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**Steel heat exchanger tubes for low
temperature service**

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In the event of any doubts arising as to the contents,
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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 The Japan Iron and Steel Federation (JISF) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS G 3464:2013** is replaced with this Standard.

However, **JIS G 3464:2013** may be applied in the **JIS** mark certification based on the relevant provisions of Article 19 Clause 1, etc. of the Industrial Standardization Law until March 19, 2019.

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Steel heat exchanger tubes for low temperature service

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 9329-3 : 1997**, Edition 1 and **ISO 9330-3 : 1997**, Edition 1 with some modifications of the technical contents.

Upon agreement with the manufacturer, the purchaser can specify the supplementary quality requirements and U-bent tubes, which are indicated in Annex JA and Annex JB, respectively. The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standards. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies the steel tubes used for the purpose of exchanging the heat between the inside and the outside of tubes at exceptionally low temperatures of freezing point or under, such as heat exchanger tubes and condenser tubes (hereafter referred to as tubes).

This Standard is generally applicable to the tubes of 15.9 mm to 50.8 mm in outside diameter.

NOTE 1 Austenitic stainless steel tubes specified in **JIS G 3463** may be used as the steel heat exchanger tubes for low temperature service.

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

ISO 9329-3 : 1997 *Seamless steel tubes for pressure purposes — Technical delivery conditions — Part 3 : Unalloyed and alloyed steels with specified low temperature properties*

ISO 9330-3 : 1997 *Welded steel tubes for pressure purposes — Technical delivery conditions — Part 3 : Electric resistance and induction welded unalloyed and alloyed steel tubes with specified low temperature properties* (Overall evaluation : 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 G 0320 *Standard test method for heat analysis of steel products*

JIS G 0321	<i>Product analysis and its tolerance for wrought steel</i>
JIS G 0404	<i>Steel and steel products — General technical delivery requirements</i>
JIS G 0415	<i>Steel and steel products — Inspection documents</i>
JIS G 0582	<i>Automated ultrasonic examination of steel pipes and tubes</i>
JIS G 0583	<i>Automated eddy current examination of steel pipes and tubes</i>
JIS Z 2241	<i>Metallic materials — Tensile testing — Method of test at room temperature</i>
JIS Z 2242	<i>Method for Charpy pendulum impact test of metallic materials</i>
JIS Z 2245	<i>Rockwell hardness test — Test method</i>
JIS Z 8401	<i>Guide to the rounding of numbers</i>

3 Symbol of grade

Tubes are classified into 3 grades. The classification and the symbols of grade are as given in Table 1.

Table 1 Symbols of grade and symbols of manufacturing method

Classification	Symbol of grade	Symbol of manufacturing method		
		Tube manufacturing method	Finishing method	Marking
Carbon steel tubes	STBL380	Seamless : S Electric resistance welded : E	Hot-finished : H Cold-finished : C As electric resistance welded : G	As given in 13 b).
Nickel steel tubes	STBL450 STBL690	Seamless : S		

4 Manufacturing method

The manufacturing method shall be as follows.

- Tubes shall be manufactured from killed steels. Tubes of STBL380 shall be seamless or electric resistance welded, and those of STBL450 and STBL690 shall be seamless. The symbols of manufacturing method are as given in Table 1.
- Tubes shall be heat treated as given in Table 2. Other heat treatment may be applied upon agreement between the purchaser and the manufacturer. Cold-finished tubes shall be heat treated after the cold-finishing.

Table 2 Heat treatment

Symbol of grade	Heat treatment
STBL380	Normalizing, normalizing and tempering, or quenching and tempering
STBL450	
STBL690	Normalizing twice and tempering, or quenching and tempering

- c) Tubes shall be furnished with plane ends, unless otherwise specified.
- d) When tubes are manufactured by electric resistance welding, the weld beads on internal and external surfaces shall be removed so as to obtain a weld joint smooth along the contour of tube, unless otherwise specified. If removing internal weld beads is difficult, the tube may be supplied as welded.

5 Chemical composition

Tubes shall be tested in accordance with 11.1, and the obtained heat analysis values shall conform to Table 3. When the product analysis is requested by the purchaser, the tubes shall be tested in accordance with 11.1. The obtained product analysis values shall satisfy the requirements in Table 3 within the tolerances specified in JIS G 0321. The applicable tolerances are as follows.

- Seamless steel tubes of STBL380 : Table 3 of JIS G 0321
- Electric resistance welded steel tubes : Table 2 of JIS G 0321
- Tubes of STBL450 and STBL690 : Table 4 of JIS G 0321

Table 3 Chemical composition

						Unit : %
Symbol of grade	C	Si	Mn	P	S	Ni
STBL380 ^{a)}	0.25 max.	0.35 max.	1.35 max.	0.035 max.	0.035 max.	^{b)}
STBL450	0.18 max.	0.10 to 0.35	0.30 to 0.60	0.030 max.	0.030 max.	3.20 to 3.80
STBL690	0.13 max.	0.10 to 0.35	0.90 max.	0.030 max.	0.030 max.	8.50 to 9.50
Alloy elements other than those in this table may be added as necessary.						
Notes ^{a)} If the impact test on tubes of STBL380 is omitted by reason of 6.4 c), the tubes shall contain at least 0.010 % of acid soluble aluminium. Alternatively, the total aluminium content may be determined and the content shall be 0.015 % or more. For the value of Al in product analysis, if it is carried out, either of the above shall apply.						
^{b)} When Ni is added as necessary, it shall not be added to such a degree that the specified values of other grades are satisfied, making the grades no longer discernible.						

6 Mechanical properties

6.1 Tensile strength, yield point or proof stress, and elongation

Tubes shall be tested in accordance with 11.2.3, and the tensile strength, yield point or proof stress, and elongation shall conform to Table 4. When the tensile test is carried out using Test piece No. 12 for tubes under 8 mm in wall thickness, the elongation shall conform to Table 5.

Table 4 Mechanical properties

Symbol of grade	Tensile strength ^{a)} N/mm ²	Yield point or proof stress N/mm ²	Elongation %		
			Outside diameter, tensile test piece and direction of tensile test		
			Outside diameter under 10 mm	Outside diameter 10 mm or over to and excl. 20 mm	Outside diameter 20 mm or over
			Test piece No. 11	Test piece No. 11	Test piece No. 11 or Test piece No. 12
			Parallel to tube axis	Parallel to tube axis	Parallel to tube axis
STBL380	380 min.	205 min.	27 min.	30 min.	35 min.
STBL450	450 min.	245 min.	22 min.	25 min.	30 min.
STBL690	690 min.	520 min.	13 min.	16 min.	21 min.

NOTE 1 N/mm² = 1 MPa

Note ^{a)} The purchaser may specify the upper limit of tensile strength. In this case, the upper limit of tensile strength shall be the value specified in this table to which 120 N/mm² is added for tubes of STBL380, and the value to which 150 N/mm² is added for tubes of STBL450 and STBL690.

Table 5 Elongation of Test piece No. 12 taken from tubes under 8 mm in wall thickness (parallel to tube axis)

Unit : %

Symbol of grade	Wall thickness						
	Over 1 mm up to and incl. 2 mm	Over 2 mm up to and incl. 3 mm	Over 3 mm up to and incl. 4 mm	Over 4 mm up to and incl. 5 mm	Over 5 mm up to and incl. 6 mm	Over 6 mm up to and incl. 7 mm	Over 7 mm to and excl. 8 mm
STBL380	26 min.	28 min.	29 min.	30 min.	32 min.	34 min.	35 min.
STBL450	21 min.	22 min.	24 min.	26 min.	27 min.	28 min.	30 min.
STBL690	12 min.	14 min.	15 min.	16 min.	18 min.	20 min.	21 min.

NOTE The elongation in this table is calculated by subtracting 1.5, for every 1 mm decrease from 8 mm in wall thickness, from the elongation value given in Table 4, and rounded to the integer according to Rule A in JIS Z 8401.

6.2 Flattening property

Tubes shall be tested in accordance with 11.2.4, and the test piece shall be free from cracks until the distance between the platens (H) reaches the value given by Formula (1).

$$H = \frac{(1+e)t}{e + \frac{t}{D}} \dots\dots\dots(1)$$

where, H : distance between platens (mm)
 t : wall thickness of tube (mm)
 D : outside diameter of tube (mm)
 e : constant 0.08

NOTE For the flattening test, see 11.2.4.

6.3 Flaring property

Tubes shall be tested in accordance with 11.2.5, and they shall be free from cracks when flared into a trumpet shape until the outside diameter reaches 1.14 times the original outside diameter. For the tubes of the outside diameter exceeding 101.6 mm, this requirement applies when requested by the purchaser.

NOTE For the flaring property test, see 11.2.5.

6.4 Absorbed energy

The absorbed energy shall be as follows.

- a) Tubes shall be tested in accordance with 11.2.6, and the absorbed energy obtained in Charpy impact test shall conform to Table 6. In this case, the test temperature for tubes of STBL380 shall be -45°C , -100°C for tubes of STBL450, and -196°C for tubes of STBL690. The test temperature lower than those may be determined upon agreement between the purchaser and the manufacturer.
- b) Electric resistance welded steel tubes shall be subjected to the impact test for the weld in addition to the impact test of a). The absorbed energy shall conform to Table 6. In this case, the test temperature shall be -45°C . In the case where the test is carried out at a temperature lower than those, the test may be substituted by the test of this temperature upon agreement between the purchaser and the manufacturer.
- c) The impact test shall be omitted for tubes having dimensions insufficient to take a test piece of $10\text{ mm} \times 5\text{ mm}$.

Table 6 Absorbed energy in Charpy impact test

Dimensions of test piece mm	Absorbed energy in charpy impact test J		Test piece
	Mean value of 3 test pieces	Value of each test piece ^{a)}	
10 × 10	21 min.	14 min.	V-notch test piece
10 × 7.5	18 min.	12 min.	
10 × 5	14 min.	10 min.	
Note ^{a)} The values of two test pieces among three shall be equal to or higher than the mean value of 3 test pieces in this table.			

7 Hydrostatic test characteristics and nondestructive test characteristics

Tubes shall be tested in accordance with 11.3, and their hydrostatic test characteristics and nondestructive test characteristics shall be as follows. Which characteristics to be tested shall be specified by the purchaser. If not specified, it shall be left to the discretion of the manufacturer.

- a) **Hydrostatic test characteristics** Shall be as follows.
 - 1) When the purchaser does not specify the test pressure, tubes shall be subjected to the minimum hydrostatic test pressure (P) (5 MPa if exceeding 5 MPa) calculated