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**Methods of radiographic
examination for welded joints
in stainless steel**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law. Consequently **JIS Z 3106 : 1971** is replaced with **JIS Z 3106 : 2001**.

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Methods of radiographic examination for welded joints in stainless steel

1 Scope This Japanese Industrial Standard specifies the methods of radiographic examination for welded joints of stainless steel, heat-resistant steel, corrosion- and heat-resistant superalloy, nickel and nickel alloy, which are carried out by the direct radiography through the irradiation of X-rays or gamma-rays (hereafter referred to as “radiation”) using industrial X-ray films.

2 Normative references The standards listed in Attached Table 1 contain provisions which, through reference in this Standard, constitute provisions of this Standard. The most recent editions of the standards (including amendments) shall be applied.

3 Definitions For the purposes of this Standard, the definitions given in **JIS Z 2300** and **JIS Z 3001**, and the following definitions apply.

- a) **thickness of base metal** For a butt welded joint whose two base metals differ in thickness, the lighter thickness shall be the thickness of base metal. For a circumferentially welded joint for pipe, the lighter wall thickness shall be the thickness of base metal. And for a Tee welded joint, the thickness of T1 material as shown in Annex 3 Fig. 1 and Annex 3 Fig. 2 shall be the thickness of base metal.
- b) **test part** The weld metal to be examined, including its heat-affected zone.

4 Classification of radiograph image quality The image quality of radiograph shall be classified into five grades; Grade A, Grade B, Grade P1, Grade P2 and Grade F. Grade A can be obtained by applying usual radiographic technique and Grade B can be obtained by applying a radiographic technique capable of attaining high detection sensitivity for flaws. Grade P1 and Grade P2 are normal image qualities obtainable when the radiograph of a circumferentially welded joint for pipe is taken by applying duplex penetration through its wall; the former available for the radiograph taken on one side of the joint and the latter for the radiograph taken on both sides of the joint. Grade F is normal image quality obtainable in the radiographic examination of a Tee welded joint. The application of these image qualities shall depend on the shape of welded joints, as shown in Table 1.

Table 1 Classification of radiograph image quality

Shape of welded joint	Classification of image quality
Butt welded joint for plate and other welded joints whose geometrical conditions at the time of taking radiographs can be deemed equal to those of the butt welded joint	Grade A, Grade B
Circumferentially welded joint for pipe	Grade A, Grade B, Grade P1, Grade P2
Tee welded joint	Grade F

5 Test engineer The test engineers who undertake the radiographic examination shall be those who have passed the examination specified in **JIS Z 3861** or those with ability equal or superior to them.

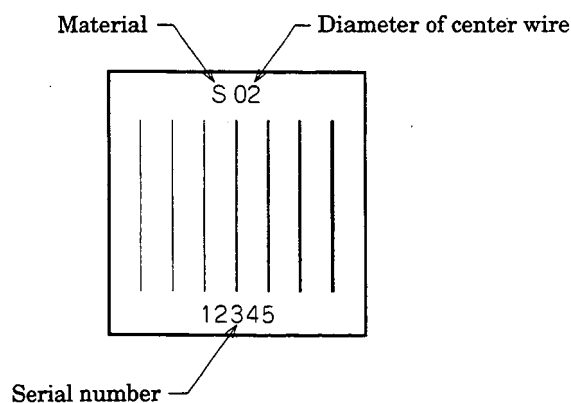
6 Radiographic equipment and auxiliary devices

6.1 Radiographic equipment The radiographic equipment shall be the X-ray apparatus and the X-ray generator using an electron accelerator specified in **JIS Z 4606** and the gamma-ray apparatus specified in **JIS Z 4560** and the equipment with performance equal or superior to them.

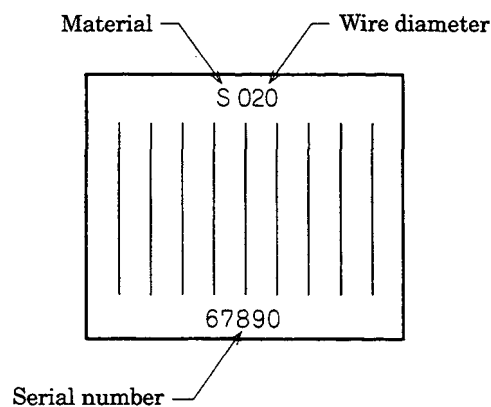
6.2 Sensitive materials The industrial X-ray films (hereafter referred to as "films") shall be any of low-sensitive/super ultrafine-grained type, low-sensitive/ultrafine-grained type, medium-sensitive/fine-grained type or high-sensitive/fine-grained type. Intensifying screens, when used, shall be lead-foil type, fluorescent type or metal fluorescent type.

6.3 Penetrometer For the penetrometer, the F-type or S-type general model specified in **JIS Z 2306** shall be used. For taking the radiographs of a circumferentially welded joint for pipe, the F-type or S-type penetrometer of a band model shall be used. But the F-type or S-type penetrometer of a general model may also be used.

Informative reference : As for the S-type penetrometer specified in **JIS Z 2306**, examples of configuration for the general model and the band model are shown in Informative Fig. 1 and Informative Fig. 2, and the relationship between nominal number and wire diameter is shown in Informative Table 1 and Informative Table 2.



Informative Fig. 1 Configuration of S-type penetrometer of general model



Informative Fig. 2 Configuration of S-type penetrometer of band model

Informative Table 1 Dimensions for S-type penetrometer of general model

Nominal number	Wire diameter and series thereof mm	Allowance on wire diameter %
S01	0.05 0.063 0.08 0.10 0.125 0.16 0.20	± 5
S02	0.10 0.125 0.16 0.20 0.25 0.32 0.40	
S04	0.20 0.25 0.32 0.40 0.50 0.63 0.80	
S08	0.40 0.50 0.63 0.80 1.0 1.25 1.6	
S16	0.80 1.0 1.25 1.6 2.0 2.5 3.2	
S32	1.6 2.0 2.5 3.2 4.0 5.0 6.3	

Informative Table 2 Wire diameters for S-type penetrometer of band model

Nominal number	Wire diameter mm	Allowance on wire diameter %
S005	0.05	± 5
S006	0.063	
S008	0.08	
S010	0.10	
S012	0.125	
S016	0.16	
S020	0.20	
S025	0.25	
S032	0.32	
S040	0.40	
S050	0.50	
S063	0.63	
S080	0.80	
S100	1.0	

6.4 Contrastmeter The type, structure, dimensions and material of the contrastmeter shall be as follows:

- a) The type, structure and dimensions of the contrastmeter shall be as shown in Fig. 1.

Dimensional tolerances for the contrastmeter shall be $\pm 5\%$ for thickness and ± 0.5 mm for side length.

- b) The material of the contrastmeter shall be the steel materials specified in **JIS G 3101** and the SUS 304 specified in **JIS G 4304** or **JIS G 4305**.

Unit : mm

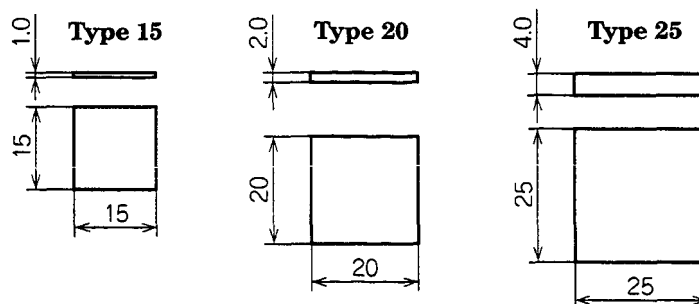


Fig. 1 The type, structure and dimensions of contrastmeter

6.5 Viewing illuminator The viewing illuminator shall be as specified in **JIS Z 4561** or that with performance equal or superior to it.

6.6 Densitometer The densitometer subjected to proper calibration using the standard densitometer shall be used.

7 Radiographic method

7.1 Combination of irradiation source and sensitive material The combination of the irradiation source and the sensitive material shall be such that the minimum perception wire diameter of the penetrometer can be identified.

7.2 Symbol When taking radiographs, use identification symbols so that the radiograph taken can be checked with the record.

7.3 Radiation field In taking radiographs, it is preferable that the radiation field be controlled not to be unnecessarily wide by the use of a diaphragm or a treatment cone.

7.4 Radiographic method The radiographic method shall conform to the Annexes shown in Table 2, depending on the shape of a welded joint.

Table 2 Annexes specifying the radiographic method

Shape of welded joint	Annex
Butt welded joint for plate and other welded joints whose geometrical conditions at the time of taking radiographs can be deemed equal to those of the butt welded joint	Annex 1
Circumferentially welded joint for pipe	Annex 2
Tee welded joint	Annex 3

8 Requirements for radiograph As for the radiograph taken, requirements for the radiograph at the test part shall conform to the Annexes shown in Table 3, depending on the shape of a welded joint.

The radiograph shall be free of uneven development, film flaw or other defects detrimental to the assessment of image quality and the grouping of flaw image.

Table 3 Annexes specifying requirements for radiographs

Shape of welded joint	Annex
Butt welded joint for plate and other welded joints whose geometrical conditions at the time of taking radiographs can be deemed equal to those of the butt welded joint	Annex 1
Circumferentially welded joint for pipe	Annex 2
Tee welded joint	Annex 3

9 Observation of radiograph

9.1 Viewing illuminator For the observation of radiograph, the viewing illuminator specified in 6.5 shall be applied according to the division of Table 4.

Table 4 Application division for observing instrument

Type of viewing illuminator	Maximum density in radiograph ⁽¹⁾
Type D10	1.5 or under
Type D20	2.5 or under
Type D30	3.5 or under
Type D35	4.0 or under

Note (1) Maximum density observed at the test part in each radiograph.

9.2 Method of observation The observation of radiograph shall be made in a dark room using a fixed mask that suits the size of the radiograph.

10 Method of grouping flaw images The grouping of flaw images observed on a radiograph shall conform to Annex 4.

11 Record The following necessary items shall be stated on a record of test results so that the collation of the record with the test part is possible.

a) Matters relevant to test part

- 1) Builder's or manufacturer's name
- 2) Work or product name
- 3) Symbol or number of test part
- 4) Material
- 5) Thickness of base metal (wall thickness and outside diameter for tubular products)
- 6) Shape of welded joint (whether there is reinforcement of weld, etc.)

b) Radiographing date

c) Test engineer's position and name

d) Test conditions

- 1) Equipment and materials used
 - 1.1) Name of radiation equipment and size of effective focus
 - 1.2) Types of film and intensifying screen
 - 1.3) Type of penetrometer
 - 1.4) Type of contrastmeter
- 2) Radiographic conditions
 - 2.1) Tube voltage used or type of radioactive isotope
 - 2.2) Tube current used or intensity of radioactivity

- 2.3) Exposure time
- 3) Radiographic setup
 - 3.1) Distance between radiation source and film ($L_1 + L_2$)
 - 3.2) Distance between the radiation source side surface of test part and film (L_2)
 - 3.3) Effective length of test part L_3 (both sides of double wall: $L_3 = L_3' + L_3''$)
- 4) Development conditions
 - 4.1) Developer, temperature of development and time of development (for manual processing)
 - 4.2) Name of automatic processor and developer (for automatic processing)
- e) **Confirmation of requirements for radiograph**
 - 1) Type of viewing illuminator and observing conditions
 - 2) Classification of image quality (Grade A, Grade B, Grade P1, Grade P2 or Grade F)
 - 3) Minimum perception wire diameter of penetrometer
 - 4) Density at test part
 - 5) Value on contrastmeter (density difference/density)
 - 6) Acceptability of radiograph
- f) **Date of flaw image grouping**
- g) **Result of flaw image grouping**
 - 1) Result of grouping flaw images by flaw mark
 - 1.1) Grouping of Type 1 flaw image
 - 1.2) Grouping of Type 4 flaw image
 - 1.3) Whether Type 1 flaw image and Type 4 flaw image coexist
 - 1.4) Grouping of the flaw images which coexist
 - 2) Grouping of Type 2 flaw image
 - 3) Grouping of Type 3 flaw image
 - 4) Whether two or more Type 2 flaw images exist in the field of examination
 - 5) Overall grouping
- h) **Other necessary items**
- i) **Remarks**

Attached Table 1

JIS G 3101	<i>Rolled steels for general structure</i>
JIS G 3446	<i>Stainless steel pipes for machine and structural purposes</i>
JIS G 3448	<i>Light gauge stainless steel tubes for ordinary piping</i>
JIS G 3459	<i>Stainless steel pipes</i>
JIS G 3463	<i>Stainless steel boiler and heat exchanger tubes</i>
JIS G 4304	<i>Hot rolled stainless steel plates, sheets and strip</i>
JIS G 4305	<i>Cold rolled stainless steel plates, sheets and strip</i>
JIS G 4312	<i>Heat-resisting steel plates and sheets</i>
JIS G 4902	<i>Corrosion-resisting and heat-resisting superalloy plates and sheets</i>
JIS G 4903	<i>Seamless nickel-chromium-iron alloy pipes</i>
JIS G 4904	<i>Seamless nickel-chromium-iron alloy heat exchanger tubes</i>
JIS H 4551	<i>Nickel and nickel alloy plate, sheet and strip</i>
JIS H 4552	<i>Nickel and nickel alloy seamless pipes and tubes</i>
JIS Z 2300	<i>Glossary of terms used in nondestructive testing</i>
JIS Z 2306	<i>Radiographic image quality indicators for non-destructive testing</i>
JIS Z 3001	<i>Welding terms</i>
JIS Z 3861	<i>Standard qualification procedure for radiographic testing technique of welds</i>
JIS Z 4560	<i>Industrial γ-ray apparatus for radiography</i>
JIS Z 4561	<i>Viewing illuminators for industrial radiograph</i>
JIS Z 4606	<i>Industrial X-ray apparatus for radiographic testing</i>

Annex 1 (normative)
Method of radiographing butt welded joint for plate
and requirements for radiograph

1 Scope This Annex specifies the method of radiographing a butt welded joint by the direct radiography using radiation and requirements for radiographs.

2 Radiographic method

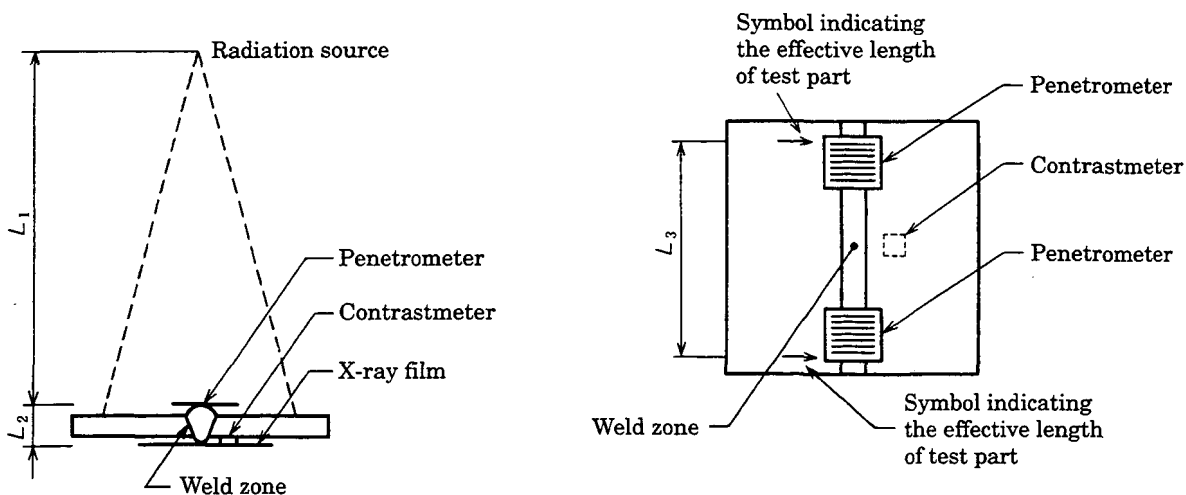
2.1 Classification of radiograph image quality The image quality of radiographs shall be classified into Grade A and Grade B.

2.2 Irradiation direction of radiation Radiographs shall be taken by irradiating the radiation from the direction that can minimize the thickness of radiation penetrating through test part.

2.3 Use of penetrometers Two penetrometers including the minimum perception wire diameter (refer to 4.1 of Annex 1) shall each be placed on the radiation source side surface of test part over the welded joint, so that the finest wire of each penetrometer comes in the vicinity of each end of the effective length L_3 of the test part, as shown in Annex 1 Fig. 1. On this occasion, the fine wire side shall be placed outward.

When the penetrometer and the film are apart from each other at a distance ten times or more the minimum perception wire diameter, the penetrometer may be placed on the film side. In this case, the symbol F should be put down on each penetrometer to make it clear from the radiographs taken that the penetrometer was located on the film side.

When the effective length of the test part is not more than three times the width of the penetrometer, one penetrometer may be placed in the middle of the test part.



Annex 1 Fig. 1 Photographic setup

2.4 Use of contrastmeter The contrastmeter shall be used in accordance with the division given in Annex 1 Table 2 for a welded joint 50 mm or less in the thickness of base metal multiplied by the coefficient B obtainable from Annex 1 Table 1 depending on the material. On this occasion, the contrastmeter shall be placed on the film side of base metal in a position not so far from the middle of the effective length of the test part. However, when the value of the contrastmeter not less than the values given in Annex 1 Table 7 can be obtained, the contrastmeter may be placed on the radiation source side.