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JAPANESE INDUSTRIAL STANDARD

**Carbon Steel Plates for Pressure
Vessels for Intermediate and
Moderate Temperature Service**

JIS G 3118—1987

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JAPANESE INDUSTRIAL STANDARD

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Carbon Steel Plates for Pressure Vessels for
Intermediate and Moderate Temperature Service

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1. Scope

This Japanese Industrial Standard specifies the hot rolled carbon steel plates, hereinafter referred to as the "steel plates", to be used for pressure vessels mainly for intermediate and moderate temperature service.

Remark: The units and numerical values given in { } in this standard are in accordance with the International System of Units (SI), and are appended for reference.

Further, the traditional units and numerical values in this Standard shall be converted to the SI units and numerical values on Jan. 1, 1991.

2. Classification and Symbols

The steel plate shall be classified into three and their symbols are as shown in Table 1-1 or Table 1-2.

Table 1-1. Class and Symbol (Applicable till the end of 1990)

Symbol	Applied thickness mm
SGV 42	6 and over, up to and incl. 200
SGV 46	
SGV 49	

Table 1-2. Class and Symbol (Applicable on and after Jan. 1, 1991)

Symbol		Applied thickness mm
SI units	Traditional units (reference)	
SGV 410	SGV 42	6 and over, up to and incl. 200
SGV 450	SGV 46	
SGV 480	SGV 49	

3. Chemical Composition

3.1 Ladle Analysis Values The steel plate shall be tested in accordance with 9.2 and the values obtained by ladle analysis shall conform to Table 2-1 or Table 2-2.

Table 2-1. Chemical Composition (applicable till the end of 1990)

Symbol	Chemical composition %				
	C	Si	Mn	P	S
SGV 42	Up to and incl. 12.5 mm in thickness				
	Over 12.5 mm, up to and incl. 50 mm in thickness				
	Over 50 mm, up to and incl. 100 mm in thickness				
	Over 100 mm, up to and incl. 200 mm in thickness				
SGV 46	Up to and incl. 12.5 mm in thickness				
	Over 12.5 mm, up to and incl. 50 mm in thickness				
	Over 50 mm, up to and incl. 100 mm in thickness				
	Over 100 mm, up to and incl. 200 mm in thickness				
SGV 49	Up to and incl. 12.5 mm in thickness				
	Over 12.5 mm, up to and incl. 50 mm in thickness				
	Over 50 mm, up to and incl. 100 mm in thickness				
	Over 100 mm, up to and incl. 200 mm in thickness				

Remark: In the case of SGV 42 steel plate 12.5 mm and under in thickness, the content of manganese may be 0.60 to 0.90 %.

Table 2-2. Chemical Composition (Applicable on and after Jan. 1, 1991)

Symbol	Chemical composition %				
	C	Si	Mn	P	S
SGV 410	Up to and incl. 12.5 mm in thickness	0.15 to 0.30	0.85 to 1.20	0.035 max.	0.040 max.
	Over 12.5 mm, up to and incl. 50 mm in thickness				
	Over 50 mm, up to and incl. 100 mm in thickness				
	Over 100 mm, up to and incl. 200 mm in thickness				
SGV 450	Up to and incl. 12.5 mm in thickness	0.15 to 0.30	0.85 to 1.20	0.035 max.	0.040 max.
	Over 12.5 mm, up to and incl. 50 mm in thickness				
	Over 50 mm, up to and incl. 100 mm in thickness				
	Over 100 mm, up to and incl. 200 mm in thickness				
SGV 480	Up to and incl. 12.5 mm in thickness	0.15 to 0.30	0.85 to 1.20	0.035 max.	0.040 max.
	Over 12.5 mm, up to and incl. 50 mm in thickness				
	Over 50 mm, up to and incl. 100 mm in thickness				
	Over 100 mm, up to and incl. 200 mm in thickness				

Remark: In the case of SGV 410 steel plate 12.5 mm and under in thickness, the content of manganese may be 0.60 to 0.90 %.

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3.2 Product Analysis Values When required by the purchaser, the product analysis shall be made in accordance with 9.1, and the values obtained shall conform to Table 2-1 or Table 2-2. In this case, the value of silicon shall be 0.13 to 0.33 %, and that of manganese 0.80 to 1.25 %, or 0.56 to 0.94 % when Remark of Table 2-1 or Table 2-2 are applied.

4. Mechanical Properties

The steel plate shall be tested in accordance with 9.2 and its yield point, tensile strength, elongation and bendability shall comply with Table 3-1 or Table 3-2.

When subjected to bendability, it shall show no crack on the outside of the bent portion.

5. Grain Size

The steel plate shall be tested in accordance with 9.3 and the austenite grain size of the steel plate shall be 5 or finer.

Table 3-1. Mechanical Properties (Applicable till the end of 1990)

Symbol	Yield point kgf/mm ² {N/mm ² }	Tensile strength kgf/mm ² {N/mm ² }	Elongation %	Tensile test piece	Bendability	
					Bend angle	Inside radius
SGV 42	23 min. {226} min.	42 to 50 {412 to 490}	21 min.	No.1 A	180°	Up to and incl. 25 mm in thickness 0.5 x thickness
			25 min.	No.10		Over 25 mm, up to and incl. 50 mm in thickness 0.75 x thickness Over 50 mm, up to and incl. 100 mm in thickness 1.0 x thickness Over 100 mm, up to and incl. 200 mm in thickness 1.25 x thickness
SGV 46	25 min. {245} min.	46 to 55 {451 to 539}	19 min.	No.1 A	180°	Up to and incl. 25 mm in thickness 0.75 x thickness
			23 min.	No.10		Over 25 mm, up to and incl. 50 mm in thickness 1.0 x thickness Over 50 mm, up to and incl. 100 mm in thickness 1.0 x thickness Over 100 mm, up to and incl. 200 mm in thickness 1.25 x thickness
SGV 49	27 min. {265} min.	49 to 60 {481 to 588}	17 min.	No.1 A	180°	Up to and incl. 25 mm in thickness 1.0 x thickness
			21 min.	No.10		Over 25 mm, up to and incl. 50 mm in thickness 1.0 x thickness Over 50 mm, up to and incl. 100 mm in thickness 1.25 x thickness Over 100 mm, up to and incl. 200 mm in thickness 1.5 x thickness

- Remarks 1. For steel plate of 50 mm and under in thickness, No. 1 A test piece shall be used. For steel plate over 50 mm in thickness, No. 10 test piece shall be used. For those over 40 mm in thickness, however, No. 10 test piece may be used.
2. The elongation of No. 1 A test piece for steel plate under 8 mm in thickness shall be deducted by 1 % from the elongation value given in the above Table for each decrease of 1 mm or its fraction in thickness.
3. The elongation of No. 1 A test piece for steel plate over 20 mm in thickness shall be deducted by 0.5 % from the elongation value given in the above Table for each increase of 3 mm or its fraction in thickness. The deduction rate shall not exceed 3 %.
4. The elongation of No. 10 test piece for steel plate over 90 mm in thickness shall be deducted by 0.5 % from the elongation value given in the above Table for each increase of 12.5 mm or its fraction in thickness. The deduction rate shall not exceed 3 %.

Table 3-2. Mechanical Properties (Applicable on and after Jan. 1, 1991)

Symbol	Yield point N/mm ²	Tensile strength N/mm ²	Elongation %	Tensile test piece	Bendability	
					Bend angle	Inside radius
SGV 410	225 min.	410 to 490	21 min.	No.1 A	180°	Up to and incl. 25 mm in thickness 0.5 x thickness
			25 min.	No.10		Over 25 mm, up to and incl. 50 mm in thickness 0.75 x thickness Over 50 mm, up to and incl. 100 mm in thickness 1.0 x thickness Over 100 mm, up to and incl. 200 mm in thickness 1.25 x thickness
SGV 450	245 min.	450 to 540	19 min.	No.1 A	180°	Up to and incl. 25 mm in thickness 0.75 x thickness
			23 min.	No.10		Over 25 mm, up to and incl. 50 mm in thickness 1.0 x thickness Over 50 mm, up to and incl. 100 mm in thickness 1.0 x thickness Over 100 mm, up to and incl. 200 mm in thickness 1.25 x thickness
SGV 480	265 min.	480 to 590	17 min.	No.1 A	180°	Up to and incl. 25 mm in thickness 1.0 x thickness
			21 min.	No.10		Over 25 mm, up to and incl. 50 mm in thickness 1.0 x thickness Over 50 mm, up to and incl. 100 mm in thickness 1.25 x thickness Over 100 mm, up to and incl. 200 mm in thickness 1.5 x thickness

- Remarks 1. For steel plate of 50 mm and under in thickness, No. 1 A test piece shall be used. For steel plate over 50 mm in thickness, No. 10 test piece shall be used. For those over 40 mm in thickness, however, No. 10 test piece may be used.
2. The elongation of No. 1 A test piece for steel plate under 8 mm in thickness shall be deducted by 1 % from the elongation value given in the above Table for each decrease of 1 mm or its fraction in thickness.
3. The elongation of No. 1 A test piece for steel plate over 20 mm in thickness shall be deducted by 0.5 % from the elongation value given in the above Table for each increase of 3 mm or its fraction in thickness. The deduction rate shall not exceed 3 %.
4. The elongation of No. 10 test piece for steel plate over 90 mm in thickness shall be deducted by 0.5 % from the elongation value given in the above Table for each increase of 12.5 mm or its fraction in thickness. The deduction rate shall not exceed 3 %.

6. Shape, Dimensions, Mass and Tolerances

The shape, dimension, mass and tolerances of the steel plate shall comply with JIS G 3193, on condition that the following requirements are satisfied:

- (1) Tolerances on the length of the steel plate and on the width of cut edged steel shall be same as Tolerance A, unless particularly specified, and tolerances on thickness shall conform to Table 4.
- (2) For calculating the mass of the steel plate, the value obtained by adding the numerical value given in Table 5 to the indicated thickness shall be used in place of the indicated thickness.

Table 4. Tolerances on Thickness

Unit: mm

Thickness \ Width	Up to 1600	1600 and over, up to 2000	2000 and over, up to 2500	2500 and over, up to 3150	3150 and over, up to 4000	4000 and over, up to 5000
6.00 and over, up to 10.0	+ 0.95	+ 1.05	+ 1.25	+ 1.45	+ 1.65	+ 1.85
10.0 and over, up to 16.0	+ 0.95	+ 1.15	+ 1.35	+ 1.55	+ 1.75	+ 1.95
16.0 and over, up to 25.0	+ 1.15	+ 1.35	+ 1.55	+ 1.75	+ 2.15	+ 2.35
25.0 and over, up to 40.0	+ 1.35	+ 1.55	+ 1.75	+ 1.95	+ 2.35	+ 2.55
40.0 and over, up to 63.0	+ 1.55	+ 1.75	+ 2.15	+ 2.35	+ 2.55	+ 2.75
63.0 and over, up to 100	+ 1.95	+ 2.15	+ 2.55	+ 2.75	+ 2.95	+ 3.15
100 and over, up to 160	+ 2.35	+ 2.55	+ 2.95	+ 3.15	+ 3.35	+ 3.55
160 and over	+ 2.95	+ 3.15	+ 3.55	+ 3.75	+ 3.95	+ 4.15

Remark: Tolerances on the minus side shall be 0.25 mm.

Table 5. Numerical Value to Be Added for Calculating Mass of Steel Plate

Unit: mm

Width Thickness	Up to 1600	1600 and over, up to 2000	2000 and over, up to 2500	2500 and over, up to 3150	3150 and over, up to 4000	4000 and over, up to 5000
6.00 and over, up to 10.0	0.35	0.40	0.50	0.60	0.70	0.80
10.0 and over, up to 16.0	0.35	0.45	0.55	0.65	0.75	0.85
16.0 and over, up to 25.0	0.45	0.55	0.65	0.75	0.95	1.05
25.0 and over, up to 40.0	0.55	0.65	0.75	0.85	1.05	1.15
40.0 and over, up to 63.0	0.65	0.75	0.95	1.05	1.15	1.25
63.0 and over, up to 100	0.85	0.95	1.15	1.25	1.35	1.45
100 and over, up to 160	1.05	1.15	1.35	1.45	1.55	1.65
160 and over	1.35	1.45	1.65	1.75	1.85	1.95

7. Appearance

Appearance of steel plates shall conform to 6. of JIS G 0303. Where welding repair is needed, however, the purchaser's approval shall be obtained.

8. Manufacture and Heat Treatment

8.1 Manufacture The steel plate shall be manufactured from fine-grained killed steel by hot rolling.

8.2 Heat Treatment of Steel Plate Heat treatment of steel plate shall be as follows:

- (1) The steel plate 38 mm and under in thickness shall be delivered as rolled, unless the purchaser designates the normalization of the steel plate for improving the absorption energy. For the convenience of the manufacturer, however, the steel plate may be normalized.
- (2) The steel plate over 38 mm in thickness shall be normalized to obtain normal grain size, or heated uniformly, in process of hot forming, at such normalizing temperature that will ensure effect equal to the above. The foregoing normalizing process shall include accelerated cooling to improve the absorption energy and the subsequent tempering.

8.3 Designation of Heat Treatment of Steel Plate The purchaser shall designate in the order which of the purchaser or the manufacturer shall perform the normalizing process specified in 8.2.

8.4 Heat Treatment of Test Piece Heat treatment of test piece shall be performed as follows:

(1) When the manufacturer is to normalize the steel plate, the test piece shall be taken from the normalized steel plate.

(2) When the purchaser is to normalize the steel plate, the manufacturer shall cut out test piece from the steel plate as rolled, and heat-treat it in accordance with the designation of the purchaser.

If no designation is given by the purchaser, the manufacturer shall heat-treat the test piece in the way he considers appropriate to obtain normal grain size and to meet the requirements of mechanical properties, and the manufacturer shall inform the purchaser of the method of the heat treatment carried out on the test piece.

(3) When the purchaser designates the stress relieving of the test piece, the manufacturer shall heat-treat the test piece in accordance with the designation of the purchaser. In this case, the purchaser shall report the number of times and conditions of the heat treatment to the manufacturer. If no instruction is given, the heat treatment shall be performed as follows:

The test piece shall be gradually heated to a temperature of 595 to 650 °C, after being held at that temperature for 1 h or more per 25 mm of thickness, shall be cooled to 300 °C in the furnace and then be to let to stand in the atmosphere.

(4) The heat treatment for the test piece specified in (2) and (3) shall be performed in the state as it is in the form of test specimen.

8.5 Symbol for Heat Treatment The symbol for heat treatment to be noted in the order shall be as follows:

- | | |
|--------------------------------------|----|
| (1) Steel plate to be normalized | N |
| (2) Test piece to be only normalized | TN |
| (3) Test piece to be stress-relieved | SR |

Examples: 1-1 (Applicable till the end of 1990)

SGV 42 N Steel plate to be normalized.

SGV 49 NSR Steel plate to be normalized, and moreover test piece to be stress-relieved.

SGV 49 TNSR Steel plate not to be normalized, but only test piece to be normalized and stress-relieved.

Examples: 1-2 (Applicable on and after Jan. 1, 1991)

SGV 410 N	Steel plate to be normalized.
SGV 480 NSR	Steel plate to be normalized, and moreover test piece to be stress-relieved.
AGV 480 TNSR	Steel plate not to be normalized, but only test piece to be normalized and stress-relieved.

9. Test

9.1 Analysis Analysis test shall be performed as follows:

- (1) The general rules for the analytical examination and the sampling of the test specimen for the ladle analysis shall be the same as those provided in 3. of JIS G 0303.
- (2) The sampling of the test specimen for the product analysis shall be the same as that provided in 3.3.1 of JIS G 0321. The test piece after it is ruptured in the tensile test can be used as a test specimen.
- (3) The analysis shall conform to any of the following Standards:

JIS G 1211	JIS G 1212	JIS G 1213	JIS G 1214
JIS G 1215	JIS G 1252	JIS G 1253	JIS G 1256
JIS G 1257			

9.2 Mechanical Test

9.2.1 The general rules for the mechanical test shall follow the provisions of 4. in JIS G 0303. The method of sampling shall be the same as that of Class A, and the number of test pieces and the position where the test piece is to be taken shall comply with the following:

(1) Number of Tensile Test and Bend Test Pieces

- (a) Tensile Test Piece One from every steel plate as rolled from the same slab or directly from the same ingot.
- (b) Bend Test Piece One from every steel plate as rolled from the same slab or directly from the same ingot.

The number of test pieces from heat-treated steel plate shall comply with the provisions (a) and (b) for every same heat-treating condition.

(2) Position for Sampling Tensile Test and Bend Test Pieces

- (a) Tensile Test Piece Where the final rolling direction of the steel plate is parallel to the direction of the ingot axis, the test piece shall be taken from a corner of the steel plate corresponding to the bottom end of the ingot; where the final rolling direction of

the steel plate is at right angles to the direction of the ingot axis, or the correlation between them is unknown, the test piece shall be taken from a corner of either end, and the direction of taking the test piece shall be at right angles to the final rolling direction. In case of using No. 10 test piece, the axis of the test piece shall be positioned at 1/4 of thickness apart from the surface of the steel plate.

- (b) Bend Test Piece The test piece shall be taken from the middle of the width of the steel plate opposite the end where the tensile test piece has been taken, and the direction of taking the test piece shall be at right angles to the final rolling direction.

9.2.2 Test Piece The test pieces for the tensile and bend tests shall be as follows:

- (1) No. 1 A or No. 10 test piece specified in JIS Z 2201 shall be used.
- (2) No. 1 test piece specified in JIS Z 2204 shall be used.

9.2.3 Test Method The test methods for the tensile and bend tests shall conform to the following Standards:

- (1) JIS Z 2241
- (2) JIS Z 2248

9.3 Test for Austenite Grain Size Test for austenite grain size shall be as follows:

- (1) One test specimen shall be sampled from a position adjacent to the tensile test piece.
- (2) The test method shall follow the Standard below. In this case, a carburizing process shall be applied.

JIS G 0551

10. Inspection

Inspection shall be as follows:

- (1) The test results of chemical composition, mechanical property, austenite grain size, shape, dimensions, mass and appearance shall satisfy the requirements of 3., 4., 5., 6. and 7. When designated by the purchaser, however, the test and inspection of the mechanical properties may be partially or entirely omitted.
- (2) In addition to the inspection specified in (1), the purchaser may designate the nondestructive inspection, such as sulfur print and ultrasonic flaw detection, and impact test. In this case, agreement on the method of sampling, method of test, criterion of acceptance, etc. shall be reached in advance between the parties concerned.
- (3) Reinspection The steel plate having failed in the tensile test or the bend test or both may be retested for acceptance in accordance with the provisions of 4.4 in JIS G 0303.

11. Marking

The steel plate having passed the inspection shall be marked clearly on each steel plate with the following items in a suitable way:

- (1) Symbol of class
- (2) Heat number or inspection number
- (3) Size
- (4) Manufacturer's name or its abbreviation

12. Report

The report shall comply with the provisions of 8. in JIS G 0303.

Applicable Standards:

- JIS G 0303-General Rules for Inspection of Steel
- JIS G 0321-Product Analysis and Its Tolerance for Wrought Steel
- JIS G 0551-Methods of Austenite Grain Size Test for Steel
- JIS G 1211-Methods for Determination of Carbon in Iron and Steel
- JIS G 1212-Methods for Determination of Silicon in Iron and Steel
- JIS G 1213-Methods for Determination of Manganese in Iron and Steel
- JIS G 1214-Methods for Determination of Phosphorus in Iron and Steel
- JIS G 1215-Methods for Determination of Sulfur in Iron and Steel
- JIS G 1252-Emission-Spectroscopic Analysis for Carbon Steel and Low Alloy Steel
- JIS G 1253-Method for Photoelectric Emission Spectrochemical Analysis of Iron and Steel
- JIS G 1256-Method for X-ray Fluorescence Spectrometric Analysis of Iron and Steel
- JIS G 1257-Atomic Absorption Spectrochemical Analysis of Iron and Steel
- JIS G 3193-Dimensions, Weight and Permissible Variations of Hot Rolled Steel Plates, Sheets and Strip
- JIS Z 2201-Test Pieces for Tensile Test for Metallic Materials
- JIS Z 2204-Bend Test Pieces for Metallic Materials
- JIS Z 2241-Method of Tensile Test for Metallic Materials
- JIS Z 2248-Method of Bend Test for Metallic Materials

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