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**Axles for railway rolling stock—
Quality requirements**

ICS 45.040

Descriptors : railway vehicle components, axles, transport engineering

Reference number : JIS E 4502-1 : 2001 (E)

Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Land, Infrastructure and Transport through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. By this establishment, **JIS E 4502 : 1989** was withdrawn and replaced by both Standards of **JIS E 4502-1** *Axles for railway rolling stock—Quality requirements* and **JIS E 4502-2** *Axles for railway rolling stock—Dimensional requirements*.

In this establishment, for the purpose of developing Japanese Industrial Standard harmonized with International Standard, the corresponding International Standard, **ISO 1005-3 : 1982** *Railway rolling stock material—Part 3 : Axles for tractive and trailing stock—Quality requirements* was entirely adopted, and in consideration of avoiding users' confusion when they were faced with the drastic revision of the conventional **JIS E 4502 : 1989** to which users have been used for the last ten and several years, the requirements of the conventional **JIS** are described as “items added” and “contents added” to the bare minimum of the range, enabling users to have a larger choice.

JIS E 4502 series contain the following parts.

JIS E 4502-1 *Part 1 : Axles for railway rolling stock—Quality requirements*

JIS E 4502-2 *Part 2 : Axles for railway rolling stock—Dimensional requirements*

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In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

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Axles for railway rolling stock— Quality requirements

Introduction This Japanese Industrial Standard specifies the quality requirements of axles for railway rolling stock as **JIS E 4502-1 : 2001** *Axles for railway rolling stock—Quality requirements* by reviewing entirely the former standard, **JIS E 4502 : 1989** *Axles for railway rolling stock* from a view point of conforming with the corresponding **ISO** Standard.

The former standard, **JIS E 4502 : 1989** consisted of one standard into which quality requirements and dimensional requirements are incorporated, but since the corresponding **ISO** Standard consists of two parts, **ISO 1005-3 : 1982** *Railway rolling stock material—Part 3 : Axles for tractive and trailing stock—Quality requirements* and **ISO 1005-9 : 1986** *Railway rolling stock material—Part 9 : Axles for tractive and trailing stock—Dimensional requirements*, as a result of promoting conformity with the International Standard system (adoption of International Standard drafting rules, introduction of part number system), Part 1 specifies the quality requirements and Part 2 specifies the dimensional requirements.

1 Scope

1.1 This Standard is used for railway rolling stock and specifies the requirements for manufacture and supply of axles for tractive and trailing stock made of non-alloy and alloy complied with Table 1·1, Table 1·2 and Clause 4.

1.2 In addition to this Standard, **ISO 404 : 1992** can also be applied.

Remarks : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

ISO 1005-3 : 1982 *Railway rolling stock material—Part 3 : Axles for tractive and trailing stock—Quality requirements*
(MOD)

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For undated references, the latest editions of the standards indicated below shall be applied.

ISO 83 : 1976 *Steel—Charpy impact test (U-notch)*

ISO 377-1 : 1989 *Selection and preparation of samples and test pieces of wrought steels—Part 1 : Samples and test pieces for mechanical test*

ISO 377-2 : 1989 *Selection and preparation of samples and test pieces of wrought steels—Part 2 : Samples for the determination of the chemical composition*

ISO 404 : 1992 *Steel and steel products—General technical delivery requirements*

- ISO 643 : 1983 *Steel—Micrographic determination of the ferritic or austenitic grain size*
- ISO 5948 : 1994 *Railway rolling stock material—Ultrasonic acceptance testing*
- ISO 6506-1 : 1999 *Metallic materials—Brinell hardness test—Part 1 : Test method*
- ISO 6506-2 : 1999 *Metallic materials—Brinell hardness test—Part 2 : Verification and calibration of testing machines*
- ISO 6506-3 : 1999 *Metallic materials—Brinell hardness test—Part 3 : Calibration of reference blocks*
- ISO 9001 : 1994 *Quality systems—Model for quality assurance in design, development, production, installation and servicing*
- ISO 9002 : 1994 *Quality systems—Model for quality assurance in production, installation and servicing*
- JIS E 4502-2 *Axles for railway rolling stock—Dimensional requirements*
- JIS G 0303 *General rules for inspection of steel*
- JIS G 0565 *Method for magnetic particle testing of ferromagnetic materials and classification of magnetic particle indication*
- JIS G 1214 *Iron and steel—Methods for determination of phosphorous content*
- JIS G 1215 *Iron and steel—Methods for determination of sulfur content*
- JIS G 1253 *Iron and steel—Method for spark discharge atomic emission spectrometric analysis*
- JIS G 1257 *Iron and steel—Methods for atomic absorption spectrometric analysis*
- JIS Z 2201 *Test pieces for tensile test for metallic materials*
- JIS Z 2202 *Test pieces for impact test for metallic materials*
- JIS Z 2204 *Bend test pieces for metallic materials*
- JIS Z 2241 *Method for tensile test for metallic materials*
- JIS Z 2242 *Method of impact test for metallic materials*
- JIS Z 2246 *Shore hardness test—Test method*
- JIS Z 2248 *Method of bend test for metallic materials*
- JIS Z 2344 *General rule of ultrasonic testing of metals by pulse echo technique*
- JIS Z 9901 *Quality systems—Model for quality assurance in design, development, production, installation and servicing*
- JIS Z 9902 *Quality systems—Model for quality assurance in production, installation and servicing*

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 Standard
- b) the grade of steel (see 4.1 and Table 1.1 or Table 1.2)
- 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 3.1, Table 3.2)
- 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 3.1, Table 3.2)
- h) the dimensional characteristics (see 5.4.1)
- i) if any special marking is required (see 5.5)
- j) the conditions of inspection required (see 7.1)
- k) if special preparation and sampling of test pieces is required (see 7.7.2)
- l) the method of protection against corrosion (see 8.1)
- m) 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 to be used, the heat-treatment condition of delivery, the degree of finish and any optional tests or inspection required (see Table 3.1, column 4 or Table 3.2, column 4).

4.1 Steel grades This Standard specifies the following grades of steel in accordance with the properties given in Table 1.1 or Table 1.2.

- a) **unalloyed steels** A1 and A2 in Table 1.1
- b) **alloyed steels** A3 and A4 in Table 1.1
- c) **carbon steels** Class 1 to 4 in Table 1.2

4.2 Types of heat treatment condition on delivery The axles shall be supplied in the following condition.

- a) untreated [no symbol⁽¹⁾] — grades A0, A1, A2, A3 and A4 in Table 1.1, or
- b) normalized or normalized and tempered (symbol N) — grades A1, A2 in Table 1.1 or grades Class 1, Class 2 in Table 1.2 or
- c) quenched and tempered (symbol T) — grades A1, A2, A3, A4 in Table 1.1 or grades Class 3, Class 4 in Table 1.2 or
- d) high-frequency quenched and tempered for the designated location (symbol IH) — grade Class 4 in Table 1.2

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.

Note (1) With the exceptions specified in Table 1.1, Note (8), 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 1.1.

4.3 Degree of finish⁽²⁾ 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.

Note (2) As for terms of the degree of finish, there are definitions of terms used commonly at the time of enquiry and order. The terms "rough-machined" and "half-finished" referred here correspond commonly to those of "material" or "half-finished" while the term "finished" corresponds to that of "half-finished". The comparison table regarding these terms shall be as shown in Annex 1 (informative).

Table 1.1 Grade of steel, chemical composition, types of heat-treatment in delivery condition and mechanical properties

Grade of steel	Chemical composition ⁽³⁾ , (m/m) max.									Heat-treatment ⁽⁴⁾	Mechanical properties ⁽⁵⁾			
	C	Si	Mn	P	S	Cr	Cu	Mo	V		R_e ⁽⁶⁾ N/mm ² min	R_m N/mm ²	A % min	KU J min ⁽⁷⁾
A1 ⁽⁸⁾	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

Notes (3) See 5.1.1

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

(5) R_e = yield strength [see Note (4)], R_m = tensile strength, A = percentage elongation after fracture ($L_0 = 5.65 \sqrt{S_0}$), KU = impact strength for ISO U-notch test piece at 20 °C, 1 N/mm² = 1 MPa.

- (6) 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 is equal to or greater than the value specified for R_e .
- (7) 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.
- (8) 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 are to be carried out and the following mechanical properties apply to the delivery condition:

$R_e = 280 \text{ N/mm}^2 \text{ min.}$, $R_m = 500 \text{ to } 600 \text{ N/mm}^2$, $A = 20 \% \text{ min.}$,
 $KU = 20 \text{ J min.}$

Table 1-2 Grade of steel, chemical composition, types of heat-treatment in delivery condition and mechanical properties

Grade of steel			Chemical composition		Heat treatment in delivery condition ⁽¹⁰⁾	Mechanical properties ⁽¹¹⁾							Re- marks
Class ⁽⁹⁾	Symbol	% max.	P	S		Yield strength N/mm ² min.	Tensile strength N/mm ² min.	Elongation % min.	Contraction of area % min.	Bending		Informative Charpy absorbed energy J min.	Prin- cipal uses
										Bend- ing angle degree	Inside radius mm		
Class 1	A	SFA 55A	0.035	0.040	N	275	540	23	35	180	16	39	Trail- ing axles
	B	SFA 55B	0.045	0.045									
Class 2	A	SFA 60A	0.035	0.040	N	295	590	20	30	180	22	31	Driv- ing axles and trail- ing axles
	B	SFA 60B	0.045	0.045									
Class 3	A	SFA 65A	0.035	0.040	T	345	640	23	45	180	16	39	
	B	SFA 65B	0.045	0.045									
Class 4	A	SFAQA	0.035	0.040	T and IH	295	590	20	30	180	22	31	
	B	SFAQB	0.045	0.045									

Notes (9) Subclass A means that of smaller contents of P and S in chemical composition as compared with subclass B and therefore is fit for the ultrasonic testing and surface flaw testing.

(10) N = normalized or normalized and tempered, T = quenched and tempered, IH = quenched and tempered at high-frequency for the designated location.

The surface hardness of high-frequency quenched and tempered portions of Class 4 shall be HS55 or over.

(11) Mechanical properties of Class 4 indicate values before high-frequency quenching.

5 Requirements

5.1 Chemical composition

5.1.1 The maximum contents of the various elements are given in Table 1.1 and Table 1.2. 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. The product analysis in the case of Table 1.1 may deviate from the requirements in Table 1.1 by the values given in Table 2. In the case of Table 1.2, the product analysis shall be performed by JIS G 0303.

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)
C	0.30 to 0.50	+0.03
Si	0.50	+0.04
Mn	0.80	+0.06
	1.20	+0.08
	1.60	+0.10
P	0.04	+0.005
S	0.04	+0.005

5.2 Appearance and soundness

5.2.1 Appearance Appearance shall be in accordance with JIS E 4502-2.

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 : 1983, the grain size concerning the grade of steel in Table 1.1 shall not be coarser than 5. The grain size concerning the grade of steel in Table 1.2 shall be as agreed between the manufacturer and the purchaser.

5.2.2.3 Other characteristics for appearance and soundness If, for the verification of soundness, magnetic particle flaw detection, ultrasonic tests 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.

5.3 Mechanical properties The mechanical properties of the axles after heat treatment shall be those shown in Table 1.1 and Table 1.2.

5.4 Dimension and form

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 Tolerances on dimension and form shall be in accordance with **JIS E 4502-2**.

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 the order or its appended documents.

Unless otherwise specified, each axle in accordance with Table 1.1 shall be stamped with the following marks:

- a) manufacturer's mark or abbreviation;
- b) grade of steel and heat-treatment condition (N for normalized or normalized and tempered, T for quenched and tempered, nothing for untreated axles) [see the exception given in Note (8) of Table 1.1];
- c) date of manufacture (month and the last two figures of the year of manufacture);
- d) cast number.

Each axle in accordance with Table 1.2 shall be stamped with the following marks. However, b) and e) may be omitted.

- a) Manufacturer's name or abbreviation;
- b) Symbol of grade of steel;
- c) Year or month of manufacture or its abbreviation;
- d) Cast number;
- e) Standard axle burden mass (a burden mass for one axle, only for the axles for passenger and freight cars)

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.

6 Manufacture

6.1 Steelmaking process The axles shall be made from steel manufactured in an open-hearth furnace, electric furnace or oxygen converter; other processes may be used by agreement between the manufacturer and the purchaser.

Unless otherwise agreed, the steel shall be killed in the furnace or in the ladle and the axles shall be made by bottom pouring or continuous casting method.

6.2 Manufacture of the axles The axles shall be manufactured from ingots or cast billets.

- 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 blooms shall be not greater than one-fourth of the minimum cross-sectional area of the original blooms. The maximum cross-sectional area of the axles obtained by rolling and followed by forging ingots shall be not greater than one-eighth 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 depth of the stamp shall be shallow enough so that 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 $(t_T - 30)$ °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 Standard.

6.7.2 Authorized repairs With the exception of fine-finished surfaces, for example wheel seats, journals and dust guard seat and others 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

- under delegated inspection by the qualified department of the manufacturer, or
- in the presence of the purchaser, his representative or a body designated by him.

Unless otherwise specified in the order, the provisions of Table 3·1, column 5, or Table 3·2, 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, if he does not acquire the certification on **JIS Z 9901** or **JIS Z 9902**, 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 Standard 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 Standard have been complied with (see 7.5).

7.3 Inspection of the characteristics of the axles

7.3.1 Types of test Table 3·1 for grade of steel of Table 1·1 and Table 3·2 for grade of steel of Table 1·2 specify the types of test to be carried out respectively 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 3·1, column 7 for grade of steel of Table 1·1 and in Table 3·2, column 7 for grade of steel of Table 1·2 respectively.

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 inspecting axles conformed to the requirements specified in Table 1·1, the condition of the axles shall comply with the requirements of Table 3·1, column 6.

When submitted for inspecting axles conformed to the requirements specified in Table 1·2, the condition of the axles shall be as agreed between the purchaser and the manufacturer.

Table 3.1 Type and number of tests for grades of steel of Table 1.1

1	2	3	4	5	6	7	8	9	10
	Heat treatment in delivery condition ⁽¹²⁾	Types of checks and tests	Remarks			Test unit ⁽¹⁶⁾	Number of axles per batch to be subjected to the checks and tests		Number of tests per axle
			(13)	(14)	(15)		Total number of axles in the batch		
							≤ 100	> 100	
1	All	Chemical analysis ⁽¹⁷⁾	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 ⁽¹⁸⁾	m	b	f	c	1	2	1
		— for steels A1 to A4 ⁽¹⁹⁾	m	b	h	c	1	2	1
4	N.T	Impact test (<i>KU</i>)	m	b	h	c, h	1	2	3
5	—	Impact test (<i>KU</i>)							
		— for steel A0 ⁽¹⁸⁾	m	b	f	c	1	2	3
		— for steels A1 to A4 ⁽¹⁹⁾	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	m	a	f	p	100 %	100 %	1

Notes ⁽¹²⁾ N = normalized or normalized and tempered, T = quenched and tempered, — = untreated (see 4.2).

⁽¹³⁾ m = mandatory tests, o = optional, i.e. tests need only be carried out if so stated in the order or its appended documents.

⁽¹⁴⁾ The checks and tests are to be carried out:

- under delegated inspection by the manufacturer's qualified department (see ISO 404 : 1992), or
- in the presence of the purchaser.

⁽¹⁵⁾ 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.

⁽¹⁶⁾ 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.

⁽¹⁷⁾ See 5.1.1, 5.1.2 and 7.7.3.1.

⁽¹⁸⁾ See Note (8) in Table 1.1.

⁽¹⁹⁾ 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 Note (1) in 4.2].

Table 3.2 Type and number of tests for grades of steel of Table 1.2

1	2	3	4	5	6	7	8	9	10
	Grade of steel ⁽²⁰⁾	Types of checks and tests	Remarks			Test unit ⁽²⁴⁾	Number of axles per batch to be subjected to the checks and tests		Number of tests per axle
			(21)	(22)	(23)		Total number of axles in the batch		
							≤ 100	> 100	
1	All	Chemical analysis ⁽²⁵⁾	m	a		c	(25)	(25)	(25)
2	All	Tensile test	m	a	h	c, h	1	2	1
3	All	Bending test	m	a	h	c, h	1	1	1
4	All	Impact test	m	a	h	c, h	1	2	1
5	Class 4	Hardness test ⁽²⁶⁾	m	a	h	c, h	1	1	1
6	Class 4	Macroscopic structure of section ⁽²⁷⁾	o	a	h	c, h	1	2	1
7	Class 4	Hardness distribution of section ⁽²⁷⁾	o	a	h	c, h	1	2	1
8	Class 4	Microscopic structure of section ⁽²⁷⁾	o	a	h	c, h	1	2	1
9	Class 4	Residual stress distribution of surface and section ⁽²⁷⁾	o	a	h	c, h	1	2	1
10	Class 4 to 1A	Ultrasonic test	m	a	h	p	100 %	100 %	1
11	Class 4 to 1A	Magnetoscopy	m	a	h	p	100 %	100 %	1
12	All	Appearance	m	a	f	p	100 %	100 %	1

Notes ⁽²⁰⁾ See Table 1.2.

⁽²¹⁾ m = mandatory tests, o = optional, i.e. tests need only be carried out if so stated in the order or its appended documents.

⁽²²⁾ The checks and tests are to be carried out:

- a) under delegated inspection by the manufacturer's qualified department, or
- b) in the presence of the purchaser.

⁽²³⁾ h = The tests shall not be carried out before the specified heat treatment. However, for tensile test, bending test and impact test of Class 4 of grade of steel, the test shall be carried out under the heat treatment condition before high-frequency quenching.

f = The acceptance tests shall be carried out in the final delivery condition.

⁽²⁴⁾ c = Axle 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.

⁽²⁵⁾ See 5.1.1, 5.1.2 and 7.7.3.1.

⁽²⁶⁾ Surface hardness of the high-frequency quenched portions.

⁽²⁷⁾ The checks and tests are to be carried out for the high-frequency quenched portions of axles of Class 4.

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 3.1 or in accordance with Table 3.2 by the agreement between the purchaser and the manufacturer 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 Standard have been complied with. The final test certificate shall also include the results of the following tests:

- a) When in accordance with Table 3.1,
 - chemical analysis;
 - tensile test;
 - impact test.
- b) When in accordance with Table 3.2,
 - chemical analysis;
 - tensile test;
 - impact test;
 - bend 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, 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 3.1, columns 8 to 10, for the grade of steel in Table 1.1 and in Table 3.2, columns 8 to 10, for the grade of steel in Table 1.2.

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 377-1 : 1989** and **ISO 377-2 : 1989** with the following additional requirements.

In the case of axles ordered untreated, with the exception of axles of type A0 [see Table 1.1, Note (8)], samples intended for the mechanical tests shall undergo the heat treatment specified for the grade of steel concerned. Where two different heat treatments are specified 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, for the grade of steel in Table 1.1, 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.

For the grade of steel in Table 1.2, samples shall be taken in accordance with **JIS G 0303**.

7.7.3.2 Tensile test The method of sampling test pieces shall be as specified below.

For the grade of steel in Table 1.1, the test pieces shall be prepared with a diameter of 10 to 16 mm and a gauge length of $5 \times$ diameter from the position of the sample shown in Figure 1.

For the grade of steel in Table 1.2, the test piece to be used shall be No. 4 specified in accordance with the requirements of **JIS Z 2201**.

7.7.3.3 Impact test (U-notch) For the grade of steel of Table 1.1, 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 : 1976**. The axis of the cylindrical bottom of the notch shall be parallel to diameter AA in Figure 2.

For the grade of steel of Table 1.2, the test pieces to be used shall be No. 3 specified in accordance with the requirements of **JIS Z 2202**.

7.7.3.4 Microstructure examination The test piece for the grade of steel of Table 1.1 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 : 1983**.

For the axle of Class 4 of the grade of steel of Table 1·2, microstructure examination shall be carried out on the section of the high-frequency quenched and tempered portions when considered particularly necessary by the parties concerned with delivery.

7.7.3.5 Macrostructure, ultrasonic test, magnetoscopic examination For the grade of steel of Table 1·1, 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 : 1994** shall apply.

For the grade of steel of Table 1·2, the examination shall be carried out in accordance with the following.

- For the axle of Class 4 of the grade of steel, macrostructure examination shall be carried out on the section of the high-frequency quenched and tempered portions when considered particularly necessary by the parties concerned with delivery.
- Ultrasonic test shall be carried out in accordance with the requirements of **JIS Z 2344**.
- Magnetoscopic examination shall be carried out after machining the axles in accordance with the requirements of **JIS G 0565**.

7.7.3.6 Bend test For the grade of steel of Table 1·2, the bend test shall be carried out. The test pieces shall be taken in accordance with the method of sampling test pieces specified in 7.3.2 and test pieces to be used in the test shall be No. 5 A specified in accordance with the requirements of **JIS Z 2204**.

7.7.3.7 Hardness test For the axle of Class 4 of the grade of steel of Table 1·2, the hardness test shall be carried out on the surface of the high-frequency quenched and tempered portions.

7.7.3.8 Hardness distribution of section For the axle of Class 4 of the grade of steel of Table 1·2, the hardness distribution shall be measured on the section of the high-frequency quenched and tempered portions when considered particularly necessary by the parties concerned with delivery.

7.7.3.9 Residual stress distribution For the axle of Class 4 of the grade of steel of Table 1·2, the residual stress distribution shall be measured on the surface and the section of the high-frequency quenched and tempered portions when considered particularly necessary by the parties concerned with delivery.

7.8 Test methods

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

JIS G 1214

JIS G 1215

JIS G 1253

JIS G 1257

7.8.2 Tensile test The tensile test shall be carried out in accordance with the requirements of **JIS Z 2241**.

7.8.3 Impact test (with U-shaped notch)—The impact test shall be carried out in accordance with the requirements of **ISO 83 : 1976** or **JIS Z 2242**.

7.8.4 Microstructure examination For the grade of steel of Table 1·1, the microstructure examination shall be carried out in accordance with the requirements of **ISO 643 : 1983**.

For the grades of steel of Table 1·2, the test methods and the criteria of acceptance shall be as agreed upon by the parties concerned.

7.8.5 Macrostructure, ultrasonic tests, magnetoscopic examination For the grades of steel of Table 1·1, 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 out in accordance with the requirements of **ISO 5948 : 1994**.

For the grades of steel of Table 1·2, the tests shall be carried out in accordance with the following test methods.

- The test methods and the criteria of acceptance of the macrostructure examination shall be as agreed between the manufacturer and the purchaser.
- The ultrasonic acceptance tests shall be carried in accordance with the requirements of **JIS Z 2344**.
- Magnetoscopic examination shall be carried out after machining the axles in accordance with **JIS G 0565**.

7.8.6 Bend test For the grade of steel of Table 1·2, the bend test shall be carried out in accordance with the requirements of **JIS Z 2248**.

7.8.7 Hardness test For Class 4 of grade of steel of Table 1·2, the hardness test shall be carried out on the surface of the high-frequency quenched and tempered portions in accordance with the requirements of **JIS Z 2246**.

7.8.8 Hardness distribution of section The hardness distribution of section shall be measured for the axle of Class 4 in grades of steel of Table 1·2. The test methods and the criteria of acceptance shall be as agreed between the manufacturer and the purchaser.

7.8.9 Residual stress distribution The residual stress distribution shall be measured for the axle of Class 4 of grades of steel of Table 1·2. The test methods and the criteria of acceptance shall be as agreed between the manufacturer and the purchaser.

7.8.10 Checking of appearance The appearance shall be checked by visual inspection before delivery.

7.8.11 Checking of dimensions The dimensions shall be checked in accordance with the requirements of **JIS E 4502-2**.