

Australian Standard™

**Calibration blocks and their methods of
use in ultrasonic testing**



This Australian Standard was prepared by Committee Current, Non-Destructive Testing of Metals and Materials. It was approved on behalf of the Council of Standards Australia on 8 June 2005. This Standard was published on 8 July 2005.

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STANDARDS AUSTRALIA

RECONFIRMATION
OF
AS 2083—2005
Calibration blocks and their methods of use in ultrasonic testing

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Technical Committee MT-007 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

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NOTES

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Calibration blocks and their methods of use in ultrasonic testing

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-007, Non-Destructive Testing of Metals and Materials to supersede AS 2083—1981, *Calibration blocks and their methods of use in ultrasonic testing*. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this Standard is to specify the requirements for a range of ultrasonic calibration blocks and testing methods for non-destructive testing.

The objective of this revision is to revise the range of calibration blocks used in ultrasonic testing.

In the preparing of this edition of the Standard, the Committee decided to include requirements for reference blocks and blocks for use in the measurement of thickness of metal by acoustic energy.

Methods included for the calibration of ultrasonic testing equipment are considered by the Committee to be those based on accepted good practice and in widespread use, although the Committee is aware that other methods are used.

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STANDARDS AUSTRALIA

Australian Standard

Calibration blocks and their methods of use in ultrasonic testing

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for a range of calibration blocks and their methods of use in ultrasonic testing.

NOTE: Calibration blocks of different designs within this Standard may be used for equipment calibrations.

1.2 APPLICATION

Calibration blocks shall comply with the relevant requirements of Section 1 and with the specific requirements of the following Sections, as appropriate to the type of block:

Block No.1 (IIW).....	Section 2
Block No.2 (IOW)	Section 3
Block No.3	Section 4
Block No.4	Section 5
Block No.5 (Miniature Block).....	Section 6
Block No.6 (Resolution Block)	Section 7
Reference Blocks.....	Section 9
Block No.7 (Thickness Measurement)	Section 10

The methods of use shall be as specified in the relevant Section.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard.

AS	
1733	Methods for the determination of grain size in metals
1929	Non-destructive testing—Glossary of terms

1.4 DEFINITIONS

For the purpose of this Standard, the terms and definitions given in AS 1929 apply.

1.5 CONSTRUCTION OF BLOCKS

1.5.1 Material

Calibration blocks shall be manufactured from a normalized plain carbon steel of grain size No.5 or finer (refer to AS 1733).

Finished, machined test blocks, when tested across their minor dimension using a 4 MHz to 6 MHz, 10 mm diameter compression wave probe, shall not exhibit—

- (a) variations in attenuation of more than ± 3 dB; and
- (b) any discontinuities of reflectivity greater than 12 dB below that of a 1.5 mm diameter hole 15 mm from the surface.

NOTE:

- 1 Steel used for the manufacture of blocks should be checked for cleanliness and attenuation by ultrasonic testing.
- 2 Other materials may be used provided that the quality is suitable. It is recognized that dimensions for blocks given in this Standard apply to the compression and shear wave velocities appropriate to the type of steel specified.

1.5.2 Dimensions

All dimensions of blocks shall be accurate to ± 0.1 mm of the specified value except where otherwise specified in this Standard.

Faces of blocks shall be machined perpendicular or parallel to each other unless shown otherwise.

1.5.3 Surface finish

The surface roughness of any block face shall not exceed $0.8 \mu\text{m } R_a$.

SECTION 2 REQUIREMENTS FOR CALIBRATION BLOCK NO.1 AND METHODS OF USE

2.1 GENERAL

Calibration block No.1 is used for the calibration of equipment and probes. This section details the use of normal and angle probes in calibrating equipment and for determining probe characteristics. Section 11 details the frequency of such testing activities.

2.2 PROBES

2.2.1 Equipment and probe calibration—Normal probes

Normal probes may be used for the assessment of the following equipment and probe characteristics:

- (a) Calibration of test range.
- (b) Assessment of horizontal linearity.
- (c) Assessment of vertical linearity.
- (d) Measurement of dominant frequency.
- (e) Assessment of probe resolution.
- (f) Assessment of resolution by the measurement of pulse length.
- (g) Assessment of overall system gain.

2.2.2 Equipment and probe calibration—Angle probes

Angle probes shall be used for the following:

- (a) Calibration of test range.
- (b) Determination of probe index.
- (c) Determination of beam angle.
- (d) Setting reference sensitivity.
- (e) Assessment of beam alignment.
- (f) Measurement of dominant frequency.
- (g) Assessment of resolution by measurement of pulse strength.

NOTE: Calibration blocks of different design within this Standard may be used for equipment calibration as listed in this Section.

2.3 DIMENSIONS

Calibration block No.1 shall conform to the dimensions shown in Figure 2.1.

The sides of the block shall be engraved to permit beam angle measurement within the range of 35 degrees to 80 degrees inclusive at 5 degree intervals for angles up to 50 degrees, and at 2 degree intervals for angles greater than 50 degrees. The engraving shall be—

- (a) relative to the 50 mm diameter hole for angles from 35 degrees to 75 degrees; and
- (b) relative to the 1.5 mm diameter hole for angles from 75 degrees to 80 degrees.

2.4 METHODS OF USE—NORMAL PROBES

2.4.1 Probe positions

In the test methods which follow, reference is made to probe positions. These positions are identified as shown in Figure 2.2.

2.4.2 Calibration of test range

The test range shall be calibrated by adjusting the time base and delay controls so that multiple back echoes from a section of known thickness are displayed at appropriate graticule markings. The probe shall be placed at the following positions:

- (a) For ranges below 200 mm, at position 'H'.
- (b) For ranges of 200 mm and above, at position 'F'.

2.4.3 Assessment of horizontal linearity (Method No.1)

2.4.3.1 General

Each coarse range setting used shall be assessed for horizontal linearity using probes of such frequency and pulse length as to enable the requisite number of multiple echoes to be clearly resolved.

2.4.3.2 Procedure

The procedure shall be as follows:

- (a) For ranges up to 100 mm.
Use calibration block No.1 or alternatively block No.5 (Figure 6.1). Place the probe on the block and adjust the time base (see step (c)) so as to produce several multiple echoes within the chosen range, the preferred number being 4 or 5 echoes.
- (b) For ranges 100 mm to 500 mm.
Use the procedure given in step (a) except that the cross-section of the test block used should be large enough to prevent the appearance of delayed sidewall echoes.
- (c) Setting the time base.
Two of the repeat echo signals shall be set to coincide with appropriate scale divisions, e.g. in a 5-echo display choose the 1st and the 4th echoes, and in a 4-echo display choose the 1st and 3rd echoes. The remaining echoes should then coincide with their assigned positions.
- (d) Setting the gain.
Successive echoes should be brought to the same amplitude, i.e. 80 percent of full screen height when measuring their position against the graticule.
- (e) Recording and plotting of results.
Record the actual echo position on the screen. Plot on a graph the actual echo position as a function of the theoretical echo position as shown in Figure 2.3.

2.4.4 Assessment of horizontal linearity (Method No.2)

2.4.4.1 Procedure for test ranges 250 mm to 500 mm

The procedure shall be as follows:

- (a) Position the probe at 'H', or on any sample which complies with the requirements of Clause 2.4.4.2 below.
- (b) Adjust the time base so that not less than 10 nor more than 20 multiple back echoes are displayed on the screen.

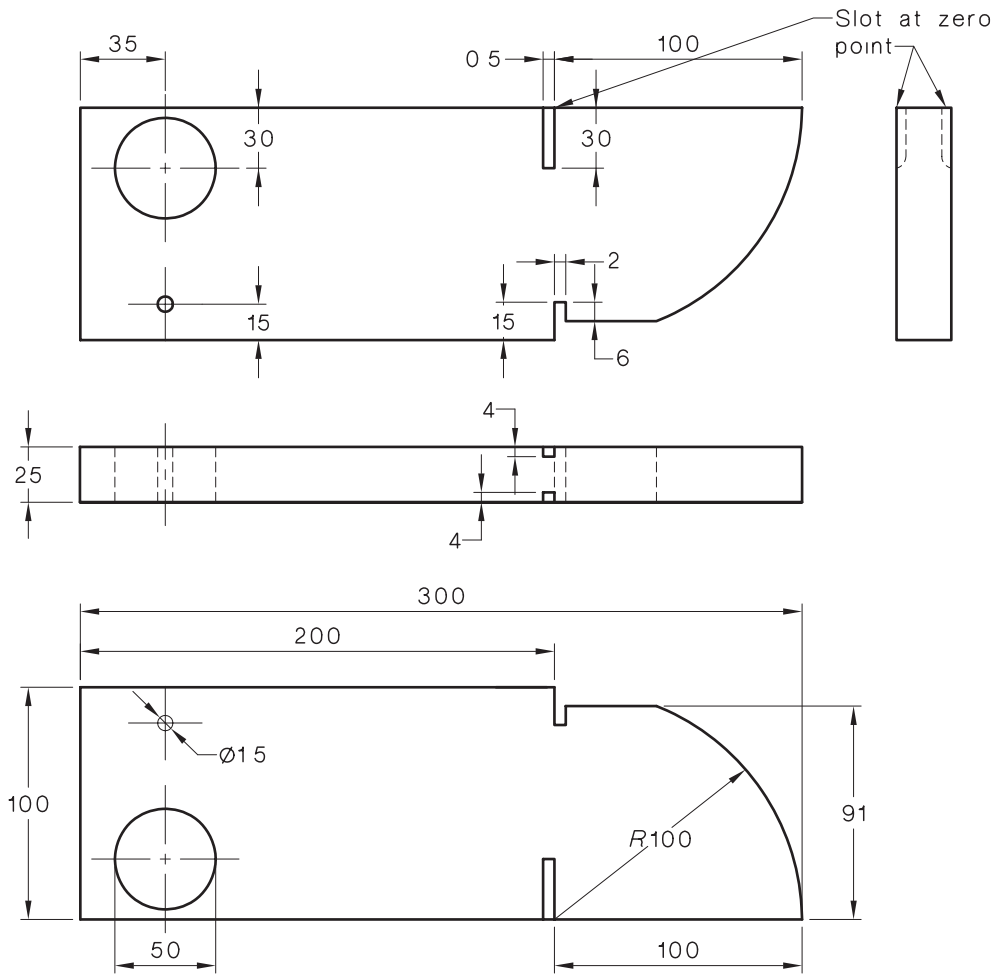
- (c) Adjust the amplitude of the first back echo to a convenient height not less than half-screen height and position its leading edge to be coincident with the first screen vertical marker as shown in Figure 2.4.
- (d) Assess the positions of the leading edges of subsequent echoes at the baseline relative to the graticule with their amplitudes adjusted to that selected above. Record these positions to an accuracy of ± 0.5 mm.
- (e) Plot the distance between each echo and its successor ($d_{(n+1)} - d_n$) as a function of its distance along the time base as shown in Figure 2.5.
- (f) Draw a straight line ('ab', Figure 2.5) parallel to the horizontal axis through the flat portion of the resultant curve.
- (g) On either side of 'ab' draw two further parallel lines at the distance corresponding to the required linearity limits. Thus, for the display represented in Figure 2.5, which is of total graticule width 100 mm, 1 percent linearity requires that all plotted points lie within 1 mm of the mean and the additional lines are therefore drawn 1 mm either side of the 'ab'.
- (h) Express horizontal linearity in terms of the percentage length of the used horizontal base line representing the relevant percentage linearity. For example, the display represented in Figure 2.5 exhibits 1 percent linearity over full graticule width and 0.5 percent linearity over 92 percent of graticule width.

2.4.4.2 Procedure for other test ranges

Other test ranges shall be assessed by applying the probe to a parallel-sided sample of material the nature and thickness of which is such as to permit the display of the number of multiple back echoes required by Clause 2.4.4.1, at the test range to be assessed. The dimensions of the sample shall be such that, with the probe used, no echoes which result from sidewall reflections are displayed.

When assessing the linearity of relatively long test ranges, it may be found that, at the high gain setting required to display the required number of back echoes, the presence of 'grass' interferes with the assessment of echo position. In such cases, suppression may be used to clarify the display provided that all echoes are assessed with the same degree of suppression introduced.

When assessing test ranges of 25 mm or less, it may be found that it is not possible to resolve the required number of back echoes at the base line. If higher frequency and/or shorter pulse length probes are not available, an assessment of linearity may be made by measuring the positions of the echo peaks. Such a procedure is at best approximate and is not recommended.



DIMENSIONS IN MILLIMETRES

FIGURE 2.1 DIMENSIONS OF CALIBRATION BLOCK NO.1

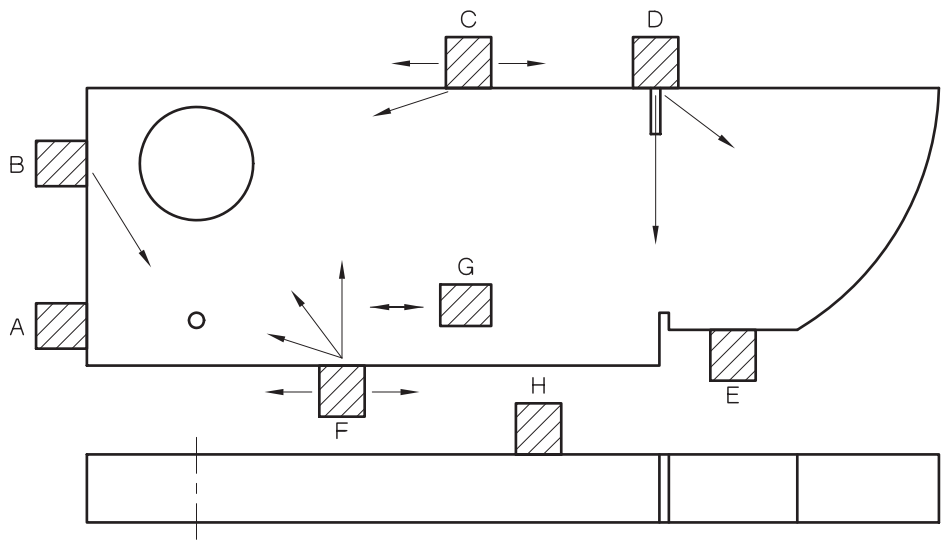


FIGURE 2.2 PROBE POSITIONS FOR BLOCK 1

2.4.5 Assessment of vertical linearity

2.4.5.1 General

Each frequency range used shall be assessed for vertical linearity using any compression wave probe compatible with the test frequency range.

2.4.5.2 Procedure

The procedure shall be as follows:

- (a) Turn all accessible suppression and/or swept gain controls to the ‘off’ position.
- (b) Select a test range of approximately 250 mm and place the probe at position ‘H’.
- (c) Select a back echo (the n th echo) which is adjacent to the centre of the screen and adjust the gain so that its height (h_n) is 5 mm, or 10 percent of graticule height.
- (d) Measure and record the height of the next succeeding back echo ($h_{(n+1)}$). Repeat this procedure, adjusting the gain so that h_n is increased by increments of 5 mm or 10 percent of graticule height.
- (e) Present the information graphically by plotting values of height (h_n) in either distance units (mm) or as a percentage on the vertical axis against values of height-ratio ($h_n/h_{(n+1)}$) on the horizontal axis as shown in Figure 2.6. Draw a line ‘ab’ which is parallel to the vertical axis and passes through the intersection of the curve and the graticule height line.
- (f) Draw an additional line parallel to ‘ab’ at a position representing the limits at which the accuracy is to be assessed determined by multiplying the value of the height-ratio represented by ‘ab’ by the appropriate factor given below.

Accuracy of assessment	Factor
± 0.5 dB	1.12
± 1 dB	1.26
± 2 dB	1.58

- (g) Express vertical linearity in terms of the graticule height range over which the plotted points lie between the last drawn lines. For example, the display represented in Figure 2.6 exhibits ± 0.5 dB linearity from 32 percent to 100 percent of graticule height and ± 2 dB linearity from 12 percent to 100 percent.

2.4.6 Measurement of dominant frequency

The procedure shall be as follows:

- (a) Position the probe at ‘D’ and use the echoes from the slot and bottom face to calibrate accurately the portion of the display in which they occur (see Note 1).
- (b) Using an unrectified display, bring any back echo into the calibrated section of the display so that its leading edge coincides with an appropriate graticule division.
- (c) Estimate the dominant frequency for the particular instrument/probe combination by counting the number of cycles occurring in 1 μ s (see Note 2).

NOTES:

- 1 The distance travelled by compression waves in steel in 1 μ s is 5.9 mm. By convention, the time base is calibrated for range so that 6 mm represents 12 mm total path length and a travel time of 2 μ s.
- 2 Figures 2.7(a) and 2.7(b) are reproductions of typical unrectified displays for a 2.5 MHz and 4 MHz probe respectively.

2.4.7 Assessment of resolution—Normal probes

The resolution of the equipment/probe combination shall be assessed as follows:

- (a) Calibrate the range to 100 mm in accordance with Clause 2.4.2 and then position the probe at 'D' (see Figure 2.2).
- (b) With the suppression control in the 'off' position, adjust the probe position to bring the echoes from the 91 mm and 100 mm beam path surfaces both to 80 percent graticule height.
- (c) Assess the resolution in accordance with the procedures specified in (i) or (ii) below:
 - (i) Assess the resolution, in millimetres, by comparing the echoes displayed from the 85 mm and 91 mm beam path presentations by use of one of the following formulas:

$$(A) \quad (91 - 85) \frac{a}{a - b} = 6 \frac{a}{a - b}$$

where a and b are determined from Figure 2.8(A), in millimetres

$$(B) \quad (91 - 85) \frac{d}{c} = 6 \frac{d}{c}$$

where c and d are determined from Figure 2.8(A), in millimetres

The higher the numerical value obtained, the poorer is the resolution. Typical forms of traces used in the assessment of resolution are given in Figure 2.8(A).

NOTE: The preferred method for the assessment of resolution is given in Section 7.

- (ii) Use the difference in display height (h) between the 91 mm and 100 mm echoes and the separating trough.

Note the calibrated gain setting (see Clause 2.4.7.1(b)). Adjust the calibrated gain to bring the trough to 80 percent graticule height and note the new setting. The difference (h) between the two gain settings, expressed in decibels, gives an assessment of the resolution of the equipment/probe combination (see Figure 2.8(B)).