INTERNATIONAL STANDARD

ISO 5948

Third edition
2018-12

Railway rolling stock material — Ultrasonic acceptance testing

Matériel roulant de chemin de fer — Essai de réception aux ultrasons

Reference number
ISO 5948:2018(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 15, *Railway rails, rails fasteners, wheels and wheelsets*.

This third edition cancels and replaces the second edition (ISO 5948:1994), which has been technically revised. The main changes compared with the previous edition are as follows:

— a test of hollow axles has been included;

— a testing technique to determine the ultrasonic permeability of axles with a reference block for choice has been added;

— more stringent acceptance levels applicable to wheels and axles used under the service condition of high train speed or high axle load have been added;

— the normative references have been updated.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Railway rolling stock material — Ultrasonic acceptance testing

1 Scope

This document specifies the test conditions and the acceptance levels for ultrasonic acceptance tests for the railway rolling stock material, such as tyres, axles and wheels.

Unless otherwise agreed, this document is applied when the product standards require mandatory ultrasonic tests or when the ordered optional tests are made mandatory (see ISO 1005-1, ISO 1005-3 and ISO 1005-6).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

ISO/TS 18173, *Non-destructive testing — General terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577 and ISO/TS 18173 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Ordering

4.1 If ultrasonic acceptance tests are optional according to this document but the purchaser requires that such tests shall be carried out this shall be specified in the order.

4.2 The types of tests, main characteristics and conditions for all kinds of products covered by this document (see Clause 1) are summarily provided in Table 1.

4.3 Where appropriate, the following details may be agreed upon at the time of enquiry and order:

a) the type(s) of ultrasonic acceptance test(s) to be carried out (see Table 1, columns 1 to 6);

b) the manufacturing stage(s) at which ultrasonic testing shall be performed (see Clause 6);

c) details of the surface condition (see 7.1);

d) the requirements for the ultrasonic instrument (see 8.1), probes (see 8.2) and other devices (see 8.3);

e) details of the reference blocks (see Clause 10 and Annexes A and B);

f) the areas to be scanned, and the volume(s) to be tested (see column 11 and Clause 11);

g) the acceptance levels (see Clause 13);

h) details of the ultrasonic permeability testing of axles (see Table 1, last row, and 8.2, 10.4, 11.4, 12.3 and 13.3), if this test is required.

When these possibilities are used for agreements, care shall be taken that the test conditions and the acceptance levels remain compatible.

4.4 If the order and its technical specification does not specify the details given in 4.3, the manufacturer may assume that the type of test indicated with an "m" in Table 1, column 2, shall be carried out, and that the normal test conditions and acceptance levels specified in this document shall apply.

Table 1 — Main characteristics and conditions of the different types of tests

1	2	3	4	5	6	7	8	9	10	11	12
Symbol	Remark[a]	Products	Main characteristics of the ultrasonic tests			Probes[b]		Reference block	Sensitivity setting (see 10.1 and subclause)	Area to be scanned[c]	Acceptance levels (see subclause)
			Purpose of the tests	Beam direction	Evaluation method	Type	Frequency MHz				
D1	m	Tyres and solid wheels	Discontinuity detection tests	Axial	Distance-gain-size (DGS), or	Longitudinal wave	2 to 10	—	10.2.1	On the face of the rim situated on the inside of the flange[d]	13.2
					Distance-amplitude curve (DAC)			Figure A.1	10.2.2		
					And loss of back-wall echo			Figure A.2	10.2.3		
D2	m			Radial	DGS, or			—	10.2.1	On the tread	
					DAC			Figure A.3	10.2.2		
Da	m	Axles	Discontinuity detection tests	Radial, unless otherwise agreed	DGS, or	Longitudinal wave	2 to 10	—	10.3.1	On the whole length[e], unless otherwise agreed upon	
					DAC			Figure A.4 or Figure A.5	10.3.2 and 10.3.3		
					And loss of back-wall echo				10.3.4		
T	o		Ultrasonic permeability tests	Axial	Comparison method (loss of back-wall echo)		To be agreed upon	To be agreed upon	10.4	To be agreed upon	13.3

[a] m = mandatory, see 4.4; o = optional test only to be carried out if so stated in the order or its appended documents.

[b] The probes shall be of a design and dimensions appropriate for the tests. Probes and ultrasonic instruments shall be selected so that the "dead zone" is limited to 30 mm. However, when testing wheel/tyre treads in a radial direction, probes and ultrasonic instruments shall be adequate to limit the "dead zone" to 10 mm. When testing hollow axles by scanning on the bore surfaces, the "dead zone" should be no more than 15 mm. When scanning curved areas (for example, the treads of wheels or tyres, the cylindrical surfaces of axles), the use of contoured probes to suit the diameter may be appropriate to ensure adequate contact area.

[c] Where discontinuities are indicated or where abnormal losses in back-wall echo height occur, scanning should also be carried out on other areas of the surface, if this seems appropriate for estimating the sizes of discontinuities.

[d] Unless otherwise specified, testing from the opposite side of the flange is also permitted for immersion testing.

[e] In order to effectively detect the potential discontinuity near the external surface, the solid axle and hollow axle before boring shall be scanned around 360° on the external surface except certain parts (such as fillets and grooves). If the hollow axle needs to be tested after boring, it shall be scanned on the bore surface, unless otherwise agreed.

5 Location of testing and qualification of the personnel

When ultrasonic tests are specified for the acceptance of the products, these shall be carried out at the manufacturer's works, in the presence of the purchaser's representative if so requested.

The test personnel shall be qualified in accordance with ISO 9712 or an equivalent that is acceptable to both the purchaser and the manufacturer.

6 Time of testing

6.1 Ultrasonic testing shall be performed after the final heat-treatment and before the corrosion protection is applied.

6.2 When choosing the time of testing, it shall be taken into consideration that, depending on the heat-treatment conditions, discontinuities can occur during a certain period after the steel has reached ambient temperature.

6.3 The ultrasonic permeability testing of axles shall be carried out following axle end facing and centre drilling but before marking and drilling cap screw holes, and the ultrasonic permeability testing of hollow axles shall be carried out before boring.

6.4 Unless otherwise agreed, for hollow axles the manufacturer may choose to perform radial ultrasonic testing before boring or after boring. If the manufacturer chooses to test before boring, it shall be taken into consideration that there can be differences between the test results by scanning on the external surface before boring and by scanning on the bore surface after boring. How to deal with the possible differences should be agreed upon at the time of enquiry and order.

7 Surface condition of the products

7.1 Unless otherwise agreed, independent of the surface condition in which the product is to be delivered, ultrasonic testing may be carried out either in the unmachined or machined condition, provided that the requirements of 7.2 to 7.4 are observed.

7.2 The surface condition of both the scanning and reflecting surfaces of the products shall be such that there is no interference with the test.

7.3 When ultrasonic acceptance tests are carried out on products in the unmachined condition, any scale shall tightly adhere to the metallic surface and shall be sufficiently smooth to meet the conditions of 7.2.

7.4 When products are machined before ultrasonic testing, the operation shall ensure that a surface finish suitable for ultrasonic testing is achieved.

8 Characteristics of test equipment

8.1 Ultrasonic instrument

A suitable ultrasonic pulse-echo instrument, which conforms to the applicable standard or technical specification, shall be used.

The ultrasonic instrument shall have a minimum capability for testing at frequencies from 1 MHz to 10 MHz.

8.2 Probes

The suitable probes specified in Table 1, columns 7 and 8, and which conform to the applicable standard or technical specification, shall be used.

For axles to be tested for the ultrasonic permeability, the frequency of the probe shall be specified in the technical specification.

8.3 Other devices

Adequate devices shall be available to ensure that products not conforming to the acceptance levels are identified accordingly.

An automated ultrasonic testing technique should preferably be applied.

9 Couplants

9.1 In order to ensure that adequate transmission of ultrasound is obtained between the probe and the test object, a suitable couplant shall be applied.

9.2 The same couplant shall be used for the setting of the ultrasonic pulse-echo instrument and for carrying out the tests.

10 Setting of the sensitivity of the ultrasonic instrument

10.1 General

The setting of the sensitivity of the ultrasonic instrument shall be carried out under the same conditions (see 8.2 and Clause 9) as the tests.

When testing to detect discontinuities, in each case the sensitivity shall be set so that, within the area to be scanned outside the "dead zone" (see Table 1, footnote b), a reference reflector with a diameter specified as the acceptance level in Clause 13 can be detected positively, irrespective of its distance from the surface to be scanned.

Reference blocks for establishing the distance-amplitude curve (DAC) and setting the sensitivity according to 10.2 and 10.3 are specified in Annex A.

The testing sensitivity shall be checked using the reference blocks at least every 8 h of testing and on completion of testing. Checks shall also be carried out whenever any part of the test equipment is changed, or whenever any change in the testing sensitivity is suspected.

10.2 Sensitivity setting for wheels or tyres

10.2.1 For wheels and tyres to be tested with the sound beam in the axial or radial direction and to be evaluated by the distance-gain-size (DGS) method, the sensitivity shall be set with the help of the DGS diagram and the back-wall echo occurring when axially testing the tyre or the wheel rim.

10.2.2 For wheels and tyres to be tested in the axial or radial direction and to be evaluated by the DAC method, the DAC shall be prepared and the sensitivity shall be set with the help of a reference block of the type respectively shown in Figure A.1 or Figure A.3.

10.2.3 For wheels and tyres to be tested for the loss of back-wall echo in the axial direction, the sensitivity shall be set with the help of a reference block of the type shown in Figure A.2.

10.3 Sensitivity setting for testing axles in the radial direction

10.3.1 For axles to be tested radially and to be evaluated by the DGS method, the sensitivity shall be set with the help of the DGS diagram and the occurring back-wall echo.

10.3.2 For solid axles to be tested radially by the DAC method, the DAC shall be prepared and the sensitivity shall be set with the help of a reference block of the type shown in Figure A.4. If the axle has too many sections of diverse diameters, transfer corrections for curved surfaces may be applied.

10.3.3 If hollow axles need to be tested radially after boring, the DAC shall be prepared and the sensitivity shall be set with the help of a reference block of the type shown in Figure A.5.

10.3.4 For axles to be tested for the loss of back-wall echo in a radial direction, the sensitivity shall be set with the help of a reference block of the type shown in Figure A.4 or Figure A.5.

10.4 Sensitivity setting for determining the ultrasonic permeability of axles

There are two optional techniques to determine the ultrasonic permeability of axles as described in the following a) and b). The choice between them shall be agreed upon at the time of enquiry and order.

a) Comparison with a reference axle.

   Using this technique, the height of the first back-wall echo obtained on a reference axle admitted by the purchaser shall be set at 90 % of the full screen height.

b) Comparison with a reference block.

   Using this technique, the sensitivity setting shall be performed on a reference block with a specified flat-bottomed hole, and the echo height of the flat-bottomed hole shall be set at the specified screen height.

   A recommendation for the reference block for determining the ultrasonic permeability of axles is given in Annex B.

11 Scanning

11.1 Each individual product shall be scanned. Unless otherwise agreed in the order or its appended documents, the scanning shall be carried out on the areas specified in Table 1, column 11.

11.2 The probe(s) shall be arranged and/or moved over the test surface to ensure that the maximum possible volume of the test object is scanned by the ultrasonic beam.

11.3 Adequate coupling between the probe and the test object shall be maintained during scanning.

11.4 For axles where the ultrasonic permeability has to be determined, the scanning area shall be specified.

NOTE The specified scanning area for the ultrasonic permeability testing can vary with different types of axles.

12 Evaluation of indications

12.1 Estimation of the size of discontinuities

When any significant discontinuity is indicated during scanning, the operator shall use one of the following two methods to estimate its size.

a) DGS method.

   In this case, the maximum echo height from a discontinuity is expressed as the equivalent diameter of a disk reflector perpendicular to the beam axis and at the same sound path length by applying a DGS diagram.

b) DAC method.

   In this case, the maximum echo height from a discontinuity is expressed as the number of dB above or below the one from a specified flat-bottomed hole at the same sound path length by applying a DAC.

Other than the methods shown above, unless otherwise agreed and except in cases of dispute, the "one hole comparison method" may be used. In this case, the sensitivity should be set so that the echo of the flat-bottomed hole situated most distant from the probe is equal to 50 % of the screen height. Each signal greater than this 50 % limit is regarded as a reason for rejection, independent of the distance of the relevant discontinuity from the probe. Products rejected on the basis of the results of the one hole comparison method may, for a final decision on rejection or acceptance, be retested according to the DGS method or the DAC method.

12.2 Evaluation of the loss of back-wall echo

If the height of the first back-wall echo obtained on the test object during scanning is lower than the one obtained on the corresponding reference block during the sensitivity setting in accordance with 10.2.3 or 10.3.4, it is necessary to confirm that the loss of back-wall echo is not due to the insufficient coupling or to a normal geometrical feature of the test object, and to investigate whether the loss of back-wall echo is caused by the presence of a discontinuity.

12.3 Determination of the ultrasonic permeability of axles

The ultrasonic permeability is determined by comparing the height of the first back-wall echo obtained on the tested axle with the acceptance level in accordance with 13.3.

13 Acceptance levels

13.1 General

There are several applicable classes of different acceptance levels for choice in the light of service conditions (such as the train speed and/or axle load during operation).

13.2 Discontinuity detection

In the case of discontinuity detection tests on wheels, tyres or axles, the echo height of the discontinuity shall not be greater than the echo height of a flat-bottomed hole situated at the same distance from the probe as the discontinuity and with a diameter as specified in Table 2.

Unless otherwise agreed, the loss of the back-wall echo due to internal discontinuities shall not be greater than 4 dB on axial tests of wheels and tyres, and radial tests of axles.

Centre-line discontinuities are permitted in axles, within a zone to be agreed upon at the time of enquiry and order, on condition that these discontinuities will not prevent or interrupt subsequent testing to be carried out in service.

Table 2 — Diameter of the flat-bottomed hole as the acceptance level

Type of test	**Diameter of the flat-bottomed hole** (mm)
Axial and radial test of wheel or tyre	3 or 2 or 1[a]
Radial test of axle	3 or 2[a]
[a] Which value is used as the acceptance level shall be specified in the technical specification.	

13.3 Ultrasonic permeability of axles

The height of the first back-wall echo obtained on the axles being tested shall be no less than a certain per cent of the full screen height as the acceptance level, which shall be specified in the technical specification.

Moreover, the noise level beyond the first 15 % of the time base shall not exceed 5 % of the full screen height.

Annex A
(normative)

Reference blocks for discontinuity detection tests

A.1 General

A.1.1 Reference blocks shall have acoustic properties and test surface finish equivalent or similar to that of the products to be tested.

A.1.2 It is recommended that the reference blocks for testing wheels, tyres and axles are made of the equivalent kind of products to be tested, and remain the same surface finish.

A.1.3 The material to be used to fabricate reference blocks shall be ultrasonically tested and be free from any discontinuity which can affect the procedure of range and sensitivity setting.

A.1.4 The tolerances of reference blocks may refer to the applicable standard, or shall conform to the technical specification agreed upon at the time of enquiry and order.

A.2 Figures of reference blocks

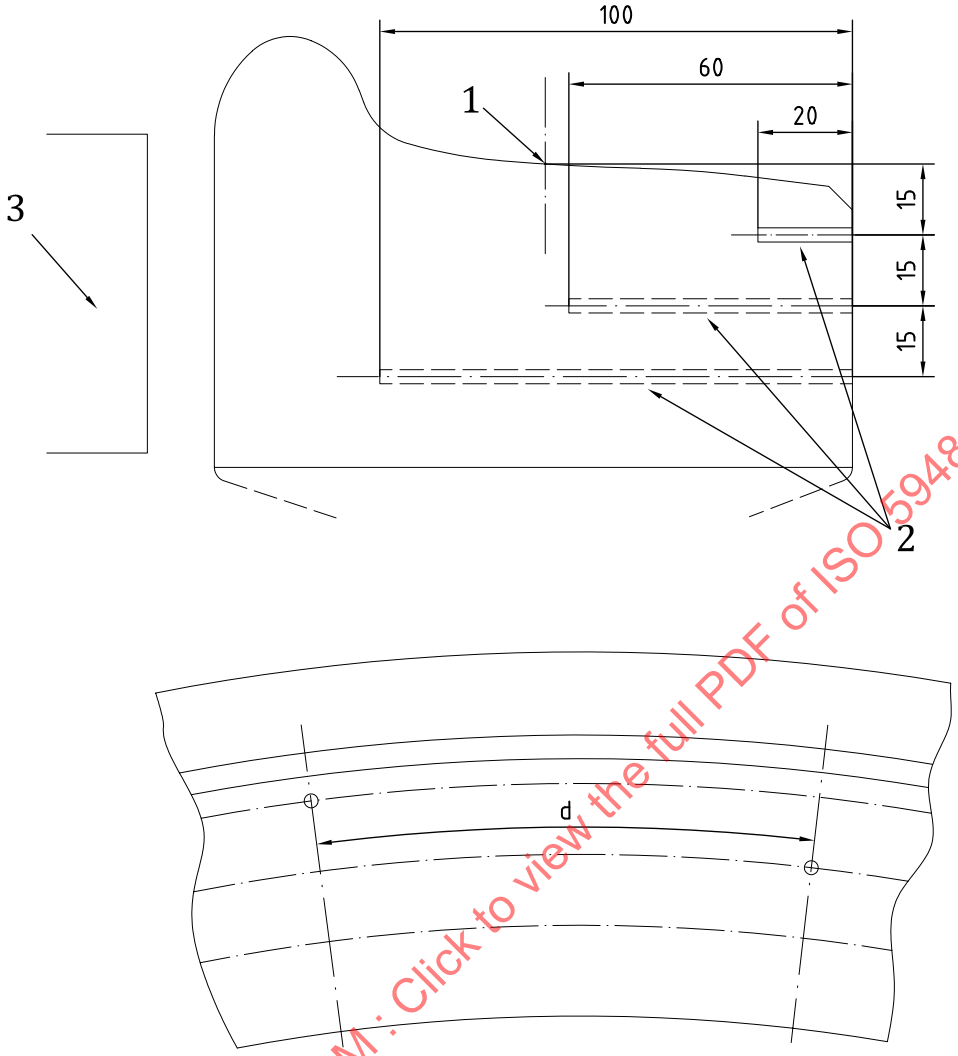
A.2.1 The reference blocks for discontinuity detection tests on wheels, tyres and axles are shown in Figures A.1, A.2, A.3, A.4 and A.5.

A.2.2 The diameter of the flat-bottomed holes in reference blocks for testing by the DAC method shall be the same as the acceptance level (see 13.2).

A.2.3 The diameter of the taper-bottomed holes in reference blocks for evaluating the loss of back-wall echo shall be selected so that the loss of back-wall echo is equal to 4 dB, unless otherwise agreed.

A.2.4 All figures are typical designs. They may vary depending on the design of the product to be tested.

Dimensions in millimetres



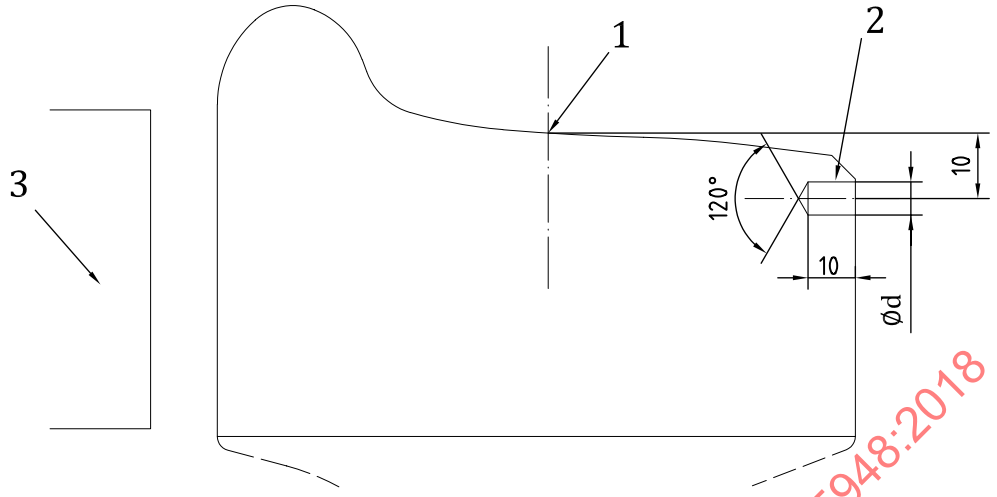
Key

1 rolling circle
2 flat-bottomed hole
3 probe
d minimum 100 mm (circumferential distance between the two adjacent FBHs)

NOTE If the height of the wheel rim/tyre is smaller (such as less than 50 mm), the radial distance between two adjacent holes may be less than 15 mm. The reference block design may vary depending on the height and width of wheel rim and tyre to be tested.

Figure A.1 — Reference block for axial testing of wheels and tyres by the DAC method

Dimensions in millimetres

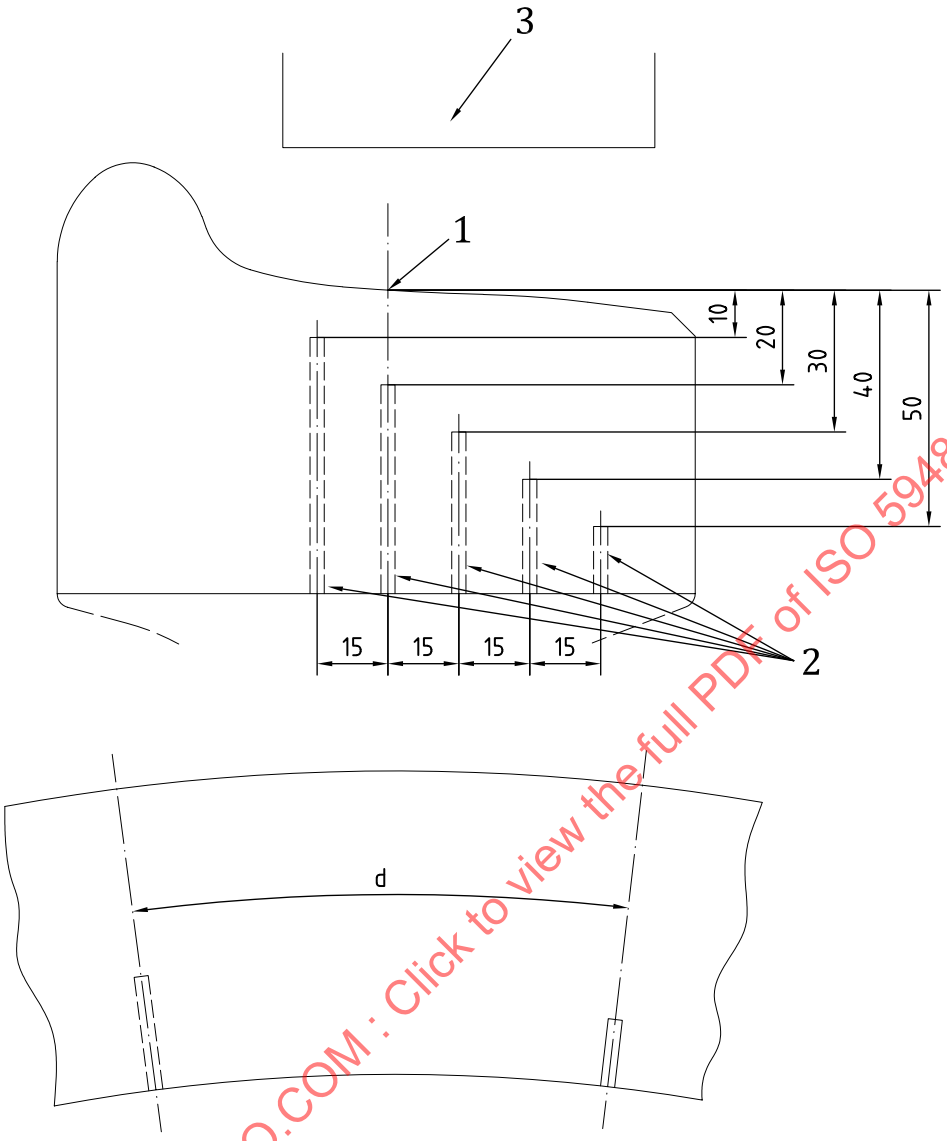


Key

1 rolling circle
2 taper-bottomed hole
3 probe

Figure A.2 — Reference block for axial testing of wheels and tyres by evaluating the loss of back-wall echo

Dimensions in millimetres



Key

1 rolling circle
2 flat-bottomed hole
3 probe
d minimum 100 mm (circumferential distance between the two adjacent FBHs)

NOTE If the height of the wheel rim/tyre is smaller (such as less than 50 mm), the number of holes may be reduced to 4 or 3. The reference block design may vary depending on the height and width of wheel rim and tyre to be tested.

Figure A.3 — Reference block for radial testing of wheels and tyres by the DAC method