

# JIS

## JAPANESE INDUSTRIAL STANDARD

### Quenched and Tempered Alloy Steel Forgings for Pressure Vessels

### JIS G 3204—1988

Translated and Published

by

Japanese Standards Association

**In the event of any doubt arising,  
the original Standard in Japanese is to be final authority.**

## JAPANESE INDUSTRIAL STANDARD

J I S

Quenched and Tempered Alloy Steel  
Forgings for Pressure Vessels

G 3204-1988

1. Scope

This Japanese Industrial Standard specifies the quenched and tempered alloy steel forgings, hereinafter referred to as the "forgings", for pressure vessels and components thereof, in which especially weldability is taken into consideration.

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 informative reference.

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

2. Designation of Grade

Designation of grade of the forgings shall be as shown in Table 1.

Table 1. Designation of Grade

| Designation of grade |
|----------------------|
| SFVQ 1 A             |
| SFVQ 1 B             |
| SFVQ 2 A             |
| SFVQ 2 B             |
| SFVQ 3               |

3. Chemical Composition

The forgings shall be subjected to the test of 9.2, and the chemical composition thereof shall be as follows:

- (1) The chemical composition of the forgings shall be determined by the ladle analysis, and the values obtained shall conform to Table 2.
- (2) When the product analysis on the forgings is performed by the request of the purchaser, its tolerance shall conform to the requirements of Table 3 in JIS G 0321.

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Applicable Standards: See page 7.

Table 2. Chemical Composition

Unit: %

| Designation of grade | C         | Si        | Mn           | P          | S          | Ni           | Cr           | Mo           | V         |
|----------------------|-----------|-----------|--------------|------------|------------|--------------|--------------|--------------|-----------|
| SFVQ 1A<br>SFVQ 1B   | 0.25 max. | 0.40 max. | 1.20 to 1.50 | 0.030 max. | 0.030 max. | 0.40 to 1.00 | 0.25 max.    | 0.45 to 0.60 | 0.05 max. |
| SFVQ 2A<br>SFVQ 2B   | 0.27 max. | 0.40 max. | 0.50 to 1.00 | 0.030 max. | 0.030 max. | 0.50 to 1.00 | 0.25 to 0.45 | 0.55 to 0.70 | 0.05 max. |
| SFVQ 3               | 0.23 max. | 0.40 max. | 0.20 to 0.40 | 0.020 max. | 0.020 max. | 2.75 to 3.90 | 1.50 to 2.00 | 0.40 to 0.60 | 0.03 max. |

Remark: For all grades other than grade SFVQ 3, the upper limit of P and S may designate 0.025 %, when used for a component of nuclear reactor.

#### 4. Mechanical Properties

The forgings shall be subjected to the test of 9.3, and the yield point or proof stress, tensile strength, elongation, reduction of area, and Charpy absorbed energy shall be as given in Table 3-1 or Table 3-2.

Table 3-1. Mechanical Properties

(Applicable till the end of 1990)

| Designation of grade | Yield point or proof stress<br>kgf/mm <sup>2</sup><br>{N/mm <sup>2</sup> } | Tensile strength<br>kgf/mm <sup>2</sup><br>{N/mm <sup>2</sup> } | Elongation<br>%     | Reduction of area<br>% | Impact test temperature<br>°C | Charpy absorbed energy<br>kgf·m {J} |                       |
|----------------------|----------------------------------------------------------------------------|-----------------------------------------------------------------|---------------------|------------------------|-------------------------------|-------------------------------------|-----------------------|
|                      |                                                                            |                                                                 |                     |                        |                               | Mean value of three test pieces     | Individual value      |
|                      |                                                                            |                                                                 | No. 14 A test piece |                        |                               | No. 4 test piece                    |                       |
| SFVQ 1A              | 35 min.<br>{343} min.                                                      | 56 to 74<br>{549 to 726}                                        | 16 min.             | 38 min.                | 0                             | 4.1 min.<br>{40} min.               | 3.5 min.<br>{34} min. |
| SFVQ 1B              | 46 min.<br>{451} min.                                                      | 63 to 81<br>{618 to 794}                                        | 14 min.             | 35 min.                | 20                            | 4.8 min.<br>{47} min.               | 4.1 min.<br>{40} min. |
| SFVQ 2A              | 35 min.<br>{343} min.                                                      | 56 to 74<br>{549 to 726}                                        | 16 min.             | 38 min.                | 0                             | 4.1 min.<br>{40} min.               | 3.5 min.<br>{34} min. |
| SFVQ 2B              | 46 min.<br>{451} min.                                                      | 63 to 81<br>{618 to 794}                                        | 14 min.             | 35 min.                | 20                            | 4.8 min.<br>{47} min.               | 4.1 min.<br>{40} min. |
| SFVQ 3               | 50 min.<br>{490} min.                                                      | 63 to 81<br>{618 to 794}                                        | 18 min.             | 48 min.                | -30                           | 4.8 min.<br>{47} min.               | 4.1 min.<br>{40} min. |

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

| Designa-<br>tion of<br>grade | Yield point<br>or proof<br>stress<br><br>N/mm <sup>2</sup> | Tensile<br>strength<br><br>N/mm <sup>2</sup> | Elongation             | Reduction<br>of area<br><br>% | Impact<br>test<br>temper-<br>ature<br><br>°C | Charpy absorbed energy<br>J        |                     |
|------------------------------|------------------------------------------------------------|----------------------------------------------|------------------------|-------------------------------|----------------------------------------------|------------------------------------|---------------------|
|                              |                                                            |                                              | %                      |                               |                                              | Mean value of<br>three test pieces | Individual<br>value |
|                              |                                                            |                                              | No. 14 A<br>test piece |                               |                                              | No. 4 test piece                   |                     |
| SFVQ 1 A                     | 345 min.                                                   | 550 to 730                                   | 16 min.                | 38 min.                       | 0                                            | 40 min.                            | 34 min.             |
| SFVQ 1 B                     | 450 min.                                                   | 620 to 790                                   | 14 min.                | 35 min.                       | 20                                           | 47 min.                            | 40 min.             |
| SFVQ 2 A                     | 345 min.                                                   | 550 to 730                                   | 16 min.                | 38 min.                       | 0                                            | 40 min.                            | 34 min.             |
| SFVQ 2 B                     | 450 min.                                                   | 620 to 790                                   | 14 min.                | 35 min.                       | 20                                           | 47 min.                            | 40 min.             |
| SFVQ 3                       | 490 min.                                                   | 620 to 790                                   | 18 min.                | 48 min.                       | -30                                          | 47 min.                            | 40 min.             |

#### 5. Shape, Dimensions, and Tolerances Thereon

The forgings shall be subjected to the test of 9.4, and the shape and dimensions thereof and tolerances thereon shall be as agreed upon between the delivery parties concerned.

#### 6. Appearance

The forgings shall be subjected to the test of 9.5, and the appearance shall be good in finish and free from cracks, flaws, etc. detrimental to practical use.

#### 7. Soundness

The forgings, when requested by the purchaser, shall be subjected to ultrasonic examination in accordance with 9.6 or by an appropriate method, and the soundness thereof shall be free from defects detrimental to practical use.

Further, the criterion on the soundness of the forgings shall be as agreed upon between the delivery parties concerned.

#### 8. Manufacturing Method

**8.1 General Matter of Manufacturing Method** General matter of the manufacturing method shall be as described in 3. of JIS G 0306. However, the vacuum treatment of molten steel shall be as agreed upon between the delivery parties concerned.

**8.2 Heat Treatment** Heat treatment applied to the forgings shall conform to each clause of the following:

- (1) The forgings shall be preliminary heat-treated. This is the process before reheating, and in it the heat treatment shall be performed in such manner that the forgings are cooled to complete the transformation of austenite.

- (2) The forgings shall be heat treated by quenching and tempering. The tempering temperature shall be as shown in Table 4, and its duration time shall be not less than 30 minutes per 25 mm with respect to the largest thickness. In tempering, unless otherwise especially designated, the forgings shall be furnace-cooled from the tempering temperature. However, accelerated cooling may be applied to the forgings, when the test piece is heat treated according to (3).
- (3) When the purchaser designates the heat treatment of the test piece for stress relieving, etc., the manufacturer shall cut out test piece from test specimen specified in 9.3, and further shall perform heat treatment in compliance with the purchaser's indication. In this case, the purchaser shall specify the details of heat treatment conditions such as heat treating temperature, duration time, cooling rate, and number of times of heat treatment.

Table 4. Tempering Temperature

| Designation of grade | Tempering temperature °C |
|----------------------|--------------------------|
| SFVQ 1 A             | 650 min.                 |
| SFVQ 1 B             | 620 min.                 |
| SFVQ 2 A             | 650 min.                 |
| SFVQ 2 B             | 620 min.                 |
| SFVQ 3               | 610 min.                 |

Remark: When the temperature of post welding heat treatment (PWHT) for grade SFVQ 1 A and SFVQ 2 B is 620°C and below, the tempering temperature may be changed to 635°C.

8.3 Repair by Welding The defect detected through the inspection shall be repaired in accordance with 3.4 in JIS G 0306.

## 9. Test

9.1 Test Place The test place shall be, as a rule, a proper manufactory.

Further, when requested by the purchaser, the manufacturer shall make the purchaser attend the test.

## 9.2 Analytical Test

9.2.1 General Matter of Analytical Test General matter of the analytical test shall be as described in 4.1 of JIS G 0306.

9.2.2 Analytical Method The analytical method shall be in accordance with any one of the following methods:

|            |            |            |            |
|------------|------------|------------|------------|
| JIS G 1211 | JIS G 1212 | JIS G 1213 | JIS G 1214 |
| JIS G 1215 | JIS G 1216 | JIS G 1217 | JIS G 1218 |
| JIS G 1221 | JIS G 1253 | JIS G 1256 | JIS G 1257 |

### 9.3 Mechanical Test

9.3.1 Sampling of Test Material Sampling of a test material shall be as described in 4.2.2 (1.1) of JIS G 0306.

9.3.2 Sampling of Test Piece Sampling of a test piece shall be as described in 4.2.2 (1.2) of JIS G 0306. However, when 4.2.2 (1.2.3) (a) of JIS G 0306 is applied, a thickness of the forging shall not, as a rule, exceed the values given in Table 5.

Table 5. Applied Thickness

| Designation of grade | Applied thickness mm |
|----------------------|----------------------|
| SFVQ 1 A<br>SFVQ 2 A | 200 max.             |
| SFVQ 1 B<br>SFVQ 2 B | 150 max.             |
| SFVQ 3               | 1000 max.            |

9.3.3 Number of Test Materials and Test Pieces The number of test materials and test pieces shall be as described in 4.2.2 (1.3) of JIS G 0306.

9.3.4 Test Method The test method shall be as follows:

- (1) The tensile test method shall be as described in 4.2.2 (1.4) of JIS G 0306.
- (2) The impact test method shall be as described in 4.2.2 (1.5) of JIS G 0306.

9.4 Shape and Dimensions The shape and measurement of dimensions of the forging shall be as described in 4.5 of JIS G 0306.

9.5 Appearance The appearance test of the forgings shall be as described in 4.3 of JIS G 0306.

9.6 Ultrasonic Examination The purchaser can designate ultrasonic examination. The test method thereof shall be in accordance with JIS G 0587.

### 10. Retest

10.1 Mechanical Test The retest of the mechanical test shall be as described in 5.1 of JIS G 0306.

10.2 Test after Repair by Welding When repair by welding is performed in accordance with 8.3, the test shall be as described in 5.2 of JIS G 0306.

### 11. Inspection

11.1 The inspection of the forgings shall be as follows:

- (1) General matter of the inspection shall be as described in 6. of JIS G 0306.
- (2) The chemical composition shall conform to the requirements specified in 3.
- (3) The mechanical properties shall conform to the requirements specified in 4.
- (4) The shape and dimensions shall conform to the requirements specified in 5.
- (5) The appearance shall conform to the requirements specified in 6.
- (6) The soundness shall conform to the requirements specified in 7.

11.2 The purchaser may specify to inspect any item as listed in the following, in addition to the items specified in 11.1. In this case, the inspection items, sampling method, test method, and acceptance criterion shall be previously agreed upon between the delivery parties concerned.

Hardness test <sup>(1)</sup>, magnetic particle inspection <sup>(2)</sup>, liquid penetrant inspection <sup>(3)</sup>, macro-structure detecting inspection <sup>(4)</sup>, grain size inspection <sup>(5)</sup>, non-metallic inclusion inspection <sup>(6)</sup> and microscopic structure inspection.

Notes <sup>(1)</sup> In accordance with JIS Z 2243 or JIS Z 2246.

<sup>(2)</sup> In accordance with JIS G 0565.

<sup>(3)</sup> In accordance with JIS Z 2343.

<sup>(4)</sup> In accordance with JIS G 0553.

<sup>(5)</sup> In accordance with JIS G 0551.

<sup>(6)</sup> In accordance with JIS G 0555.

## 12. Marking

The marking on the forgings which have passed the inspection shall be as described in 7. of JIS G 0306.

13. Report The report shall conform to the specifications of 8. in JIS G 0306.

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Applicable Standards:

- JIS G 0306-General Rules for Inspection of Steel Forgings
- JIS G 0321-Product Analysis and Its Tolerance for Wrought Steel
- JIS G 0551-Methods of Austenite Grain Size Test for Steel
- JIS G 0553-Macrostructure Detecting Method for Steel
- JIS G 0555-Microscopic Testing Method for the Non-Metallic Inclusions in Steel
- JIS G 0565-Methods for Magnetic Particle Testing of Ferromagnetic Materials and Classification of Magnetic Particle Indication
- JIS G 0587-Methods for Ultrasonic Examination for Carbon and Low Alloy Steel Forgings
- 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 1217-Methods for Determination of Chromium in Iron and Steel
- JIS G 1218-Methods for Determination of Molybdenum in Iron and Steel
- JIS G 1221-Methods for Determination of Vanadium in Iron and 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 Z 2243-Method of Brinell Hardness Test
- JIS Z 2246-Method of Shore Hardness Test
- JIS Z 2343-Methods for Liquid Penetrant Testing and Classification of Indication



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