Base Load Power Hub (BLPH)

NDE PROCEDURE
VARIABLE AREA FLOWMETERS 3809G

Document Number: 1724000791-NDT-PRO-00005

Document Class: 3

ROSETTI MARINO

1	NO COMMENTS - APPROVED - WORK MAY PROCEED
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Sign	Date
Comandini Massimo Level III NDT EN - ISO9712 WI CSWIP 3.1	30-09-2024

Rev.	Date	Description	Prepared	Reviewed	Approved
02	24/9/2024	ISSUE FOR INFORMATION (IFI)	Róbert Seres	Mária Poór	Zsanett Molnár
01	25/7/2024	ISSUE FOR INFORMATION (IFI)	Róbert Seres	Mária Poór	Zsanett Molnár
00	10/5/2024	ISSUE FOR INFORMATION (IFI)	Róbert Seres	Mária Poór	Zsanett Molnár

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Revision / Change Log

Rev.	Description
00	ISSUE FOR INFORMATION (IFI)
01	ISSUE FOR INFORMATION (IFI)
02	ISSUE FOR INFORMATION (IFI)

HOLDS LIST

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Document addendum

Form QA-18-A-004

	Subject	Addendum for NDE PROCEDURE
	Customer	Rosetti
	Company document nr.	1724000791-NDT-PRO-00005
	PO number	PO 1724000791
	Item description/scope	Flow Meter (Rotameter)
	TAG numbers	as per order

Radiographic Examination Procedure

3. Personnel

Replace with the following text:

Radiography shall be performed by a person with at least a Level II EN ISO 9712 qualified and certified personnel. Evaluation and interpretation shall be performed by a Level II or III qualified personnel in accordance with EN ISO 9712.

Liquid Penetrant Examination Procedure

5. REFERENCES

Replace with the following text:

(the latest version)
SNT-TC-1A
MSZ EN ISO 9712
ASTM E165/E165M
ASME Code Section V
ASME Code Section VIII, Div 1
EN ISO 3452-1:2021
EN ISO 3452-2:2021
EN ISO 3452-4
EN ISO 23277
ASME B31.3

7.5 EXAMINATION MATERIALS

Add the following text:

“Only In-date consumables showing a batch number that can be traced to a certificate of conformity shall be used”

REV	DATE	CREATED BY	INIT.
2	23/09/2024	Robert Seres	RS

Radiographic Examination Procedure of items for Brooks Instrument Ltd.

APPLICABLE TO WELDS

This Procedure to be used for Work according to the requirements of ASME Code, Sections V. and VIII. Div. 1. Ed. 2021 or ASME B31.3-2020.

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Prepared by ASNT Level III 09.11.2022	Approved by QCM of AGMI Pte Co. L Date 12.12.2022.	Approved by ASNT Level III 04.12.2022

List of revisions:

Rev.	Description	Revised by:	Signature	Date
0	First edition	L. Lukovits		
1	Revision	L. Lukovits		
2	General revision	L. Lukovits		
3	ASME B31.3 2014	L. Lukovits		
4	ASME Code 2015	L. Lukovits		
5	ASME B31.3 2016	L. Lukovits		
6	General revision	Kövári, A.		
7	ASME B31.3 2020 and ASME, Sec. V + VIII. Div. 1. Ed. 2021	Rene Sallaberger		

1. Scope

This procedure is applicable to steel welds, manufactured for Brooks Instrument Ltd. in accordance with ASME Code Section VIII, Div. 1, UW-51, or alternatively B31.3 Table 341.3.2, Severe Cyclic Conditions and relevant Addenda's in conjunction with the referencing Code Section V., Article 2.
The nondestructive examination methods included in this procedure are applicable to most geometric configurations and materials encountered in fabrication in normal condition.
However, special configurations and materials may require modified methods and techniques, in which case special procedures shall be developed.

2. General Requirements

2.1 Procedure Requirements

All radiographic examination shall be performed in accordance with written procedure.
Each procedure shall include at least the following information, as applicable:

(a) material type and thickness range,
(b) isotope or maximum X-ray voltage used,
(c) Source to object distance (D in Para. 8.4.),
(d) Distance from source side of object to the film (d in Para. 8.4.),
(e) Source size (F in Para. 8.4.),
(f) film brand and designation, and
(g) screens used.

2.2 Procedure Demonstration

Demonstration of the density and IQI image requirements of the written procedure on production or technique radiographs shall be considered satisfactory evidence of compliance with that procedure.

2.3. Surface preparation for materials:

Surfaces shall satisfy the requirements of the applicable materials specification or referencing Code Section, with additional conditioning, if necessary, by any suitable process to such a degree that the images of surface irregularities cannot mask or be confused with the image of any discontinuity on the resulting radiograph.

2.4 Surface Preparation of Welds:

The weld ripples or weld surface irregularities on both the inside (where accessible) and outside shall be removed by any suitable process to such a degree that the images of surface irregularities cannot mask or be confused with the image of any discontinuity on the resulting radiograph.

The finished surface of all butt welded joints may be flush with the base material or may have reasonably uniform crowns, with reinforcement not to exceed that specified in the referencing Code Section.

Welds shall be cleaned for at least 1 in. (25mm) on each side.

If any radiograph shows ambiguous defect like indications, more surface conditioning and re-shooting is necessary.

2.5 Backscatter Radiation:

A lead symbol "B" with minimum dimension 11 mm in height and 1,5 mm in thickness, shall be attached to the back of each film holder during each exposure to determine if backscatter radiation is exposing the film. The lead symbol "B" shall be placed in a location so that it would appear within an area on the radiograph that meets the requirements of Para. 11.2.

2.6 System of Identification

A system shall be used to produce on each radiograph an identification that is traceable to the item being radiographed and that is permanent for the required retention period of the radiograph. This information shall include the contract, component, weld number, or part number, as appropriate. In addition the AGMI's symbol or name and the date of radiograph shall be plainly and permanently included with the identification information on each radiograph. The identification system does not necessarily require that the information appear as radiographic images. In any case, this information shall not obscure the area of interest.

2.7 Repair Identification

Radiographs of repairs shall be identified by the letter of R and may include -1,-2 etc. for the number of repair(s).

2.8 Monitoring Density Limitations of Radiographs:

Either a densitometer or step wedge comparison film shall be used for judging film density.

2.9 Extent of Examination

The extent of radiographic examination shall be as specified by referencing Code Section or by Customer.

3. Personnel

Radiography shall be performed by a person with at least a Level II SNT-TC-1A and/or EN ISO 9712:2013 qualified and certified personnel. Evaluation and interpretation shall be performed by a Level II or III qualified personnel in accordance with SNT-TC-1A and/or EN ISO 9712:2013.

4. Equipment

X-Ray equipment used are Eresco 300, maximum voltage 300 Kilovolts. Isotope containers TI and TIF for 1,5-3,7 TBq of Ir 192. Isotope container Gammamat TK100 for max 3,7 TBq of Co 60 sources shall be used.

5. Film Selection

5.1. Used films:

Radiograph shall be made using Class I. or Class II. (acc. to ASTM E-1815-18) industrial radiographic film with original package. In general film with lead screen shall be used, quality and degree of fineness of which shall correspond to the economical exposure time, to the density to be achieved and image quality.

Table 1: Industrial film classification

Film Type (ASTM E-1815-18)	Description		
	Speed	Contrast	Graininess
Class I. (AGFA Structurix D3, D4, D5) (Carestream Industrex M100, Mx125, T200) (FUJI IX50, IX 80)	Low	Very high	Very low
Class II. (AGFA Structurix D7) (Carestream Industrex AA 400) (FUJI IX100)	Medium	High	Low

5.2 Intensifying Screens

Intensifying screens may be used when performing radiographic examination in accordance with this written practice. Leads screens are used in direct contact with films.

5.3 Image Quality Indicator (IQI) Design

IQI shall be wire type, and it shall be manufactured and identified in accordance with the requirements or alternates allowed in SE-747, except the largest wire number or the identity number may be omitted. ASME standard IQI shall consist of those in Table No. 2. (ASME B&PV Code Sect. V., Art. 2, T-233.2) for wire type.

Table No.2: IQI Sizes
Wire Diameters

EN 462-1:1995/ ISO 19232-1:2013				ASME BPVC Sect. V. Art. 2. T-233.2			
			Dia [mm]				Dia [mm
				SET D	W21		8,13
					W20		6,35
					W19		5,08
					W18		4,06
W1	W1		3,20		W17	SET C	3,20
	W2		2,50		W16		2,54
	W3		2,00		W15		2,03
	W4		1,60		W14		1,60
			1,25		W13		1,27
	W6	W6	1,00		W12		1,02
	W7		0,80	SET B	W11		0,81
	W8		0,63		W10		0,64
	W9		0,50		W9		0,51
W10	W10		0,40		W8		0,41
	W11		0,32		W7		0,33
	W12		0,25		W6	SET A	0,25
	W13	W13	0,20		W5		0,20
	W14		0,16		W4		0,16
	W15		0,125		W3		0,13
	W16		0,10		W2		0,10
	W17		0,08		W1		0,08
	W18		0,063				
	W19		0,05				

5.4 Facilities for Viewing of Radiographs

Viewing facilities shall provide subdued background lighting of an intensity that will not cause reflections, shadows, or giere an the radiograph that interfere with the interpretation process. Equipment used to view radiographs for interpretation shall provide a variable light source sufficient for the designated wire to be visible for the specified density range. The viewing condition shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

6. Calibration

6.1 Verification of Source Size

The equipment manufacturer's or supplier's publications, such as technical manuals, decay curves, or written statements documenting the actual or maximum source size or focal spot, shall be acceptable as source size verification.

6.2. Determination of Source Size

When manufacturer's or supplier's publications are not available, source size may be determined as follows:

6.2.1. X-Ray Machines for X-Ray

Machines operating at 1000 kV and less, the focal spot size may be determined by the pinhole method, or in accordance with SE-1165 (SE-1165 Standard Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging).

6.2.2. Iridium-192 Sources

For Iridium-192; the source size may be determined in accordance with SE-1114. (SE- 1114 Standard Test Method for Determining the Focal Size of Iridium-192 Industrial Radiographic Sources.)
SE-1114, NOTE 1—The European standard EN 12679:2018 describes a simplified procedure for measurement of source size of Ir-192, Co-60 and Se-75. The resulting source size is comparable to the results obtained by SE-1114 test method.

7. Densitometer and Step Wedge Comparison Film

7.1. Densitometers

Densitometers shall be calibrated at least every 3 months during the use as follows:

a) A national step tablet or a step wedge calibration film, traceable to national standard tablet and having at least 5 steps with neutral densities from at least 1.0 through 4.0, shall be used. The step wedge calibration film shall have been verified within the last year by comparison with national standard step tablet unless, prior to the first use, it was maintained in the original light-tight and waterproof sealed package as sealed by the Manufacturer. Step wedge

calibration films may be used without verification for one year upon opening, provide it is within the manufacturer's stated shelf life.

b) The densitometer manufacturer's step-by-step instructions for the operation of the densitometer shall be followed.

c) The density steps closest to 1.0, 2.0, 3.0 and 4.0 on the national standard step tablet or step wedge calibration film shall be read.

d) The densitometer is acceptable if the density readings do not vary by more than ± 0,05 density units from the actual density stated on the national standard step tablet or step wedge calibration film.

7.2. Step Wedge Comparison Films

Step Wedge Comparison Films shall be verified prior to first use, unless performed by the manufacturer, as follows:

a) The density of the steps on a step wedge comparison film shall be verified by a calibrated densitometer.

b) The step wedge comparison film is acceptable if the density readings do not vary by more than ± 0,1 density units from the density stated on the step wedge comparison film.

7.3. Periodic Verification

a) Densitometers. Periodic calibration verification check shall be performed as described in point 7.1 at the beginning of each shift, after 8 hr of continuous use, or after change of apertures whichever comes first.

b) Step Wedge Comparison Films. Verification checks shall be performed annually per 7.2.

7.4. Documentation

a) Densitometers. Densitometer calibrations required by point 7.1 shall be documented, but the actual readings for each step do not have to be recorded. Periodic densitometer verification checks required by point 7.3(a) do not have to be documented.

b) Step Wedge Calibration Films. Step wedge calibration film verifications required by point 7.1(a) shall be documented, but the actual readings for each step do not have to be recorded.

c) Step Wedge Comparison Films. Step wedge comparison film verifications required by point 7.2 and 7.3(b) shall be documented, but the actual readings for each step do not have to be documented.

8. Examination

8.1. Radiographic Technique

Single wall exposure technique shall be used for radiography whenever practical. When it is not practical to use single wall technique, a double wall technique shall be used. An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained.

(a) Single Wall Technique

In the single wall technique, the radiation passes through only one wall or the weld (material), which is viewed for acceptance on the radiograph.

(b) Double Wall Technique

When it is not practical to use a single wall technique, one of the double wall techniques shall be used:

(a) Single Wall Viewing

For materials and for welds in components, a technique may be used in which the radiation passes through two walls and only the weld (material) on the film side wall is viewed for acceptance on the radiograph. When complete coverage is required for circumferential welds (materials), a minimum of three exposures taken 120 deg. from each other shall be made.

(b) Double Wall Viewing of Welds

For materials and for welds in components 89 mm or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld (material) in both walls is viewed for acceptance on the same radiograph. For double wall viewing, only a source side IQI shall be used. Care should be exercised to ensure that the required geometric unsharpness in not exceeded. If the geometric unsharpness requirement cannot be met, then single wall viewing shall be used.

1. For welds, the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source side and film side portions of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90 deg. to each other shall be made for each joint.
2. As an alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed. When complete coverage is required, a minimum of three exposures taken at either 60 deg. or 120 deg. to each other shall be made for each joint.
3. Additional exposures shall be made if the required radiographic coverage cannot be obtained using the minimum number of exposures indicated in (b)(1) or (b)(2) above.

8.2. Radiation Energy

The radiation energy employed for any radiographic technique shall achieve the density and IQI image requirements of this written practice.
Parameters shall be determined according to exposition diagrams of X-ray machine.

Minimum thickness			
Material	Ir 192	Co 60	X-ray (max. 300kV)
Steel	19 mm	38 mm	≤1 mm

When it is not practical to perform radiography within the limitation above , the procedure shall be proven satisfactory by actual demonstration of penetrameter resolution on the required thickness of the material radiographed.

8.3. Direction of Radiation

The direction of the central beam of radiation should be centered on the area of interest whenever practical.

8.4. Geometric Unsharpness

Geometric unsharpness of the radiograph shall be determined in accordance with:

$$Ug = F*d/D$$

Where
Ug = geometric unsharpness
F = source size. The maximum projected dimension of the radiating source (or effective focal spot) in the plane perpendicular to the distance D from the weld or object being radiographed
D = distance from the source of radiation to weld or object being radiographed
d = distance from source side of weld or object being radiographed to the film

8.4.1. *Geometric Unsharpness Limitations*
Geometric unsharpness of radiograph shall not exceed the following:

Table No. 3

Material thickness		Geometric Unsharpness Limitation U_g	
In.	mm	In.	mm
Under 2	Under 50,8	0,02	0,51
2 through 3	50,8 through 76,2	0,03	0,76
3 through 4	over 76,2 through 101,6	0,04	1,02
Over 4	Greater than 101,6	0,07	1,78

8.5. Location Markers

Location Markers (see Supplement No. 3. /Para. T-275 of ASME Code Section V, Art. 2/) which are to appear as radiographic images on the radiograph, shall be placed on the part, not on the exposure holder / cassette. Their location shall be permanently marked on the surface of the part being radiographed when permitted, or on map, in a manner permitting the area of interest on a radiograph to be accurately traceable to its location on the part, for the required retention period of the radiograph. Evidence shall also be provided on the radiograph that the required coverage of the region being examined has been obtained. Location markers shall be placed as follows.

8.5.1. Single-Wall Viewing

a. Source Side Markers
   Source Side Markers Location markers shall be placed on the source side when radiographing the following
   1. flat components or longitudinal joints in cylindrical or conical components;
   2. curved or spherical components whose concave side is toward the source and when the "source to material" is less then the inside radius of the component;
   3. curved or spherical components whose convex side is toward the source.

b. Film Side Markers
   1. Location markers shall be placed on the film side when radiographing either curved, or spherical components whose concave side is toward the source and when the "source to material" distance is greater, then the inside radius.
   2. As an alternative to source side placement in Para. 8.5.1 (a)(1), location markers may be placed on the film side when the radiograph shows coverage beyond the location markers to the extent demonstrated by Supplement No. 3. sketch (e), and when this alternate is documented in accordance with Para. 16

c. Either Side Markers Location markers may be placed on either the source side or film side when radiographing either curved or spherical components whose concave side is toward the source and the "source to material" distance equals the inside radius of the component.

8.5.2. Double Wall Viewing

For double wall viewing, at least one location marker shall be placed adjacent to the weld (or on the material in the area of interest) for each radiograph.

8.5.3. Mapping the Placement of Location Markers

When inaccessibility or other limitations prevent the placement of markers as stipulated in paragraphs *Single Wall Viewing* and *Double Wall Viewing*, a dimensioned map of the actual marker placement shall accompany the radiographs to show that full coverage have been obtained.

9. Image Quality Indicator (IQI) Selection

9.1. Material

IQIs shall be selected from either the same alloy material group or grade as identified in SE-747 or from an alloy material group or grade less radiation absorption than the material being radiographed. Use on all products made of carbon steel, low-alloy steels, stainless steels wire penetrameters shall be made of carbon steel or Type 300 series stainless steel - Materials group 1.

9.2. Size

The designated essential IQI wire be as specified in Supplement No. 2. (ASME Code Section V, Article 2, Table T-276.) For wire-type IQIs, a smaller-diameter wire may be substituted for the essential wire required for any section thickness listed in Table T-276.

a) Welds With Reinforcements. The thickness on which the IQI is based is the nominal single-wall material thickness plus the weld reinforcement thickness estimated to be present on both sides of the weld (I.D. and O.D.). The values used for the estimated weld reinforcement thicknesses shall be representative of the weld conditions and shall not exceed the maximums permitted by the referencing Code Section. Physical measurement of the actual weld reinforcements is not required. Backing rings or strips shall not be considered as part of the thickness in **IQI** selection.

b) Welds Without Reinforcement The thickness on which the **IQI** is based is the nominal single wall thickness. Backing rings or strips shall not be considered as part of the weld thickness in **IQI** selection.

c) Actual Values. With regard to (a) and (b) above, when the actual material/weld thickness is measured, IQI selection may be based on these known values.

The values used for the estimated weld reinforcement thicknesses shall be representative of the weld conditions and shall not exceed the maximums permitted by the referencing Code Section.

9.3. Welds Joining Dissimilar Materials or Welds With Dissimilar Filier Metal:

When the weld metal is of an alloy group or grade that has a radiation attenuation that differs from the base material, the IQI material selection shall be based on the weld metal and be in accordance with Para. 9.1. (IQI Selection, Material). When density limits of Para. 11.2.2 cannot be met with one IQI, and the exceptional density area(s) is at the interface of the weld metal and the base metal, the material selection for the additional IQIs shall be based on the base material, and be accordance with Para. 9.1 (IQI Selection, Material). The actual measurement of the weld reinforcement is not required.

10. Use of IQIs to Monitor Radiographic Examination

10.1. Placement of IQIs

a) Source Side IQIs: The IQIs shall be placed on the source side of the part being examined, except for the condition described in Para.10.1. (b) When due part or weld configuration or size, it is not practical to place the IQI(s) on the part or weld; the IQI(s) may be placed on a separate block. Separate blocks shall be made of the same radiographically similar materials (as defined in SE-1025) and may be used to facilitate IQI positioning. There is no restriction on the separate block thickness, provided the IQI / area of interest density tolerance requirements of Para. 11.2.2 are met.

(1)The IQI on the source side of the separate block shall be placed no closer to the film than the source side of the part being radiographed.

(2)The separate block shall be placed as close as possible to the part being radiographed.

b) Film side IQIs: Where inaccessibility prevents hand placing the IQI(s) on the source side, the IQI(s) shall be placed on the film side in contact with the part being examined. A lead letter "F" shall be placed adjacent to or on the IQI(s), but shall not mask it.

c) IQI Placement for Welds —Wire IQIs: The IQI(s) shall be placed on the weld so that the lengths of the wires transverse to the longitudinal axis of the weld. The identification numbers and, when used, the lead letter "F" shall not be in the area of interest, except when geometric configuration makes it impractical.

d) IQI placement for Material other than Welds: The IQI(s) with the IQI identification number(s), and, when used, the lead "F", may be placed in the area of interest.

10.2. Number of IQIs

When one or more film holders are used for an exposure, at least one IQI image shall appear on each radiograph except as outlined in (b) below:

(a) Multiple IQIs

If the requirements of Para. 11.2 are met by using more than one IQI, one shall be representative of the lightest area of interest and the other the darkest are of interest; the intervening densities on the radiograph shall be considered as having acceptable density.

(b) Special Cases

1. For cylindrical components where the source is placed on the axis of the component for a single exposure, at least three IQIs spaced approximately 120 deg. Apart, are required under the following conditions:
   (a) When the complete circumference is radiographed using one or more film holders, or;
   (b) When a section or sections of the circumference, where the length between the ends of the outermost sections span 240 or more deg., is radiographed using one or more film holders. Additional film locations may be required to obtain necessary IQI spacing.
2. For cylindrical components where the source is placed on the axis of the component for a single exposure, at least three IQIs, with one placed at each end of the span of the circumference radiographed and one in the approximate center of the span, are required under the following conditions:
   (a) When a section of circumference, the length of which is greater than 120 deg. and less then 240 deg. is radiographed using just one film holder, or;
   (b) (b)When a section or sections of the circumference, where the length between the ends of the outermost section spans is less than 240 deg., is radiographed using more than one film holder.
3. In (1) and (2) above, where sections of longitudinal welds adjoining the circumferential weld are radiographed simultaneously with the circumferential weld, an additional IQI shall be placed on each longitudinal weld at the end of the section most remote from the junction with the circumferential weld being radiographed.
4. For spherical components where source is placed at the center of the component for a single exposure, at least three IQIs, spaced approximately 120 deg. apart, are required under the following conditions:
   (a) When a complete circumference is radiographed using one or more film holders, or;
   (b) When a section or sections of a circumference where the length between the ends of the outermost sections span 240 or more deg, is radiographed using one or more film holders. Additional film locations may be required to obtain necessary IQI spacing.
5. For spherical components where the source is placed at the center of the component for a single exposure, at least three IQIs, with one placed at each end of the radiographed span of the circumference radiographed and one in the approximate center of the span, are required under the following conditions:
   (a) When a section of circumference, the length of which greater than 120 deg and less than 240 deg, is radiographed using just one film holder, or;
   (b) When a section or sections of a circumference, where the length between the ends of outermost sections span less than 240 deg is radiographed using more than one film holder.

6. In (4) and (5) above, where outer welds are radiographed simultaneously with the circumferential weld, one additional IQI shall be placed on each other weld.
7. For segments of a flat or curved (i.e. Ellipsoidal, tori-spherical et.) component where the source is placed perpendicular to the center of length of weld for a single exposure when using more than three film holders, at least three IQIs one placed at each end of the radiographed span and one in the approximate center of span required.
8. When an array of components in a circle is radiographed, at least one IQI shall show on each component image.
9. In order to maintain continuity of records involving subsequent exposures, all radiographs exhibiting IQIs that qualify the techniques permitted in accordance with (1) through (7) above shall be retained.

11. Evaluation of Film Quality

11.1. Quality of Radiographs

All radiographs shall be free from mechanical, chemical, or other blemishes to the extent that they do not mask and are not confused with the image of any discontinuity in the area of interest of the object being radiographed. Such blemishes include, but are not limited to:
(a) fogging
(b) processing defects such as streaks, watermarks, or chemical stains;
(c) scratches, finger marks, crimps, dirtiness, static marks, smudges, or tears;
(d) false indications due to defective screens.

11.2. Radiographic Density

Either a densitometer or step wedge comparison film shall be used for judging film density requirements.

11.2.1. Density Limitations

The transmitted film density through the radiographic image of the Body adjacent to the essential wire of a wire type IQI and the area of interest shall be 1,8 minimum for a single film viewing for radiographs made with X-ray source and 2,0 minimum for radiographs made with a gamma ray source. For composite viewing of multiple film exposures, each film of the composite set shall have a minimum density of 1,3. The maximum density shall be 4,0 for either single or composite viewing. A tolerance of 0,05 in density is allowed for variations between densitometer readings.

11.2.2. Density Variation

a) The density of the radiograph anywhere through the area of interest shall not
   (1) vary by more than minus 15% or plus 30% from the density through the Body of the adjacent to the essential wire of a wire-type IQI, and
   (2) exceed the minimum/maximum allowable density ranges specified in Para. Density Limitations
   When calculating the allowable variation in density, the calculation may be rounded to the nearest 0.1 within the range specified in Para. Density Limitations

b) When the requirements of (a) above are not met, then an additional IQI shall be used for each exceptional area or areas and the radiograph retaken.

11.3. IQI Sensitivity

11.3.1. Required Sensitivity

Radiography shall be performed with a technique of sufficient sensitivity to display the essential wire of wire type IQI. The radiographs shall also display the IQI identifying numbers and letters. If the essential wire of a wire type IQI, do not show on any film in a multiple film technique, but do show in composite film viewing, interpretation shall be permitted only by composite film viewing.

For wire-type IQIs, the essential wire shall be visible within the area of interest representing the thickness used for determining the essential wire, inclusive of theallowable density variations described in T-282.2.

11.3.2. Excessive Backscatter

If a light image of the "B", as described in Para. 2 Backscatter Radiation, appears on a darker background of the radiograph, protection from backscatter is insufficient and the radiograph shall be considered unacceptable. A dark image of the "B" on a lighter background is not cause for rejection.

12. Evaluation by AGMI Pte Co. Ltd. NDT Lab.

Our company — AGMI Pte Co. Ltd. NDT Lab. — is responsible for the review, interpretation, evaluation, and acceptance of the completed radiographs to assure compliance with the requirements of Section V, Article 2 and referencing Code Section. As an aid to the review and evaluation, the radiographic technique documentation required by Para. 16 shall be completed prior the evaluation. The radiographic technique details and the radiograph review form documentation shall accompany the radiographs. Acceptance shall be completed prior to presentation of the radiographs and accompanying documentation to the Inspector.

13. Selection of energy of radiation

Note: Material thickness is the thickness on which the IQI is based.

13.1. X-Radiation:

The radiographic energy employed for any radiographic technique shall demonstrate that the required radiographic sensitivity and density requirements have been obtained in accordance with this procedure.
NOTE: Overall radiographic sensitivity is influenced by factors such as film selection, intensifying screen selection, geometric unsharpness and film density.

13.2. Gamma Radiation.

13.2.1. The recommended minimum thicknesses for which radioactive isotopes may be used are as follows:

Material	Iridium-192	Cobalt-60
Steel	0.75 in. (19mm)	1.5 in. (38mm)

13.2.2. The maximum thickness for the use of radioactive isotopes is primarily dictated by exposure time; therefore, the upper material limits are not listed. The minimum recommended thickness limitations may be reduced when the radiographic technique used demonstrates that the required radiographic sensitivity and density requirements have been obtained.
NOTE: Overall radiographic sensitivity is influenced by factors such as: film selection, intensifying screen selection, geometric unsharpness and film density.

13.3. Special Cases

Under special conditions when it is not practical to perform radiography within the limitations outlined in 5.2 or when radioactive isotopes other than Iridium-192 or Cobalt-60 are used, the procedure shall be proven satisfactory by actual demonstration of IQI resolution an the minimum material thickness being rad iographed.

14. Extent of examination

According to the approved drawings and/or welding plans.

15. Film Processing

To produce a satisfactory radiograph, the care used in making the exposure must be followed by equal care in processing.

15.1. Automatic processing

The essence of the automatic processing is control. Film characteristic must be compatible with processing conditions. It is essential that the recommendation of the film, processor and chemical manufacturers be followed.

Drying can vary from still air at ambient temperature to as high as 60°C with air circulated by fan

16. Documentation

16.1. Radiographic Technique Documentation Details

Radiographic technique details shall be prepared and documented. As a minimum, the following information shall be provided.

(a) Identification, e.g. job/contract number and heat number (in accordance with para. 2.6)
(b) Dimensional Map (if used of marker placement in accordance with para. 8.5.3)
(c) Number of radiographs (exposures)
(d) X-ray voltage or isotope type used
(e) X-ray machine focal spot size or isotope physical source size
(f) Base material type and thickness, weld thickness, weld reinforcement thickness, as applicable
(g) Source to object distance (D in Para. 8.4.)
(h) Distance from source side of object to the film (d in Para 8.4.)
(i) Film manufacturer and Manufacturer's type/designation
(j) Number of film in each film holder/cassette
(k) Single or double wall exposure
(l) Single or double wall viewing
(m)Date of examination
(n) Identification of the weld, part, or component examined including weld number, serial number or other identifier.
(o) Examination method, technique, procedure identification, and revision
(p) Name and/or identity and certification level for personnel performing the examination
(q) Result of the examination

Test reports and films shall be sent to Customer.

16.2. Identification of Radiographs

The radiographs shall be marked to identify precisely with the weld which they represent giving at least the following information:

(a) AGMI Pte Co. Ltd.´s symbol or name
(b) job number or film number
(c) weld identification letters and numbers
(d) location markers
(e) repairs (see Note)
(f) date of the radiograph

The identification system does not necessarily require that the information appear as radiographic images.
The identification shall not obscure the area of interest.
Note: All radiographs of repair areas shall be marked with the letter "R" followed by number identifying the number of repairs: -R1- is the first repair of same area etc.

17. Acceptance standards

17.1. Acceptance Criteria according to Section VIII. Div. 1 UW 51, Radiographic examination of welded joints

a) All welded joints to be radiographed shall be examined in accordance with this procedure.
   (1) A complete set of radiographic images and examination records, as described in Section V, Article 2, for each vessel or vessel part shall be retained by the Manufacturer, as follows:
      (-a) radiographic images until the Manufacturer's Data Report has been signed by the Inspector
      (-b) examination records as required by this Procedure
   (2) A written radiographic examination procedure is not required. Demonstration of acceptable density on radiographic films and the ability to see the prescribed image quality indicator (IQI) image and the specified hole or the designated wire of a wire IQI shall be considered satisfactory evidence of compliance with Section V, Article 2.
   (3) The requirements of Para. 8.4.1. (Section V, Article 2, T-274.2), are to be used only as a guide for film-based radiography.

b) Indications revealed by radiography within a weld that exceed the following criteria are unacceptable and therefore are defects. Defects shall be repaired as provided in UW-38, and the repaired area shall be reexamined.
   (1) Any indication characterized as a crack or zone of incomplete fusion or penetration;
   (2) Any other elongated indication on the radiograph which has length greater than:
      (-a) 1/4 in. (6 mm) fort up to 3/4 in. (19 mm)
      (-b) 1/3t for t from 3/4 in. (19 mm) to 21/4 in.(57 mm)
      (-c) 3/4 in. (19 mm) fort over 21/4 in. (57 mm),
      where:
      t = the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in "t" .
   (3) Any group of aligned indications that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group;
   (4) Rounded indications in excess of that specified by the acceptance standards given in Supplement No. 4.

17.2. Acceptance standards of butt welds according to ASME Code B31.3

17.2.1. Weldments

17.2.1.1 Extent of Radiography

(a) 100% Radiography. This applies only to girth and miter groove welds and to fabricated branch connection welds comparable to Fig. 328.5.4E, unless otherwise specified in the engineering design.

(b) Random Radiography. This applies only to girth and miter groove welds.

(c) Spot Radiography. This requires a single exposure radiograph in accordance with para. 17.5.1.2.2 at a point within a specified extent of welding. For girth, miter, and branch groove welds the minimum requirement is

(1) for sizes 65 (NPS 21/2), a single elliptical exposure encompassing the entire weld circumference

(2) for sizes >DN 65, the lesser of 25% of the inside circumference or 152 mm (6 in.)

For longitudinal welds the minimum requirement is 152 mm (6 in.) of weld length.

17.2.1.2 Spot Radiography

(a) Longitudinal Welds. Spot radiography for longitudinal groove welds required to have a weld joint factor Ej of 0.90 requires examination by radiography in accordance with para. 17.5.1.2.1 of at least 300 mm (1 ft) in each 30m (100 ft) of weld for each welder or welding operator. Acceptance criteria are those stated in Supplement 10 for radiography under Normal Fluid Service.

(b) Circumferential Butt Welds and Other Welds. It is recommended that the extent of examination be not less than one shot on one in each 20 welds for each welder or welding operator. Unless otherwise specified, acceptance criteria are as stated in Supplement No. 5 (Table 341.3.2 of ASME B31.3) for radiography under Normal Fluid Service for the type of joint examined.

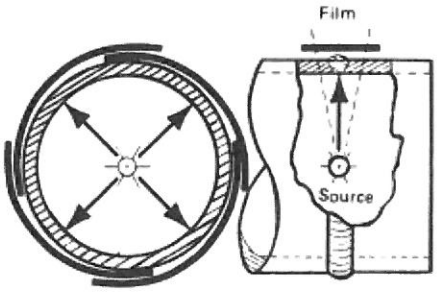
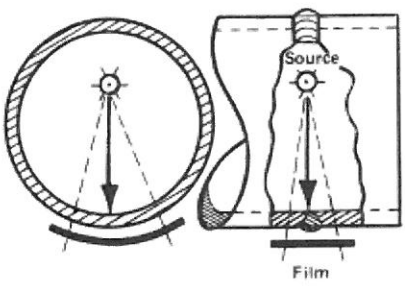
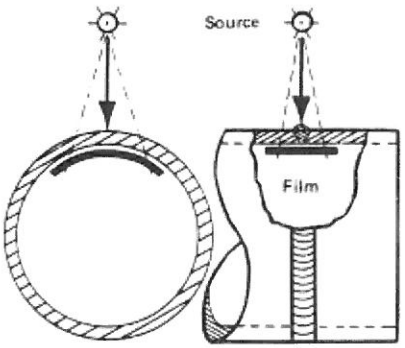
(c) Welds to Be Examined. The locations of welds and the points at which they are to be examined by spot radiography shall be selected or approved by the Inspector.

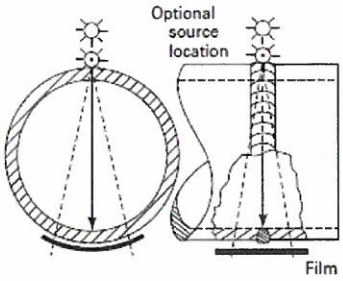
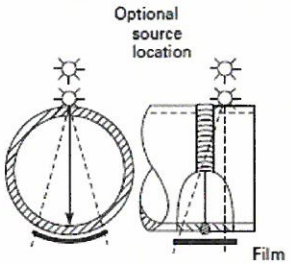
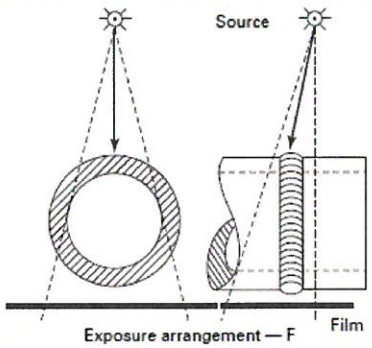
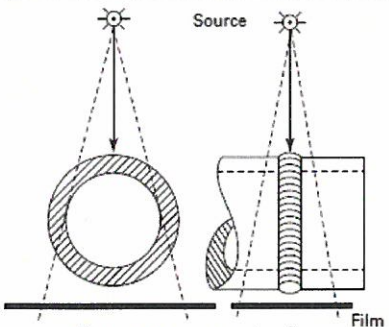
18. Demonstration

Demonstration of the density and IQI image requirements of the written procedure on production or technique radiographs shall be considered satisfactory evidence of compliance with this procedure.

This procedure may be demonstrated to the satisfaction of the Authorized Inspector, according to T-221.2 (Section V)

Supplement No. 1: Radiographic techniques

Pipe O.D.	Exposure Technique	Radiograph Viewing	Source-Weld-Film Arrangement		IQI		Location Marker Placement
			End View	Side View	Selection	Placement	
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — A		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Either Side T-275.3 T-275.1(c)
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — B		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1 (b)(1)
Any	Single-Wall T-271.1	Single-Wall	 Exposure Arrangement — C		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Source Side T-275.1 (a)(3)

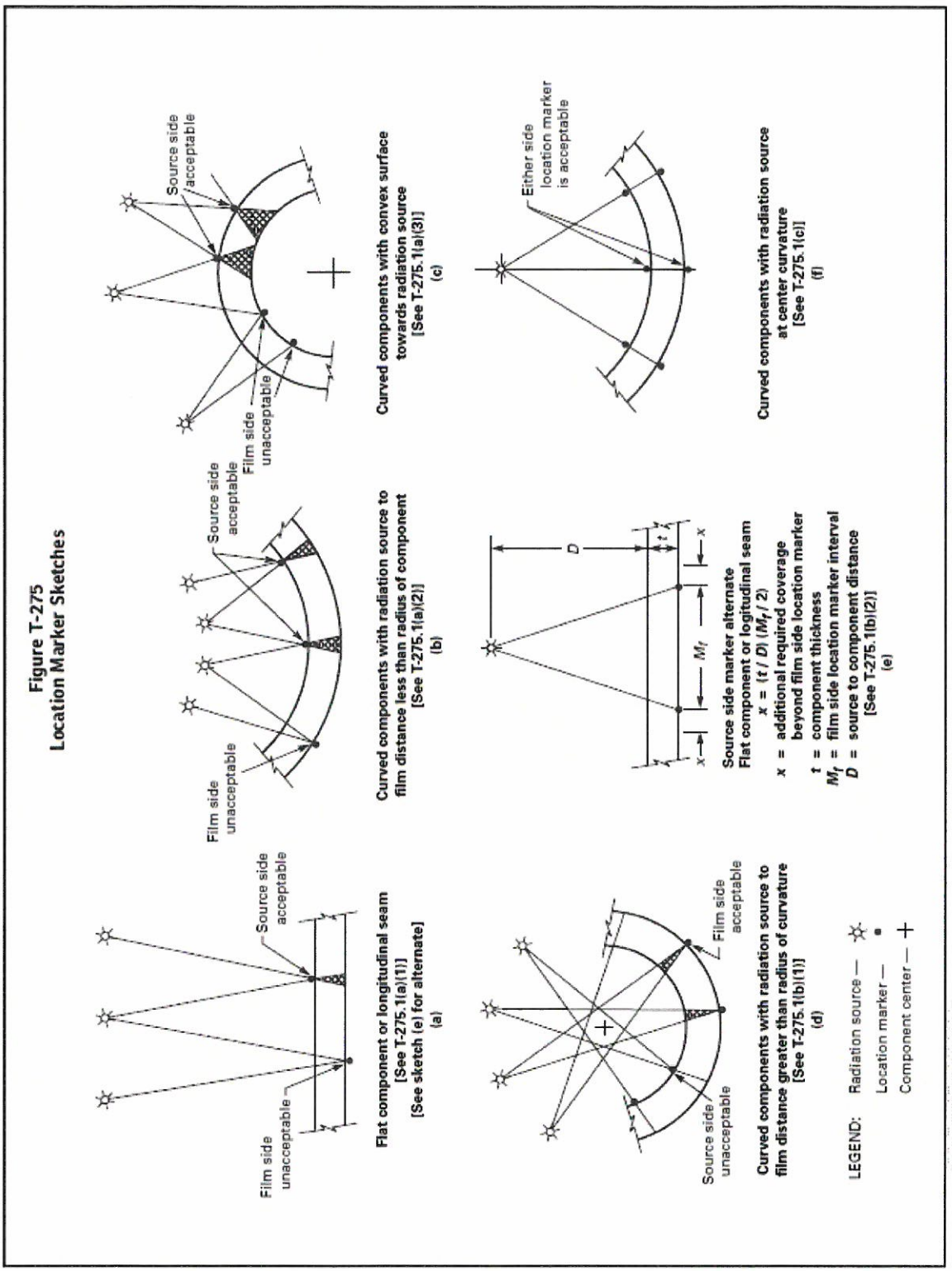
O.D.	Exposure Technique	Radiograph Viewing	Source-Weld-Film Arrangement		IQI		Location Marker Placement
			End View / Side View		Selection	Placement	
Any	Double- Wall: T-271.2(a) at Least 3 Exposures 120 deg to Each Other for Complete Coverage	Single-Wall	 Exposure arrangement — D		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1(b) (1)
Any	Double- Wall: T-271.2(a) at least 3 Exposures 120 deg to Each Other for Complete Coverage	Single-Wall	 Exposure arrangement — E		T-276 and Table T-276	Source Side T-277.1(a) Film Side T-277.1(b)	Film Side T-275.1(b) (1)
3½ in. (89 mm) or Less	Double-Wall T-271.2(b)(1) at Least 2 Exposures at 90 deg to Each Other for Complete Coverage	Double-Wall (Ellipse): Read Offset Source Side and Film Side Images	 Exposure arrangement — F		T-276 and Table T-276	Source Side T-277.1(a)	Either Side T-275.2
3½ in. (89 mm) or Less	Double-Wall: T-271.2(b)(2) at Least 3 Exposures at 60 deg or 120 deg to Each Other for Complete Coverage	Double-Wall: Read Super-imposed Source Side and Film Side Images	 Exposure arrangement — G		T-276 and Table T-276	Source Side T-277.1(a)	Either Side T-275.2

Supplement No. 2: IQI Selection

Table T-276
IQI Selection

Nominal Single-Wall Material Thickness Range, in. (mm)	IQI					
	Source Side			Film Side		
	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire
≤0.25 (≤6.4)	12	2T	5	10	2T	4
>0.25 through 0.375 (>6.4 through 9.5)	15	2T	6	12	2T	5
>0.375 through 0.50 (>9.5 through 12.7)	17	2T	7	15	2T	6
>0.50 through 0.75 (>12.7 through 19.0)	20	2T	8	17	2T	7
>0.75 through 1.00 (>19.0 through 25.4)	25	2T	9	20	2T	8
>1.00 through 1.50 (>25.4 through 38.1)	30	2T	10	25	2T	9
>1.50 through 2.00 (>38.1 through 50.8)	35	2T	11	30	2T	10
>2.00 through 2.50 (>50.8 through 63.5)	40	2T	12	35	2T	11
>2.50 through 4.00 (>63.5 through 101.6)	50	2T	13	40	2T	12
>4.00 through 6.00 (>101.6 through 152.4)	60	2T	14	50	2T	13
>6.00 through 8.00 (>152.4 through 203.2)	80	2T	16	60	2T	14
>8.00 through 10.00 (>203.2 through 254.0)	100	2T	17	80	2T	16
>10.00 through 12.00 (>254.0 through 304.8)	120	2T	18	100	2T	17
>12.00 through 16.00 (>304.8 through 406.4)	160	2T	20	120	2T	18
>16.00 through 20.00 (>406.4 through 508.0)	200	2T	21	160	2T	20

Supplement No. 3: Location markers



Supplement No. 4: Rounded indications charts acceptance standard for radiographically determined rounded indications in welds

Terminology

(a) Rounded Indications: Indications with a maximum length of three times the width or less an the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical, or irregular in shape and may have teils. When evaluating the size of an indication, the tail shall be included. The indication may be from any imperfection in the weld, such as porosity, slag, or tungsten.

(b) Aligned Indications: A sequence of four or more rounded indications shall be considered to be aligned when they touch a line parallel to the length of the weld drawn through the center of the two outer rounded indications.

(c) Thickness t: t is the thickness of the weld, excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

S4.1. Acceptance criteria

(a) Image Density: Density within the image of the indication may vary and is not a criterion for acceptance or rejection.

(b) Relevant Indications: (See Table 4-1 for examples) Only those rounded indications which exceed the following dimensions shall be considered relevant.
  (1) 1/10t for t less than 1/8 in. (3 mm)
  (2) 1/64 in. (0,4 mm) for t from 1/8 in. (3mm) to 1/4 in. (6 mm), incl.
  (3) 1/32 in. (0,8 mm) for t greater than 1/4 in. (6 mm) to 2 in. (50 mm), incl.
  (4) 1/16 in. (1,6 mm) for t greater than 2 in. (50 mm)

(c) Maximum Size of Rounded Indication: (See Table 4-1 for examples.) The maximum permissible size of any indication shall be 1/4 t, or 5/32 in. (4 mm), whichever is smaller; except that an isolated indication separated from an adjacent indication by 1 in. (25 mm) or more may be 1/3 t, or 1/4 in. (6 mm), whichever is less. For tgreater than 2 in. (50 mm) the maximum permissible size of an isolated indication shall be increased to 3/8 in. (10 mm).

(d) Aligned Rounded Indications: Aligned rounded indications are acceptable when the summation of the diameters of the indications is less than t in a length of 12t . See Figure 4-1. The length of groups of aligned rounded indications and the spacing between the groups shall meet the requirements of Figure 4-2.

(e) Spacing: The distance between adjacent rounded indications is not a factor in determining acceptance or rejection, except as required for isolated indications or groups of aligned indications.

(f) Rounded Indication Charts: The rounded indications characterized as imperfections shall not exceed that shown in the charts. The charts in Figures 4-3 through 4-8 illustrate various types of assorted, randomly dispersed and clustered rounded indications for different weld thicknesses greater than 1/8 in. (3 mm). These charts represent the maximum acceptable concentration limits for rounded indications. The charts for each thicknessrange represent full-scale 6 in.

(150 mm) radiographs, and shall not be enlarged or reduced. The distributions shown are not necessarily the patterns that may appear an the radiograph, but are typical of the concentration and size of indications permitted.

(g) Weld Thickness t Less Than 1/8 in. (3mm): For t less than 1/8 in. (3 mm) the maximum number of rounded indications shall not exceed 12 in a 6 in. (150 mm) length of weld. A proportionally fewer number of indications shall be permitted in welds less than 6 in. (150 mm) in length.

(h) Clustered indications: The illustrations for clustered indications show up to four times as many indications in a local area, as that shown in the illustrations for random indications. The length of an acceptable cluster shall not exceed the lesser of 1 in. (25 mm) or 2t. Where more than one cluster is present, the sum of the lengths of the clusters shall not exceed 1 in. (25 mm) in a 6 in. (150 mm) length weld.

Table 4-1

Customary Units

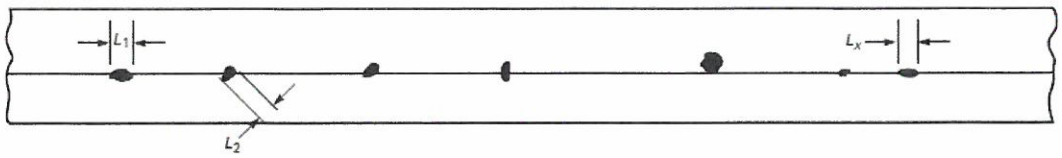
Thickness, *t*, in.	Maximum Size of Acceptable Rounded Indication, in.		Maximum Size of Nonrelevant Indication, in.
	Random	Isolated	
Less than 1/8	1/4 *t*	1/3 *t*	1/10 *t*
1/8	0.031	0.042	0.015
3/16	0.047	0.063	0.015
1/4	0.063	0.083	0.015
5/16	0.078	0.104	0.031
3/8	0.091	0.125	0.031
7/16	0.109	0.146	0.031
1/2	0.125	0.168	0.031
9/16	0.142	0.188	0.031
5/8	0.156	0.210	0.031
11/16	0.156	0.230	0.031
3/4 to 2, incl	0.156	0.250	0.031
Over 2	0.156	0.375	0.063

SI Units

Thickness, *t*, mm	Maximum Size of Acceptable Rounded Indication, mm		Maximum Size of Nonrelevant Indication, mm
	Random	Isolated	
Less than 3	1/4 *t*	1/3 *t*	1/10 *t*
3	0.79	1.07	0.38
5	1.19	1.60	0.38
6	1.60	2.11	0.38
8	1.98	2.64	0.79
10	2.31	3.18	0.79
11	2.77	3.71	0.79
13	3.18	4.27	0.79
14	3.61	4.78	0.79
16	3.96	5.33	0.79
17	3.96	5.84	0.79
19.0 to 50, incl.	3.96	6.35	0.79
Over 50	3.96	9.53	1.60

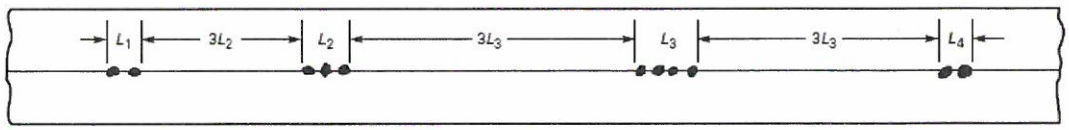
GENERAL NOTE: This Table contains examples only.

Figure 4-1: Aligned rounded indications



GENERAL NOTE: Sum of L_1 to L_x shall be less than t in a length of $12t$.

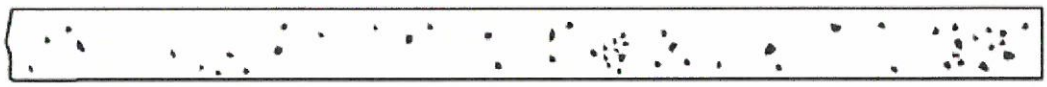
Figure 4-2: Groups of aligned rounded indications



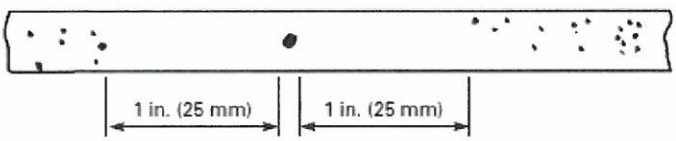
Maximum Group Length	Minimum Group Spacing
L = 1/4 in. (6 mm) for t less than 3/4 in. (19 mm) L = 1/3t for t 3/4 in. (19 mm) to 2 1/4 in. (57 mm) L = 3/4 in. (19 mm) for t greater than 2 1/4 in. (57 mm)	$3L$ where L is the length of the longest adjacent group being evaluated

GENERAL NOTE: Sum of the group lengths shall be less than t in a length of $12t$.

Figure 4-3: Charts for t equal to 1/8 in. (3 mm) to 1/4 in. (6 mm), inclusive



(a) Random Rounded Indications [See Note (1)]



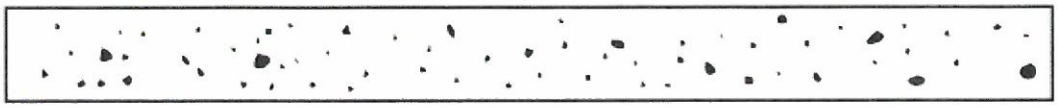
(b) Isolated Indication [See Note (2)]



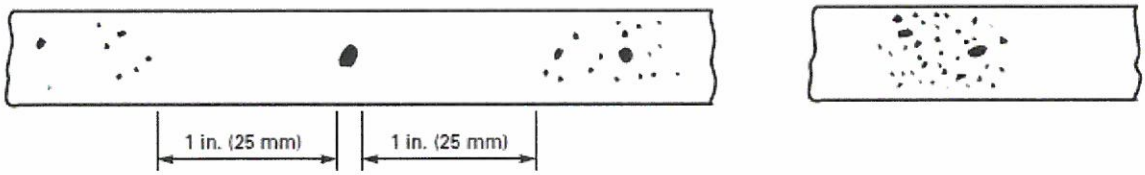
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Fiqure 4-4: Charts for t over 1/4 in. (6 mm) to 3/8 in. (10 mm), inclusive



(a) Random Rounded Indications [See Note (1)]

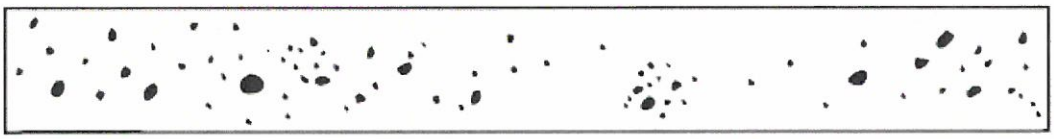


(b) Isolated Indication [See Note (2)]

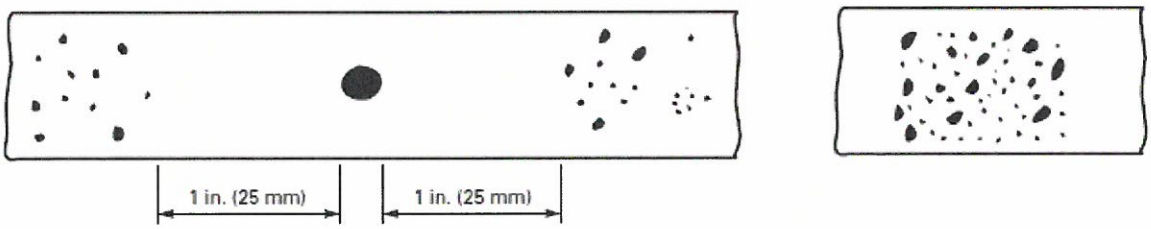
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-5: Charts for t over 3/8 in. (10 mm) to 3/4 in. (19 mm), inclusive



(a) Random Rounded Indications [See Note (1)]

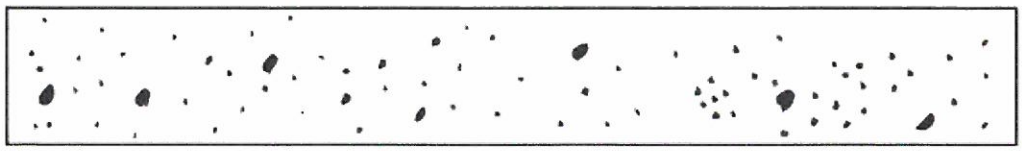


(b) Isolated Indication [See Note (2)]

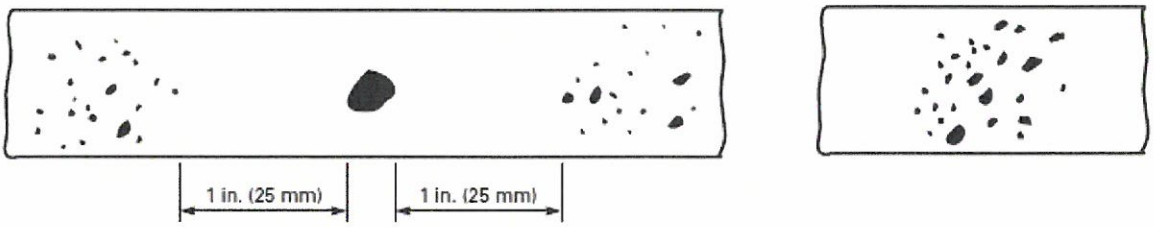
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Fiqure 4-6: Charts for t over 3/4 in. (19 mm) to 2 im. (50 mm), inclusive



(a) Random Rounded Indications [See Note (1)]

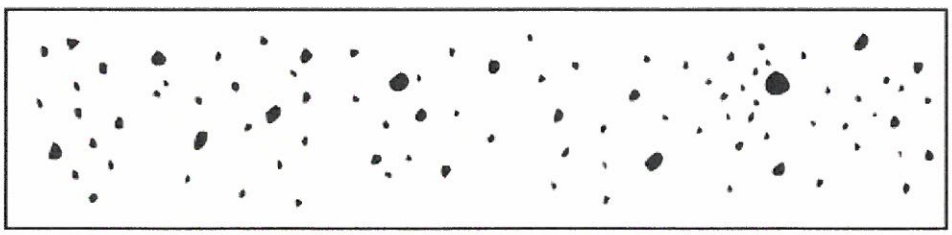


(b) Isolated Indication [See Note (2)]

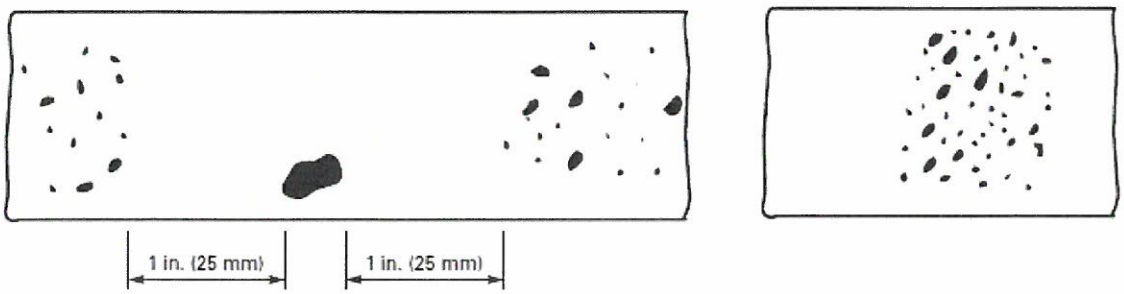
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-7: Charts for t over 2 in. (50 mm) to 4 in. (100 mm), inclusive



(a) Random Rounded Indications [See Note (1)]

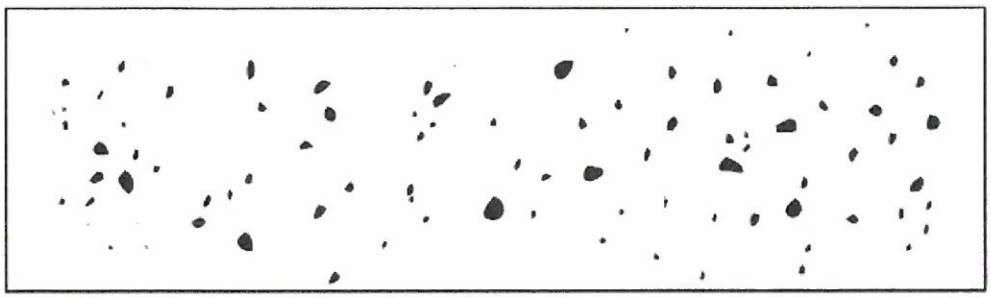


(b) Isolated Indication [See Note (2)]

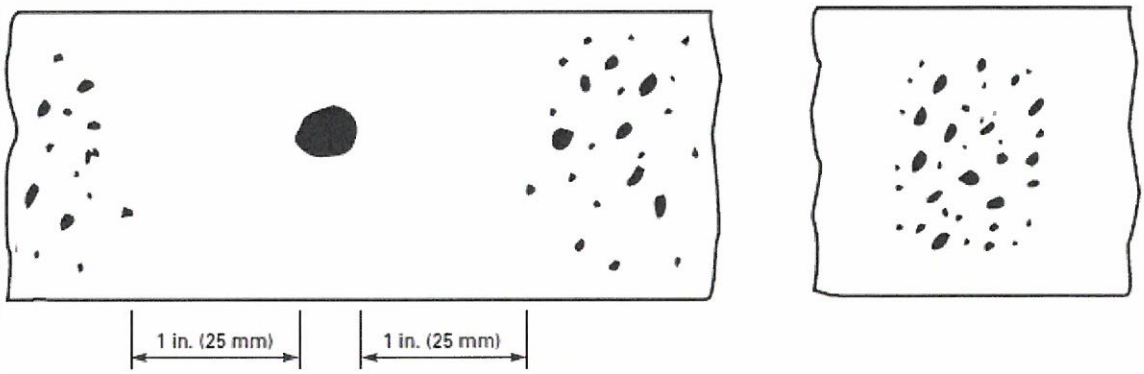
(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Figure 4-8: Charts for t over 4 in. (100 mm)



(a) Random Rounded Indications [See Note (1)]



(b) Isolated Indication [See Note (2)]

(c) Cluster

NOTES:
(1) Typical concentration and size permitted in any 6 in. (150 mm) length of weld.
(2) Maximum size per Table 4-1.

Supplement No. 5: Acceptance Criteria for Weldings in accordance with ASME B 31.3-2020

Criteria (A to M) for Types of Welds and for Service Conditions [Note (1)]												Examination Methods	
Normal and Category M Fluid Service			Severe Cyclic Conditions			Category D Fluid Service				Weld Imperfection			
Girth. Miter Groove, and Branch Connection Welds [Note (2)]	Longitudinal Groove Weld [Note (3)]	Fillet Weld [Note (4)]	Girth. Miter Groove, and Branch Connection Welds [Note (2)]	Longitudinal Groove Weld [Note (3)]	Fillet Weld [Note (4)]	Girth and Miter Groove Welds	Longitudinal Groove Weld [Note (3)]	Fillet Weld [Note (4)]	Branch Connection Weld [Note (2)]			Visual	Radiography
A	A	A	A	A	A	A	A	A	A	Crack		✓	✓
A	A	A	A	A	A	C	A	N/A	A	Lack of fusion		✓	✓
B	A	N/A	A	A	N/A	C	A	N/A	B	Incomplete penetration		✓	✓
E	E	N/A	D	D	N/A	N/A	N/A	N/A	N/A	Rounded Indications		...	✓
G	G	N/A	F	F	N/A	N/A	N/A	N/A	N/A	Linear indications		...	✓
H	A	H	A	A	A	I	A	H	H	Undercutting		✓	✓
A	A	A	A	A	A	A	A	A	A	Surface porosity or exposed slag inclusion [Note (5)]		✓	...
N/A	N/A	N/A	J	J	J	N/A	N/A	N/A	N/A	Surface finish		✓	...
K	K	N/A	K	K	N/A	K	K	N/A	K	Concave surface, concave root, or burn-through		✓	✓
L	L	L	L	L	L	M	M	M	M	Weld reinforcement or internal protrusion		✓	...

GENERAL NOTES:

(a) Weld imperfections are evaluated by one or more of the types of examination methods given, as specified in paras. 341.4.1, 341.4.2, 341.4.3, and M341.4, or by the engineering design.
(b) "N/A" indicates the Code does not establish acceptance criteria or does not require evaluation of this kind of imperfection for this type of weld.
(c) Check (✓) indicates examination method generally used for evaluating this kind of weld imperfection.
(d) Ellipsis (...) indicates examination method not generally used for evaluating this kind of weld imperfection.

NOTES:

(1) Criteria given are for required examination. More-stringent criteria may be specified in the engineering design. See also paras. 341.5 and 341.5.3.
(2) Branch connection weld includes pressure containing welds in branches and fabricated laps.
(3) Longitudinal groove weld includes straight and spiral (helical) seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1, Table A-1M, or Table 326.1. Alternative Leak Test requires examination of these welds; see para. 345.9.
(4) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports.
(5) These imperfections are evaluated only for welds ≤5 mm ($^{3}/_{16}$ in.) in nominal thickness.

Criterion Value Notes for Table 341.3.2

Criterion Symbol	Criterion Measure	Acceptable Value Limits [Note (1)]
A	Extent of imperfection	Zero (no evident imperfection)
B	Cumulative length of incomplete penetration	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less
C	Cumulative length of lack of fusion and incomplete penetration	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less
D	Size and distribution of rounded indications	See ASME BPVC, Section VIII, Division 1, Appendix 4 [Note (2)]
E	Size and distribution of rounded indications	For $T_w \le 6$ mm (¼ in.), limit is same as D [Note (2)] For $T_w > 6$ mm (¼ in.), limit is 1.5 × D [Note (2)]
F	Linear indications	
	Individual length	$\le T_w/3$
	Individual width	≤2.5 mm (3/32 in.) and $\le T_w/3$
	Cumulative length	$\le T_w$ in any 12 T_w weld length [Note (2)]
G	Linear indications	
	Individual length	$\le 2T_w$
	Individual width	≤3 mm (⅛ in.) and $\le T_w/2$
	Cumulative length	$\le 4T_w$ in any 150 mm (6 in.) weld length [Note (2)]
H	Depth of undercut	≤1 mm (1/32 in.) and $\le T_w/4$
	Cumulative length of internal and external undercut	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less
I	Depth of undercut	≤1.5 mm (1/16 in.) and $\le$[$T_w/4$ or 1 mm (1/32 in.)]
	Cumulative length of internal and external undercut	≤38 mm (1.5 in.) in any 150 mm (6 in.) weld length or 25% of total weld length, whichever is less
J	Surface roughness	≤12.5 μm (500 μin.) R_a in accordance with ASME B46.1
K	Depth of surface concavity, root concavity, or burn-through	Total joint thickness, including weld reinforcement, $\ge T_w$ [Notes (3) and (4)]
L	Height of reinforcement or internal protrusion [Note (5)] in any plane through the weld shall be within limits of the applicable height value in the tabulation at right, except as provided in Note (6). Weld metal shall merge smoothly into the component surfaces.	For T_w, mm (in.) / Height, mm (in.) ≤6 (¼) / ≤1.5 (1/16) >6 (¼), ≤13 (½) / ≤3 (⅛) >13 (½), ≤25 (1) / ≤4 (5/32) >25 (1) / ≤5 (3/16)
M	Height of reinforcement or internal protrusion [Note (5)] as described in L. Note (6) does not apply.	Limit is twice the value applicable for L above

NOTES:

(1) Where two limiting values are separated by "and," the lesser of the values determines acceptance. Where two sets of values are separated by "or," the larger value is acceptable. T_w is the nominal wall thickness of the thinner of two components joined by a butt weld.

Criterion Value Notes for Table 341.3.2 (Cont'd)

NOTES: (Cont'd)

(2) Porosity and inclusions such as slag or tungsten are defined as rounded indications where the maximum length is three times the width or less. These indications may be circular, elliptical, or irregular in shape; may have tails; and may vary in density. Indications where the length is greater than three times the width are defined as linear indications and may also be slag, porosity, or tungsten.

(3) For circumferential groove welded joints in pipe, tube, and headers made entirely without the addition of filler metal, external concavity shall not exceed the lesser of 1 mm ($^1/_{32}$ in.) or 10% of the joint nominal thickness. The contour of the concavity shall blend smoothly with the base metal. The total joint thickness, including any reinforcement, shall not be less than the minimum wall thickness, t_m.

(4) For radiography, acceptability may be determined by comparing the density of the image through the affected area to the density through the adjacent base metal (T_w). If digital radiography is used, brightness comparison may be utilized. A density or brightness darker than the adjacent base metal is cause for rejection.

(5) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat. Figure 328.5.2A: internal protrusion does not apply.

(6) For welds in aluminum alloy only, internal protrusion shall not exceed the following values:
(a) 1.5 mm ($^1/_{16}$ in.) for thickness ≤2 mm ($^5/_{64}$ in.)
(b) 2.5 mm ($^3/_{32}$ in.) for thickness >2 mm and ≤6 mm ($^1/_4$ in.)
For external reinforcement and for greater thicknesses, see the tabulation for symbol L.

Supplement No. 6: NDE Report

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Radiographic
Test Report

Job no.:			
Contact:			
Client:	BROOKS Instrument Kft.	PO no.:	
	H-8001 Székesfehérvár, Berényi u. 72-100., Hungary	Contact:	

Object id. nr:		Examination Standard:		
Object:		Acceptance Standard:		
Client order no.:		Examination Procedure:	AGMI NDT Written Procedure No. 004	Rev.
Quantity:		Acceptance Procedure:	AGMI NDT Written Procedure No. 004	Rev.
Material:		Type of Film:	Screen	
Weld method:	GTAW Welder id.	I.Q.I Type:	Front: Back:	

Source:	x	Seifert ERESCO 300	Focus: 0,3x3		Ir-192	Focus:		Co-60	Focus:

No.	Film				Material thickness (mm)	Source-Object Distance (mm)	Object-Film Distance (mm)	Energy				I.Q.I-wire			Discontinuity		Judgement	
	Sign.	Size (cm)	Quantity in casette	Single (1) or double (2) wall				kV	mA	Activity (GBq)	Time (min)	Density	Side	Visible	Type	Local	Acceptable	Not Acceptable
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		

Defects in Welds

CR	Cracks	PI	Incomplete penetration	SI	Slag, inclusions	CC	Concave root surface (suck up)
LF	Lack of fusion	IP	Internal porosity	UC	Undercutting		

Date:	Prepared and reviewed by:	Interpreted and evaluated by:	Accepted by:
Page(s):			
1 of 1			

BROOKS INSTRUMENT	BROOKS WRITTEN PROCEDURE	**Number:** *ISP041* **Rev:** 8 **Date:** *November 9th, 2022.*

LIQUID PENETRANT EXAMINATION PROCEDURE

THIS PROCEDURE TO BE USED FOR WORK ACCORDING TO THE REQUIREMENTS OF ASME CODE ED. 2021 SECTION V, ARTICLE 6, SECTION VIII, DIV.1, ASME 31.3-2020 OR ALTERNATIVELY EN ISO 23277: 2015

Approval Signatures

	Authorized Representative	Date
Prepared By:	René Sallaberger, ASNT Level III Operator	04.12.2022
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1.0 SCOPE

Detection, interpretation and evaluation of surface discontinuities (voids, inclusions, cracks, etc.) on cast, formed, machined surfaces, welds and their HAZ.

2.0 PURPOSE

Liquid penetrant examination of welds according to ASME Code Edition 2021, Section V Art. 6 and Section VIII Div.1, Mandatory App. 8., ASME B31.3-2020 and alternatively EN ISO 23277:2015 level 1.

3.0 TERMS, ABBREVIATIONS

Term, abbreviation	Description
AI	Authorized Inspector

4.0 FORMS

ISP041-01 Liquid penetrant Test Report

5.0 REFERENCES

SNT-TC-1A-2016
MSZ EN ISO 9712:2013
ASTM E165/E165M-18
ASME Code Section V, Ed.2021
ASME Code Section VIII, Div 1, Ed.2021
EN ISO 3452-1:2013
EN ISO 3452-2:2013
EN ISO 3452-4:1998
EN ISO 23277:2015
ASME B31.3-2020

6.0 REVISION HISTORY

Date	Revision	Description	Author
01/15/2012	1	*Release*	A. Demeter
06/15/2016	2	ASME Code 2015	L. Lukovits
05/15/2017	3	-Modify type of cleaner -Add information to 7.6	J. Strausz
Jan.22,2019	4	ASME Code 2017	A. Kővári
Dec.06,2019	5	ASME Code 2019, ASME B31.3 added	A. Kővári
April 27, 2020	6	EN ISO standards added	A. Kővári
Oct. 27,2021	7	Correspondence with ASME Code 2021 Edition and ASME B31.3-2020 reviewed	A. Kővári
Nov. 09, 2022	8	Revised	René Sallaberger

7.0 PROCEDURE

7.1. PRINCIPLE OF METHOD

In principle a liquid penetrant is applied to the previously cleaned surface to be examined and allowed to enter discontinuities. All excess penetrant is then removed, the part is dried and a developer is applied. The developer acts both as a blotter to absorb penetrant that has been trapped in discontinuities, and as a contrasting background to enhance the visibility of penetrant indications.
The liquid penetrant examination method is an effective means for detecting discontinuities which are open to the surface of nonporous metals and other materials.
Typical discontinuities detectable by this method are:

- Cracks
- Seams
- Laps
- Cold shuts
- Laminations
- Porosity
- Through leaks or
- Lack of fusion.

7.2. PERSONNEL QUALIFICATION

Personnel implementing examination and evaluation shall have at least Level II qualification according to SNT-TC-1A, Code accepted Edition and/or EN ISO 9712. Examination shall be supervised by Level III according to EN ISO 9712 and/or SNT-TC-1A.

7.3. WRITTEN PROCEDURE REQUIREMENTS

Liquid penetrant examination shall be performed in accordance with this procedure which contains the requirements listed in Table 1.

Table 1

Requirements of Liquid Penetrant Examination Procedure

Requirement	Essential Variable	Non-essential Variable
Identification of any change in type or family group of penetrant material including developers etc.	X	
Surface preparation (finishing and cleaning, including type of cleaning solvent)	X	
Method of applying penetrant	X	
Method of removing excess surface penetrant	X	
Method of applying developer	X	
Minimum and maximum time periods between steps and drying aids	X	
Decrease in penetrant dwell time	X	
Increase in developer dwell time (Interpretation time)	X	
Minimum light intensity	X	
Surface temperature outside 10 to 52 °C or as previously qualified	X	
Performance demonstration, when required	X	
Personnel qualification requirements		X
Materials, shapes, or sizes to be examined and the extent of examination		X
Post examination cleaning technique		X

Any change of requirement in Table 1 identified as an essential variable from the specified value, or range of values, shall require re-qualification of the written procedure. A change of a requirement identified as a nonessential variable from the specified value, or range of values, does not require re-qualification of written procedure. All changes of essential, or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.

7.4. EXAMINATION VARIABLES

- In wintertime test items shall be transported to laboratory area one shift in advance of examination.

- Surface to be examined shall be cleaned from scale, welding flux. Wire disk, grit blasting or any other method capable to close surface discontinuities are prohibited. After mechanical cleaning surface shall be de-greased according to 7.6.1.
- During visual inspection — prior liquid penetrant examination — the minimum light intensity 1076 lx.
- In case of visible penetrant examination minimum acceptable white light intensity is 1076 lux measured at the part surface.
- The temperature of the penetrant materials and the surface of the part to be inspected shall be in the temperature range of 10 and 52 °C. When it is not possible to comply with these temperature limits, local heating or cooling is allowed.
- In case of simultaneous examination, multiple parts possible shift of technological times are to be considered. The minimum dwell time can't be changed.

7.5. EXAMINATION MATERIALS

Examination materials definition includes all materials (cleaner, penetrant, remover, developer, etc.) being used during examination.
Type and method being used during examination: ASTM E165/E165M-12 Type II, Method C. This means visible penetrant solvent removable penetrant examination.
The assurance and applicability of examination materials shall be proved by certificates containing batch numbers and contaminant contents.
Examination materials shall meet ISO 3452 and Low sulfur and halogen content according to ASME Code, Section V, Article 6. standard requirements. Intermixing different examination material families is prohibited.
Materials used:

Table 1 Materials used:

	Visible
Cleaner:	KD-Check PR-2
Penetrant:	KD-Check RDP-1
Penetrant remover:	KD-Check PR-2
Developer:	KD-Check SD-1

7.6. SPECIFIC PRACTICES

ASME V. Table T-621.1
Requirements of Liquid Penetrant Examination Procedure

Procedure Step	Minimum	Maximum
Drying after preparation (T-643)	X	
Penetrant dwell (T-672)	X	X
Penetrant removal (solvent removable) (T-673.3)		
Drying after penetrant removal (T-674)		X
Solvent removable penetrants		X
Developer application (T-675)		X
Developing and interpretation time (T-675.3 and T-676)	X	X

7.6.1. SURFACE TREATMENT

Prior to each liquid penetrant examination, the surface to be examined and all adjacent areas within at least 1 inch (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux, weld spatter, paint, oil and other extraneous matter that could obscure surface openings or otherwise interfere with examination.
Cleaner used: KD-Check PR-2
Cleaner shall be applied either from hand pumped spray dose or by wetted cloth or absorbent towel.

7.6.2. DRYING AFTER CLEANING

After cleaning the surface to be examined shall be dried by natural evaporation. Minimum drying time is 5 min.

7.6.3. APPLICATION OF PENETRANT

The penetrant shall be brushed to the surface.
Penetrant used: KD-Check RDP-1
Penetration (Dwell) time is critical. The minimum penetration shall be as required in Table 2 or as qualified by demonstration for specific applications. The dwell time shall not exceed 2 hours or as qualified by demonstration for specific application.

Table 2
Minimum Dwell Times

Material	Penetrant Dwell Time min
Austenitic steel; Austenitic cladding Nickel base weld; Titanium	>30

7.6.4. EXCESS PENETRANT REMOVAL

In case of solvent removable penetrants, care shall be taken to remove as small amount of penetrant, as possible from surface discontinuities.
Solvent-removable penetrant shall be removed by first wiping the excess penetrant with a clean, lint-free, dry cloth or absorbent towel, repeating the wiping operation until most traces of penetrant have been removed. A single stroke shall be used in one direction, so that maximum amount of penetrant will be removed. A clean, lint-free material shall then be lightly moistened with solvent and used to wipe the remaining penetrant from the surface of the part. Again a single stroke shall be used in one direction. The wet wiping shall be followed by a dry wiping. The part surface shall not be flushed with solvent and the cloth or towel shall not be saturated with solvent. Sometimes additional wet wipings are necessary, but examiner shall keep in mind, every additional stroke removes penetrant from surface discontinuities, thus reducing sensitivity of examination.
After cleaning the surface shall be dried by natural evaporation.
Penetrant remover used: KD-Check PR-2
Drying time: 3 - 5 min
After excess penetrant removal cleanliness of surface shall be checked.

7.6.5. APPLICATION OF DEVELOPER

The developer shall be sprayed to the surface. Before use, cans shall be thoroughly shaken. The developer shall be applied to provide a thin, even coating over the entire area being inspected. The coating shall be applied as uniformly as possible. The coating shall not be so thick as to mask any potential light indications.
Developer used: KD-Check SD-1
The minimum development time is 10 minutes and the maximum development time is 60 minutes.

7.6.6. EXTENT OF EXAMINATION

All pressure boundary weld and its adjacent 10 mm areas shall be examined in full extent.

7.6.7. **INTERPRETATION**

Color Contrast Penetrants.
With a color contrast penetrant, the developer forms a reasonably uniform white coating. Surface discontinuities are indicated by bleed-out of the penetrant which is normally a deep red color that stains the developer. Indications with a light pink color may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult. A minimum visible light intensity of 1076 lx is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications.

It is hard to determine the type of discontinuity if penetrant diffuses in excess amount to developer. If this condition occurs, close observation of the formation of indication(s) during application of the developer may assist in characterizing and determining the extent of the indication(s).
Interpretation can be done with a 5-10X magnifier lens.
Items for certain reason unable to evaluate or unacceptable, the examination can be repeated twice. Between the repeated examinations an extensive cleaning is necessary.

7.6.8. **EVALUATION**

An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications with major dimensions greater than $^{1}/_{16}$ in. (1,5 mm) shall be considered relevant.

- A linear indication is one having a length greater than three times the width.
- A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width.
- Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

The minimum and maximum evaluation times are 10 minutes and 60 minutes, respectively, if 7.6.5 point is fulfilled. If bleed out does not alter results, a longer time is allowed. Indications shall be marked, logged, if necessary photographed.

7.6.9. ACCEPTANCE STANDARDS

7.6.9.1. ACCEPTANCE ACCORDING TO ASME CODE SECTION VIII, DIV. 1, MANDATORY APP. 8

All surfaces to be examined shall be free of:

- relevant linear indications;
- relevant rounded indications greater than $^{3}/_{16}$ in. (5 mm);
- four or more relevant rounded indications in a line separated by $^{1}/_{16}$ in. (1,5 mm) or less (edge to edge).

7.6.9.2. ACCEPTANCE ACCORDING TO EN ISO 23277 LEVEL 1

Type of discontinuity	Acceptance level		
	1	2	3
Linear	l ≤ 2 mm	N/A	N/A
Nonlinear	d ≤ 4 mm	N/A	N/A

Note: “d” is the longer axis of indication

7.6.9.3. ACCEPTANCE ACCORDING TO ASME B31.3

All surfaces to be examined shall be free of
(1) relevant linear indications
(2) relevant rounded indications >5.0 mm ($^{3}/_{16}$ in.)
(3) four or more relevant rounded indications in a line separated by 1.5 mm ($^{1}/_{16}$ in.) or less, edge to edge

7.6.9.4. POST INSPECTION CLEANING

Post inspection cleaning shall be carried out as soon as possible, after evaluation and documentation. This shall be done with wiping the area with cleaner moistened rug. Final cleaning can be made with high pressure water or steam jet.

7.7. RE-EXAMINATION AND REPAIR

Unacceptable indications shall be repaired and re-examination performed to assure removal or reduction to an acceptable size. Whenever an imperfection is repaired by chipping or grinding and subsequent repair by welding is not required, the excavated area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners.
Repair welding shall be performed using a qualified procedure and the method and extent of repair shall be acceptable to the Inspector.

7.8. INDICATIONS BELIEVED NON-RELEVANT

Any indication which is believed to be non-relevant shall be regarded as an imperfection unless it is shown by re-examination by the same method or by use of other nondestructive methods and/or by surface conditioning that no unacceptable imperfection is present.

7.9. EXAMINATION OF AREAS FROM WHICH DEFECTS HAVE BEEN REMOVED

After a defect is thought to have been removed and prior to making repairs, the area shall be examined by suitable methods to ensure it has been removed or reduced to an acceptably sized imperfection.

7.10. RE-EXAMINATION OF REPAIR AREAS

After repairs have been made, the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices or corners and
reexamined by the liquid penetrant method and by all other methods of examination, that were originally required for the affected area.

7.11. DOCUMENTATION

7.11.1. RECORDING OF INDICATIONS

Non-rejectable Indications. Non-rejectable Indications shall be recorded as specified by referencing Code Section.
Rejectable Indications. Rejectable Indications shall be recorded. As a minimum, the type of indications (linear or rounded) location and extent (length or diameter or aligned) shall be recorded.

All data that influence the result of the examination shall be recorded in the report. The description of the defects may be practically simplified by making a photo of the image of the defects. If it is necessary to help the evaluation, a tape measure and markings for the identification and tracing shall be placed on the photograph.

7.12. EXAMINATION RECORDS

For each examination the following information shall be recorded:
(a) manufacturer
(b) procedure identification and revision
(c) liquid penetrant type (visible or fluorescent)
(d) examination materials (number or letter designation of each penetrant, penetrant remover, and developer used)
(e) examination personnel identity and if required by referencing Code Section,
(f) qualification level;
(g) map of record of indications
(h) material and thickness;

(i) lighting equipment;
(j) date examinations were performed.
(k) identificaton of the weld, part, or component examened
(l)results of examination

7.13. POST EXAMINATION CLEANING

If the post examination cleaning is required, it should be conducted as soon as practical after Evaluation and Documentation, by brushing.

7.14. PERIODIC INSPECTIONS, CALIBRATIONS

Thermometer, light meter shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used. Visible light shall achieve a minimum of 1076 lux on the surface of the part being examined throughout the examination.
The visible light source, technique used, and light level verification is required to be demonstrated one time, documented, and maintained on file.

7.15. SAFETY

Since penetrant materials have adverse effect on health material safety data sheet requirements to be followed. Use of gloves, mask, glasses and protecting cloth shall be used when necessary. Empty doses, containers and used testing materials shall be handled according to requirements of manufacturer.

7.16. DEMONSTRATION

Testing procedures shall be demonstrated to the satisfaction of the Authorized Inspector (AI). Procedure demonstration shall be documented.

Hereby we certify that this procedure has been demonstrated to the satisfaction of the AI, and it is capable of detecting discontinuities under the conditions defined in the procedure.

BROOKS INSTRUMENT

Liquid Penetrant

Test Report

Brooks Instrument
Kft
Berényi str 72-100
8000

Report nr:

Object id. nr:			**Examination Standard:**	ASME V, Art. 6			
Client order nr:			**Acceptance Standard:**	ASME B31.3			
Size and Model			**Examination Procedure:**	ISP041			Rev.
Quantity:			**Acceptance Procedure:**	ISP041			Rev.
Parent material thickness:		mm	**Equipment:**			**Technique:**	**Brush**
Parent material:		**Heat treated**	**Serial no.:**			**Calibration exp.:**	
Welding procedure:			**Material**	**Nomination**	**Batch no.**		**Time (min)**
Weld material:			**Pre & Post cleaning:**				
Temp. obj.:		°C	**Penetrant:**				
Surface:			**Penetrant remover:**				
Object:			**Developer:**				

Purpose of examination: detection of surface defects

Items examined:

Result: Body(s) Acceptable according to "Acceptance Standard".

Defect(s): -

Operator:	**Signature:**		**Accepted by QA:**	Signature:	
	Name:				
	Level:	PT level II EN ISO 9712 / SNT-TC-1A		Name:	
Page(s):			**Date:**		
1 of 1					

POSITIVE MATERIAL IDENTIFICATION

Approval Signatures

	Authorized Representative	Date
Prepared By:	Robert Seres, Senior Quality Process Technician	22/04/2022
Approved By:	Attila Demeter, Quality manager	22/04/2022

Company Confidential

The data contained herein is proprietary to the Brooks Instrument and shall not be disclosed in whole or in part for any purpose other than evaluation, provided that, if a contract is awarded to Brooks Instrument, as a result of or in connection with the submission of such data, the customer shall have the right to duplicate, use or disclose this data to the extent provided in the contract.

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1.0 SCOPE

This document defines the process of performing Positive Material Identification at the Hungarian facility of Brooks Instrument.

2.0 PURPOSE

The document provides guidance for the qualification of personnel, preparation and performing the needed test and to record the findings. The main purpose is to assure that the specified materials are according the design requirements.

3.0 TERMS, ABBREVIATIONS

Term, abbreviation	Description
PMI	Positive Material Identification

4.0 FORMS

ISP042-01 PMI report

5.0 REFERENCES

ISP016 Positive Material Identification instruction
MT3800194 PMI identification drawing for 3809 screwed meters
MT3800195 PMI identification drawing for 3809 flanged meters
MT3800196 PMI identification drawing for 3809 welding neck flanged meters
3750120 PMI identification drawing for 3750 all body construction
ASME Section II Part A Ed. 2019
ASME Section II Part C Ed. 2019

6.0 REVISION HISTORY

Date	Revision	Description	Author
2/4/2014	2	Adding section 7.8 (Marking)	Attila D
15/06/2016	3	Issuing ASME Code 2015	L. Lukovits
01/02/2019	4	Overall update, excluding ASME code	Attila D
08/28/2020	5	Correction in section 7.3	Attila D
24/06/2021	6	Added to references and terms, abbreviations sections	R Seres
20/04/2022	7	Correction in section 7.10 (remove 316L and C)	R Seres

7.0 PROCEDURE

7.1. GENERAL

PMI testing is performed on components listed in this instruction. Testing of other components on customer demand should be clarified in the order entry phase.
PMI testing primarily should be done after the welding activity, before assembly activities would start.
PMI test is done whenever a customer request is placed and manufacturing order is referring to it.

7.2. RESPONSIBILITIES

It is the responsibility of the QA department to:
- support the qualification process of new testing personnel
- maintain personnel qualifications

Testing personnel is responsible to adhere to the requirements of this instruction and in case of any deviation to report to direct superior or QA department. Furthermore it is responsible to consider all safety precautions during testing.

7.3. METHOD OF EXAMINATION

Test method mentioned in this document is used to identify the nominal composition of alloy materials and welds verifying that it meets the material specification minimum requirements.
The equipment used for verification is a hand-held energy dispersive X-ray fluorescent analyzer. The working principle of this equipment is based on X-ray excitation. The X-ray tube of the instrument emits X-ray photons with certain energy what can kick out an inner electron of the atom of interest. To terminate this instable energy state, an electron from the outermost orbit jumps to the empty position emitting the energy difference as characteristic energy what is detectable by the device. The value of this energy determines qualitatively the atom itself.
Using this method Carbon content can not be detected. If PMI test with Carbon content is requested, test should be performed by a qualified third party laboratory using an optical emission spectrograph.

7.4. EQUIPMENT SET-UP

The PMI equipment should be operated in accordance with the operating manual of the manufacturer.

7.5. EQUIPMENT VERIFICATION

Proper functioning of the equipment is insured by the standardization procedure. The standardization is done on a sample alloy material provided by the manufacturer. This activity must be performed automatically each time the instrument is started up. Samples used for standardization shall be a Certified Reference Material obtained from the manufacturer of the equipment.

During verification the PMI equipment collects a spectrum on a known standard (316 stainless steel alloy) and then compares a variety of parameters with the preset values. When results are within preset tolerances, the unit confirms that it is properly calibrated.

7.6. PREPARATION OF SAMPLE

Sample surface shall be clean, free of dirt and oil, free of oxides and paint.
Surfaces should not be blasted. In case tested surfaces are already blasted, customer approval should be requested prior to start testing and a remark should be added to the test report, referring to the condition of the surface prior to testing.

7.7. ANALYZE MATERIAL

Mentioned test method identifies the nominal composition of alloy materials and welds and verifies that the nominal composition meets the minimum material specification requirements. An alloy should be positively identified if alloying components are present and concentration deviations do not exceed +/-10% of the specified value.

7.8. COMPONENTS SUBJECT TO PMI

PMI testing is performed on all pressure containing, pressure retaining component, such as:

- Pressure containing piping elements (flanges, tubes, end fittings)
- External valve components (body, bonnet, plugs)
- Welds (Note: in case PMI test with carbon content is requested on welds, separate test coupon should be prepared using the same heat of filler material, as used for the flow body)
- If requested by the customer order, other components can be tested as well, meeting the surface preparation requirements.

PMI testing is done 100% on above mentioned components when required by the production order.

7.9. ACCEPTANCE CRITERIA

For all components requiring PMI, the measured value of alloying elements shall be within +/10% of the specified range in the applicable materials standards.
Components tested shall contain the amount of alloying elements specified for ferrous materials as per ASME Section IIA. Alloys not listed including castings, shall be acceptable if the alloying elements are within the ranges permitted by the material specification plus the tolerance of the equipment used.
Welds shall contain the amounts of alloying elements specified in ASME Section IIC.
If the PMI test results fall outside the permitted range, then test should be repeated. If results still fail, it should be investigated. Until the investigation of the rejected material is not completed, materials from suspected heat should be segregated and marked. Nonconforming materials should be scrapped or deviation approval should be obtained from the customer.

7.10. REPORTING ALLOY ELEMENTS

Alloying elements listed in below table are reported. Other elements might be reported in case customer order clearly defines these.

Generic type	Alloy	Reported elements						
		Cr	Ni	Mo	Fe	W	Ti	Cu
Austenitic SS	316	X	X	X				
Nickel alloy	Hastelloy C-276	X		X	X	X		
	Inconel 625	X	X	X				
	Monel K-500		X		X			X
Titanium	Grade 2				X		X	

7.11. RECORDS

Test results are stored first in the test equipment and are later recorded in a Test report. Test report should be prepared in any case, both for acceptable and rejected results.
Test report can be found in the Attachment of this document and should contain as a minimum:

- report number
- item identification data
- order identification data
- used equipment
- key elements with quantities in %
- identified alloy material
- disposition
- date
- Operator performing the test

7.12. MARKING AND DISPOSITION OF TESTED MATERIAL

All verified components with an acceptable analysis shall be marked with letters “PMI1”. Marking should be done using a dye stamp, being of low stress type. Marking should be placed in the close proximity of the tested point (for example flanges to be marked on the rim, tubes to be marked next to heatcode engraving).
Components with not acceptable PMI results should be clearly marked with a red tag and segregated till further disposition.

7.13. PROCEDURE AND PERSONAL QUALIFICATION

PMI test should be performed by operators qualified for this activity. Qualification of operators consists of two steps:

1- Practical experience of at least 80 hours (2 weeks, 8 hours per day)
2- Formal training course held by the manufacturer/distributor on operating the PMI equipment

Training records for both of the two steps should be kept on file and retained as per the general retention procedure.
Test personnel must be knowledgeable in operating the test equipment, be aware of the required safety precautions and must be able to recognize the limitations of the instrument in terms of material and surface profile requirements.

7.14. SAFETY

PMI equipment must only be used by trained and authorized operators in accordance with proper safety procedures. Do not use the equipment if there is any evidence of damage. In case of damage, equipment shall be forwarded to a qualified service center.
The handheld Innov-X XRF instrument emits a small diameter focused X-ray beam. Although the intensity is decreasing in the function of distance, the rays can pass several meters in the air, if it is improperly used. The equipment, if properly used, is safe and can not cause injuries.

Brooks Instrument Kft
Berényi str 72-100
8000 Székesfehérvár
Hungary

PMI TEST REPORT

Report nr:

Client order nr:	Procedure nr:	
Test equipment: Olympus Innov-X Delta Premium 2000 element analyzer XRF spectrometer		Test equipment nr: 82000/001 Last test date:
Date of examination:	Specification:	
Place of examination: Szekesfehervar		

Object id. nr:	Model description	Part Description	% MIN: MAX:	% MIN: MAX:	% MIN: MAX:	% MIN: MAX:	% MIN: MAX:	% MIN: MAX:

Analysis done by:	Signature Name		Accepted by QA	Signature Name	
Results in accordance with specification:					
Above mentioned items are marked with low stress dye-stamp:					

Remarks: ND - Not Detectable