twin 4 MHz
$\geq 15 \leq 40$	Single 4 MHz
$\geq 40 \leq 180$	Single 2 MHz

A5 INFORMATION TO BE SUPPLIED WHEN ORDERING UNIVERSAL SECTIONS

The purchaser should supply the following information with the inquiry and order of universal sections.

- (a) The number of this Australian Standard, i.e. AS 1710.
- (b) Identification of section to include:
 - (i) Serial number (where available).
 - (ii) Universal section dimensions (nominal ordered).
 - (iii) Material specification.
- (c) Any departure from test methods outlined in this Standard.
- (d) Whether a test report is required.
- (e) This Standard requires scanning to be carried out at the extremities of the universal section. Should the purchaser require additional regions of the beam or column to be examined, then this should be specified at the time of order.

APPENDIX B
SIZING METHODS
(Normative)

B1 PROCEDURE FOR SIZING LAMINATIONS USING 6 dB DROP TECHNIQUE

The procedure for sizing shall be as follows:

- (a) Move probe over discontinuity to obtain a maximum from the last significant echo (see Figure B1).
- (b) At this point, adjust the gain to obtain an echo between 80 percent and 100 percent graticule height (see Figure B2).
- (c) Decrease gain by 6 dB and note echo height (see Figure B3).
- (d) Return gain to original setting
- (e) Move probe over edge of discontinuity until the echo is reduced to the level noted in Step (c) (see Figure B4).
- (f) Mark positions of centre-line of the probe. (This will be the edge of the discontinuity).

B2 PROCEDURE FOR SIZING INCLUSION CLUSTER DISCONTINUITIES USING THE LAST SIGNIFICANT ECHO TECHNIQUE

The procedure shall be as follows:

- (a) Move probe over discontinuity until the last significant echo is obtained (see Figure B1).
- (b) Continue to move probe towards edge of discontinuity area until the echo just starts to decrease in amplitude.
- (c) Mark position of the centre-line of probe. (This will be edge of the discontinuity area for evaluation purposes).

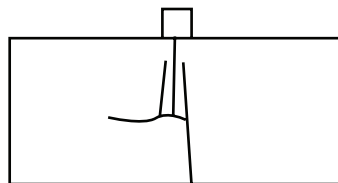


FIGURE B1 POINT AT LAST SIGNIFICANT ECHO

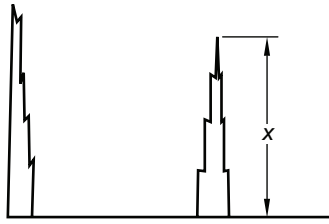


FIGURE B2 ECHO AT 80 – 100 PERCENT

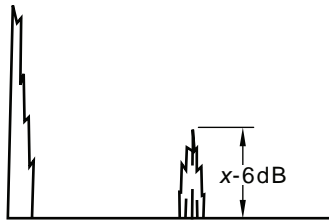


FIGURE B3 6 dB DOWN FROM SIGNAL IN FIGURE B2

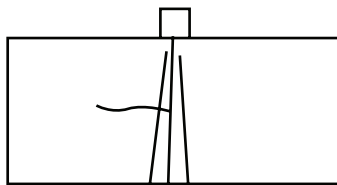


FIGURE B4 PROBE POSITION 6 dB DOWN ON DISCONTINUITY

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