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JAPANESE INDUSTRIAL STANDARD

**Manganese-Molybdenum and
Manganese-Molybdenum-Nickel
Alloy Steel Plates Quenched and
Tempered for Pressure Vessels**

JIS G 3120—1987

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JAPANESE INDUSTRIAL STANDARD

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Manganese-Molybdenum and Manganese-Molybdenum-
Nickel Alloy Steel Plates Quenched and
Tempered for Pressure Vessels G 3120-19871. Scope

This Japanese Industrial Standard specifies quenched and tempered manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates, hereinafter referred to as the "steel plate", excellent especially in low temperature toughness and weldability, or suited for thermal refining by quenching and tempering, and to be used for nuclear reactors and other pressure vessels.

Remark: The units and numerical values shown in () in this Standard are based on the International System of Units (SI) and are appended for informative reference.

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

2. Classification and Symbol

Steel plates shall be classified into 6 types and the type symbol of the steel plates shall be as shown in Table 1.

Table 1. Type Symbols

Type symbol
SQV 1 A
SQV 1 B
SQV 2 A
SQV 2 B
SQV 3 A
SQV 3 B

3. Chemical Composition

3.1 Cast Analysis Steel plates shall be tested in accordance with 8.1 and the values of cast analysis shall conform to Table 2.

Table 2. Chemical Composition

Type symbol	Chemical composition %						
	C	Si	Mn	P	S	Ni	Mo
SQV 1 A	0.25 max.	0.15 to 0.30	1.15 to 1.50	0.035 max.	0.040 max.	—	0.45 to 0.60
SQV 1 B	0.25 max.	0.15 to 0.30	1.15 to 1.50	0.035 max.	0.040 max.	—	0.45 to 0.60
SQV 2 A	0.25 max.	0.15 to 0.30	1.15 to 1.50	0.035 max.	0.040 max.	0.40 to 0.70	0.45 to 0.60
SQV 2 B	0.25 max.	0.15 to 0.30	1.15 to 1.50	0.035 max.	0.040 max.	0.40 to 0.70	0.45 to 0.60
SQV 3 A	0.25 max.	0.15 to 0.30	1.15 to 1.50	0.035 max.	0.040 max.	0.70 to 1.00	0.45 to 0.60
SQV 3 B	0.25 max.	0.15 to 0.30	1.15 to 1.50	0.035 max.	0.040 max.	0.70 to 1.00	0.45 to 0.60

3.2 Product Analysis When required by the purchaser, the product analysis shall be made in accordance with 8.1, and the values obtained shall conform to Table 2, where Si shall be 0.13 to 0.32 %, Mn 1.10 to 1.55 %, Ni of SQV 2 A and SQV 2 B be 0.37 to 0.73 %, Ni of SQV 3 A and SQV 3 B be 0.67 to 1.03 %, and Mo 0.41 to 0.64 %.

4. Mechanical Properties

Steel plates shall be tested in accordance with 8.2 and the obtained proof stress, tensile strength, elongation and bendability shall conform to Table 3-1 or Table 3-2. Further, as to bendability, no crack shall be identified on the outside of the bent portion.

The Charpy absorbed energy and test temperature of steel plate over 12 mm in thickness shall conform to Table 4-1 or Table 4-2. In that case, even though the requirements specified in Table 4-1 or Table 4-2 are satisfied, there shall not be two values that fall short of the specified average values of three test pieces.

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

Type symbol	Proof stress kgf/mm ² {N/mm ² }	Tensile strength kgf/mm ² {N/mm ² }	Elongation %	Tensile test piece	Bendability	
					Bending angle	Inside radius
SQV 1 A	35 min. {343} min.	56 to 70 {549 to 686}	18 min.	No. 1 A ⁽¹⁾ or No. 10	180°	1.75 x thickness
SQV 1 B	49 min. {481} min.	63 to 81 {618 to 794}	16 min.			
SQV 2 A	35 min. {343} min.	56 to 70 {549 to 686}	18 min.			
SQV 2 B	49 min. {481} min.	63 to 81 {618 to 794}	16 min.			
SQV 3 A	35 min. {343} min.	56 to 70 {549 to 686}	18 min.			
SQV 3 B	49 min. {481} min.	63 to 81 {618 to 794}	16 min.			

Note ⁽¹⁾ When No. 1 A test piece is used, the gauge length for determining elongation shall be 50 mm, and the fracture shall be included in the measurement.

- Remarks
1. For steel plates 20 mm or under in thickness, No. 1 A test piece shall be used.
 2. For steel plates over 40 mm in thickness, No. 10 test piece shall be used.
 3. For steel plates over 20 mm up to 40 mm in thickness, either No. 1 A test piece or No. 10 shall be used.
 4. The elongation of No. 10 test piece of steel plates over 90 mm in thickness shall be deducted by 0.5 % from the values given in Table 3 for each increase of 12.5 mm or fraction thereof in thickness. This rate of deduction shall not exceed 3 %.

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

Type symbol	Proof stress N/mm ²	Tensile strength N/mm ²	Elongation %	Tensile test piece	Bendability	
					Bending angle	Inside radius
SQV 1 A	345 min	550 to 690	180 min.	(1) No. 1 A or No. 10	180°	1.75 x thickness
SQV 1 B	480 min.	620 to 790	16 min.			
SQV 2 A	345 min.	550 to 690	18 min.			
SQV 2 B	480 min.	620 to 790	16 min.			
SQV 3 A	345 min.	550 to 690	18 min.			
SQV 3 B	480 min.	620 to 790	16 min.			

Note (1) When No. 1 test piece is used, the gauge length for determining elongation shall be 50 mm and the fracture shall be included in the measurement.

- Remarks 1. For steel plates 20 mm or under in thickness, No. 1 A test piece shall be used.
2. For steel plates over 40 mm in thickness, No. 10 test piece shall be used.
3. For steel plates over 20 mm up to 40 mm in thickness, either No. 1 A test piece or No. 10 shall be used.
4. The elongation of No. 10 test piece of steel plates over 90 mm in thickness shall be deducted by 0.5 % from the values given in Table 3 for each increase of 12.5 mm or fraction thereof in thickness. The rate of deduction shall not exceed 3 %.

Table 4-1. Charpy Absorbed Energy (Applicable till the end of 1990)

Type symbol	Charpy absorbed energy kg·m {J}		Test piece
	Average value of three test pieces	Individual value	
SQV 1 A	4.1 min. {40.2} min.	3.5 min. {34.3} min.	No. 4
SQV 1 B	4.8 min. {47.1} min.	4.1 min. {40.2} min.	
SQV 2 A	4.1 min. {40.2} min.	3.5 min. {34.3} min.	
SQV 2 B	4.8 min. {47.1} min.	4.1 min. {40.2} min.	
SQV 3 A	4.1 min. {40.2} min.	3.5 min. {34.3} min.	
SQV 3 B	4.8 min. {47.1} min.	4.1 min. {40.2}	

Remark: The test temperature shall be decided by agreement between the parties concerned.

Table 4-2. Charpy Absorbed Energy (Applicable on and after Jan. 1, 1991)

Type symbol	Charpy absorbed energy kg·m J		Test piece
	Average value of three test pieces	Individual value	
SQV 1 A	40 min.	34 min.	No. 4
SQV 1 B	47 min.	40 min.	
SQV 2 A	40 min.	34 min.	
SQV 2 B	47 min.	40 min.	
SQV 3 A	40 min.	34 min.	
SQV 3 B	47 min.	40 min.	

Remark: The test temperature shall be decided by agreement between the parties concerned.

5. Shape, Dimensions, Mass and Tolerances

Shape, dimensions, mass and tolerances of steel plates shall be as specified in JIS G 3193 and satisfy the following requirements:

- (1) Unless otherwise specified, Tolerance A applies to the length of steel plate and to the width of cut edged one. Tolerances on thickness shall be as given in Table 5.
- (2) In the calculation of the mass of steel plates, the value obtained by adding the numerical value given in Table 6 to the indicated thickness shall be used in place of the indicated thickness.

Table 5. Tolerances on Thickness

Unit: mm

Width Thickness	Under 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 6. Additional Numerical Values to Be Used for
Mass Calculation of Steel Plate

Unit: mm

Width Thickness	Under 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

6. Appearance

Appearance of steel plates shall conform to 7. of JIS G 3193. However, when a steel plate is to be repaired by welding, the affair shall be agreed on in advance between the parties concerned.

7. Heat Treatment**7.1 Heat Treatment of Steel Plates**

7.1.1 Quenching and Tempering Steel plates shall be quenched and tempered as follows:

Steel plates shall be heated to a suitable temperature within the range 855 to 1000 °C, and quenched in water after having been heated sufficiently to attain a uniform temperature throughout the plate thickness; next, the plates shall be heated to a suitable temperature 610 °C or higher considered to satisfy the mechanical properties and shall be tempered while maintained at the above temperature for 30 min or over per 25 mm of thickness, the minimum holding time being 30 min.

7.1.2 Heat Treatment Conditions If the purchaser performs the heat treatment specified in 7.1.1, the steel plates shall be heat-treated as rolled, stress relieved or as specified, in any case to be selected by agreement between the purchaser and the manufacturer.

Remark: Because the steel plates specified in this Standard, as they are rolled, are liable to produce cracks in the period till immediately before the plates are worked, especially in the case of thickness 25 mm and over, the steel plates should preferably be heat-treated.

7.2 Specification for Heat Treatment of Steel Plates The purchaser shall specify in the order which of the purchaser and the manufacturer shall perform the quenching and tempering specified in 7.1.1, and if the purchaser is to perform the treatment he shall specify the heat treating conditions provided in 7.1.2.

7.3 Heat Treatment of Test Pieces The heat treatment of test pieces shall be as follows:

- (1) If the manufacturer performs the quenching and tempering of the steel plates, the test pieces shall be taken from the quenched and tempered steel plates.
- (2) If the purchaser is to perform the quenching and tempering of the steel plates, the test specimen shall be taken from the steel plate that has undergone the heat treatment prescribed in 7.1.2, and then the test pieces shall be cut out of the test specimen after it is heat-treated as indicated by the purchaser. If no request is made by the purchaser, the test pieces shall be cut out of the test specimen on which the manufacturer has performed the heat treatment he considered appropriate in accordance with 7.1.1. The manufacturer shall inform the purchaser of dimensions of the test pieces, heat treatment temperature, holding time and cooling method together with the test results.
- (3) If the purchaser specifies stress relieving of the test pieces, the manufacturer shall perform the additional heat treatment on the quenched and tempered test pieces in accordance with the specification of the purchaser.

In this case, the purchaser shall indicate to the manufacturer the stress relieving temperature, holding time and the number of times of heat treatment.

- (4) The heat treatment for the test pieces specified in (2) and (3) shall be performed under the state before they are taken out of the test specimen.

7.4 Symbols for Heat Treatment The symbols for heat treatment to be used in the order shall be as follows:

- | | |
|---|----|
| (1) When the steel plates are quenched and tempered | Q |
| (2) When the steel plates are stress relieved | P |
| (3) When the test piece alone are quenched and tempered | TQ |

- (4) When the test pieces alone are stress relieved SR

Examples: SQV 1 AQ When the steel plates are quenched and tempered

SQV 1 AQSR When the steel plates are quenched and tempered, and moreover, the test pieces are stress relieved

SQV 1 APTQ When the steel plates are stress relieved, and moreover, the test pieces are quenched and tempered

SQV 1 APTQSR When the steel plates are stress relieved, and moreover, the test pieces are quenched and tempered and stress relieved

SQV 1 ATQSR When the steel plates are not heat-treated, and the test pieces only are quenched and tempered and stress relieved

8. Test

8.1 Analysis

- (1) General rules common to the analysis and the sampling of the test specimen for the cast analysis shall be as provided in 3. of JIS G 0303.
- (2) The sampling of the test specimen for the product analysis shall be as provided in 3.3.1 of JIS G 0321. The tension test piece after ruptured may be utilized in the analysis.
- (3) The methods of 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 1216	JIS G 1218	JIS G 1252
JIS G 1253	JIS G 1256	JIS G 1257	

8.2 Mechanical Tests

8.2.1 Tests in General General rules for mechanical tests shall comply with 4. in JIS G 0303. The sampling method shall conform to Class A, and the number of test pieces and the position to take the test pieces shall conform to the following:

(1) Number of Tensile Test, Bend Test and Impact Test Pieces

- (a) Tensile Test Pieces Two from each group of steel plates as rolled from the same slab or directly from the same ingot. In the case where a steel plate as rolled is cut into two or more pieces and they are heat-treated in accordance with 7.1.1, two from each group of steel plates of the same treatment.
- (b) Bend Test Pieces One from each group of steel plates as rolled from the same slab or directly from the same ingot. In the case where a steel plate as rolled is cut into two or more pieces and they are heat-treated in accordance with 7.1.1, one from each group of steel plates of the same treatment.

- (c) Impact Test Pieces One set of three test pieces from each group of steel plates as rolled from the same slab or directly from the same ingot. In the case where a steel plate as rolled is cut into two or more pieces and they are heat-treated in accordance with 7.1.1, one set of three test pieces from each group of steel plates of the same heat treatment.
 - (d) The number of test pieces of the heat-treated steel plates shall be in accordance with (a), (b) or (c) for each type of condition of heat treatment.
- (2) Positions for Sampling Tensile Test, Bend Test and Impact Test Pieces
- (a) Tensile Test Pieces The tensile test pieces shall be taken from the corners of the top and bottom sides of the steel plate in the direction perpendicular to the final rolling direction. In this case, the portion between gauge marks of the test piece shall be at a distance not less than the thickness from any heat-treated steel plate edge.

When No. 10 test piece is used, the axis of the test piece shall be at a position $1/4$ of the thickness distant from the surface of the steel plate.
 - (b) Bend Test Pieces If the final rolling direction of the steel plate is parallel to the direction of ingot axis, the test piece shall be taken from the middle of the width of the steel plate at the top side of the ingot and, if the final rolling direction is perpendicular to the direction of ingot axis or their relationship is unknown, the test piece shall be taken from the middle of width of the steel plate at either end, the direction of taking the test piece being perpendicular to the final rolling direction.
 - (c) Impact Test Pieces Unless otherwise specified, the test piece shall be taken from the part adjacent to the place where the tension test piece has been taken at the bottom side of the steel plate in the direction parallel to the final rolling direction. In this case, the notch of the test piece shall be at a distance not less than the thickness from any heat-treated plate edge, and the axis of the test piece shall be at a position $1/4$ of the thickness distant from the surface of the steel plate.

8.2.2 Test Pieces The test pieces for the tensile, bend and impact tests shall be as follows:

- (1) No. 1 A or No. 10 test piece specified in JIS Z 2201, for the tensile test.
- (2) No. 1 test piece specified in JIS Z 2204, for the bend test.
- (3) No. 4 test piece specified in JIS Z 2202, for the impact test. The notch shall be made in the direction of thickness.

8.2.3 Test Method The tensile, bend and impact tests shall follow any one of the following Standards:

(1) JIS Z 2241

(2) JIS Z 2248

(3) JIS Z 2242

9. Inspection

- (1) The results of the tests for chemical composition, mechanical properties, shapes, dimensions, mass and appearance shall conform to the requirements of 3., 4., 5. and 6. However, when indicated by the purchaser, part or whole of a test and inspection of mechanical properties may be omitted.
- (2) In addition to the inspection specified in (1) the purchaser may designate nondestructive inspection such as sulphur print, ultrasolic flaw detection, magnetic particle flaw detection and high temperature tension test. For that matter, the method of sampling, method of test, acceptance criterion, etc. shall be previously agreed on between the parties concerned.
- (3) The steel plates which have failed in the tensile test, bend test or impact test may be retested for acceptance in accordance with 4.4 of JIS G 0303.

10. Marking

The steel plates having passed the inspection shall be marked clearly on each plate with the following items by suitable means:

- (1) Type symbols
- (2) Heat number or inspection number
- (3) Dimensions
- (4) Manufacturer's name or its abbreviation.

11. Report

The report shall comply with 8. of 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 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 1216-Methods for Determination of Nickel in Iron and Steel

JIS G 1218-Methods for Determination of Molybdenum 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 Fluorescent X-ray 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-Tension Test Pieces for Metallic Materials

JIS Z 2202-Impact Test Pieces for Metallic Materials

JIS Z 2204-Bend Test Pieces for Metallic Materials

JIS Z 2241-Method of Tension Test for Metallic Materials

JIS Z 2242-Method of Impact Test for Metallic Materials

JIS Z 2248-Method of Bend Test for Metallic Materials

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