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JAPANESE INDUSTRIAL STANDARD

Method of nondestructive examination for weld of pipeline

JIS Z 3050—1995

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In the event of any doubt arising,
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Method of nondestructive examination
for weld of pipeline

Z 3050-1995

1. Scope This Japanese Industrial Standard specifies the method of non-destructive examination for circular butt weld of steel pipeline for the transport of petroleum, gas, etc., 100 mm to 2000 (excl.) mm in outside diameter and 6 mm to 40 (incl.) mm in wall thickness under working pressure of 0.98 MPa or more.

However, this Standard is applicable for liquefied gases regardless of the pressure with this respect, the steel pipe shall have the minimum tensile strength of 340 N/mm² to 570 N/mm² (incl.) in accordance with the Japanese Industrial Standard or equivalent one thereto, and the weld shall be the arc-welded one using a welding method qualified by the welding procedure test.

Furthermore, the criteria for the test results are specified in Annex.

Remarks: The standards cited in this Standard are as follows:

- JIS G 0565 Method for magnetic particle testing of ferromagnetic materials and classification of magnetic particle indication
- JIS K 7652 Photography – Density measurements – Parts 2: Geometric conditions for transmission density [ISO 5-2: 1991]
- JIS K 7653 Photography – Density measurements – Part 3: Spectral conditions [ISO 5-3: 1984]
- JIS Z 2300 Glossary of terms used in nondestructive testing
- JIS Z 2306 Radiographic image quality indicators for non-destructive testing
- JIS Z 2343 Method for liquid penetrant testing and classification of the indication
- JIS Z 2345 Standard test blocks for ultrasonic testing
- JIS Z 3060 Method for ultrasonic examination for welds of ferritic steel
- JIS Z 3104 Methods of radiographic examination for welded joints in steel
- JIS Z 4560 Industrial γ -ray apparatus for radiography
- JIS Z 4561 Viewing illuminators for industrial radiograph
- JIS Z 4606 Industrial X-ray apparatus for radiographic testing

2. Definitions For the main terms used in this Standard, the definitions in JIS Z 2300 apply.

3. General matters

3.1 Technical classification of nondestructive testing The technical classification of the nondestructive testing shall be the procedure A and procedure B according to the laying environment of the pipeline, or the like.

- (1) Procedure A This applies to general portions of pipeline. The weld shall, as a rule, be subjected to appearance test and radiographic testing. In the case where these testings are infeasible, or in special cases, the weld shall be subjected to ultrasonic testing from the outside surface, and also magnetic particle testing or liquid penetrant testing therefrom.
- (2) Procedure B This applies to particular portions of pipeline such as those where especially strength is required. The weld, as a rule, shall be subjected to appearance test, radiographic testing and ultrasonic testing from the outside surface, and further subjected to magnetic particle testing and liquid penetrant testing therefrom.

3.2 Examination engineer Engineers who engage in nondestructive inspection shall have acquired the fundamental technique concerning nondestructive testings and shall have sufficient knowledge and experience with regard to the properties and testing methods of the weld subjected to inspection.

4. Test method

4.1 Appearance test The test shall be carried out visually on the following items:

- (1) Shape of weld reinforcement
- (2) Size and status of distribution of undercut
- (3) Cracks, traces of arc strike, overlap, pit, trace of jig, shape of bead, and presence of adhesion of slag and spatter in test part and its surrounding area

4.2 Radiographic testing Radiographic testing for the weld shall be conducted in accordance with the following procedures. However, the matters not specified in the procedures shall, as a rule, conform to the text and Annex 2 of JIS Z 3104.

4.2.1 Method of photographing The method of photographing being applied shall be any one of internal source technique, internal film technique, or double wall single image technique specified in the Annex 2 of JIS Z 3104.

4.2.2 Classification of image quality of radiograph Class A or class P1 of JIS Z 3104 shall apply to the image quality of the radiograph.

4.2.3 Radiographic testing apparatus, photosensitive material and viewing illuminator

- (1) The X-ray apparatus specified in JIS Z 4606 or the equivalent one shall, as a rule, be used for the radiographic testing apparatus.

The γ -ray apparatus specified in JIS Z 4560 or the equivalent one may be used as necessary.

- (2) The X-ray film shall be the one for industrial use of non-screen and ultra-fine particle type or ultra-fine particle type. When the intensifying screen is used, it shall be of lead foil type or of fluorometallic type.
- (3) The viewing illuminator specified in JIS Z 4561 shall be used. The viewing illuminator being used and the maximum density of the radiograph shall be as specified in Table 1.

Table 1. Classification of application of viewing illuminator

Type of viewing illuminator	Maximum density of 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⁾ The maximum density of the test part in each radiograph.

- (4) The densitometer which conform to JIS K 7652 and JIS K 7653 shall be used.

4.2.4 Application of penetrameter and contrast indicator

- (1) In taking radiograph, a penetrameter which expresses material designation symbol F or S among the wire type penetrameters specified in JIS Z 2306 shall be used for the weld and taken simultaneously radiographs with the test part.
- (2) When the applicable image quality of the radiograph is Class A, the radiograph of the weld shall be taken simultaneously with the test part by using the contrast indicator specified in JIS Z 3104. The classification of application of the contrast indicator shall be in accordance with Table 2.

Table 2. Classification of application of contrast indicator

Wall thickness of pipe ⁽²⁾ mm	Type of contrast indicator
20.0 or under	Type 15
over 20.0 up to and incl. 40.0	Type 20

Note⁽²⁾ Nominal thickness of the pipe being used. Where the thicknesses for the pipes at both sides of the joint differ, the thinner value shall be taken.

4.2.5 Symbol In taking radiograph, symbols shall be simultaneously photographed so that the radiograph is able to collate with the records.

4.2.6 Photographing arrangement

- (1) The photographing arrangement in the case of the internal source technique shall be as follows:
 - (a) The distance ($L_1 + L_2$) between the radiation source and the film, as shown in Fig. 1, shall not be less than m times of the distance L_2 between the surface of the radiation source side of the test part and the film. The value m is $\frac{f}{d}$, where f is the dimensions (mm) of the radiation source, and d is the minimum perceptible wire diameter (mm) of the penetrameter as specified in 4.2.8(1).
 - (b) The direction of the radiation of the beam shall make, as a rule, the center line of the flux of radiation the center of the test portion, and also perpendicular to the film surface.
 - (c) When the strip-shaped penetrameter is used, each penetrameter shall be placed on the surface of the radiation source side of the test part at the position including each end of the effective length L_3 of the test part across the weld joint. In this case, two strip-shaped penetrameters and the strip-shaped penetrameter and the contrast indicator shall not be overlapped. However, when one strip-shaped penetrameter is feasible to cover the effective length of the test part sufficiently, one strip-shaped penetrameter is acceptable.
 - (d) When a general type penetrameter is used, two penetrameters shall be placed on the surface of the radiation source side of the test part across the weld joint as shown in Fig. 1. In this case, the penetrameters shall be placed in such a manner that the minimum perceptible wire diameter of the penetrameter specified in 4.2.8(1) shall be on or outside the boundary of the effective length L_3 respectively, and the fine wire shall be outside the effective length. When two penetrameters are infeasible to place within the effective length L_3 of the test part, one strip-shaped penetrameter shall be used.
 - (e) When it is difficult to place the penetrameter on the surface of the radiation source side, the penetrameter may be placed by closely contacting the penetrameter onto the surface of the film side. In this case, the distance between the penetrameter and the film shall be ten times or more the minimum perceptible wire diameter of the penetrameter specified in 4.2.8(1).

In this case, the symbol F is marked on the part of penetrameter to identify that it is placed on the film side when the radiograph is examined.

- (f) When the contrast indicator is used, it shall be placed on the film side of the base metal part not far away from the center on the radiation source side of the test part as shown in Fig. 1. However, when the value of the contrast indicator is not less than the value specified in 4.2.8(3), the contrast indicator may be placed on the radiation source side.
- (g) In the case of the simultaneous radiographing of the full circumference, respective four penetrameters and contrast indicators shall be placed as shown in Fig. 2, as a rule, on the circular surface of the radiation source side of the test part so that each of them is situated in the symmetrical portion to divide the circle into quarters.

In addition, the distance between the radiation source and the center of pipe shall not exceed $\frac{1}{6}$ of the inside radius.

- (h) The symbol expressing the effective length L_3 of the test part shall, as a rule, be placed inside the pipe when the distance between the radiation source and the film is smaller than the radius of the pipe, while outside the pipe when the distance is larger than the radius of the pipe. When the distance between the radiation source and the film is smaller than the radius of the pipe, the symbol may be placed outside the pipe if the relative position where the symbol is placed inside and outside the pipe from the geometric relationship of the photographing arrangement is preliminarily clarified.

Fig. 1 Photographing arrangement of internal source technique (divisional photographing)

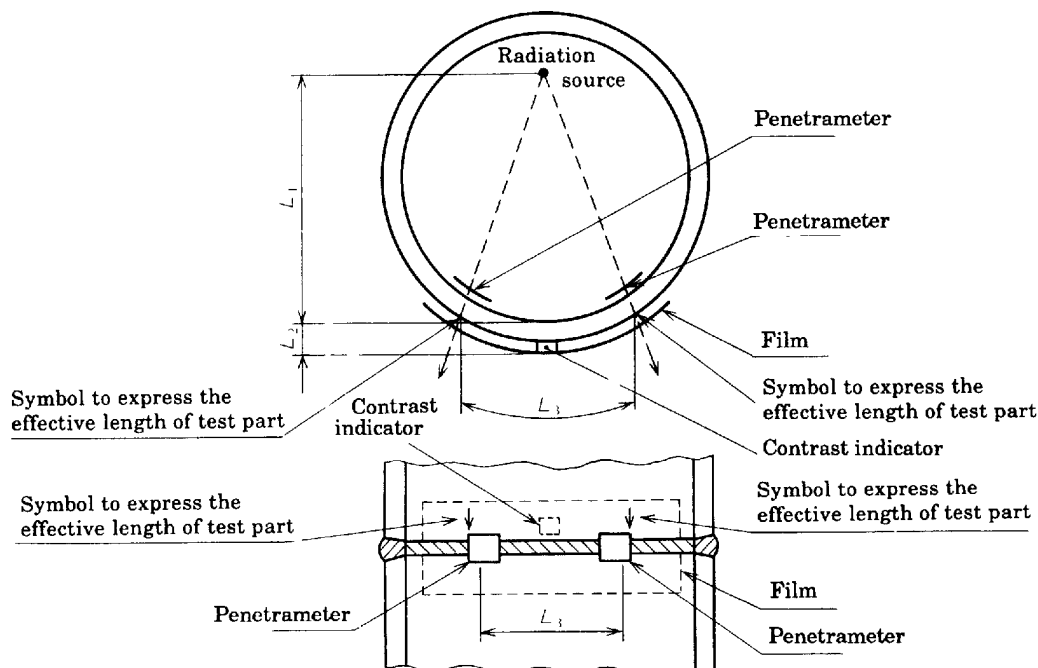
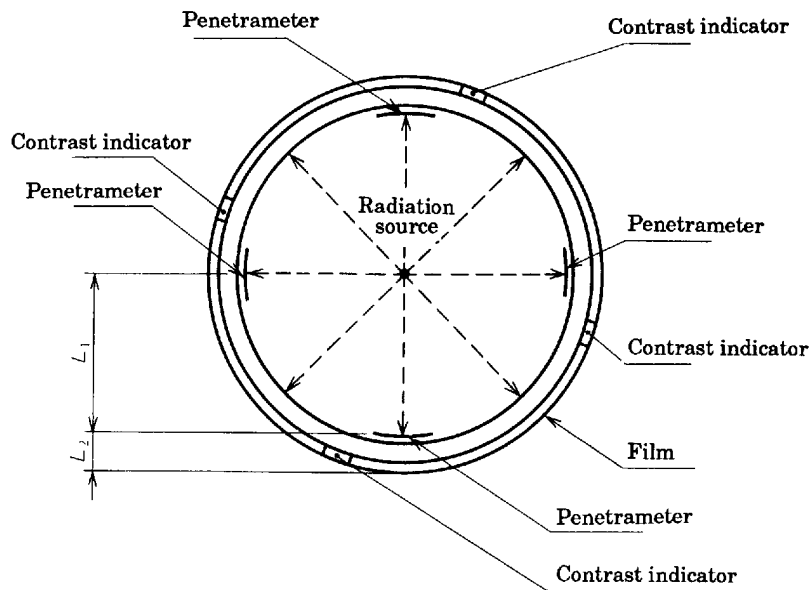
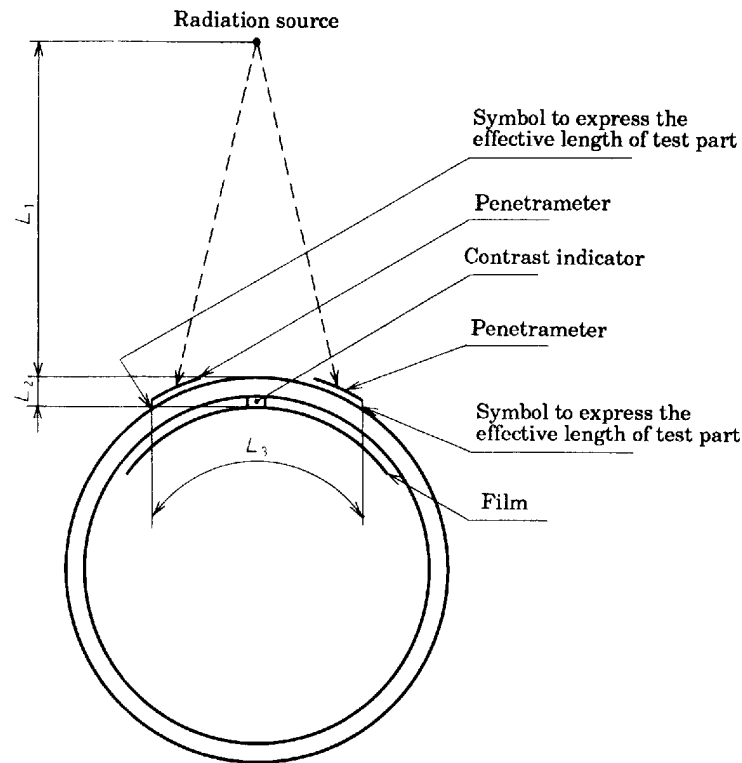


Fig. 2. Photographing arrangement of internal source technique
(simultaneous radiographing of the full circumference)



- (2) The photographing arrangement in the internal film technique shall be as follows:
- (a) The distance ($L_1 + L_2$) between the radiation source and the film shall be m or more times the distance L_2 between the surface of the radiation source side of the test part and the film as shown in Fig. 3, where m shall be as specified in 4.2.6(1)(a).
 - (b) The direction of the radiation of the beam shall be as specified in 4.2.6(1)(b).
 - (c) When the strip-shaped penetrometer is used, it shall be in accordance with 4.2.6(1)(c).
 - (d) When the general type penetrometer is used, it shall be in accordance with 4.2.6(1)(d). However, the photographing arrangement shall be as shown in Fig. 3.
 - (e) If it is difficult to place the penetrometer on the surface of the radiation source side, the requirement in 4.2.6(1)(e) shall be followed.
 - (f) When the contrast indicator is used, it shall be in accordance with 4.2.6(1)(f).
 - (g) The symbol to express the effective length L_3 of the test part shall be placed outside the pipe.

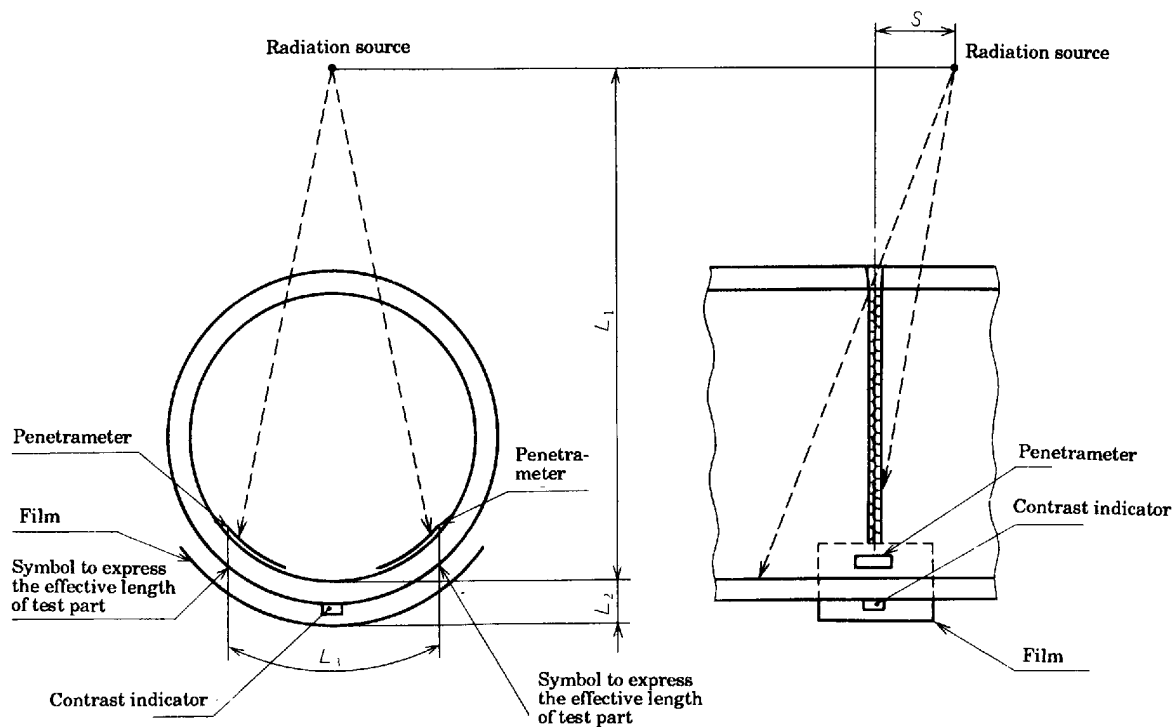
Fig. 3 Photographing arrangement in the internal film technique



- (3) The photographing arrangement in the double wall single image technique shall be as follows:
- (a) The distance ($L_1 + L_2$) between the radiation source and the film shall be m or more times the distance L_2 between the surface of the radiation source side of the test part and the film as shown in Fig. 4, where m shall be as specified in 4.2.6(1)(a).
 - (b) The radiation shall be irradiated from the oblique direction to the plane including the weld zone as indicated in Fig. 4. In this case, the distance "S" between the planes including the radiation source and the test part shall not be greater than $\frac{1}{4}$ of L_1 .
 - (c) When the strip-shaped penetrameter is used, it shall be in accordance with 4.2.6(1)(c).
 - (d) When the general type penetrameter is used, it shall be in accordance with 4.2.6(1)(d). However, the photographing arrangement shall be as shown in Fig. 4.
 - (e) If it is difficult to place the penetrameter on the surface of the radiation source side, the requirement in 4.2.6(1)(e) shall be followed.
 - (f) When the contrast indicator is used, it shall be in accordance with 4.2.6(1)(f).

- (g) The symbol to express the effective length L_3 of the test part shall be placed outside the pipe.

Fig. 4 Photographing arrangement in double wall single image technique



4.2.7 Interpretation of radiograph The radiograph shall, as a rule, be interpreted by using the fixed mask suitable for the dimension of the radiograph by means of the viewing illuminator specified in 4.2.3(3). The radiograph shall be interpreted in the dark room.

4.2.8 Necessary conditions for radiograph

- (1) **Minimum perceptible wire diameter of penetrameter** The wire diameter not greater than the value indicated in Table 3 shall be identified on the radiograph being taken.

Table 3. Minimum perceptible wire diameter of penetrometer

Unit: mm

Wall thickness of pipe	Classification of image quality	
	Class A	Class P1
6.3 or under	0.16	0.25
over 6.3 to 8.0 or under	0.20	0.32
over 8.0 to 10.0 or under	0.20	0.32
over 10.0 to 12.5 or under	0.25	0.40
over 12.5 to 16.0 or under	0.32	0.50
over 16.0 to 20.0 or under	0.40	0.63
over 20.0 to 25.0 or under	0.50	0.80
over 25.0 to 32.0 or under	0.50	1.00
over 32.0 to 40.0 or under	0.63	1.25

- (2) Range of density of radiograph The photographing density of the part of image except that of flaw of the test part shall conform to the range indicated in Table 4.

Table 4. Range of density of radiograph

Classification of image quality	Range of density
Class A	1.3 or over to 4.0 or under
Class P1	1.0 or over to 4.0 or under

- (3) Value of contrast indicator In the radiograph where the contrast indicator is used, the density of the part of the base metal close to the contrast indicator and that of the center part of the contrast indicator shall be measured, and the value of the density difference divided by the density of the part of the base metal shall not be less than the value indicated in Table 5.

Table 5. Value of contrast indicator

Wall thickness of pipe mm	Density difference Density	Type of contrast indicator
6.3 or under	0.10	Type 15
over 6.3 to 8.0 or under	0.081	
over 8.0 to 10.0 or under	0.081	
over 10.0 to 12.5 or under	0.062	
over 12.5 to 16.0 or under	0.046	
over 16.0 to 20.0 or under	0.035	
over 20.0 to 25.0 or under	0.049	Type 20
over 25.0 to 32.0 or under	0.049	
over 32.0 to 40.0 or under	0.032	

- (4) Finish of radiograph The radiograph shall be free from irregular development, stain, flaw or the like in the part being tested.

4.2.9 Effective length of test part The effective length L_3 of the test part in one photographing shall fall in the range where the minimum perceptible wire diameter of the penetrometer, the density range of the radiograph and the value of the contrast indicator meet the requirements of 4.2.8. However, when the detection of the transverse crack in the test part is specially required, the range shall be the one where the minimum perceptible wire diameter of the penetrometer, the density range of the radiograph and the value of the contrast indicator meet the requirements of 4.2.8, and also meet the limit in Table 6.

Table 6. Effective length of test part

Photographing technique	Effective length
Internal source technique (divisional photographing)	$\frac{1}{2}$ or under of the distance L_1 between the radiation source and the surface of the radiation source side of test part
Internal film technique	$\frac{1}{2}$ or under of the circumference of the pipe
Double wall single image technique	$\frac{1}{6}$ or under of the circumference of the pipe

4.3 Ultrasonic testing Ultrasonic testing for the weld shall be conducted as follows. However, items not specified in this procedure shall, as a rule, conform to the text and the Annex 2 in JIS Z 3060.