

JIS

JAPANESE INDUSTRIAL STANDARD

**Stainless steel forgings
for pressure vessels**

JIS G 3214—1991

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
Stainless steel forgings for pressure vessels

J I S
G 3214-1991

1. Scope

This Japanese Industrial Standard specifies the stainless steel forgings mainly used for corrosion resistant and high temperature pressure vessels and their parts (hereafter referred to as the "forgings"). However, pertaining to austenitic stainless steel forgings, this Standard is also applicable to low temperature pressure vessels and low temperature service parts.

Remarks: Applicable standards to this Standard are shown as follows.

JIS B 0601-Definitions and Designation of Surface Roughness

JIS G 0306-Steel Forgings — General Technical Requirements

JIS G 0321-Product Analysis and its Tolerance for Wrought Steel

JIS G 0565-Methods for Magnetic Particle Testing of Ferromagnetic
Materials and Classification of Magnetic Particle Indication

JIS G 0567-Method of High Temperature Tensile Test for Steels and Heat-
Resisting Alloys

JIS G 0571-Method of 10 Per Cent Oxalic Acid Etch Test for Stainless
Steels

JIS G 0575-Method of Copper Sulfate-Sulfuric Acid Test for Stainless
Steels

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 1219-Methods for Determination of Copper in Iron and Steel

JIS G 1223-Methods for Determination of Titanium in Iron and Steel

JIS G 1228-Methods for Determination of Nitrogen in Iron and Steel

JIS G 1237-Methods for Determination of Niobium in 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-Methods for Atomic Absorption Spectrochemical Analysis of
Iron and Steel

JIS K 2238-Machine Oils

JIS Z 2343-Methods for Liquid Penetrant Testing and Classification of Indication

JIS Z 2344-General Rule of Ultrasonic Testing of Metals by the Pulse Echo Technique

2. Symbol of grade and classification

The symbols of grades and classification of forgings shall be as given in Table 1.

3. Chemical composition

Forgings shall be subjected to the analytical test of 9.2 and their chemical compositions shall be as follows:

- (1) The chemical compositions of forgings shall be ladle analyses and they shall be as given in Tables 2, 3 or 4.
- (2) In the case where the product analysis of forgings is requested by the purchaser, their permissible variation shall be as given in Table 4 (permissible variation of product analysis) of JIS G 0321.

Table 1. Symbol of grade and classification

Symbol of grade	Classification	Symbol of grade	Classification	Symbol of grade	Classification
SUS F 304	Austenitic series	SUS F 316L	Austenitic series	SUS F 347H	Austenitic series
SUS F 304H		SUS F 316N		SUS F 410-A	Martensitic series
SUS F 304L		SUS F 316LN		SUS F 410-B	
SUS F 304N		SUS F 317		SUS F 410-C	
SUS F 304LN		SUS F 317L		SUS F 410-D	
SUS F 310		SUS F 321		SUS F 6B	
SUS F 316		SUS F 321H		SUS F 6NM	
SUS F 316H		SUS F 347		SUS F 630	Precipitation hardening series

Table 2. Chemical composition of austenitic stainless steel forgings

Unit: %

Symbol of grade	C	Si	Mn	P (¹)	S	Ni	Cr	Mo	N	Others
SUS F 304	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	—	—	—
SUS F 304H	0.04 to 0.10	1.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 12.00	18.00 to 20.00	—	—	—
SUS F 304L	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	18.00 to 20.00	—	—	—
SUS F 304N	0.08 max.	0.75 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	—	0.10 to 0.16	—
SUS F 304LN	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	—	0.10 to 0.16	—
SUS F 310	0.15 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	19.00 to 22.00	24.00 to 26.00	—	—	—
SUS F 316	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—	—
SUS F 316H	0.04 to 0.10	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—	—
SUS F 316L	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 15.00	16.00 to 18.00	2.00 to 3.00	—	—
SUS F 316N	0.08 max.	0.75 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 14.00	16.00 to 18.00	2.00 to 3.00	0.10 to 0.16	—
SUS F 316LN	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	0.10 to 0.16	—
SUS F 317	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—	—
SUS F 317L	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—	—
SUS F 321	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 12.00	17.00 min.	—	—	Ti 5 × C% to 0.60
SUS F 321H	0.04 to 0.10	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 12.00	17.00 min.	—	—	Ti 4 × C% to 0.60
SUS F 347	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	17.00 to 20.00	—	—	Nb 10 × C% to 1.00
SUS F 347H	0.04 to 0.10	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	17.00 to 20.00	—	—	Nb 8 × C% to 1.00

Note (¹) The content of P for parts for reactor pressure vessels may be specified as 0.030 % max.

Table 3. Chemical composition of martensitic stainless steel forgings

Unit: %

Symbol of grade	C	Si	Mn	P	S	Ni	Cr	Mo	Cu
SUS F 410-A SUS F 410-B SUS F 410-C SUS F 410-D	0.15 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.50 max.	11.50 to 13.50	—	—
SUS F 6B	0.15 max.	1.00 max.	1.00 max.	0.020 max.	0.020 max.	1.00 to 2.00	11.50 to 13.50	0.40 to 0.60	0.50 max.
SUS F 6NM	0.05 max.	0.60 max.	0.50 to 1.00	0.030 max.	0.030 max.	3.50 to 5.50	11.50 to 14.00	0.50 to 1.00	—

Table 4. Chemical composition of precipitation hardening stainless steel forgings

Unit: %

Symbol of grade	C	Si	Mn	P	S	Ni	Cr	Cu	Nb
SUS F 630	0.07 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	3.00 to 5.00	15.00 to 17.50	3.00 to 5.00	0.15 to 0.45

4. Mechanical properties

Forgings shall be subjected to the mechanical tests of 9.3 and their mechanical properties shall be as follows:

- (1) The proof stress, tensile strength, elongation, reduction of area, and hardness of austenitic stainless steel forgings shall be as given in Table 5.
- (2) The proof stress, tensile strength, elongation, reduction of area, and hardness of martensitic stainless steel forgings shall be as given in Table 6.
- (3) The proof stress, tensile strength, elongation, reduction of area, hardness, and Charpy absorbed energy of precipitation hardening stainless steel forgings shall be as given in Table 7.

Table 5. Mechanical properties of austenitic stainless steel forgings

Symbol of grade	Diameter or thickness in heat treatment mm	Proof stress N/mm ²	Tensile strength N/mm ²	Elongation %	Reduction of area %	Hardness HB
				No. 14A test piece		
SUS F 304	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 304H	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 304L	Under 130 130 or over up to and incl. 200	175 min. 175 min.	480 min. 450 min.	29 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 304N	Under 130 130 or over up to and incl. 200	240 min. 240 min.	550 min. 550 min.	29 min. 24 min.	50 min. 45 min.	217 max. 217 max.
SUS F 304LN	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	29 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 310	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	34 min. 29 min.	50 min. 40 min.	187 max. 187 max.
SUS F 316	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 316H	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 316L	Under 130 130 or over up to and incl. 200	175 min. 175 min.	480 min. 450 min.	29 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 316N	Under 130 130 or over up to and incl. 200	240 min. 240 min.	550 min. 550 min.	29 min. 24 min.	50 min. 45 min.	217 max. 217 max.
SUS F 316LN	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	29 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 317	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	29 min. 29 min.	50 min. 50 min.	187 max. 187 max.
SUS F 317L	Under 130 130 or over up to and incl. 200	175 min. 175 min.	480 min. 450 min.	29 min. 29 min.	50 min. 50 min.	187 max. 187 max.
SUS F 321	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 321H	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 347	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.
SUS F 347H	Under 130 130 or over up to and incl. 200	205 min. 205 min.	520 min. 480 min.	43 min. 29 min.	50 min. 45 min.	187 max. 187 max.

Remarks: The elongation and reduction of area of forgings of which the diameter or thickness in heat treatment exceeds 200 mm, shall be agreed upon between the parties concerned with delivery.

Table 6. Mechanical properties of martensitic stainless steel forgings

Symbol of grade	Proof stress N/mm ²	Tensile strength N/mm ²	Elongation %	Reduction of area %	Hardness HBS or HBW
			No. 14A test piece		
SUS F 410-A	275 min.	480 min.	16 min.	35 min.	143 to 187
SUS F 410-B	380 min.	590 min.	16 min.	35 min.	167 to 229
SUS F 410-C	585 min.	760 min.	14 min.	35 min.	217 to 302
SUS F 410-D	760 min.	900 min.	11 min.	35 min.	262 to 321
SUS F 6B	620 min.	760 to 930	15 min.	45 min.	217 to 285
SUS F 6NM	620 min.	790 min.	14 min.	45 min.	295 max.

Table 7. Mechanical properties of precipitation hardening stainless steel forgings

Symbol of grade	Symbol for heat treatment	Proof stress N/mm ²	Tensile strength N/mm ²	Elongation %	Reduction of area %	Hardness HBS or HBW	Charpy absorbed energy J
				No. 14A test piece			
SUS F 630	H1075	860 min.	1000 min.	12 min.	45 min.	311 min.	27 min.
	H1100	795 min.	970 min.	13 min.	45 min.	302 min.	34 min.
	H1150	725 min.	930 min.	15 min.	50 min.	277 min.	41 min.

Remarks 1. Table 7 shall apply to forgings of 200 mm max. in diameter or thickness in heat treatment.

2. The proof stress, tensile strength, elongation, reduction of area, and Charpy absorbed energy of forgings in the cases where heat treatments other than those given in Table 10 are performed and where the diameter or thickness in heat treatment exceeds 200 mm shall be agreed upon between the parties concerned with delivery.

5. Shape, dimensions and tolerance

When forgings are tested in accordance with 9.4, their shapes, dimensions and tolerances shall be agreed upon between the parties concerned with delivery.

6. Appearance

When forgings are tested in accordance with 9.5, their appearance shall be excellently finished and free from cracks, flaws, etc. detrimental to practical use.

7. Special qualities

Special qualities shall be as specified in Annex. However, they shall be applied in the case where especially designated by the purchaser.

Further, the purchaser may designate a part or all of the following items.

- (1) Soundness of surface (Annex Y1)
- (2) Soundness of surface and its vicinity (Annex Y2)
- (3) Soundness of interior (Annex Y3)
- (4) Proof stress and tensile strength at high temperature (Annex Y4)
- (5) Transverse bulging in Charpy impact test (Annex Y5)

(6) Corrosion resistance (Annex Y6)

8. Manufacturing method

8.1 Steel ingot The steel ingot shall be thoroughly cut off to be cleared of harmful pipes and segregation.

8.2 Forging Forging shall be conducted as specified in 3.2 (forging) of JIS G 0306.

8.3 Heat treatment Heat treatment shall be as follows:

- (1) Austenitic stainless steel forgings shall be solution-treated as specified in Table 8.
- (2) Martensitic stainless steel forgings shall be heat treated as specified in Table 9.
- (3) Solution hardening stainless steel forgings shall be heat treated as specified in Table 10.
- (4) When forgings are hot worked after heat treatment, they shall be further subjected again to heat treatment of (1), (2) or (3).

Table 8. Heat treatment of austenitic stainless steel forgings

Symbol of grade	Solution treatment °C	Symbol of grade	Solution treatment °C
SUS F 304	1010 to 1150 rapid cooling	SUS F 316N	1010 to 1150 rapid cooling
SUS F 304H	1040 to 1150 rapid cooling	SUS F 316LN	1010 to 1150 rapid cooling
SUS F 304L	1010 to 1150 rapid cooling	SUS F 317	1010 to 1150 rapid cooling
SUS F 304N	1010 to 1150 rapid cooling	SUS F 317L	1010 to 1150 rapid cooling
SUS F 304LN	1010 to 1150 rapid cooling	SUS F 321	920 to 1150 rapid cooling
SUS F 310	1030 to 1180 rapid cooling	SUS F 321H	1050 to 1150 rapid cooling
SUS F 316	1010 to 1150 rapid cooling	SUS F 347	980 to 1150 rapid cooling
SUS F 316H	1040 to 1150 rapid cooling	SUS F 347H	1050 to 1150 rapid cooling
SUS F 316L	1010 to 1150 rapid cooling		

Table 9. Heat treatment of martensitic stainless steel forgings

Symbol of grade	Heat treatment °C	
	Quenching	Tempering
SUS F 410-A	950 to 1000 air cooling or oil cooling	715 min. air cooling or rapid cooling
SUS F 410-B	950 to 1000 air cooling or oil cooling	665 min. air cooling or rapid cooling
SUS F 410-C	950 to 1000 air cooling or oil cooling	590 min. air cooling or rapid cooling
SUS F 410-D	950 to 1000 air cooling or oil cooling	535 min. air cooling or rapid cooling
SUS F 6B	930 to 980 air cooling or oil cooling	550 to 650 air cooling
SUS F 6NM	930 to 980 air cooling or oil cooling	560 to 630 air cooling

Table 10. Heat treatment of precipitation hardening stainless steel forgings

Symbol of grade	Symbol for heat treatment	Heat treatment °C
SUS F 630	H1075	After rapid cooling at 1020 to 1060, 570 to 590 air cooling
	H1100	After rapid cooling at 1020 to 1060, 580 to 610 air cooling
	H1150	After rapid cooling at 1020 to 1060, 610 to 630 air cooling

Remarks: SUS F 630 may be subjected to heat treatments other than those specified in Table 10 according to agreement between the parties concerned with delivery.

8.4 Repair welding Defects detected in an inspection may be subjected to repair welding excepting for SUS F 410-C, SUS F 410-D, and SUS F 630 as agreed upon between the parties concerned with delivery.

9. Tests

9.1 Test site The test site shall, as a rule, be the place of manufacture.

Further, when requested by the purchaser, the manufacturer should make the test be attended by the purchaser.

9.2 Analytical test

9.2.1 General matters for analytical test General matters for analytical test shall be as specified in 4.1 (analytical test) of JIS G 0306.

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

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 1219, JIS G 1223, JIS G 1228, JIS G 1237,
JIS G 1253, JIS G 1256, JIS G 1257

9.3 Mechanical test

9.3.1 Sampling of specimen

The sampling of a test specimen shall be as specified in 4.2.2 (1.1) (sampling of specimen) of JIS G 0306.

9.3.2 Sampling of test piece The sampling of a test piece shall be as specified in 4.2.2 (1.2) (sampling of test piece) of JIS G 0306. However, the sampling position of the test piece of precipitation hardening stainless steel forgings shall be in accordance with 4.2.2 (1.2.2) of JIS G 0306.

9.3.3 Number of specimens and test pieces The number of test specimens and test pieces shall be as specified in 4.2.2 (1.3) (number of specimens and test pieces) of JIS G 0306.

9.3.4 Test methods

The test methods shall be as specified below.

- (1) The tensile test method shall be as specified in 4.2.2 (1.4) (tensile test method) of JIS G 0306.
- (2) The impact test method shall be as specified in 4.2.2 (1.5) (impact test method) of JIS G 0306.
- (3) The hardness test method shall be as specified in 4.2.2 (1.6) (hardness test method) of JIS G 0306.

9.4 Shape and dimensions The shape and measurement of dimensions of forgings shall be in accordance with 4.5 (shape and dimensions) of JIS G 0306.

9.5 Appearance test The appearance test of forgings shall be as specified in 4.3 (appearance test) of JIS G 0306.

9.6 Test regarding special qualities The tests regarding special qualities shall be as specified in Annex.

10. Retests

10.1 Mechanical tests The retest for mechanical tests shall be as specified in 5.1 (mechanical tests) of JIS G 0306.

10.2 Test after repair welding In the case where repair welding is carried out in accordance with 8.4, the test after repair welding shall be as specified in 5.2 (test after repair welding) of JIS G 0306.

11. Inspection

The inspection of forgings shall be conducted as follows:

- (1) General matters for inspection shall be as specified in 6. (general matters for inspection) 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 special qualities shall conform to the requirements specified in 7.

12. Marking

The forgings having passed the inspection shall be marked on each product with the following peculiarities. However, a part of the peculiarities may be omitted as agreed upon between the parties concerned with delivery.

- (1) Symbol of grade
- (2) Ladle number
- (3) Manufacturer's name or its abbreviation

13. Report

The report shall be as specified in 8. (report) of JIS G 0306.

Annex. Special quality specification

1. Scope

This Annex specifies the special qualities to be applied when designated by the purchaser.

2. Classification of special qualities, test methods and symbols

The classification of special qualities, test methods and symbols shall be as given in Annex Table 1.

Annex Table 1. Classification of special qualities, test methods and symbols

Classification of special qualities	Test method	Symbol
Soundness of surface	Liquid penetrant test	Y1
Soundness of surface and its vicinity	Magnetic particle test	Y2
Soundness of interior	Ultrasonic test	Y3
Proof stress and tensile strength at high temperature	High temperature tensile test	Y4
Bulging by Charpy impact test	Charpy impact test	Y5
Corrosion resistance	Corrosion test	Y6

3. Soundness of surface (Y1)

3.1 Soundness When forgings are subjected to the liquid penetrant test of 3.2, there shall be no flaw indications on the surface as below for the soundness of the surface of forgings.

- (1) The linear flaw indication of 8.2 (classification of kinds of flaw indications) of JIS Z 2343 exceeding the values given in Annex Table 2.

Annex Table 2. Criteria of lengths of linear flaw indications

Unit: mm	
Classification of thickness of forgings	Length of linear flaw indication
16 and under	2
Over 16 up to and incl. 50	4
Over 50	6

- (2) The circular flaw indication of 8.2 of JIS Z 2343 exceeding 4 mm in length.
- (3) Four or more linear flaw indications or circular flaw indications of over 1.5 mm in length standing in a line with a distance of 1.5 mm or under between neighbouring linear flaw indications or between circular flaw indications.
- (4) 10 or more linear flaw indications or circular flaw indications of over 1.5 mm in length contained within a square of 3750 mm² in area with the minimum length of one side 25 mm.

3.2 Liquid penetrant test The liquid penetrant test shall be as specified in 4. (test method) of JIS Z 2343.

4. Soundness of surface and its vicinity (Y2)

4.1 Soundness When forgings are subjected to the magnetic particle test of 4.2, there shall be no magnetic particle indications as listed below for the soundness of the surface and its vicinity of forgings.

- (1) The linear magnetic particle indication of 9.2 (classification of kinds of magnetic particle indications) of JIS G 0565 exceeding the value given in Annex Table 3.
- (2) The circular magnetic particle indication of 9.2 of JIS G 0565 exceeding 4 mm in length.
- (3) Four or more linear magnetic particle indications or circular magnetic particle indications of over 1.5 mm in length standing in a line with a distance of 1.5 mm or under between neighbouring linear magnetic particle indications or between circular magnetic particle indications.
- (4) 10 or more linear magnetic particle indications or circular magnetic particle indications of over 1.5 mm in length contained within a square of 3750 mm² in area with the minimum length of one side of 25 mm.

Annex Table 3. Criteria of lengths of linear magnetic particle indications

Unit: mm	
Classification of thickness of forgings	Length of linear magnetic particle indication
16 and under	2
Over 16 up to and incl. 50	4
Over 50	6

4.2 Magnetic particle test The magnetic particle test shall be conducted as follows:

- (1) The test shall be carried out in two directions so that the directions of magnetic field intersect each other at right angles.
- (2) The magnetic particle shall be as specified in 5.2 (magnetic particle and inspection liquid) of JIS G 0565.
- (3) The surface of materials shall be clean and smooth.
- (4) The magnetization method shall be as specified in 8.4 (magnetization) of JIS G 0565.
- (5) The magnetic field shall be so intense that the magnetic particle indications of artificial defects are clearly presented when type A standard test piece (A1-15/50 or A1-30/100) of 6. (standard test piece and reference test piece) of JIS G 0565 is magnetized.
- (6) After the material is magnetized, magnetic particles shall be scattered over the surface of the material.

5. Soundness of interior (Y3)

5.1 Soundness When forgings of over 50 mm in nominal thickness are tested in accordance with 5.2 to examine the soundness of interior, there shall be no flaw echo shown in the case of normal beam technique of Annex Table 4.

Further, the hollow forgings such as ring, flange, and the like with the ratio of outer diameter to inner diameter of 1.4 or under and the axial length of over 50 mm shall be free from not only the flaw echoes given in the case of normal beam technique but also those given in the case of angle beam technique.

Annex Table 4. Criteria of flaw echo by ultrasonic test

Test item		Flaw echo
Ultrasonic test	In the case of normal beam technique	The flaw echo accompanied by the disappearance of bottom echo not caused by the shape of forgings. In that case, the disappearance of bottom echo means that the height of bottom echo decreases to within 5 % of the scale plate.
	In the case of angle beam technique	The echo exceeding reference line ⁽¹⁾ .

Note ⁽¹⁾ The reference line herein means the curved line of distance to vibration characteristic obtained from the artificial flaw of reference test pieces.

5.2 Ultrasonic test The ultrasonic test shall be carried out in accordance with the following specifications of (1) to (6) for forgings of over 50 mm in nominal thickness and also in accordance with JIS Z 2344.

Further, in this case, the normal beam technique shall be applied to all the forgings and the angle beam technique, in addition to the normal beam technique, shall be applied to the hollow forgings such as ring, flange and the like which are within 1.4 in the ratio of outer diameter to inner diameter and over 50 mm in length in the axial direction.

- (1) Time for test The time suited for ultrasonic test shall generally be after the final heat treatment for acquiring mechanical properties for the forgings (stress relieving excepted).

Further, the testing range shall cover the entire region of the forgings. However, when the shape of forgings is not suitable for ultrasonic test, time shall be selected when the forgings are in a state ensuring a complete inspection before final heat treatment. In this case, all regions suited for tests shall be inspected after the final heat treatment. When complete inspection is not possible either before or after heat treatment as in the case of die forging or the like, the test method and criteria shall be agreed upon between the parties concerned with delivery.

- (2) State of test surface The test surface shall be in a smooth finished state of 25S or thereabouts specified in JIS B 0601 and free from tears, foreign matter and the like that interfere with inspection.
- (3) Contact medium As contact medium, machine oil equivalent to ISO VG 100 of JIS K 2238 shall be used.
- (4) Ultrasonic test by normal beam technique The ultrasonic test method by a normal beam technique shall be as follows.
- (a) The test should be carried out in two directions intersecting each other at right angles if possible.

Hollow forgings shall be tested in the radial direction and the axial direction and disc forgings shall be tested with a plane and in the radial direction.

- (b) The diameter of a transducer shall be 20 to 30 mm. However, as required, the transducer of a different diameter may be used.
 - (c) The test frequency shall be 2 MHz or 2.25 MHz. However, when the penetration of ultrasonic waves is insufficient due to the size of the material or grain size, 1 MHz (0.4 to 1 MHz in the case of austenitic stainless steel forgings) may be used. For testing comparatively near to the test surface, 4 MHz or 5 MHz may be used.
 - (d) For the working sensitivity, the height of the first bottom echo at a sound part of forgings shall be regulated at 80 % of the graticule of cathode ray tube. The regulation of working sensitivity shall be carried out for each diameter or each thickness of forgings. For the part where the surface is not parallel to bottom surface, the sensitivity regulated at parallel part of the same or thicker thickness may be applied to the region nearest to that part.
 - (e) The maximum scanning speed of the probe shall be 150 mm/s and the probe shall scan duplicating not less than 15 % of the dimension of transducer.
 - (f) When the bottom echo decreases, the testing shall be continued changing frequency to detect whether it is due to flaws or the structure.
- (5) Ultrasonic test by angle beam technique The ultrasonic test by an angle beam technique shall be as follows:
- (a) The flaw detection shall be carried out clockwise and counterclockwise on the circumference so long as the thickness and shape of forgings permit.
 - (b) The dimensions of a transducer shall be 10 mm × 10 mm in the minimum, 28 mm × 28 mm in the maximum and its angle of refraction shall be 45°. However, a transducer of other dimensions and refraction angles may be used, if necessary.
 - (c) The test frequency shall generally be 1 MHz. However, when 1 MHz is insufficient, 2 MHz or 2.25 MHz (0.4 MHz or 0.5 MHz in the case of austenitic stainless steel forgings) may be used.
 - (d) The working sensitivity shall be regulated by working the artificial flaw of (e) of reference test piece or extra length portion of forgings to be tested according to the procedure of (f). However, the reference test piece shall have almost the same ultrasonic-wave attenuation as that of the forgings to be tested.
 - (e) To prepare artificial defects of a reference test piece, artificial defects of square groove or V-shaped groove having a depth equivalent to either 10 mm or 3 % of thickness of forgings when the ultrasonic test is executed, whichever is smaller (5 % in the case of austenitic stainless steel forgings), length of about 25 mm (about 32 mm in the case of austenitic stainless steel forgings) and width at most two times the depth shall be worked for the forgings, their extra length portions, extra wall part or an independent reference test piece. The artificial defects shall be worked in parallel with the axial direction on the outer or inner peripheral surface. However, the artificial defects may be worked to 3 % of the wall thickness when the product is delivered (5 % in the case of austenitic stainless steel forgings) as agreed upon between the parties concerned with delivery.

- (f) For the working sensitivity, the height of echo in detecting the artificial defect of the forgings or a reference test piece by $\frac{1}{2}$ of a skip shall be regulated at 80 % of graticule. Further, the height of echo from an artificial defect shall be obtained by one skip with this sensitivity and the curved line of distance to vibration characteristic obtained by connecting this echo peak and the preceding echo peak shall be serially plotted onto the graticule of cathode ray tube. This shall be made the reference curve.
 - (g) The scanning speed of the probe shall be 150 mm/s or under and the scanning shall be carried out duplicating at least 15 % of transducer dimension.
- (6) For forgings in which the following defect echoes are detected, the actual conditions shall be informed to the purchaser before shipment to acquire his approval.

(6.1) In the case of normal beam technique

- (a) A defect echo exceeding bottom echo height (echo of F/BF exceeding 100 %). However, in the case of austenitic stainless steel forgings, a defect echo in which the bottom echo not caused by shape decreases to 20 % or under of graticule.
- (b) A travelling defect echo accompanied by the decrease of bottom echo. In this case, the decrease of bottom echo herein means the decrease to 40 % or under of graticule.

Further, the travelling defect echo herein means the defect echo which horizontally travels on the cathode ray tube as the probe travels 25 mm or more to right and left on the test surface.

(6.2) In the case of angle beam technique

- (a) The flaw echo exceeding 50 % of reference line.
- (b) Dense flaw echoes having a height of 10 % or over up to and including 50 % of the reference line. In that case, dense flaw echoes herein mean not less than 5 flaw echoes detected within a volume of 50 cubic mm.

6. Proof stress and tensile strength at high temperature (Y4)

6.1 Proof stress and tensile strength Both or either of proof stress and tensile strength of forgings shall be agreed upon between the parties concerned with delivery.

6.2 Tensile test at high temperature The tensile test at high temperature shall be as specified in JIS G 0567.

Further, the test temperature and the shape of test piece in the case where sampling of test piece specified in JIS G 0567 is difficult shall be agreed upon between the parties concerned with delivery.

Further, the numbers of specimens and test pieces shall be as specified in 9.3.3 of text for each temperature and the methods for sampling of specimens and test pieces shall be as specified in 9.3.1 and 9.3.2 of text.

7. Traverse bulging by Charpy impact test (Y5)

7.1 Traverse bulging Each value of the traverse bulging of forgings by Charpy impact test shall be at least 0.4 mm when the test of 7.2 is performed.

7.2 Charpy impact test The Charpy impact test shall be as follows:

- (1) The test temperature shall be agreed upon between the parties concerned with delivery.
- (2) The numbers of specimens and test pieces shall be as specified in 9.3.3 of text and the methods for sampling of specimens and test pieces shall be as specified in 9.3.1 and 9.3.2 of text. However, for the number of test pieces, each three test pieces shall make one set.
- (3) The test piece shall be as specified in 4.2.2 (1.2.6) of JIS G 0306.
- (4) The test method shall be as specified in 4.2.2 (1.5) (impact test method) of JIS G 0306.
- (5) When the mean value of bulging conforms to the requirements and only one value is in the range of 0.3 mm or over to and excluding 0.4 mm in the cases where the requirements specified in the test are not satisfied, one set (three pieces) of test pieces may be taken afresh from the same specimen for a retest to determine the acceptance or rejection. In that case, each of three values shall conform to the requirements of 7.1.

When the results of the retest do not conform to the requirements of 7.1, a retest may be further carried out after heat treating again. In that case, all mechanical tests shall be carried out again. The number of test pieces for the retest shall be the same as that for the first test.

8. Corrosion resistance (Y6)

8.1 Corrosion resistance The corrosion resistance of forgings, when subjected to the corrosion test of 8.2, shall conform to the requirements specified in Annex Table 5.

Annex Table 5. Criteria of corrosion resistance

Symbol of grade	State	The state of etched surface by 10 % oxalic acid etch test	The state of bent surface by sulfuric acid and copper sulfate corrosion test
SUS F 304L	Sensitization	In no grooved structure, accept. In presence of grooved structure, further execute a sulfuric acid and copper sulfate corrosion test, and examine for the presence of intergranular corrosion.	The bent surface shall be free from intergranular corrosion cracks.
SUS F 304LN			
SUS F 316L			
SUS F 316LN			
SUS F 317L			
SUS F 321			
SUS F 347			

8.2 Corrosion test The corrosion test shall be as follows. However, the corrosion test may be limited to the test of (2) (b) as agreed upon between the parties concerned with delivery.

- (1) Pertaining to the sampling of specimens and the number of test pieces, take one test piece from the forgings or extra length portion thereof of the same ladle and concurrent heat treatment.

Further, the residual material of mechanical test piece may serve as a specimen.

- (2) The test method shall be in accordance with the following standards:
 - (a) JIS G 0571
 - (b) JIS G 0575
- (3) When judgment of intergranular cracks is difficult due to generation of mechanical cracks in the case of bending under the bend condition specified in JIS G 0575, as an alternative, the maximum angle not causing mechanical cracks is preliminarily obtained by carrying out the bend test on the test piece of the same dimension not immersed in corrosion test liquid and then the existence or nonexistence of intergranular corrosion cracks may be tested by bending the test piece to that angle.

Reference standard:

ISO 2604-I: 1975 Steel products for pressure purposes — Quality requirements
— Part I : Forgings

244

G 3214-1991
Edition 1

Japanese Text

Established by Minister of International Trade and Industry

Date of Establishment: 1974-03-01

Date of Revision: 1991-12-01

Date of Public Notice in Official Gazette: 1991-12-09

Investigated by: Japanese Industrial Standards Committee

Divisional Council on Iron and Steel

**This English translation is published by:
Japanese Standards Association
1-24, Akasaka 4, Minato-ku,
Tokyo 107 Japan
© JSA, 1992**

**Printed in Tokyo by
Hohbunsha Co., Ltd.**

