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**Compacted vermicular graphite cast
irons**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Foundry Society, Inc. (JFSinc)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS G 5505:2013**), which has been technically revised.

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Compacted vermicular graphite cast irons

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 16112:2017**, Edition 2, with some modifications of the technical contents.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JB.

1 Scope

This Standard specifies requirements for CV graphite cast irons (hereafter referred to as castings).

NOTE 1 CV stands for “compacted vermicular”.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 16112:2017 *Compacted (vermicular) graphite cast irons—Classification* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standards and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 0403 *Castings—System of dimensional tolerances and machining allowances*

JIS G 0201 *Glossary of terms used in iron and steel (Heat treatment)*

JIS Z 2241 *Metallic materials—Tensile testing—Method of test at room temperature*

JIS Z 2243-1 *Brinell hardness test—Part 1: Test method*

NOTE Corresponding International Standard: ISO 6506-1 *Metallic materials—Brinell hardness test—Part 1: Test method*

JIS Z 2300 *Terms and definitions of nondestructive testing*

ISO 945-1 *Microstructure of cast irons—Part 1: Graphite classification by visual analysis*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions, and those given in **JIS B 0403**, **JIS G 0201** and **JIS Z 2300** apply.

3.1

compacted vermicular (CV) graphite cast irons

cast material, iron and carbon based, the carbon being present mainly in the form of compacted (vermicular) graphite particles that appear vermicular on a two-dimensional plane of polish, the graphite particles being embedded in a matrix consisting of ferrite, ferrite/pearlite, or pearlite

3.2

graphite modification treatment

treatment in which graphite spheroidizing agents etc. are added to molten cast iron, and crystallized graphite is brought into the form of compacted vermicular graphite

3.3

in-mould process

manufacturing process of iron castings in which the molten metal is reacted with spheroidizing agent in the reaction chamber installed within the mould before being poured into the mould cavity

3.4

matrix structure

part of microscopic structure of iron casting that is not occupied by graphite particles

3.5

cast sample

generic term for separately cast sample, side-by-side cast sample, and cast-on sample

3.6

separately cast sample

sample cast in a separate mould having the same thermal properties as the casting under the same manufacturing conditions as the casting (see Tables 3 to 5)

3.7

side-by-side cast sample

sample cast in the mould alongside the casting, with a connected but separate running system (see Tables 3 to 5)

3.8

cast-on sample

sample attached directly to the casting (see Table 6)

3.9

sample cut from the casting

sample obtained directly from the casting

3.10

cast test piece

test piece machined from a cast sample

It is a generic term for separately cast test piece, side-by-side cast test piece, and cast-on test piece.

3.11

test piece cut from the casting

test piece machined from a sample cut from the casting

3.12

relevant wall thickness

section of the casting to which the determined mechanical properties shall apply

3.13

test unit

number or tonnage of moulding products which are to be collectively accepted or refused based on the tests performed on parts according to the related specifications, material standards and order requirements

NOTE It is also referred to as the inspection lot or test lot.

4 Types and material designation

The castings shall be divided into five types and their material designation shall be as given in Table 1.

Table 1 Material designation

Material designation
FCV 300
FCV 350
FCV 400
FCV 450
FCV 500
In the case of test pieces prepared from separately cast samples, the indication “/S” is added at the end of the material designation. In the case of test pieces prepared from side-by-side or cast-on samples, the indication “/U” is added at the end of the material designation. In the case of test pieces cut from the casting, the indication “/C” is added at the end of the material designation. NOTE 1 The properties and application examples of casting are given in Annex C. NOTE 2 The comparison table of the material designation between JIS, ISO and principal foreign standards is given in Annex D.

5 Order information

The following information shall be supplied by the purchaser:

- a) the complete designation of the material as shown in Table 1;
- b) any special requirements provided in Clause 7 which shall be agreed upon between the manufacturer and the purchaser.

All agreements on **a)** and **b)** between the manufacturer and the purchaser shall be made by the time of acceptance of the order.

6 Manufacture

The methods of producing and heat-treating the castings, unless otherwise specified by the purchaser, shall be all left to the discretion of the manufacturer.

7 Requirements

7.1 General

The specified tensile properties values shall apply to the castings cast in the same mould as that used for the castings or in the mould having the same thermal properties as the castings. Upon agreement between the manufacturer and the purchaser, these values may also apply to the castings cast in the mould having similar thermal properties.

The material designation is based on the minimum tensile properties obtained in cast samples with a relevant wall thickness. This designation is irrespective of the type of cast sample.

The tensile properties are those mechanical properties that are tested according to the methods in **11.1**, and required to satisfy Table 2. Other properties than these are designated as specific mechanical properties.

Where the relevant wall thickness exceeds 200 mm, the requirements for the minimum tensile properties, type of cast sample, dimensions and microstructures shall be as agreed between the manufacturer and the purchaser.

Statistical analysis methods shall be used to establish process capability to meet the tensile property requirements.

7.2 Tensile properties

The tensile properties of a cast test piece, when the test is performed as specified in **11.1** using the test piece in **10.2**, shall satisfy the requirements in Table 2.

The tensile properties of a test piece cut from the casting, when the test is performed as specified in **11.1** using the test piece in **10.3**, shall satisfy the acceptance criteria agreed between the manufacturer and the purchaser (see Annex A).

NOTE 1 The tensile properties of castings can vary depending on the complexity of the castings and variation in their section thicknesses and cooling rates.

NOTE 2 Test pieces cut from a casting often have a slower cooling rate than separately cast test pieces. Therefore, the tensile properties are often lower, even if the section thickness and microstructure are similar.

NOTE 3 Mechanical properties of castings are affected not only by material properties but also by the local casting soundness.

Table 2 Minimum tensile properties of cast test piece

Material designation	Wall thickness t mm	Tensile strength R_m MPa	0.2 % proof strength $R_{p0.2}$ MPa	Elongation A %
FCV 300	$t \leq 12.5$	300	210	2.0
	$12.5 < t \leq 30$	300	210	2.0
	$30 < t \leq 60$	275	195	2.0
	$60 < t \leq 200$	250	175	2.0
FCV 350	$t \leq 12.5$	350	245	1.5
	$12.5 < t \leq 30$	350	245	1.5
	$30 < t \leq 60$	325	230	1.5
	$60 < t \leq 200$	300	210	1.5
FCV 400	$t \leq 12.5$	400	280	1.0
	$12.5 < t \leq 30$	400	280	1.0
	$30 < t \leq 60$	375	260	1.0
	$60 < t \leq 200$	325	230	1.0
FCV 450	$t \leq 12.5$	450	315	1.0
	$12.5 < t \leq 30$	450	315	1.0
	$30 < t \leq 60$	400	280	1.0
	$60 < t \leq 200$	375	260	1.0
FCV 500	$t \leq 12.5$	500	350	0.5
	$12.5 < t \leq 30$	500	350	0.5
	$30 < t \leq 60$	450	315	0.5
	$60 < t \leq 200$	400	280	0.5
NOTE 1 The tensile properties of cast test pieces can be different from the properties of the casting itself. Additional values are given in Table A.1 for guidance.				
NOTE 2 The percentage reduction in tensile properties in thick sections depends upon the casting geometry and its cooling conditions.				

7.3 Hardness

The Brinell hardness of castings shall be determined according to **11.2**, and satisfy the requirements agreed between the manufacturer and the purchaser (see Annex A). Other hardness scale may be used upon agreement between the manufacturer and the purchaser.

7.4 Microstructure

7.4.1 Graphite structure

The graphite structure shall be tested in accordance with **11.3.1** and satisfy the following.

- The graphite nodularity of castings obtained according to Formula (JA.1) shall be 20 % or greater and less than 40 %. Other nodularity range, provided it does not exceed 50 %, may be applied upon agreement between the manufacturer and the purchaser.

- b) The graphite nodularity of castings obtained according to Formula (B.2) shall not exceed 20 %. Other nodularity range, provided it does not exceed 30 %, may be applied upon agreement between the manufacturer and the purchaser.
- c) When viewed on a two-dimensional plane of polish in sections representative of the relevant wall thickness, more than 80 % of all graphite particles should be CV graphite particles with a roundness shape factor of > 10 % to 55 % and less than 20 % of all graphite particles should be graphite particles with a roundness shape factor of > 55 %.

No graphite particles with a roundness shape factor of ≤ 10 % shall exist in the casting except at the surface rim zone.

7.4.2 Matrix structure

When specified by the purchaser, the matrix structure shall be tested in accordance with **11.3.2**, and satisfy the requirement agreed between the manufacturer and the purchaser.

7.4.3 Microscopic structure

When specified by the purchaser, the microscopic structure shall be tested in accordance with **11.3.3**, and satisfy the microstructure requirement agreed between the manufacturer and the purchaser.

7.5 Specific mechanical properties

When specified by the purchaser, specific mechanical properties shall be tested in accordance with **11.4**, and satisfy the property values agreed between the manufacturer and the purchaser (see Annex A).

7.6 Physical properties

When specified by the purchaser, physical properties shall be tested in accordance with **11.5**, and satisfy the property values agreed between the manufacturer and the purchaser (see Annex A).

7.7 Internal soundness

The castings shall be tested for their internal soundness in accordance with **11.6** and be free from such flaws as providing a reason for rejection (hereafter referred to as defects). The acceptance criteria shall be as agreed between the manufacturer and the purchaser.

NOTE See **JIS Z 2300** for definitions of flaws and defects.

7.8 Shape, dimensions, dimensional tolerances, cutting stock, draft angle and mass

The purchaser or the manufacturer shall specify the dimensions and shape of the casting in drawing. The dimensional tolerances, cutting stock, and draft angle, unless otherwise specified, shall be in accordance with **JIS B 0403**. The mass of the casting shall be as agreed between the manufacturer and the purchaser.

7.9 Appearance

The appearance of castings shall be inspected in accordance with **11.7**, and free from defects. The acceptance criteria shall be as agreed between the manufacturer and the purchaser.

8 Sampling

8.1 Samples

8.1.1 General

The manufacturer shall prepare samples representative of the castings produced, for each test unit of the castings. Samples can be used for tensile test, hardness test, microstructure test, specific mechanical properties test, and physical properties test.

- a) Several types of samples (separately cast samples, side-by-side samples, cast-on samples or samples cut from a casting) can be used for tensile test, depending on the wall thickness of the casting. Which sample to use shall be determined by agreement between the manufacturer and the purchaser. In the absence of agreement, the decision may be left to the manufacturer.
- b) When the mass of the casting exceeds 2 000 kg and its wall thickness exceeds 60 mm, cast-on samples or samples cut from a casting should preferably be used upon agreement between the manufacturer and the purchaser. In the absence of agreement, the decision shall be left to the manufacturer.
- c) Side-by-side samples and cast-on samples should be produced from the last mould filled in the test unit. Separately cast samples should be produced from a separate mould after the last mould in the test unit has been filled.
- d) The dimensional tolerances for samples shall be as given in Table A.1 of **JIS B 0403**.
- e) Separately cast samples should not be used for castings produced by the in-mould process.
- f) Heat treatment of samples shall be in accordance with Clause **9**.
- g) At least one reserve sample shall be prepared in case retests are necessary.
- h) All samples shall be adequately marked to guarantee full traceability to the castings which they represent.

8.1.2 Frequency and number of tests

Samples representative of the material shall be produced at a frequency in accordance with the in-process quality-assurance procedures adopted by the manufacturer. In the absence of an in-process quality-assurance procedure, the frequency shall be left to agreement between the manufacturer and the purchaser.

8.1.3 Cast samples

8.1.3.1 Separately cast samples

Separately cast samples shall be cast in a separate sand mould using the same manufacturing conditions and material grade as the castings of the same test unit. These samples shall be representative of the castings concurrently cast.

The sampling method shall be as follows.

- a) The moulds used to cast the separately cast samples shall have comparable thermal behaviour to the mould used to produce the castings.
- b) The samples shall be cast according to an appropriate casting system plan capable of reproducing the conditions used for production of the casting.
- c) Sample shape shall be selected from Tables 3 to 5, and sample dimensions, from those provided in the selected table.
- d) The samples shall be removed from the mould at a temperature similar to that of the castings and shall not exceed 500 °C.

8.1.3.2 Side-by-side cast samples

Side-by-side cast samples shall be cast in the mould alongside the casting, with a connected but separate running system. These samples shall be representative of the castings concurrently cast.

The sampling method shall be as follows.

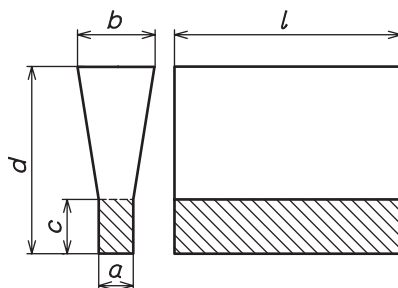
- a) For castings produced by the in-mould process, samples shall be cast with the same running system as that of the casting.
- b) Sample shape shall be selected from Tables 3 to 5, and sample dimensions, from those provided in the selected table.

8.1.3.3 Cast-on samples

Cast-on samples shall be cast by being directly attached to the casting. These samples are representative of the castings to which they are attached, and also of all other castings of a similar relevant wall thickness from the same test unit.

The sampling method shall be as follows.

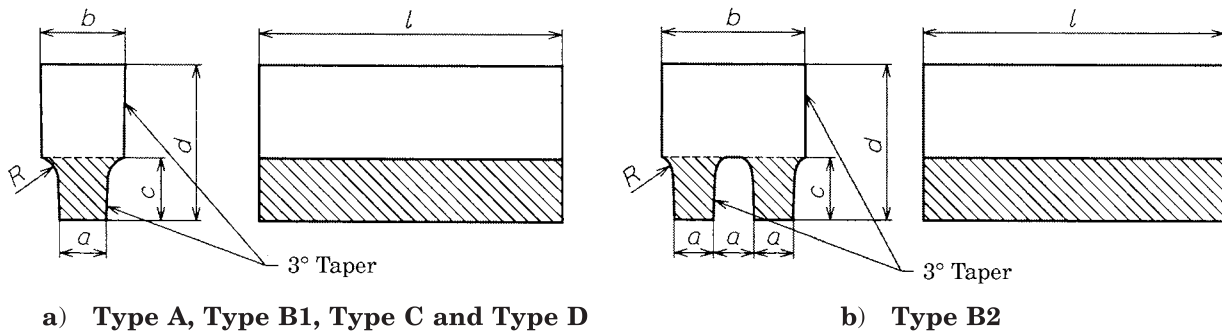
- a) The location of the samples shall be as agreed between the manufacturer and the purchaser.
- b) The sample dimensions shall be selected from Types A to D as shown in Table 6.

Table 3 Dimensions of separately cast or side-by-side cast samples (Y-shaped)

Unit: mm

Dimension	Type			
	Type A	Type B	Type C	Type D
a	12.5	25	50	75
$b^{\text{a)}}$	40	55	100	125
c	25	40	50	65
$d^{\text{a)}}$	135	140	150	175
$l^{\text{b)}}$	A function of a test piece length			
The thickness of the sand mould surrounding the samples should be 40 mm minimum for Types A and B, and 80 mm minimum for Types C and D. For the manufacture of thin-walled castings or castings in metal moulds, the tensile properties can, by agreement between the manufacturer and the purchaser, be determined on cast test pieces taken from samples of thickness, a, less than 12.5 mm. Notes ^{a)} For information only. ^{b)} The test piece size shall be chosen to allow a test piece of dimensions conforming to No. 14A or No. 4 specified in JIS Z 2241.				

Table 4 Dimensions of separately cast or side-by-side cast samples (U-shaped)



Unit: mm

Dimension	Type				
	Type A	Type B1	Type B2	Type C	Type D
a	12.5	25	25	50	75
$b^{a)}$	40	55	90	90	125
c	30	40	40 or 50	60	65
$d^{a)}$	80	100	100	150	165
R	5				
$l^{b)}$	A function of a test piece length				
The thickness of the sand mould surrounding the samples should be at least 40 mm.					
Notes ^{a)} For information only.					
^{b)} The test piece size shall be chosen to allow a test piece of dimensions conforming to No. 14A or No. 4 specified in JIS Z 2241 .					

Table 5 Dimensions of separately cast or side-by-side cast samples
(knock off)

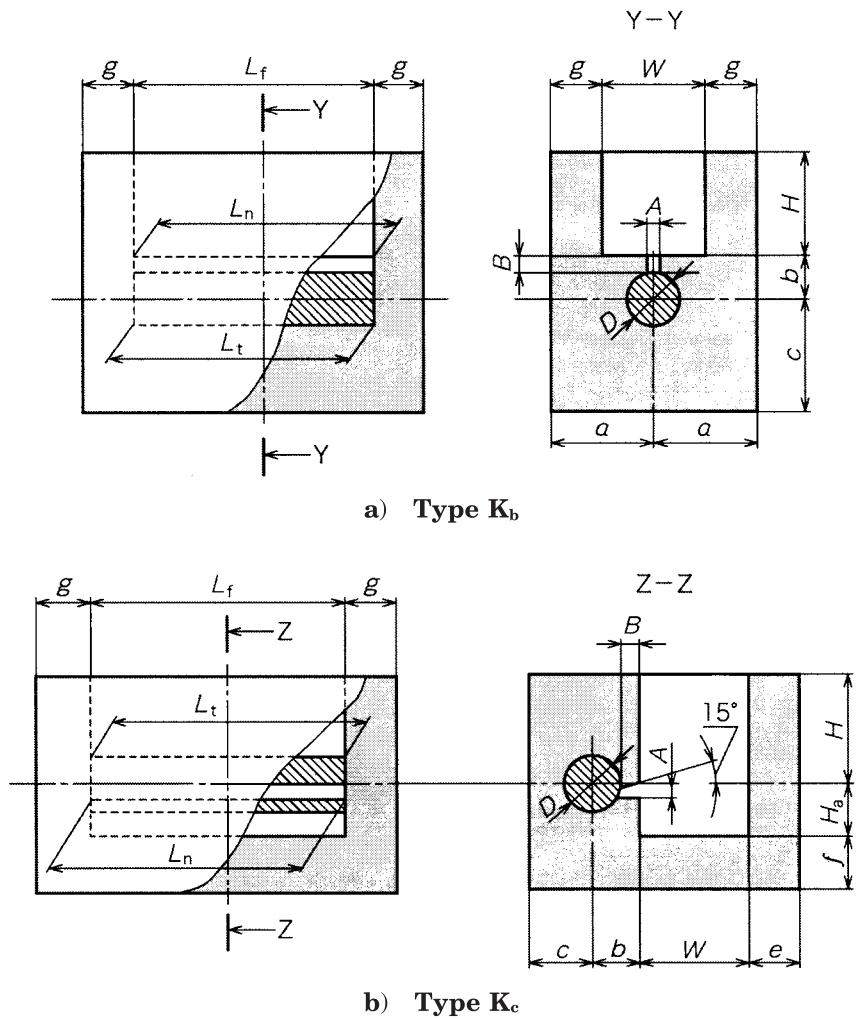


Table 5 (concluded)

Unit: mm

Dimension	Type	
	Type K _b	Type K _c
$A^{b)}$	6	6
$B^{b)}$	7.5	7.5
D	25	25
$H^{b)}$	≥ 50	≥ 50
$H_a^{b)}$	—	25
L_f	— ^{a)}	
L_n	— ^{a)}	
L_t	— ^{a)}	
$W^{b)}$	50	50
$a^{b)}$	≥ 50	—
$b^{b)}$	20	20
$c^{b)}$	≥ 55	≥ 20
$e^{b)}$	—	≥ 25
$f^{b)}$	—	≥ 70
$g^{b)}$	≥ 25	≥ 25
Notes ^{a)} L_f , L_n and L_t shall be chosen to allow a test piece of dimensions conforming to No. 14A or No. 4 specified in JIS Z 2241 . ^{a)} For information only.		