International Standard 1005/3

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Railway rolling stock material — Part 3 : Axles for tractive and trailing stock — Quality requirements

Matériel roulant de chemin de fer — Partie 3 : Essieux-axes pour le matériel moteur et pour le matériel remorqué — Prescriptions de qualité

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 1005/3 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in November 1980.

It has been approved by the member bodies of the following countries :

Austria	Iran	Romania
Bulgaria	Italy	Spain
China	Japan	Sweden
Czechoslovakia	Korea, Dem. P. Rep. of	Switzerland
Egypt, Arab Rep. of	Korea, Rep. of	Turkey
Finland	Netherlands	United Kingdom
Germany, F.R.	New Zealand	USSR
Hungary	Poland	Venezuela

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
Belgium
France
India
South Africa, Rep. of

This International Standard cancels and replaces ISO Recommendation R 1005/3-1969, of which it constitutes a technical revision.

Printed in Switzerland

Railway rolling stock material — Part 3 : Axles for tractive and trailing stock — Quality requirements

1 Scope and field of application

1.1 This part of ISO 1005 specifies requirements for the manufacture and supply of axles for tractive and trailing stock of unalloyed and alloyed steels in accordance with table 1 and clause 4.

1.2 In addition to this part of ISO 1005, the requirements of ISO 404 are applicable.

2 References

ISO 82, *Steel — Tensile testing.*

ISO 83, *Steel — Charpy impact test (U-notch).*

ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel.* [1]

ISO 404, *Steel and steel products — General technical delivery requirements.*

ISO 643, *Steels — Micrographic determination of the ferritic or austenitic grain size.* [2]

ISO 5948, *Railway rolling stock material — Ultrasonic acceptance testing.*

NOTE — Pending publication of these revisions as International Standards, it will be necessary for the relevant requirements to be agreed by the purchaser and the manufacturer.

3 Information to be supplied by the purchaser

The purchaser shall supply the following information in his enquiry and order :

a) the number of this International Standard;

b) the grade of steel (see 4.1 and table 1);

c) the type of heat treatment (see 4.2 and 6.5);

d) the degree of finish (see 4.3);

e) if a check analysis is required (see 5.1.2);

f) if a microstructure test for uniformity and grain size is required (see 5.2.2.2 and table 3);

g) the types of tests to be carried out (see 5.2.2.3, 7.3.1, 7.7.3.5, 7.8.5 and table 3);

h) the dimensional characteristics (see 5.4.1);

j) if any special marking is required (see 5.5);

k) the conditions of inspection required (see 7.1);

m) if special preparation and sampling of test pieces is required (see 7.7.2);

n) the method of protection against corrosion (see 8.1);

p) if the conditions of guarantee are to be agreed (see clause 9).

4 Classification

The axles shall be specified in the order or its appended documents according to the grade of steel used, the heat-treatment condition of delivery and the degree of finish and any optional tests or inspection required (see table 3, column 4).

4.1 Steel grades

This International Standard specifies the following grades of steel in accordance with the properties given in table 1 :

a) unalloyed steels A1 and A2;

b) alloyed steels A3 and A4.

1) Under revision.

2) At present at the stage of draft. (Revision of ISO/R 643.)

4.2 Types of heat-treatment condition on delivery

The axles shall be supplied

a) untreated [no symbol[1)]] — all grades, or

b) normalized or normalized and tempered (symbol N) — grades A1 and A2, or

c) quenched and tempered (symbol T) — grades A1, A2, A3 and A4.

Irrespective of the heat-treatment condition ordered, where no effective degassing has been carried out, suitable precautions, which may include for example slow cooling, shall be taken to avoid the formation of flakes (hydrogen cracking). If so requested, the representative of the railway authority shall be informed of the precautions taken.

4.3 Degree of finish

The degree of finish on delivery may be as follows :

a) rough-forged or rough-rolled when the axle has been obtained by hot-forging or rolling, may or may not have been subjected to consecutive heat treatment, and has not yet undergone any machining whatsoever;

b) rough-machined, when the axle has received no final machining, but has been rough-machined on all or only certain portions which have to be machined;

c) half-finished, when the axle has received final machining on certain sections which have to be machined and are considered as finished, the other portions indicated as rough-machined, having received no final machining;

d) finished, when all portions of the axle having to be machined have undergone their final machining.

Table 1 — Grade of steel, chemical composition, types of heat-treatment in delivery condition and mechanical properties

Grade of steel	Chemical composition[1)], (*m/m*) max.									Heat-treatment in delivery condition[2)]	Mechanical properties[3)]			
	C	Si	Mn	P	S	Cr	Cu	Mo	V		R_e[4)] N/mm² min.	R_m N/mm²	A % min.	KU J min.[5)]
A1[6)]	0,40	0,50	1,20	0,04	0,04	0,30	0,30	0,08	0,05	N	300	520 to 650	22	25
										T	350	550 to 700	24	40
A2	0,50	0,50	1,20	0,04	0,04	0,30	0,30	0,08	0,05	N	360	600 to 750	17	20
										T	390	620 to 770	19	25
A3	0,40	0,50	1,60	0,04	0,04	0,50	0,30	0,40	0,10	T	420	650 to 800	19	40
A4	0,30	0,50	0,80	0,04	0,04	1,20	0,30	0,35	0,10	T	420	650 to 800	19	40

1) See 5.1.1.

2) N = normalized or normalized and tempered, T = quenched and tempered (see 4.2, footnote 1, and 7.7.2, paragraph 2).

3) R_e = yield strength (see footnote 4), R_m = tensile strength, A = percentage elongation after fracture ($L_o = 5{,}65\sqrt{S_o}$), KU = impact strength for ISO U-notch test piece at 20 °C. 1 N/mm² = 1 MPa.

4) The requirement for R_e shall be regarded as complied with, if either the upper yield stress R_{eH} or the 0,2 % non-proportional proof stress $R_{p0,2}$ or, where the measured value is under 600 N/mm², the 0,5 % total elongation proof stress $R_{t0,5}$ is equal to or greater than the value specified for R_e.

5) Mean value of three tests : one of the individual results may be lower than the minimum value as specified in the table, provided that it is not less than 70 % of this minimum value.

6) If this steel is ordered in the untreated (hot-rolled or hot-forged) condition under the grade designation A0 instead of A1, then no tests on heat treated test pieces (see table 3) are to be carried out and the following mechanical properties apply to the delivery condition :

R_e = 280 N/mm² min., R_m = 500 to 650 N/mm², A = 20 % min., KU = 20 J min.

1) With the exception made in table 1, footnote 6, the following applies where the untreated condition is ordered :

a) The purchaser may specify an analysis range. In this case, the responsibility for the attainment of the required mechanical properties is that of the works carrying out the heat treatment.

b) If any analysis range is not ordered, the manufacturer should ensure, to the purchaser's satisfaction, that axles which are delivered in the untreated condition for subsequent heat treatment, are capable of meeting the mechanical properties specified in table 1.

5 Requirements

5.1 Chemical composition

5.1.1 The maximum contents of the various elements are given in table 1. These values apply to the cast analysis. In the case of Cr, Cu, Mo and V, the values apply to product analysis; however, these elements are normally verified by cast analysis.

5.1.2 If a check analysis on the product is required, this shall be stated on the enquiry and order. In this case the product analysis may deviate from the requirements in table 1 by the values given in table 2.

Table 2 — Permissible deviations between the specified cast analysis and product analysis

Element	Maximum value specified for cast analysis % (*m/m*)	Permissible deviation in the product analysis % (*m/m*)
Carbon	0,30 to 0,50	+ 0,03
Silicon	0,50	+ 0,04
Manganese	0,80	+ 0,06
	1,20	+ 0,08
	1,60	+ 0,10
Phosphorus	0,04	+ 0,005
Sulphur	0,04	+ 0,005

5.2 Physical properties

5.2.1 Appearance[1]

5.2.2 Soundness

5.2.2.1 General

The axles shall be sound throughout and without any defects detrimental to their use.

5.2.2.2 Microstructure

The microstructure of the normalized or quenched and tempered axles shall be uniform and typical for the heat treatment specified. When determined in accordance with ISO 643, the grain size shall not be coarser than 5.

5.2.2.3 Other characteristics for appearance and soundness

If, for the verification of soundness, magnetic particle flaw detection, ultrasonic tests (see ISO 5948), or macrostructure examinations by sulphur prints are specified in the order or its appended documents, then the acceptance criteria for the required tests shall be also specified in the order or its appended documents.

For the macro-examinations by sulphur prints, the album given in the annex to this part of ISO 1005 shall, if not otherwise agreed, be used as the basis for acceptance.[2]

5.3 Mechanical properties

The mechanical properties of the axles after heat treatment shall be those shown in table 1.

5.4 Dimensional characteristics

5.4.1 The dimensions shall be in accordance with those required by the order or its appended documents within the permitted tolerances.

5.4.2[3]

5.5 Manufacturer's brand marks (see 6.4)

The marks with their specified dimensions shall be stamped either hot or cold in the positions given in national standards, the order or its appended documents.

Unless otherwise specified, each axle shall be stamped with the following marks :

a) manufacturer's mark;

b) cast number;

c) grade of steel and heat-treatment condition (N for normalized, T for quenched and tempered, nothing for untreated axles) (see the exception given in footnote 6 of table 1);

d) date of manufacture (month and the last two figures of the year of manufacture).

Unless otherwise specified, the positions of the marks shall, with the exception of finished axles, be lightly stamped to a depth which will allow them to be completely removed at the finishing operations.

Stamps with acute-angled character forms may not be used if the marks are not stamped on the end-face.

1) An International Standard dealing with the surface finish of the seats for interference fits of the axles, the journals for roller bearings, the body of the axles, and the shoulders in particular, is in preparation.

2) The album will be incorporated in this document at the time of final publication.

3) An International Standard dealing with the tolerances on dimensions and form is in preparation.

6 Manufacture

6.1 Steelmaking process

The axles shall be made from steel produced by open hearth, electric arc or basic oxygen processes; other processes may be used by agreement between the manufacturer and the purchaser. The steel shall be killed in the furnace or in the ladle.

6.2 Manufacture of the axles

The axles shall be manufactured from ingots transformed

a) by forging only (see 6.2.1), or

b) by rolling only (see 6.2.2), or

c) by rolling followed by forging (see 6.2.3).

6.2.1 Axles obtained by forging only

The maximum cross-sectional area of the rough-forged axle shall be not greater than one-third of the minimum cross-sectional area of the original ingot.

6.2.2 Axles obtained by rolling only

The maximum cross-sectional area of the rough rolled axle shall be not greater than one-fifth of the minimum cross-sectional area of the original ingot.

6.2.3 Axles obtained by rolling followed by forging

The maximum cross-sectional area of the axles obtained by rolling and followed by forging shall be not greater than one-fourth of the minimum cross-sectional area of the original ingot.

6.3 Removal of defective sections

Sections of ingots, blooms or bars which do not comply with the soundness characteristics specified in 5.2.2 shall be removed before or during manufacture of the axle.

6.4 Identification of the axles during manufacture

All ingots, blooms, round bars and axles shall be suitably marked at each stage of manufacture so that before delivery each axle or test piece can be identified as required in 5.5. Where the identification marks are stamped, if they differ from the final identification marks defined in 5.5, the marks shall not be visible after machining, on the finished axle.

6.5 Heat treatment

After hot-working and marking, axles shall undergo, where applicable, the heat treatment specified in the order or its appended documents (see 4.2).

As a general rule, the different heat-treatment operations shall be carried out in such a way as to ensure

a) uniformity of structure of comparable parts of the same axle and of axles from the same batch, and

b) freedom from distortion.

6.6 Machining

The conditions for machining are to be chosen so that the axles comply with the requirements for surface quality and tolerances. Machined end-face axles shall be centred with care, to facilitate the correct execution of subsequent turning operations and to obtain the centres of the finished axles without difficulty.

6.7 Removal of defects

6.7.1 Straightening of rough axles

Straightening of the axles shall be carried out before any machining and before the test pieces for the mechanical tests and the micrographical examinations are taken.

If straightening is carried out at a temperature under 500 °C, then the axles shall be heat treated after straightening as follows :

Heat-treatment condition of the axles before straightening	Heat treatment to be carried out after straightening
a) Untreated axles which are to be delivered in the untreated condition.	These shall be stress-relieved at a temperature between 500 and 650 °C.
b) Untreated axles which are to be delivered in the normalized or quenched and tempered condition.	No additional heat treatment other than that required by the order is necessary.
c) Normalized axles.	These shall be stress-relieved at a temperature between 500 and 650 °C or be normalized again.
d) Quenched and tempered axles.	These shall be stress-relieved at a temperature between 500 °C and $(t_1 - 30)$ °C (t_T = actual tempering temperature) or be quenched and tempered again.

If normalized axles are straightened at temperatures equal to or greater than 500 °C, the conditions chosen shall be such that the mechanical properties and the structure are in accordance with the requirements of this International Standard.

6.7.2 Authorized repairs

With the exception of fine-finished surfaces, for example wheel seats, journals and radial fillets (shoulders) on which no retouching is authorized, superficial defects may be eliminated by chipping or by soft grinding, provided that no heat cracking is produced and that the dimensional tolerances are maintained.

6.7.3 Unauthorized repairs

Any welding, gas torch treatment, heating, electric burns, filling by metallization, electrolytic or chemical deposits, etc., and any retouching with the object of concealing a defect, are not permitted and shall result in the rejection of the complete batch.

7 Inspection

7.1 Responsibilities and type of inspection

7.1.1 The purchaser shall specify in the order whether inspection to ensure compliance with manufacturing methods (see clause 6) and with the quality requirements (see clause 5) is to be carried out, either

a) under delegated inspection by the qualified department of the manufacturer, or

b) in the presence of the purchaser, his representative or a body designated by him.

Unless otherwise specified in the order, the provisions of table 3, column 5, shall apply.

7.1.2 Delegation of inspection by the purchaser to the qualified department of the manufacturer does not remove the right of the purchaser to monitor the effectiveness of the manufacturing controls and of the testing and inspection methods.

In this respect, he shall be allowed to witness any of the tests made under the responsibility of the manufacturer and to inspect the recorded results.

7.2 Inspection of manufacture

7.2.1 Whether the inspection of the manufacture is the responsibility of the manufacturer's qualified department or of the purchaser, the following shall apply.

7.2.1.1 The manufacturer shall advise the purchaser of the principal process which will be used in completing the order, and shall advise the purchaser of any subsequent fundamental changes which he intends to introduce and which may affect the quality of the axles and seek his agreement.

If the inspection remains the responsibility of the purchaser, his representative shall be allowed to inspect the manufacturing processes used in order to ensure compliance with the requirements of this part of ISO 1005 and the prior agreement.

7.2.1.2 The manufacturer shall, at the time of submission for acceptance, certify that the manufacturing requirements of this part of ISO 1005 have been complied with (see 7.5).

7.3 Inspection of the characteristics of the axles

7.3.1 Types of test

Table 3 specifies the types of test to be carried out and whether they are mandatory or optional.

7.3.2 Unit of test and subdivision into batches

The appropriate unit for each type of test is given in table 3, column 7.

For acceptance testing, axles shall be grouped in batches. Each batch shall be formed of axles produced from the same cast and having undergone the same heat treatment where applicable. It may include axles of different shape and dimensions.

7.3.3 Condition of the axles when submitted for acceptance

When submitted for inspection, the condition of the axles shall comply with the requirements of table 3, column 6.

Table 3 — Type and number of tests

1	2	3	4	5	6	7	8	9	10
	Heat treatment in delivery condition [1]	Types of checks and tests	Remarks			Test unit [5]	Number of axles per batch to be subjected to the checks and tests		Number of tests per axle
							Total number of axles in the batch		
			[2]	[3]	[4]		≤ 100	> 100	
1	All	Chemical analysis [6]	m	a		c	[6]	[6]	[6]
2	N, T	Tensile test	m	b	h	c,h	1	2	1
3	—	Tensile test							
		— for steel A0 [7]	m	b	f	c	1	2	1
		— for steels A1 to A4 [8]	m	b	h	c	1	2	1
4	N, T	Impact test (KU)	m	b	h	c,h	1	2	3
5	—	Impact test (KU)							
		— for steel A0 [7]	m	b	f	c	1	2	3
		— for steels A1 to A4 [8]	o	b	h	c	1	2	3
6	N, T	Microstructure	m	a	h	c,h	1	2	1
7	—	Microstructure	o	a	h	c	1	2	1
8	All	Macrostructure	o	a	h	p	See 7.7.3.5		1
9	All	Ultrasonic test	o	a	h	p			1
10	All	Magnetoscopy	o	a	h	p			1
11	All	Appearance and dimensions	m	a	f	p	100 %	100 %	1

1) N = normalized, T = quenched and tempered, — = untreated (see 4.2).

2) m = mandatory tests, o = optional, i.e. tests need only be carried out if so stated in the order or its appended documents.

3) The checks and tests are to be carried out :

a) under delegated inspection by the manufacturer's qualified department (see ISO 404 and note in clause 2), or

b) in the presence of the purchaser.

4) h = The tests shall not be carried out before the specified heat treatment.
f = The acceptance tests shall be carried out in the final delivery condition.

5) c = Axles from the same cast.
c,h = Axles from the same cast and heat-treatment batch (see 7.3.2).
p = The axle is the test unit.

6) See 5.1.1, 5.1.2 and 7.7.3.1.

7) See footnote 6 in table 1.

8) Tests in the delivery condition and on reference test pieces having undergone the heat treatment laid down for this grade of steel (see 7.7.2, paragraph 2, and footnote 1 in 4.2).

7.4 Submission for inspection by the purchaser

7.4.1 The purchaser [see 7.1.1 b)] shall be notified in writing (see 7.5.2) of the date of submission for inspection, stating the number of axles in each batch and the order reference number.

7.4.2 If the inspection, which in accordance with table 3 is to be carried out after machining, is the responsibility of the purchaser [see 7.1.1 b)], then the manufacturer may submit the material in two stages, namely

a) after final heat treatment but before machining, and

b) in the final delivery condition.

7.5 Certification

7.5.1 Whether the inspection of manufacture is the responsibility of the manufacturer's qualified department or of the purchaser, the manufacturer shall certify that the manufacturing requirements of this part of ISO 1005 have been complied with. The final test certificate shall also include the results of the following tests :

— chemical analysis;

— tensile test;

— impact test.

7.5.2 The manufacturer shall provide the relevant certificates for those tests and checks for which he is responsible, at the following times :

a) at the time of delivery, if he has the delegated responsibility for all tests or,

b) at the time of the first submission for inspection (see 7.4.2), if for that part of the testing he has the delegated responsibility.

7.6 Number of checks and tests

The number of axles per test unit to be subjected to the checks and the number of tests per axle are given in table 3, columns 8 to 10.

7.7 Sampling and preparation of samples and test pieces

7.7.1 Sampling

After identifying the batch, the inspector shall select at random the axle(s) intended for testing. The axles shall be indelibly identified at the sample positions. The sample lengths shall be at least 200 mm long and they may be taken from axles or from prolongations of axles.

7.7.2 Preparation of samples and test pieces

Unless otherwise specified, the conditions of preparation of samples and test pieces shall be carried out in accordance with the requirements of ISO/R 377, with the following additional requirements.

In the case of axles ordered untreated, with the exception of axles of type A0 (see table 1, footnote 6), samples intended for the mechanical tests shall undergo the heat treatment specified in table 1 for the grade of steel concerned. Where table 1 specifies two different heat treatments for the grade of steel concerned, the heat treatment which shall be applied as a reference heat treatment shall be specified in the order or its appended documents.

The samples and test pieces shall retain the inspector's identification marks and stamps and may not be altered except in his presence.

7.7.3 Number and position of test pieces

Test pieces shall be taken from the previously marked sample sections, and shall be stamped for identification by the inspector.

7.7.3.1 Chemical analysis

The manufacturer shall state the cast analysis of the steel. If the purchaser wishes to verify the composition of the product for some or all elements, one of the following samples shall be taken from one of the test axles :

— at least 50 g of millings representing material from a complete transverse section of an axle, or

— in the case of spectrographic analysis, one sample from the tensile test piece shown in figure 1.

7.7.3.2 Tensile test

One test piece shall be taken from the position of the sample shown in figure 1.

The test pieces shall be prepared in accordance with the requirements of ISO 82, with a diameter of 10 to 16 mm and a gauge length of 5 × diameter.

7.7.3.3 Impact test (U-notch)

Three test pieces shall be taken from the sample positions shown in figure 2. The outer test pieces shall be closely adjacent to the middle impact test piece.

The marking of the impact test piece shall enable identification of the longitudinal surfaces of the test pieces which are parallel to diameter AA of the section of the axle (see figure 2).

The test piece shall be prepared in accordance with the requirements of ISO 83. The axis of the cylindrical bottom of the notch shall be parallel to diameter AA in figure 2.

7.7.3.4 Microstructure examination

The test piece shall be prepared from one of the undeformed ends of the tensile test piece cut along a plane perpendicular to its longitudinal axis. The section thus obtained shall be prepared in accordance with the requirements of ISO 643.

7.7.3.5 Macrostructure, ultrasonic test, magnetoscopic examination

If macrostructure or magnetoscopic examinations are specified, the details regarding the number of tests and the parts of the axles to be examined shall also be stated in the order or its appended documents.

If ultrasonic acceptance tests are specified, the requirements of ISO 5948 shall apply.

7.8 Test methods

7.8.1 Chemical analysis

The chemical analysis shall be carried out in accordance with the method defined by corresponding International Standards or by any other method agreed by the purchaser. In case of dispute, only test methods recommended by ISO shall be used.

7.8.2 Tensile test

The tensile test shall be carried out in accordance with the requirements of ISO 82.

7.8.3 Impact test (with U-shaped notch)

The impact test shall be carried out in accordance with the requirements of ISO 83.

7.8.4 Microstructure examination

The examination of the microstructure shall be carried out in accordance with the requirements of ISO 643.

7.8.5 Macrostructure, ultrasonic tests, magnetoscopic examination

The details regarding macrostructure and magnetoscopic examinations shall be given in the order or its appended documents.

Unless otherwise agreed, ultrasonic acceptance tests shall be carried in accordance with the requirements of ISO 5948.

7.8.6 Checking of appearance

The appearance shall be checked by visual inspection before delivery.

7.8.7 Checking of dimensions[1)]

7.9 Conclusion of the inspection

Any defects in appearance or dimensions shall result in rejection of the axle. The same shall apply to any ultrasonic or magnetoscopic examination revealing defects greater than those which may be tolerated. Any other result not conforming with the required standard shall entail rejection of the corresponding batch subject to the requirements of ISO 404.

7.10 Retests

Unless otherwise agreed, the requirements for retests in ISO 404 shall apply.

8 Delivery

8.1 Protection against corrosion during transport

After inspection and before storage or despatch, all finished machined parts of the accepted axles shall be protected against corrosion by a method agreed with the purchaser.

NOTE — The efficiency of any protective coatings is only of limited life, especially under conditions of sea transport or in geographical regions of high humidity. Therefore delivered axles should be inspected immediately on arrival at their destination to see if a renewal of the protection is necessary.

8.2 Protection against mechanical damage during transport

The finished machined parts at least, of the accepted axles shall be provided with effective protection against mechanical damage before despatch.

9 Guarantee

The conditions of guarantee clauses included in contracts shall be agreed between the purchaser and the manufacturer at the time of enquiry and order.

1) An International Standard dealing with the checking of dimensions is in preparation.

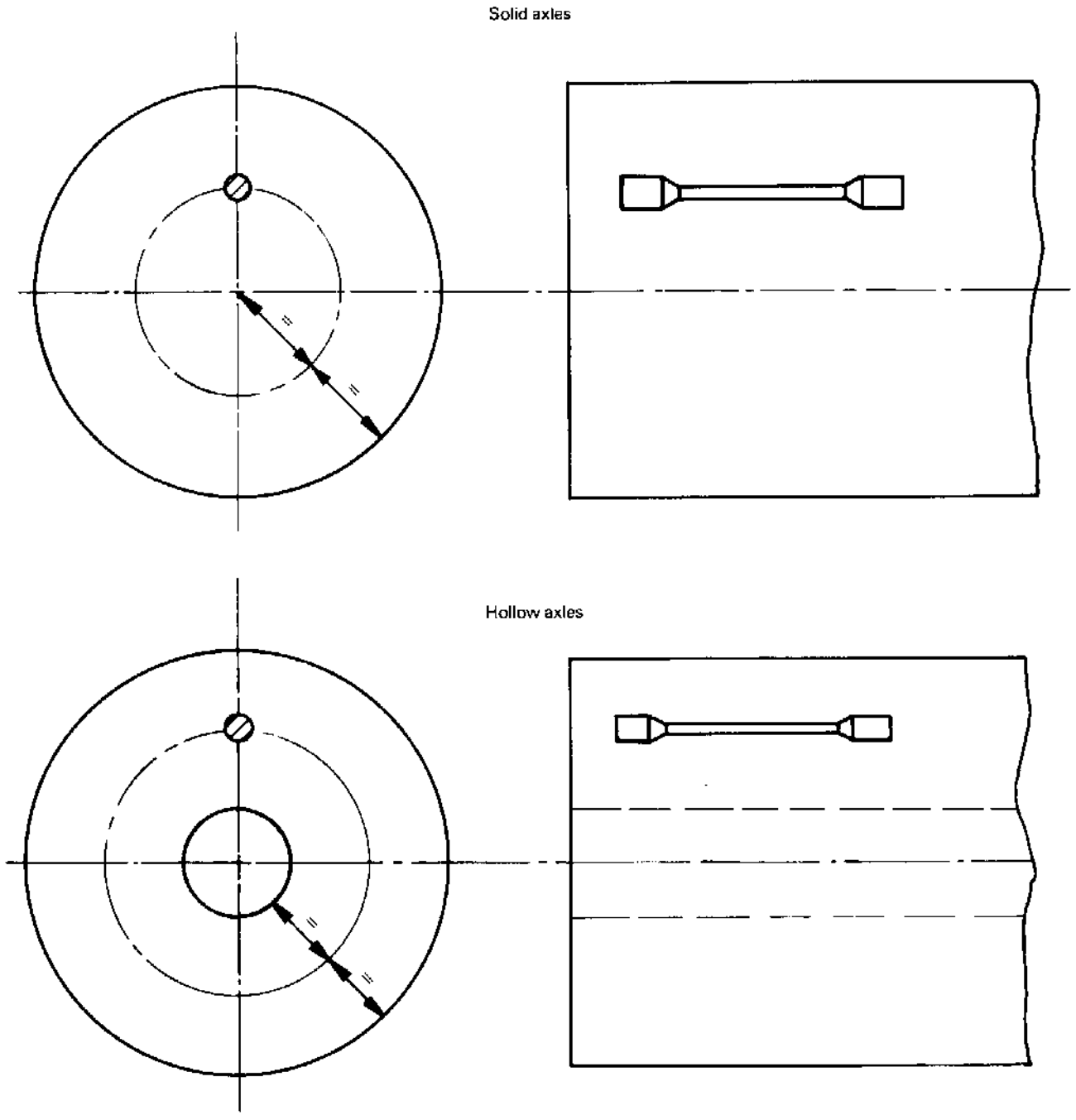

Figure 1 — Position of tensile test pieces

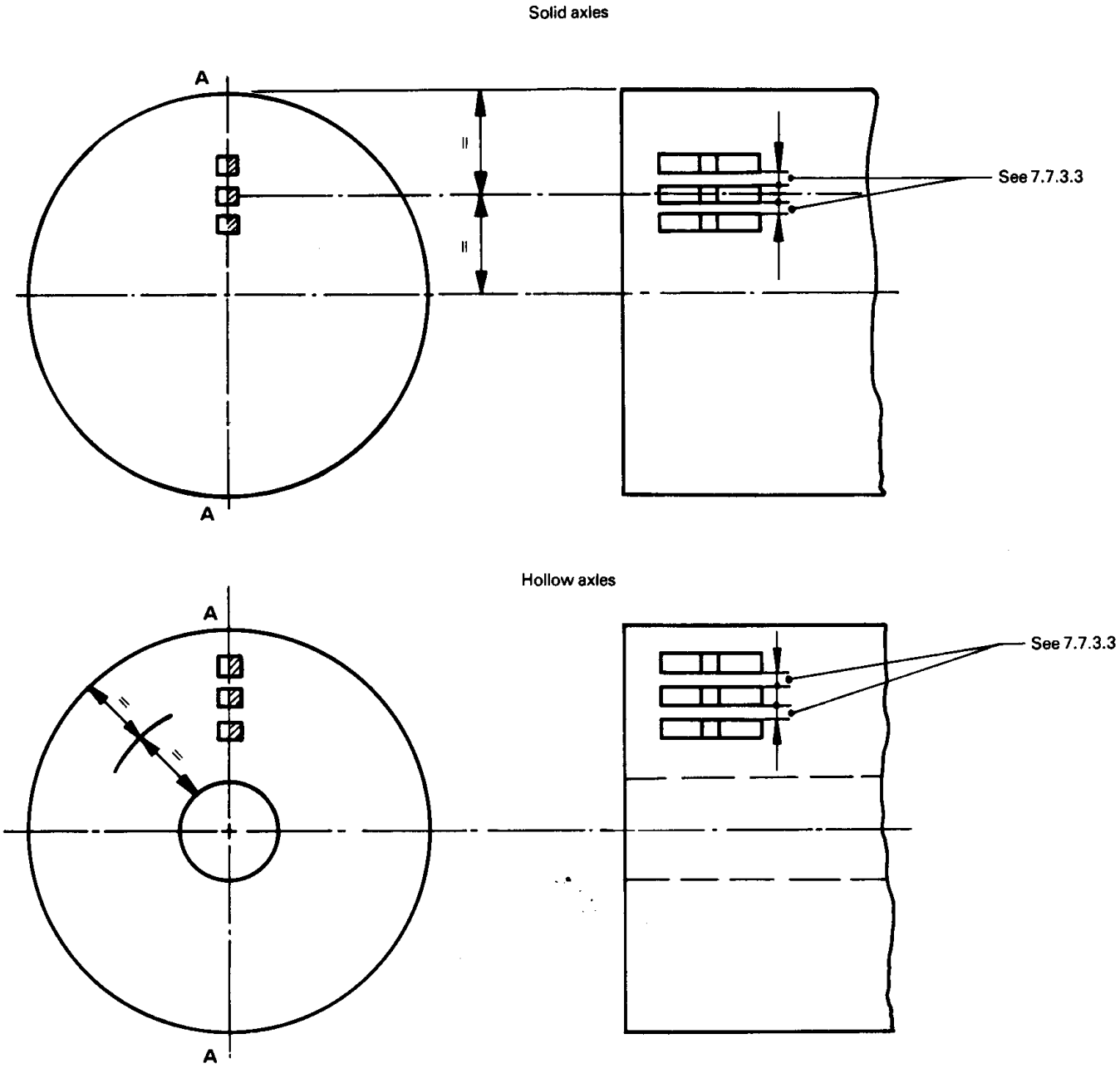

Figure 2 — Position of impact test pieces