INTERNATIONAL STANDARD

ISO 12721

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Non-destructive testing — Thermal neutron radiographic testing — Determination of beam L/D ratio

Essais non destructifs — Essais de neutronographie thermique — Détermination du rapport L/D du faisceau

Reference number
ISO 12721:2000(E)

Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 12721 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 5, *Radiation methods*.

Annex A of this International Standard is for information only.

Non-destructive testing — Thermal neutron radiographic testing — Determination of beam L/D ratio

1 Scope

This International Standard defines an empirical technique for the measurement of the effective collimation ratio and effective L/D of thermal neutron radiography beams for values between 20 and 1 000. The technique is based upon analysis of a neutron radiographic image and is independent of measurements and calculations based on physical dimensions of the collimator system. The device described in this International Standard has been developed and tested using Gd foil converters with a single emulsion, high resolution film in vacuum cassettes.

2 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

2.1
effective L/D ratio
one measure of the resolution capability of a neutron radiographic system; the ratio of the effective distance between the entrance aperture and the image plane (L) to the effective diameter of the entrance aperture (D)

NOTE The value measured may differ from the ratio obtained using physical dimensions.

2.2
umbra
the portion of the shadow image where the total primary beam has been intercepted by the object (as in total eclipse)

See Figure 1.

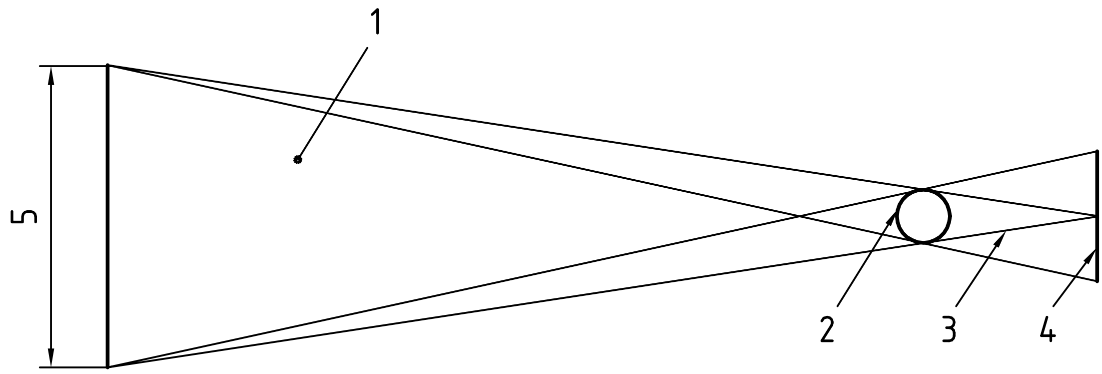
2.3
penumbra
the portion of the shadow image where only a part of the primary beam has been intercepted by the object (defines the unsharpness of the shadow)

See Figure 1.

2.4
primary beam
the beam of neutrons originating at the source and remaining essentially unscattered until it interacts with the object/detection system

3 Principle

Determination of neutron beam effective L/D ratio using the zero umbra technique is accomplished by radiographing the zero umbra device with the neutron beam to be measured and subsequently analysing the radiograph by one of three methods. Each of the three methods is based upon the determination of that point at which the umbra shadow width reaches zero.



Key

1 Radiation beam
2 Object
3 Umbra
4 Penumbra
5 Source

Figure 1 — Diagram of zero umbra configuration

4 Significance and use

The quality of a neutron radiographic image is dependent upon many factors. The L/D ratio is one of those factors. The effective L/D ratio required for specific neutron radiographic test is dependent upon the thickness of the specimen and the physical characteristics of the particular element of interest. Use of this method allows the radiographer and the user to determine and periodically check the effective collimation ratio.

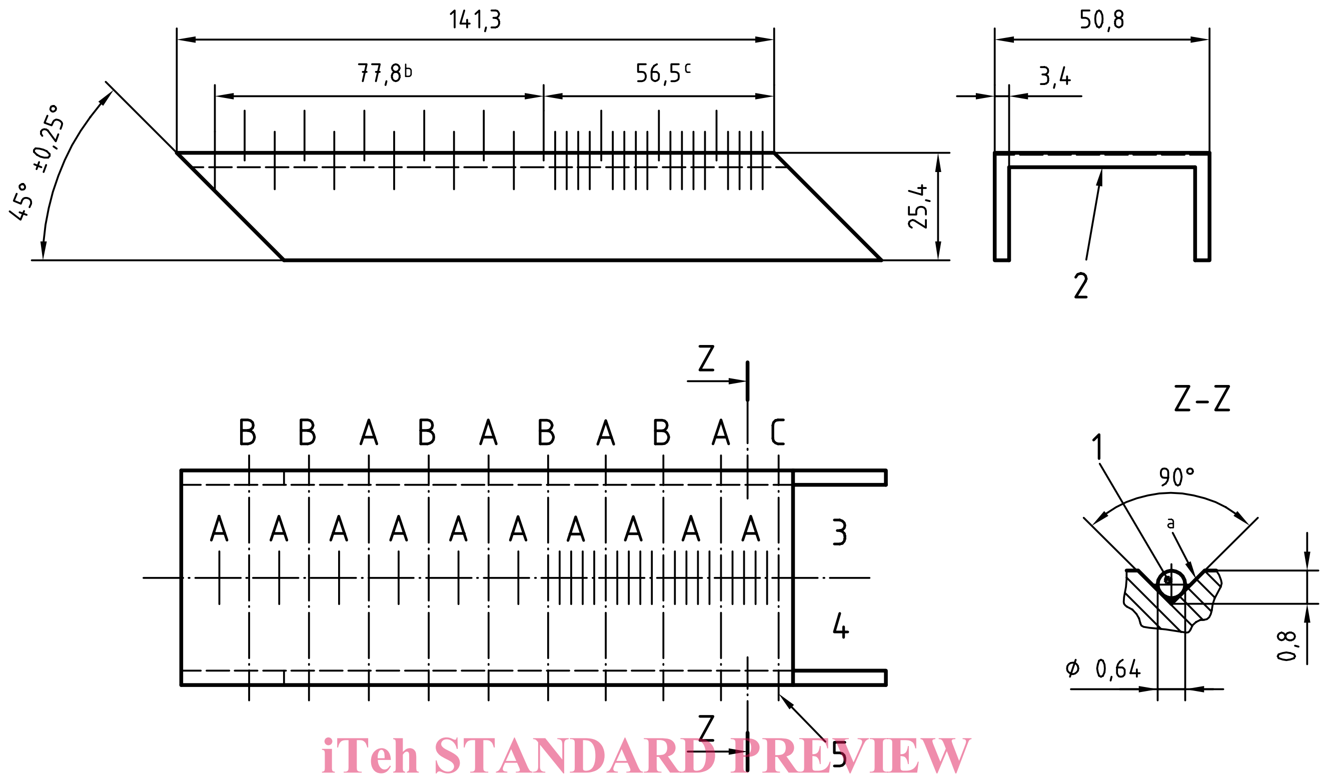
5 Apparatus

5.1 Zero umbra device, (see Figures 2 and 3) employing neutron absorbing rods positioned at various distances from the image plane.

In practice this device consists of cadmium rods located in V-grooves accurately machined in the surface of an aluminium channel section set at an angle of 45° ± 0,25° to the side support plate. Near the image plane end the V-grooves are typically machined on 2,8 mm centres. After 21 V-grooves (counting one on the end), the grooves are machined on 7,1 mm centres to the source end. The rods of diameter d, typically 0,64 mm diameter cadmium rods, are laid in the V-grooves and secured with neutron transparent adhesive tape. The aluminium channel is supported by side plates to maintain the 45° ± 0,25° angle relative to the image plane. For determination of L/D ratios greater than 150, additional offsets may be used to extend the scale as shown in Figure 4 (B unit).

If rods of diameter 0,64 mm are not available, rods of a similar but carefully measured diameter may be used, provided appropriate adjustments are made for the 0,64 mm factor in the formulae of clause 7. The "as-built" dimensions should be used in all calculations.

Dimensions in millimetres



Key

1 Rod
2 6061 T 6 aluminium
3 Nylon rods
4 Cadmium rods
5 Base line

NOTE 1 Rods at "A" positions are 10 mm each side of centreline (22 ea.).

NOTE 2 Rods at "B" positions are 20 mm each side of centreline (9 ea.).

NOTE 3 Rods at "C" positions are 25 mm each side of centreline (1 ea.).

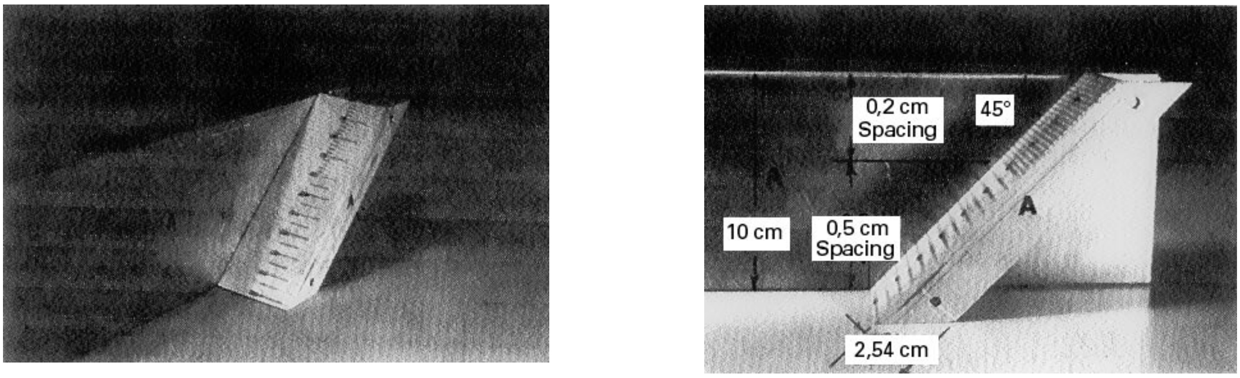
NOTE 4 All dimensions are taken from the base line in order to reduce accumulative errors.

NOTE 5 The rod arrangement shown is for a single system device. For an add-on device, to form a double system, extend the 11 spaces for 77,8 mm to 19 spaces for 134,3 mm and eliminate the close spacing (20 spaces for 56,5 mm).

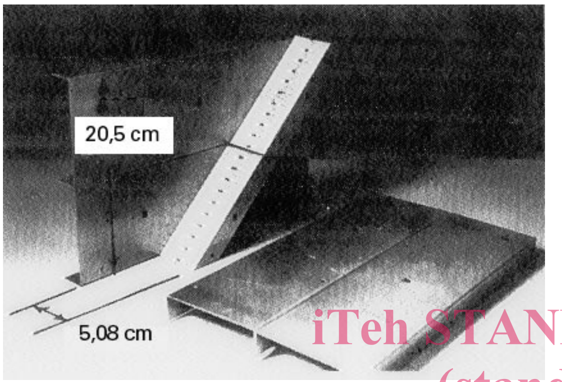
NOTE 6 Rods are held tightly in position with one layer of transparent tape.

[a] milled across entire face.
[b] 11 equal spaces (see NOTES 4 and 5).
[c] 20 equal spaces (see NOTES 4 and 5).

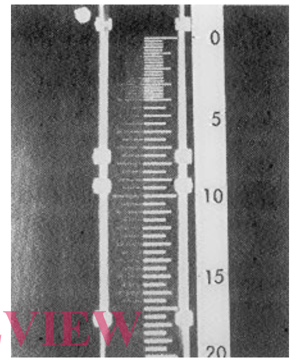
Figure 2 — Support channel subassembly with rod spacing



a) Single system image device (one side plate removed)



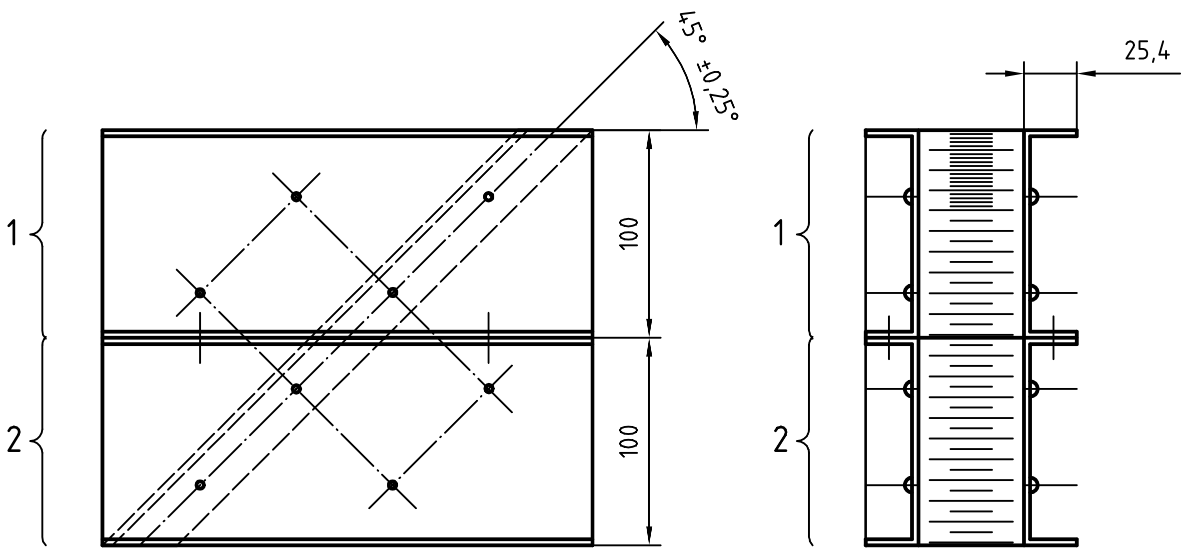
b) Double system image device (one side plate removed)



c) neutron radiograph of double system image device

Figure 3 — Zero umbra device pictorials (schematic)

Dimensions in millimetres



Key

1 A unit – single system for L/D less than 150

2 B unit – double system for L/D 150 to 300

Figure 4 — L/D apparatus assembly

6 Procedure

6.1 Place the zero umbra device against the cassette with the finely spaced rods nearest the cassette.

6.2 Align the plane of the cassette perpendicular to the axis of the neutron beam.

6.3 Expose the single-emulsion film and zero umbra device for a time span that will produce a nominal background film density of 2,5 ± 0,4.

6.4 Process the exposed film in accordance with the manufacturer's recommendations.

6.5 Analyse the resultant image in accordance with one or more of the three methods described in clause 7.

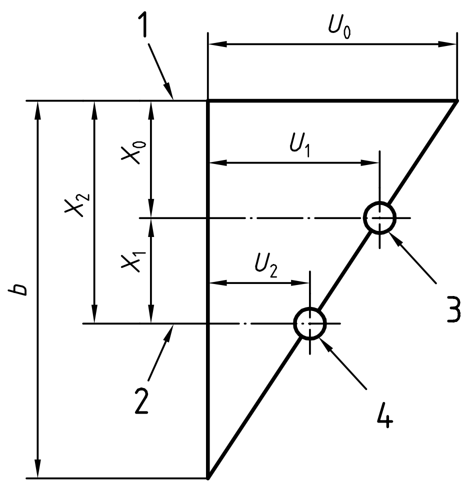
7 Data Analysis

7.1 Visual analysis

A visual determination of the effective L/D ratio shall be made directly from the neutron radiograph. When observing the individual rod images, the umbral line can be recognized as the "white" line along the centre of the rod image. This umbral line will decrease in width as the rods are located farther and farther from the film. At some point the umbral lines will disappear. Beyond this point a less intense line will appear and increase in width with increasing rod distance. Use of a 5 × to 10 × magnifier will aid in determining the point at which the umbral line disappears and then increases in width with decreased intensity. Based on this visual observation, the distance, b, between the first rod with no umbral shadow and the cassette shall be determined. The L/D ratio is as follows:

$$L / D = (b / d) \quad (1)$$

where b (Figure 5) and the rod diameter d are in the same units. This analysis method is valid up to an L/D ratio of 100. Above this value a microdensitometric analysis method shall be used.



Key

1 Film plane

2 Zero umbra

3 Rod 1

4 Rod 2

Figure 5 — Diagrammatic maths model

