SULZER

Test Procedure	Sulzer Pumps Technical Quality	
Non-destructive testing – Radiographic Examination (RT) of welded joints according to ASME BPVC Section V Art. 2		

Document control sheet for the issuing of Test Procedures (NDE) by Level III
The signatures below indicate review and approval of this NDE procedure by NDE Level 3.

检测程序（无损检测）由NDE 3级 发布文件控制单
以下的签字表示本NDE程序已由NDE 3级人员审核及批准。

Dokumentkontrollblatt zur Erstellung von Testverfahren (ZfP) nach Level III
Die folgenden Unterschriften zeigen die Überprüfung und Genehmigung dieses ZfP-Verfahrens nach ZfP Level 3.

Hoja de control de documentos para la emisión de Procedimientos de prueba (ECM) por Nivel III
Las firmas a continuación indican la revisión y aprobación de este procedimiento de ECM por NDE Nivel 3.

Folha de controle de documentos para a emissão de Procedimentos de Teste (END) pelo Nível III
As assinaturas abaixo indicam a revisão e aprovação deste procedimento de END pelo Inspetor END Nível 3.

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1 Scope

1.1 This procedure details the requirements for the radiographic examination (RT) of welded joints with wall thickness up to 101 mm, using X-ray or gamma ray source, class II or better industrial radiographic films and wire-type IQI`s, based on the ASME requirements.

2 Reference standards

2.1 The following documents are referenced in this specification. All documents shall be current issue unless specified otherwise. In case of any conflict between the current specification and the referred documents, the current document shall take precedence.

ASME Boiler and Pressure Vessel Code Sections

Section V, Article 2	Radiographic Examination
Article 22,SE-94	Standard Guide for Radiographic Examination
SE- 747	Standard Practice for Design, Manufacture and Material Grouping Classification of Wire image Quality Indicators (IQI) used for Radiology
SE- 999	Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing
SE-1114	Standard Test Method for Determining the Size of Iridium-192 Industrial Radiographic Sources
SE-1165	Standard Test Method for Measurement of Focal Spots of Industrial X-Ray Tubes by Pinhole Imaging
SE-1416	Standard Practice for Radioscopic Examination of Weldments
Section VIII, Div.1	Rules for Construction of Pressure Vessels
UW-51	Radiographic Examination of welded joints
UW-52	Spot Examination of welded joints
Section I	Rules for construction of Power Boilers
ASTM E 1815	Standard Test Method for Classification of Film Systems for Industrial Radiography
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas indutries
ASME B31.3	Process Piping / Petroleum refineries, chemical, pharmaceutical, textile, paper, semiconductor or cryogenic plants
ASME B31.1	Power Piping /electric power generating stations, industrial and institutional plants, geothermal heating systems, central and district heating and cooling systems
ASNT SNT-TC-1A	Recommended Practice for Qualification and Certification of NDT Personnel
ANSI/ASNT CP-189	Standard for Qualification and Certification of Nondestructive Testing Personnel
ACCP	ASNT Central Certification Program
ASNT 9712	ASNT 9712 Certification Program
ISO 9712	Non-destructive Testing - Qualification and Certification of NDT Personnel

3 Qualification of testing personnel

The personnel performing RT examination required in the Project Quality Plan (Inspection & Test Plan) for NDE purposes shall be qualified and certified in accordance with the Company`s Written Practice, which conforms to the Recommended practice SNT-TC-1A, the ASNT Central Certification Program (ACCP), ISO 9712, ANSI/ASNT CP-189, ASNT 9712 or equivalent national standard (e.g. CAN/CGSB 48.9712), and have a currently valid near vision and gray shades test.

An operator with RT-level 1 can perform an examination only under the supervision of personnel qualified and certified RT-level 2 or higher.

Interpretation and evaluation of results shall only be carried out by personnel qualified and certified RT-level 2 or higher, who is supervising the examination of RT-level 1 and evaluates the results. Both have to sign the records.

All qualifications and certification must comply, in full, with at least one of the standards referenced in Paragraph 2.0 of this document and, where applicable, should be in full compliance with the Project Quality Plan (Inspection & Test Plan).

4 Examination conditions

4.1 Timing of examination

Testing shall be carried out in the manner defined in the project Quality Plan (Inspection & Test Plan), both in chronological order and material condition.

4.2 Extent of examination

The extent or scope of the examination shall be as defined in the project Quality Plan (Inspection & Test Plan).

Where only a percentage of the welds are required to be examined, this shall be calculated based on the total number of butt welds multiplied by the percentage and rounded up to the next whole number. It shall be assured that work representative of each welder is included in the sample radiographed and further that at least 1 foot (30 cm) of weld seam is examined per 100 feet (30 m) of weld.

All repaired welds have to be examined in the same way as the original weld, unless other instructions are given in the project Inspection & Test Plan.

4.3 Surface preparation

Welds shall be radiographed in the "as-welded" condition with weld spatter removed. The surface condition shall be such that any irregularities shall not mask or be confused with the image of any discontinuity. Where excessive weld ripples, humps or craters occur they shall be dressed prior to radiographic examination.

4.4 Visual examination

All welds shall be visually inspected for defects that may impair the quality of the radiograph produced

5 Source

The radiation energy employed for any radiographic technique shall achieve the density and IQI image requirements of the ASME BPV Code Section V, Article 2.

Radioactive Isotopes (Co 60, Ir.192 and Se-75), or X-Ray tubes can be used.

Table 1: Examples (standard values) for maximum Voltage, when using X-Radiation

Thickness [mm]	Thickness (in)	Steel kV
< 3.2	*(1/8)*	*80*
4.76	*(3/16)*	*100*
6.35	(1/4)	120
9.5	(3/8)	150
12.7	(1/2)	200
15.8	(5/8)	250
19	(3/4)	320
25.4	(1)	400

Table 2: Recommended minimal wall thickness (steel) by isotopes (can be underrun)

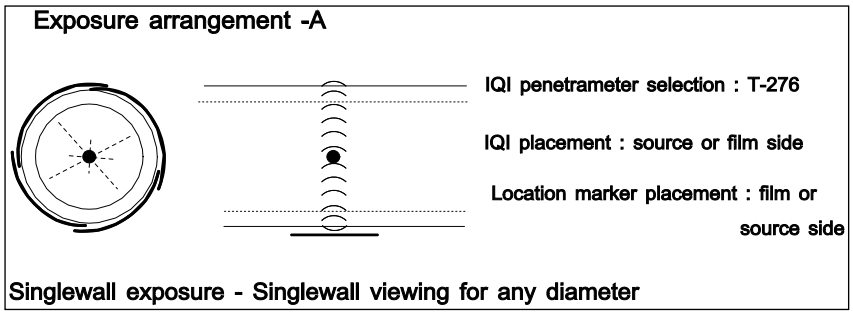
Isotope	Se 75 [mm]	(in)	Ir 192 [mm]	(in)	Co 60 [mm]	(in)
recommended:	>12.7	(1/2)	>19	(3/4)	>38	(1.5)
(minimum):	*>6.35*	*(1/4)*	*>12.7*	*(1/2)*	*>19*	*(3/4)*

The essential IQI wire required as per § 13.3, Table 5 shall be achieved.

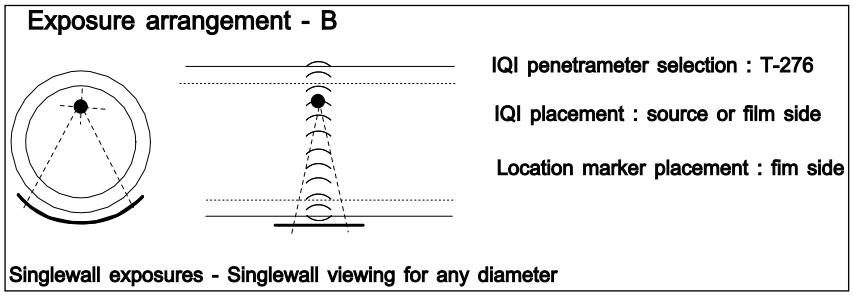
6 Technique

A suitable technique appropriate to the type and dimensions of joint and to the radiation source shall be selected from those outlined in ASME V, T-270.

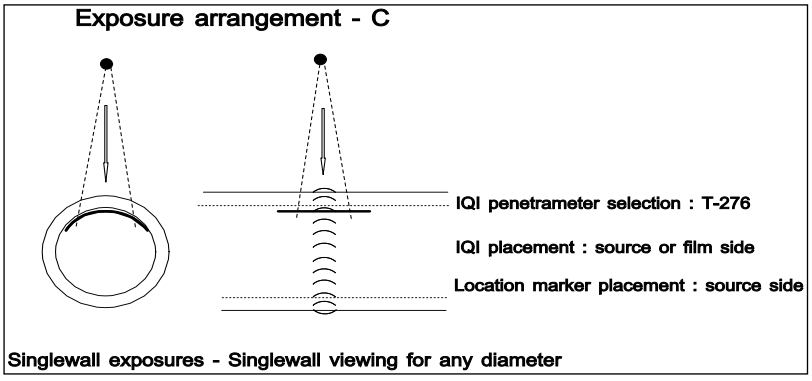
6.1 SW – SI technique; Single-Wall Radiograph Viewing



One exposure for complete coverage.

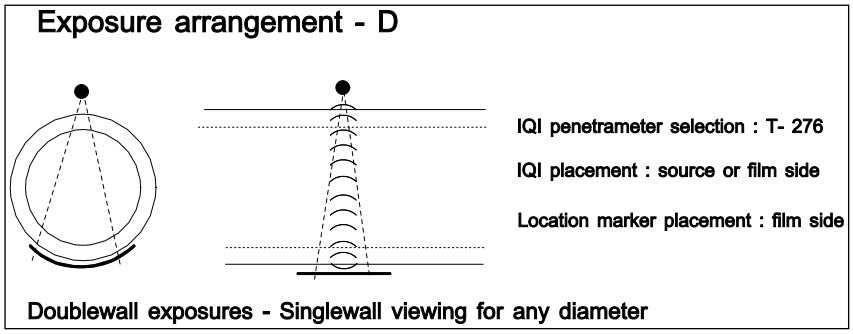


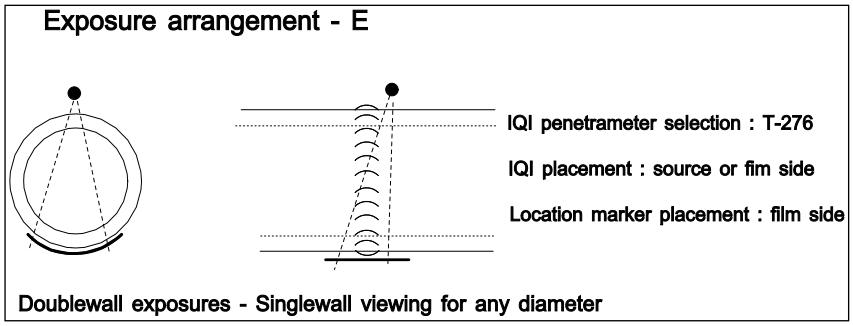
Minimum number of exposures for complete coverage; see Enclosure 1.



Minimum number of exposures for complete coverage; see Enclosure 2.

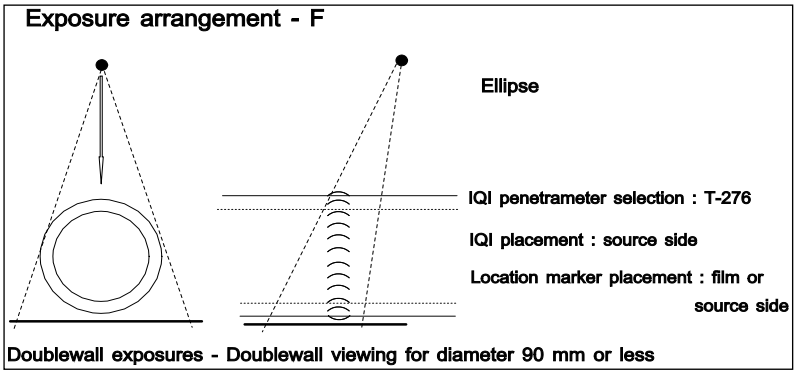
6.2 DW - SI technique; Single-Wall Radiograph Viewing





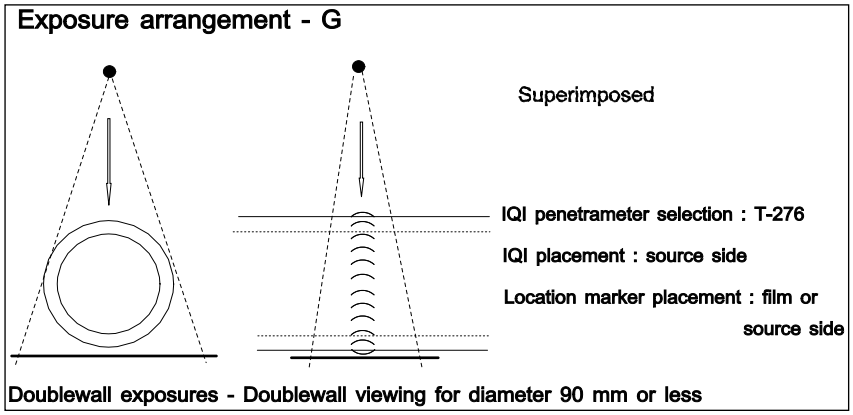
When complete coverage is required for circumferential welds (materials), a minimum of three exposures taken 120 deg to each other shall be made; see Enclosure 1.

6.3 DW - DI technique; Double-Wall Radiograph Viewing



Pipes ≤ 89 mm (3.5 inch) outside diameter by double-wall, double image (elliptical offset source side and film side images) as ASME V Article 2 arrangement F.

- At least two exposures at 90° to each other shall be made for complete coverage; see Enclosure 1.



Pipes ≤ 89 mm (3.5 inch) outside diameter by double-wall, double image (superimposed source side and film side images) as ASME V Article 2 arrangement G.

- At least three exposures at 60° or 120° to each other shall be made for complete coverage; see Enclosure 1.

7 Location markers

Location markers (that is, lead or high-atomic number metals or letters that are to appear as images on the radiographic film) should be placed on the part being examined, whenever practical, and not on the cassette. Their exact locations should also be marked on the surface of the part being radiographed, thus permitting the area of interest to be located accurately on the part, and they should remain on the part during radiographic inspection.

Markers shall be placed alongside but clear of the outer edges of the weld to identify the position of the area under examination in accordance with ASME V, T-275; see Enclosure 3.

8 Film overlap

The separate radiographs of a welded joint shall overlap to show common markers ensuring that no portion of the join remains unexamined.

9 Object – film distance

Wherever possible the film cassette shall be in contact with the weld surface. When contact is not possible the film to weld distance shall be noted in the radiographic examination reports.

For double wall, double image method the object to film distance shall be taken to be the outside diameter of the pipe.

10 Identification of radiographs

Each section of the weld radiographed shall have the following permanently included:

10.1 contract order number

10.2 pipe reference number and/or drawing number

10.3 weld reference number

10.4 section of the weld

10.5 welder's identity

10.6 date of radiograph

10.7 IQI

10.8 location marker

The weld reference number for radiographs of weld repairs shall be clearly identified (e.g. suffixed with the letter "R" and the repair sequence: "R1", "R2", etc.).

11 Marking of the radiographed item

The joint shall be marked to provide reference points for accurate re-location of each radiograph during the assessment period.

For stainless steels, markings shall be made with a marker pen containing halogen and chloride free ink.

12 Density of radiograph

The photographic density of the film shall be as defined in Table 3, below, providing adequate viewing facilities are available. Otherwise the maximum film density through the area of interest shall be max. 3.5 for all techniques.

A tolerance of 0.05 in density is allowed for variations between densitometer readings.

Table 3: Acceptance values for density

Source	Single viewing		Composite viewing of multiple film exposure	
	Minimum	Maximum	Minimum: (* Maximum) for each film	Maximum: all films together
X-ray	**1.8**	4.0	1.3 (* max 2.5)	4.0
Gamma-ray	**2.0**	4.0	1.3 (* max 2.5)	4.0

The density of the film shall be checked using a calibrated densitometer

12.1 DENSITOMETER AND STEP WEDGE COMPARISON FILM, T-262

12.1.1 Densitometers, T-262.1.

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

(a) A national standard step tablet or a step wedge calibration film, traceable to a national standard step tablet and having at least five 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 a national standard step tablet unless, prior to first use, it was maintained in the original light-tight and waterproof sealed package as supplied by the manufacturer. Step wedge calibration films may be used without verification for one year upon opening, provided 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.

12.1.2 Step Wedge Comparison Films, T-262.2.

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.

12.1.3 Periodic Verification, T-262.3.

(a) Densitometers. Periodic calibration verification checks shall be performed as described in T-262.1 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 T-262.2.

12.1.4 Documentation, T-262.4.

(a) Densitometers. Densitometer calibrations required by T-262.1 shall be documented, but the actual readings for each step do not have to be recorded. Periodic densitometer verification checks required by T-262.3(a) do not have to be documented.

(b) Step Wedge Calibration Films. Step wedge calibration film verifications required by T-262.1(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 T-262.2 and T-262.3(b) shall be documented, but the actual readings for each step do not have to be recorded.

12.2 Density Variation

The density of the radiograph anywhere through the area of interest shall not

- vary by more than minus 15% or plus 30% from the density through the body of the designated hole-type IQI adjacent to the essential hole or adjacent to the essential wire of a wire-type IQI, and
- exceed the minimum/maximum allowable density ranges specified in § 12.0.

(a) When calculating the allowable variation in density, the calculation may be rounded to the nearest 0.1 within the range specified in § 12.0.

(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.

(c) When shims are used with hole-type IQIs, the plus 30% density restriction of (a) above may be exceeded, and the minimum density requirements of § 12.0 do not apply for the IQI, provided the required IQI sensitivity is met.

13 Image quality indicators (IQI)

13.1 Selection

ASTM Set: 4 sets of 6 wires in a plastic cover

Denomination: ASTM - material group - set - denomination of the largest wire

Material group: *Number according to the Appendix 1 (1 = steel, 02 = aluminum)*
Set (manufactured after 1997): *No. of the largest wire diameter*
(old set, manufactured before 1994: *largest wire ∅ in 1/100 Inch)*
Example for steel: ***ASTM 1 A 6*** *(or old: ASTM 1 A 01)*

13.2 Material Group

Which alloy material group or grade of the IQI must be taken for which material group to be submitted to RT is named in the ASME Code Section V, Subsection B, Art. 22 Standard Practice for IQI, SE-747 Item 7.2.

01 = Titanium
02 = Aluminium
03 = Magnesium

1 = Carbon steel / Type 300 stainless steel
2 = Aluminium bronze
3 = Nickel-Chromium-Iron
4 = Nickel-copper / copper-nickel (Monel)
5 = Tin-bronze

Any group IQI may be used for any material with a higher group number, provided the applicable quality level is maintained.

As to material thickness, IQI designations, wire diameter and essential wire, see tables T-276 and T-233.2.

The penetrameters according to EN ISO 19232-1 can also be used; see comparison table 4 below.

Table 4: Comparison IQI Wire - ASTM Set and EN ISO 19232-1

ASTM Set				ASME Code V			EN ISO 19232-1 (old: EN 462-1, DIN 54 109)		
					diameter		diameter		
				No.	[inch]	[mm]	[mm]	No.	set
				-	--	--	0.050	19	
				-	--	--	0.063	18	
A	smallest			1	0.0032	0.08	0.080	17	
A				2	0.004	0.10	0.100	16	
A				3	0.005	0.13	0.125	15	
A				4	0.0063	0.16	0.160	14	
A				5	0.008	0.20	0.200	13	
A	**B**			6	0.010	0.25	0.250	12	
	B			7	0.013	0.33	0.320	11	
	B			8	0.016	0.41	0.400	10	
	B			9	0.020	0.51	0.500	9	
	B			10	0.025	0.64	0.630	8	
	B	**C**		11	0.032	0.81	0.800	7	
		C		12	0.040	1.02	1.000	6	
		C		13	0.050	1.27	1.250	5	
		C		14	0.063	1.60	1.600	4	
		C		15	0.080	2.03	2.000	3	
		C	**D**	16	0.100	2.54	2.500	2	
			D	17	0.126	3.20	3.200	1	
			D	18	0.160	4.06	--	--	
			D	19	0.200	5.08	--	--	
			D	20	0.250	6.35	--	--	
	largest		**D**	21	0.320	8.13	--	--	

13.3 Essential Wire required

The image quality level shall be 2-2T (equivalent to IQI 2.0 %) or better.

The essential wire diameter and identification number shall be as specified in the table below. The IQI shall be based on the nominal (drawing size) single wall thickness plus the actual weld reinforcement thickness estimated to be present on both sides of the weld.

The values used for the estimated weld reinforcement thicknesses shall not exceed the maximums permitted by the Referencing Code Section.

Backing ring or strip shall not be considered as part of the thickness in IQI selection

Nominal single wall material thickness range.		Wire IQI					
		source side			film side		
[mm]	(in)	Req. Wire Ø [mm]	(in)	SE 747	Req. wire Ø [mm]	(in)	SE 747
≤ 2.4	*(0.094)*	*0.10*	*(0.004)*	*2*	*0.08*	*(0.0032)*	*1*
>2.4 – 3.2	*(0.094-0.125)*	*0.13*	*(0.005)*	*3*	*0.10*	*(0.004)*	*2*
>3.2 - 4.7	*(0.125-0.187)*	*0.16*	*(0.0063)*	*4*	*0.13*	*(0.005)*	*3*
>4.7 - 6.4	*(0.187- 0.25)*	0.20	(0.008)	5	0.16	(0.0063)	4
>6.4 - 9.5	(0.25-0.375)	0.25	(0.010)	6	0.20	(0.008)	5
>9.5 - 12.7	(0.375-0.50)	0.33	(0.013)	7	0.25	(0.010)	6
>12.7-19.0	(0.50-0.75)	0.41	(0.016)	8	0.33	(0.013)	7
>19.0 - 25.4	(0.75-1.0)	0.51	(0.020)	9	0.41	(0.016)	8
>25.4 - 38.1	(1.0-1.5)	0.64	(0.025)	10	0.51	(0.020)	9
>38.1 - 50.8	(1.5-2.0)	0.81	(0.032)	11	0.64	(0.025)	10
>50.8 - 63.5	(2.0-2.5)	1.02	(0.040)	12	0.81	(0.032)	11
>63.5 - 101.6	(2.5-4.0)	1.27	(0.050)	13	1.02	(0.040)	12

Table 5: IQI Selection acc. ASME BPVC Section V, Art. 2, T-276,
Supplemented requirements for smaller wall thickness

GENERAL NOTE: It is recognized that the required hole-type designation or wire-type essential wire in this table may not achieve an IQI sensitivity level of 2–2T. This is intentional.

13.4 Placement of wire IQI's for welds

13.4.1 Source side IQI

The IQI shall be placed on the source side of the part being examined, except in the condition described below.
When, due to the 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 or radiographically similar materials (see 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 T-282.2 (variation limits < 15% and > 30%) are met.

13.4.2 Film side IQI

Where inaccessibility prevents hand placing the IQI on the source side, it 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).

13.4.3 IQI location for welds

The IQI shall be placed across the weld at the edge of the diagnostic area with the thinnest wire outmost. The IQI shall be placed on the weld, so that the lengths of the wires are transverse to the longitudinal axis of the weld.

It is not required for the essential wire to span the full width of the weld. However, the essential wire shall span at least that portion of the weld representing the nominal single wall material thickness and reinforcement for which the IQI essential wire was selected.

The density requirements of § 12 and the sensitivity requirements of § 13.3 shall also be met.

The IQI identification and, when used, the lead letter “F,” shall not be in the area of interest, except when geometric configuration makes it impractical.

13.5 Number of IQI’s

At least one IQI shall be used for an area where the radiographic densities do not vary by more than -15% / +30% from the density measured adjacent to the designated wire of the IQI.

When the film density varies more, two IQI’s sets shall be used.

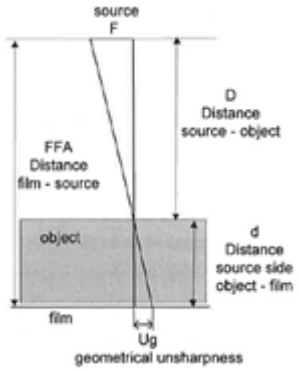
If the requirements of T-282 (variation limits < 15% and > 30%) are met by using more than one IQI, one shall be representative of the lightest area of interest and the other the darkest area of interest; the intervening densities on the radiograph shall be considered as having acceptable density.

For welds where one or more film holders are used for an exposure, at least one IQI image shall appear on each radiograph, except for circumferential welds where the source is placed on the axis of the object and one or more film holders are used for a single exposure of a complete circumference, in this case at least three IQI’s shall be spaced approximately 120° apart.

Where sections of longitudinal welds adjoining the circumferential weld are radiographed simultaneously, an additional IQI shall be placed on each longitudinal weld at the end of each section most remote from the junction with the circumferential weld being radiographed.

14 Geometric un-sharpness

The minimum source to film distance/source size combination to be used shall be such that the geometric unsharpness value does not exceed the values given in ASME V, T-274.



The distance between the source and the film shall be chosen so that the actual geometric unsharpness U_g, is less than the $U_{g\text{-}max}$ value listed in Table 2.

$$U_{g-max} \geq U_g = \frac{F \cdot d}{D}$$

The minimum distance between the source and the object being radiographed can be calculated by the formula below:

$$D \geq D_{min} = \left(\frac{F \cdot d}{U_{g-max}}\right)$$

Where:

U_g =	Actual Geometric Un-sharpness
$U_{g\text{-}max}$ =	Maximum allowable geometric un-sharpness, defined in Table 6 below.
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 object being radiographed.
D =	Actual distance from source to object being radiographed
D_{min} =	Minimum allowable distance from source to object being radiographed
d =	Distance from source side of object being radiographed to the film. When using single-wall technique, it is the thickness of the object. When using double-wall technique, it is the outer diameter.

Material thickness t	$U_{g\text{-}max}$
t < 50 mm [2 in]	0.51 mm [0.020 in]
50 mm [2 in] ≤ t ≤ 75 mm [3 in]	0.76 mm [0.030 in]
75 mm [3 in] < t ≤ 100 mm [4 in]	1.02 mm [0.040 in]

Table 6; Geometric Unsharpness Limitations

Alternatively a nomograph as shown in Standard Guide for Radiographic Examinations ASME Code Section V, Sub.B, Art.22, SE-94 may be used.

15 Film type

Radiographic film shall be in accordance with ASTM E 1815 Type II (or ISO 11699-1 Class T3) or better and have a maximum fog density of 0.3.

System class				Min. Gradient at		Min. gradient-noise ratio D=2 above D_0	Max. Grain size D=2 above D_0	e.g. AGFA
World ISO 11699-1	Europe CEN 584-1	USA ASTM E1815	Japan K7627	D=2 above D_0	D=4 above D_0			
T1	C1	Special	T1	4,5	7,5	300	0,018	D2
	C2	I		4,3	7,4	270	0,018	D3
T2	C3		T2	4,1	6,8	180	0,023	D4
	C4			4,1	6,8	150	0,028	D5
T3	C5	II	T3	3,8	6,4	120	0,032	D7
T4	C6	III	T4	3,5	5,0	100	0,039	D8
		W-A	W-A			130		
		W-B	W-B			110		
		W-C	W-C			80		

Table 7: Film system class

16 Intensify screens

All screen shall be clean and free from scratches, grease, dirt and all that can interfere with the interpretation of the film.
The use of fluorescent screen is not allowed. Preferred vacuum-packed films shall be used.

Table 8: Recommended thickness of screens

Radiation source		Front (Back) screen		
		Material	Thickness [mm]	(in)
X-ray	0 - 125 kV	Pb	none - 0.15	none – 0.006
	125 - 250 kV	Pb	0.02 - 0.15	0.0008 – 0.006
	250 - 320 kV	Pb	0.02 - 0.2	0.0008 – 0.008
	320 - 450 kV	Pb	0.1 - 0.2	0.004 – 0.008
Se 75		Pb	0.1 - 0.2	0.004 – 0.008
Ir 192		Pb	0.1 - 0.2	0.004 – 0.008
Co 60		Fe or Cu	0.25 - 0.7	0.01 - 0.028

17 Interception of unwanted and scattered radiation

A lead symbol “B,” with minimum dimensions of 11 mm in height and 1.5 mm in thickness, shall be in direct contact with the back of each film holder or cassette 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 density requirements.

17.1 Excessive scatter:

If a light image of the “B,” 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.

18 Processing

The film shall be processed manually or automatically in accordance with requirements of the film system used. The film or the processing solution or both shall be agitated during development. The development time and temperature shall be in accordance with the film manufacturer’s recommendations. The radiographs shall be free from processing imperfections or defects, which would interfere with interpretation.

Films shall be processed in accordance with the Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing, ASME V, Article 22, SE-999. The storage durability of the radiographic film shall be 25 years minimum.

19 Viewing

The radiographs shall be examined by diffused light in a darkened room with the illuminated area that will not cause troublesome reflections, shadows or glare on the radiograph image. Ambient light in the viewing area shall not exceed 30 Lux (lx).

Viewing equipment for interpretation shall include a variable light source sufficient for the essential IQI to be visible for the specified density range.

The films shall be free from all blemishes, mechanical damage or defects, which would interfere with interpretation.

The viewing conditions 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.

20 Repairs

20.1 All repair work that involves welding shall fulfil PO / ITP requirements. Any deviation requires an approved concession request prior to execution by Sulzer

20.2 All relevant indication shall be marked on the components themselves, or where this is not possible on an NDE defect map. All relevant indications shall be removed completely.

20.3 Whenever an imperfection is to be weld repaired, the excavation shall be examined by one of following method before welding to ensure complete removal of defect

20.3.1 Visual inspection, if the imperfection was found by visual inspection.

20.3.2 Penetrant testing, if the imperfection was found by PT,MT,UT or RT.

20.4 On completion of welding, repaired areas shall be blended into their surrounding surfaces to avoid any sharp contours and be examined by the same quality standards that are used to inspect the castings / welds. When subsequent heat treatment is required, examination shall be conducted after heat treatment.

21 Reporting

21.1 For each examination and for each item tested shall be completed a report. This report has to include at least following information:

21.1.1 date of the examination

21.1.2 name and/or identity and certification level (if applicable) for personnel performing the examination

21.1.3 identification of the weld, part, or component examined including weld number, serial number, or other identifier

21.1.4 examination method, technique, procedure identification, and revision

21.1.5 results of the examination

21.2 Retention of examination records and related documentation (e.g., radiographs and review forms, ultrasonic scan files, etc.) shall be as specified by the referencing Code Section.

21.3 Digital images and reviewing software shall be retained under an appropriate record retention system that is capable of securely storing and retrieving data for the time period specified by the referencing Code Section.

21.3.1 identification as required by T-224

21.3.2 the dimensional map (if used) of marker placement in accordance with T-275.3

21.3.3 number of exposures

21.3.4 X-ray voltage or isotope type used

21.3.5 source size (F)

21.3.6 base material type and thickness, weld thickness, weld reinforcement thickness, as applicable

21.3.7 source-to-object distance (D)

21.3.8 distance from source side of object to film (d)

21.3.9 film manufacturer and their assigned type/ designation

21.3.10 number of film in each film holder/cassette

21.3.11 single- or double-wall exposure

21.3.12 single- or double-wall viewing

21.4 RADIOGRAPH REVIEW FORM

The Manufacturer shall be responsible for the preparation of a radiograph review form. As a minimum, the following information shall be provided.

21.4.1 a listing of each radiograph location

21.4.2 the information required in T-291, by inclusion of the information on the review form or by reference to an attached radiographic technique details sheet

21.4.3 evaluation and disposition of the material(s) or weld(s) examined

21.4.4 identification (name) of the Manufacturer's representative who performed the final acceptance of the radiographs

21.4.5 date of Manufacturer's evaluation

21.5 Components shall be clearly identified as being either acceptable or rejectable. Non-conforming areas on components shall be marked on the components themselves or, where this is not possible, on an NDE defect map.

21.6 Customer shall be notified if any examined item is rejectable.

21.7 SYSTEM OF IDENTIFICATION, T-224

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 Manufacturer's symbol or name and the date of the radiograph shall be included with the identification information on each radiograph.

An NDE subcontractor's name or symbol may also be used together with that of the Manufacturer. This 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.

21.8 Mapping the Placement of Location Markers, . T-275.3

When inaccessibility or other limitations prevent the placement of markers as stipulated in T-275.1 and T-275.2, a dimensioned map of the actual marker placement shall accompany the radiographs to show that full coverage has been obtained.

22 Assessment of indications

Due to diversity of project requirements, defect acceptance will be as specified in the project Quality Plan (Inspection & Test Plan). The Sulzer Purchase Order or Production Order operation text will include the project specific requirements or reference the document wherein it is specified. In the absence of a Quality Plan (Inspection & Test Plan), the Sulzer quality organisation responsible for the project will advise in writing the appropriate acceptance standard.

See attachments below;

1. ASME BPVC Section VIII Div. 1, § UW51 (100%)
2. ASME BPVC Section VIII Div. 1, § UW52 (spot)
3. API Standard 610 / ISO 13709
4. ASME B31.3 - Severe Cyclic Condition
5. ASME B31.3 - Normal & Category M Fluid Service
6. ASME B31.1 – for temperature > 175°C (350°F)

7 ASME BPVC Section I

Enclosure 1: Number of exposures at arrangement D or E / F or G

Isotope

DN	"	Ø mm	5S	5	10S	10	20	30	40S	STD	40	60	80S	XS	80	100	120	140	160	XXS
15	1/2	21.3	1.65	1.65	2.11	2.11	--	2.41	2.77	2.77	2.77	--	3.73	3.73	3.73	--	--	--	4.78	7.47
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
20	3/4	26.6	1.65	1.65	2.11	2.11	--	2.41	2.87	2.87	2.87	--	3.91	3.91	3.91	--	--	--	5.56	7.82
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
25	1	33.4	1.65	1.65	2.77	2.77	--	2.90	3.38	3.38	3.38	--	4.55	4.55	4.55	--	--	--	6.35	9.09
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
32	1 ¼	42.1	1.65	1.65	2.77	2.77	--	2.97	3.56	3.56	3.56	--	4.85	4.85	4.85	--	--	--	6.35	9.70
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				2/3	3
40	1 ½	48.2	1.65	1.65	2.77	2.77	--	3.18	3.68	3.68	3.68	--	5.08	5.08	5.08	--	--	--	7.14	10.15
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				2/3	3
50	2	60.3	1.65	1.65	2.77	2.77	--	3.18	3.91	3.91	3.91	--	5.54	5.54	5.54	--	--	--	8.74	11.07
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
--	2 ½	73.0	2.11	2.11	3.05	3.05	--	4.78	5.16	5.16	5.16	--	7.01	7.01	7.01	--	--	--	9.53	14.02
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
65	--	76.1	2.11	2.11	3.05	3.05	--	4.78	5.16	5.16	5.16	--	7.01	7.01	7.01	--	--	--	9.53	14.02
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
80	3	88.9	2.11	2.11	3.05	3.05	--	4.78	5.49	5.49	5.49	--	7.62	7.62	7.62	--	--	--	11.13	15.24
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
80	3"	88.9	2.11	2.11	3.05	3.05	--	4.78	5.49	5.49	5.49	--	7.62	7.62	7.62	--	--	--	11.13	15.24
			4	4	4	4		4	4	4	4		4	4	4				XX	XX
--	3 ½	101	2.11	2.11	3.05	3.05	--	4.78	5.74	5.74	5.74	--	8.08	8.08	8.08	--	--	--	--	--
			4	4	4	4		4	4	4	4		4	4	4				--	--
100	4	114	2.11	2.11	3.05	3.05	--	4.78	6.02	6.02	6.02	--	8.56	8.56	8.56	--	11.13	--	13.49	17.12
			4	4	4	4		4	4	4	4		4	4	4		4		4	4
125	5	141	2.77	2.77	3.40	3.40	--	--	6.55	6.55	6.55	--	9.53	9.53	9.53	--	12.70	--	15.88	19.05
			4	4	4	4			4	4	4		4	4	4		4		4	4
150	6	168	2.77	2.77	3.40	3.40	--	--	7.11	7.11	7.11	--	10.97	10.97	10.97	--	14.27	--	18.26	21.95
			3	3	4	4			4	4	4		4	4	4		4		4	4
200	8	219	2.77	2.77	3.76	3.76	6.35	7.04	8.18	8.18	8.18	10.31	12.70	12.70	12.70	15.09	18.26	20.62	23.01	22.23
			3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4
250	10	273	3.40	3.40	4.19	4.19	6.35	7.80	9.27	9.27	9.27	12.70	12.70	12.70	15.09	18.26	21.44	25.40	28.58	25.40
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4
300	12	323	3.96	3.96	4.57	4.57	6.35	8.38	9.53	9.53	10.31	14.27	12.70	12.70	17.48	21.44	25.40	28.58	33.32	25.40
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4
350	14	355	3.96	3.96	4.78	6.35	7.92	9.53	9.53	9.53	11.13	15.09	12.70	12.70	19.05	23.83	27.79	31.75	35.71	--
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	

DN	"	Ø mm	5S	5	10S	10	20	30	40S	STD	40	60	80S	XS	80	100	120	140	160	XXS
400	16	406	4.19	4.19	4.78	6.35	7.92	9.53	9.53	9.53	12.70	16.66	12.70	12.70	21.44	26.19	30.96	36.53	40.49	--
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	
450	18	457	4.19	4.19	4.78	6.35	7.92	11.13	9.53	9.53	14.27	19.05	12.70	12.70	23.83	29.36	34.93	39.67	45.24	--
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	
500	20	508	4.78	4.78	5.54	6.35	9.53	12.70	9.53	9.53	15.09	20.62	12.70	12.70	26.19	32.54	38.10	44.45	50.01	--
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	
550	22	558	4.78	4.78	5.54	6.35	9.53	12.7	9.53	9.53	--	22.3	12.7	12.7	28.58	34.93	41.28	47.63	53.98	--
			3	3	3	3	3	3	3	3		3	3	3	4	4	4	4	4	
600	24	609	5.54	5.54	6.35	6.35	9.53	14.27	9.53	9.53	17.48	24.61	12.70	12.70	30.96	38.89	46.02	52.37	59.54	--
			3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	
650	26	660	--	--	--	7.92	12.70	15.88	--	9.53	--	--	--	12.70	--	--	--	--	--	--
						3	3	3		3				3						
700	28	711	--	--	--	7.92	12.70	15.88	--	9.53	--	--	--	12.70	--	--	--	--	--	--
						3	3	3		3				3						
750	30	762	6.35	6.35	7.92	7.92	12.70	15.88		9.53				12.70						
			3	3	3	3	3	3		3				3						
800	32	812	--	--	--	7.92	12.70	15.88	--	9.53	17.48	--	--	12.70	--	--	--	--	--	--
						3	3	3		3	3			3						
850	34	863	--	--	--	7.92	12.70	15.88	--	9.53	17.48	--	--	12.70	--	--	--	--	--	--
						3	3	3		3	3			3						
900	36	914	--	--	--	7.92	12.70	15.88	--	9.53	--	--	--	12.70	--	--	--	--	--	--
						3	3	3		3				3						
1000	40	1016	--	--	--	--	--	--	--	9.53	--	--	--	12.70	--	--	--	--	--	--
										3				3						
1200	48	1219	--	--	--	--	--	--	--	9.53	--	--	--	12.70	--	--	--	--	--	--
										3				3						

The code 2/3 means: 2 exposures with the elliptical technique at 90° to each other, or 3 exposures superimposed at 60° or 120° to each other.

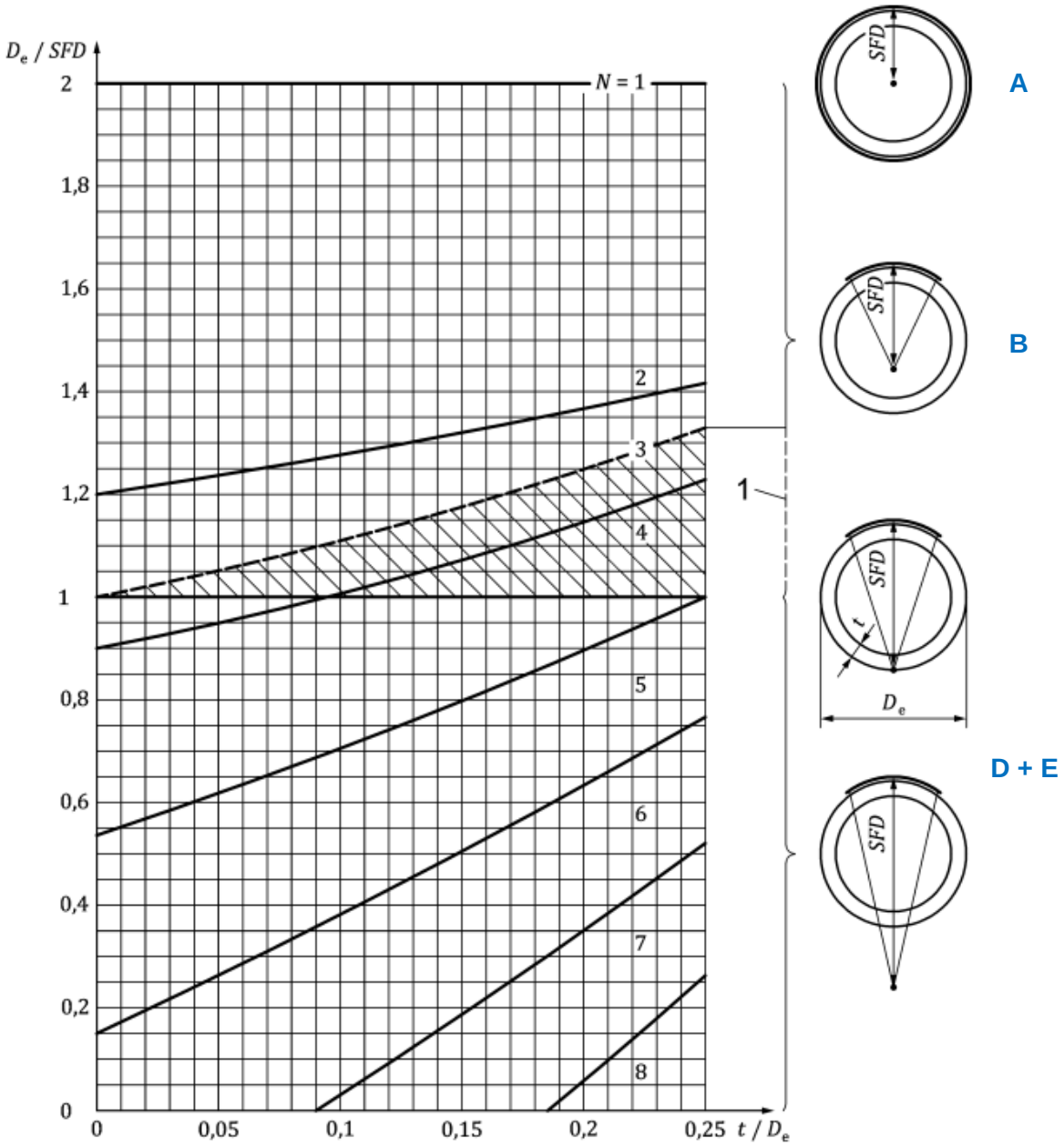
X-Ray Tube

> 3 1/2 - 6 `` 160 kV Tube source to OD + 75 mm
> 8 - 48 `` 450 kV Tube source to OD + 170 mm

DN	"	Ø mm	5S	5	10S	10	20	30	40S	STD	40	60	80S	XS	80	100	120	140	160	XXS
15	1/2	21.3	1.65	1.65	2.11	2.11	--	2.41	2.77	2.77	2.77	--	3.73	3.73	3.73	--	--	--	4.78	7.47
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
20	3/4	26.6	1.65	1.65	2.11	2.11	--	2.41	2.87	2.87	2.87	--	3.91	3.91	3.91	--	--	--	5.56	7.82
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
25	1	33.4	1.65	1.65	2.77	2.77	--	2.90	3.38	3.38	3.38	--	4.55	4.55	4.55	--	--	--	6.35	9.09
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
32	1 ¼	42.1	1.65	1.65	2.77	2.77	--	2.97	3.56	3.56	3.56	--	4.85	4.85	4.85	--	--	--	6.35	9.70
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				2/3	3
40	1 ½	48.2	1.65	1.65	2.77	2.77	--	3.18	3.68	3.68	3.68	--	5.08	5.08	5.08	--	--	--	7.14	10.15
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				2/3	3
50	2	60.3	1.65	1.65	2.77	2.77	--	3.18	3.91	3.91	3.91	--	5.54	5.54	5.54	--	--	--	8.74	11.07
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
--	2 ½	73.0	2.11	2.11	3.05	3.05	--	4.78	5.16	5.16	5.16	--	7.01	7.01	7.01	--	--	--	9.53	14.02
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
65	--	76.1	2.11	2.11	3.05	3.05	--	4.78	5.16	5.16	5.16	--	7.01	7.01	7.01	--	--	--	9.53	14.02
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
80	3	88.9	2.11	2.11	3.05	3.05	--	4.78	5.49	5.49	5.49	--	7.62	7.62	7.62	--	--	--	11.13	15.24
			2/3	2/3	2/3	2/3		2/3	2/3	2/3	2/3		2/3	2/3	2/3				3	3
--	3 ½	101	2.11	2.11	3.05	3.05	--	4.78	5.74	5.74	5.74	--	8.08	8.08	8.08	--	--	--	--	--
			5	5	5	5		5	5	5	5		(5)	(5)	(5)				--	--
100	4	114	2.11	2.11	3.05	3.05	--	4.78	6.02	6.02	6.02	--	8.56	8.56	8.56	--	11.13	--	13.49	17.12
			4	4	4	4		5	5	5	5		(5)	(5)	(5)		(5)		(5)	(5)
125	5	141	2.77	2.77	3.40	3.40	--	--	6.55	6.55	6.55	--	9.53	9.53	9.53	--	12.70	--	15.88	19.05
			4	4	4	4			4	4	4		(4)	(4)	(4)		(5)		(5)	(5)
150	6	168	2.77	2.77	3.40	3.40	--	--	7.11	7.11	7.11	--	10.97	10.97	10.97	--	14.27	--	18.26	21.95
			4	4	4	4			4	4	4		(4)	(4)	(4)		(4)		(5)	(5)
200	8	219	2.77	2.77	3.76	3.76	6.35	7.04	8.18	8.18	8.18	10.31	12.70	12.70	12.70	15.09	18.26	20.62	23.01	22.23
			5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
250	10	273	3.40	3.40	4.19	4.19	6.35	7.80	9.27	9.27	9.27	12.70	12.70	12.70	15.09	18.26	21.44	25.40	28.58	25.40
			4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5
300	12	323	3.96	3.96	4.57	4.57	6.35	8.38	9.53	9.53	10.31	14.27	12.70	12.70	17.48	21.44	25.40	28.58	33.32	25.40
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5
350	14	355	3.96	3.96	4.78	6.35	7.92	9.53	9.53	9.53	11.13	15.09	12.70	12.70	19.05	23.83	27.79	31.75	35.71	--
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	

DN	"	Ø mm	5S	5	10S	10	20	30	40S	STD	40	60	80S	XS	80	100	120	140	160	XXS
400	16	406	4.19	4.19	4.78	6.35	7.92	9.53	9.53	9.53	12.70	16.66	12.70	12.70	21.44	26.19	30.96	36.53	40.49	--
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
450	18	457	4.19	4.19	4.78	6.35	7.92	11.13	9.53	9.53	14.27	19.05	12.70	12.70	23.83	29.36	34.93	39.67	45.24	--
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
500	20	508	4.78	4.78	5.54	6.35	9.53	12.70	9.53	9.53	15.09	20.62	12.70	12.70	26.19	32.54	38.10	44.45	50.01	--
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
550	22	558	4.78	4.78	5.54	6.35	9.53	12.7	9.53	9.53	--	22.3	12.7	12.7	28.58	34.93	41.28	47.63	53.98	--
			4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	
600	24	609	5.54	5.54	6.35	6.35	9.53	14.27	9.53	9.53	17.48	24.61	12.70	12.70	30.96	38.89	46.02	52.37	59.54	--
			4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	
650	26	660	--	--	--	7.92	12.70	15.88	--	9.53	--	--	--	12.70	--	--	--	--	--	--
						4	4	4		4				4						
700	28	711	--	--	--	7.92	12.70	15.88	--	9.53	--	--	--	12.70	--	--	--	--	--	--
						4	4	4		4				4						
750	30	762	6.35	6.35	7.92	7.92	12.70	15.88		9.53				12.70						
			4	4	4	4	4	4		4				4						
800	32	812	--	--	--	7.92	12.70	15.88	--	9.53	17.48	--	--	12.70	--	--	--	--	--	--
						4	4	4		4	4			4						
850	34	863	--	--	--	7.92	12.70	15.88	--	9.53	17.48	--	--	12.70	--	--	--	--	--	--
						4	4	4		4	4			4						
900	36	914	--	--	--	7.92	12.70	15.88	--	9.53	--	--	--	12.70	--	--	--	--	--	--
						4	4	4		4				4						
1000	40	1016	--	--	--	--	--	--	--	9.53	--	--	--	12.70	--	--	--	--	--	--
										4				4						
1200	48	1219	--	--	--	--	--	--	--	9.53	--	--	--	12.70	--	--	--	--	--	--
										4				4						

At exposure arrangement A, B, D or E, the ISO 17636-1 table below can be used, as a guide.

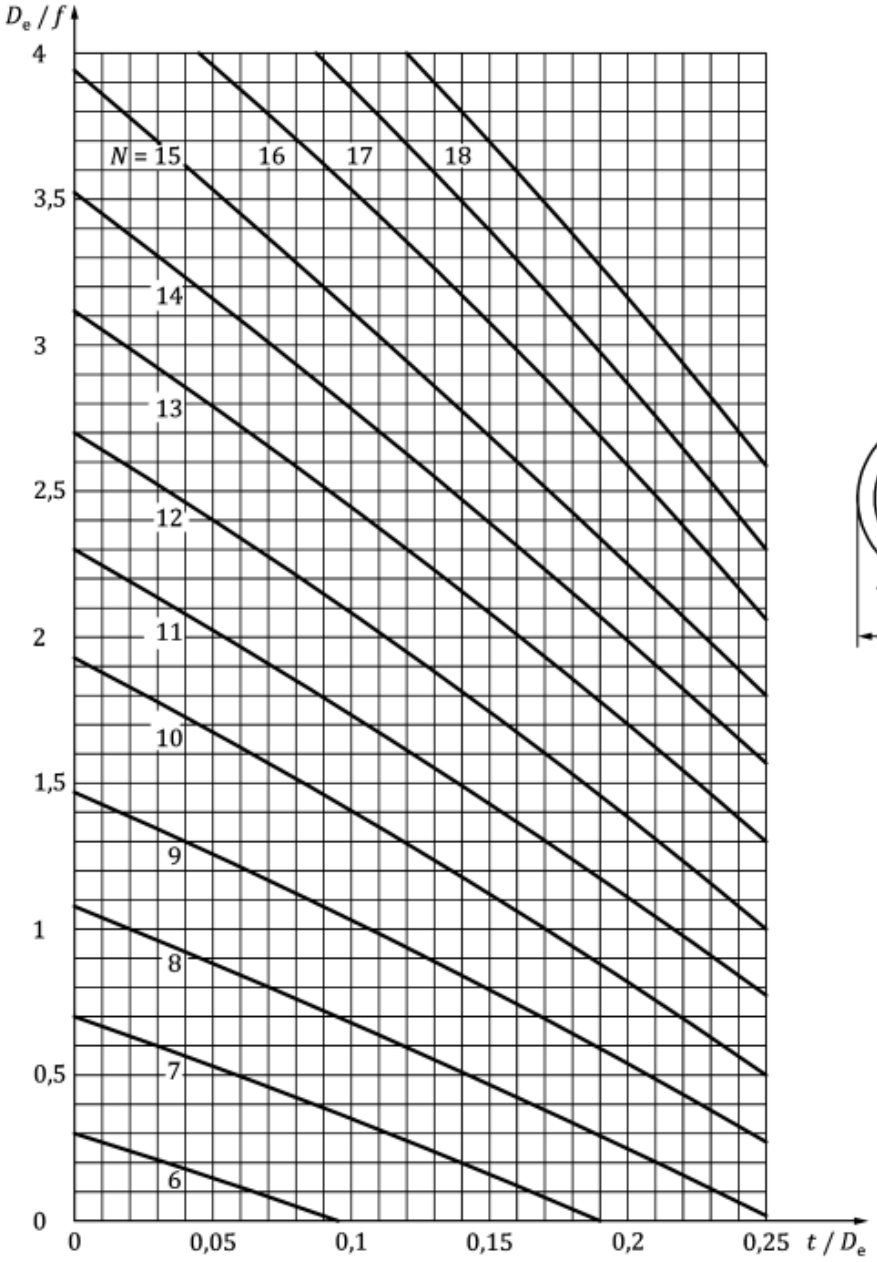


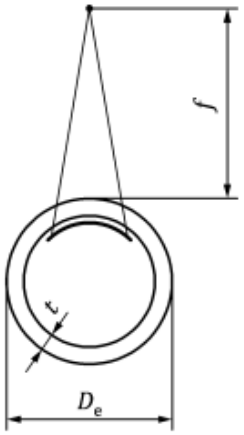
Enclosure 2: Number of exposures at arrangement C

At exposure arrangement C the minimum number of exposures shall be determined;

- make a first exposure, and determine the boundary / area of interest, within density requirement of (1.8) 2.0 – 4.0 and IQI requirement (+30% / -15%); see chapter 12.
- calculate how many exposures it takes, for complete coverage.

At circular welds on pipelines, the ISO 17636-1 table below can be used, as a guide.





C

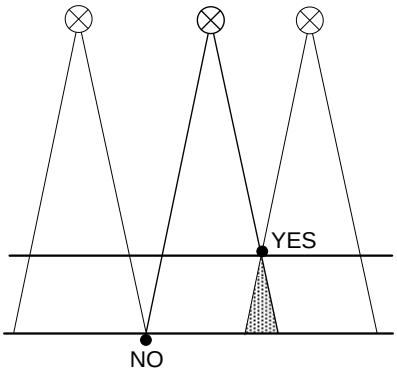
At nozzle welds, an adequate number of exposures shall be made to demonstrate, that the required coverage has been obtained.

Enclosure 3: Location markers

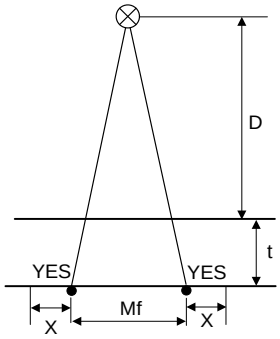
Reference: ASME V, Article 2, Figure T-275

Legend:
- ⊗ radiation source
- • localization markers
- + component center
- ▒ overlap

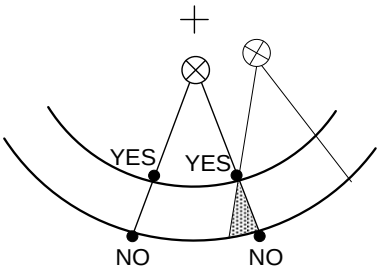
Position of the localization markers:
YES **acceptable**
NO **not acceptable**



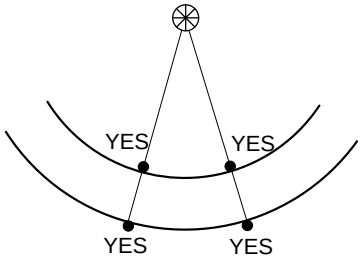
plates, longitudinal welds



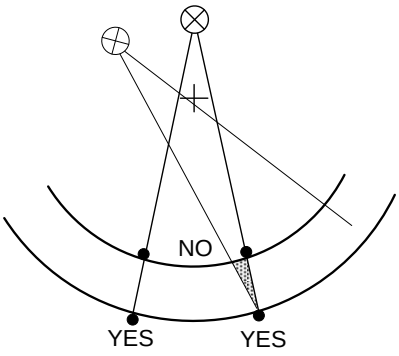
only if additional coverage: $X = \frac{t \cdot Mf}{D \cdot 2}$



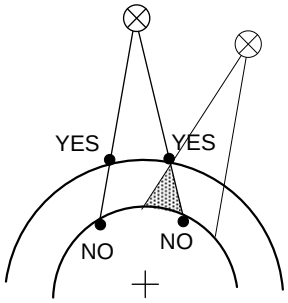
curved components from the inside
with source-film distance lesser than radius



curved components from the inside
with source-film distance equal to the radius



curved components from the inside
with source-film distance greater than radius



curved components from the outside

Attachment 1 UW-51 RADIOGRAPHIC EXAMINATION OF WELDED JOINTS

(a) All welded joints to be radiographed shall be examined in accordance with Section V, Article 2, except as specified below.

(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 Division (10-13)

(2) 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 Section V, Article 2, T-274.2, are to be used only as a guide for film-based radiography.

(4) As an alternative to the radiographic examination requirements above, all welds in which the thinner of the members joined is 1/4 in. (6 mm) thick and greater may be examined using the ultrasonic (UT) method specified by UW-53(b).

(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.

In lieu of reexamination by radiography, the repaired weld may be ultrasonically examined in accordance with Mandatory Appendix 12 at the Manufacturer's option. For material thicknesses in excess of 1 in. (25 mm), the concurrence of the user shall be obtained.

This ultrasonic examination shall be noted under Remarks on the Manufacturer's Data Report Form:

(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)	for t up to 3/4 in. (19 mm)
(-b) 1/3t	for t from 3/4 in. (19 mm) to 2 1/4 in. (57 mm)
(-c) 3/4 in. (19 mm)	for t over 2 1/4 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 Mandatory Appendix 4.

ASME BPVC Section VIII MANDATORY APPENDIX 4

ROUNDED INDICATIONS CHARTS ACCEPTANCE STANDARD FOR RADIOGRAPHICALLY DETERMINED ROUNDED INDICATIONS IN WELDS

APPLICABILITY OF THESE STANDARDS

These standards are applicable to ferritic, austenitic, and nonferrous materials.

Table 4-1

Customary Units

Thickness, t, in.	Maximum Size of Acceptable Rounded Indication, in. Random	Maximum Size of Acceptable Rounded Indication, in. Isolated	Maximum Size of Nonrelevant Indication, in.
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 Random	Maximum Size of Acceptable Rounded Indication, mm Isolated	Maximum Size of Nonrelevant Indication, mm
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.

4-2 TERMINOLOGY

(a) Rounded Indications. Indications with a maximum length of three times the width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical, or irregular in shape and may have tails. 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 .

4-3 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.)

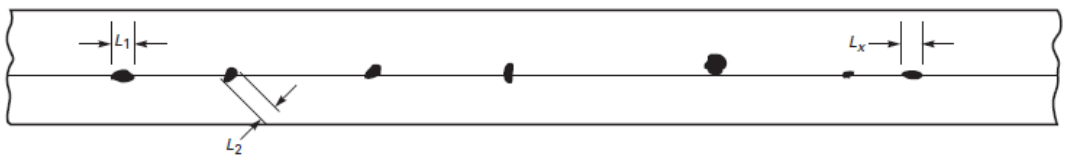
Only those rounded indications which exceed the following dimensions shall be considered relevant.

(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. to 1/4 in. (3 mm to 6 mm), incl.
(3) 1/32 in. (0.8 mm)	for t greater than 1/4 in. to 2 in. (6 mm to 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.)

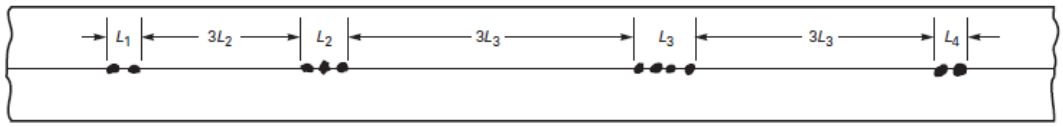
The maximum permissible size of any indication shall be 1/4t, or 5/32 in. (4 mm), whichever is smaller; except that an isolated indication separated from an adjacent indication by 1 in. (25 mm) or more may be 1/3t, or 1/4 in. (6 mm), whichever is less. For t greater than 2 in. (50 mm) the maximum permissible size of an isolated indication shall be increased to 3/8 in. (10 mm).

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 $12t$.

(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.

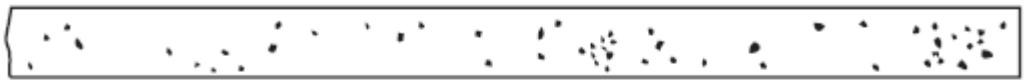
(e) Spacing. The distance between adjacent rounded indications is not a factor in determining acceptance or rejection, except as required for isolated indications or groups of aligned indications.

(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 thickness range 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 on the radiograph, but are typical of the concentration and size of indications permitted.

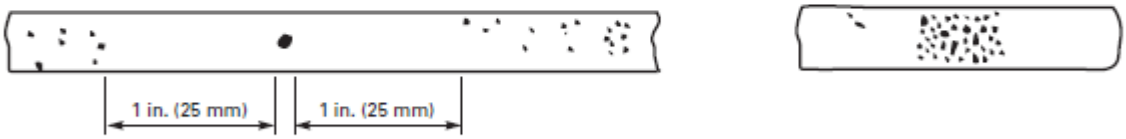
(g) Weld Thickness t Less Than 1/8 in. (3 mm). For t less than 1/8 in. (3 mm) the maximum number of rounded indications shall not exceed 12 in a 6 in. (150 mm) length of weld. A proportionally fewer number of indications shall be permitted in welds less than 6 in. (150 mm) in length.

(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.

Figure 4-3
Charts for t Equal to $\frac{3}{8}$ in. to $\frac{1}{4}$ in. (3 mm to 6 mm), Inclusive



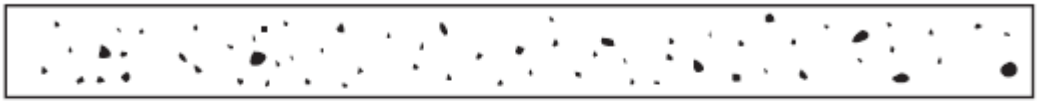
(a) Random Rounded Indications [See Note (1)]



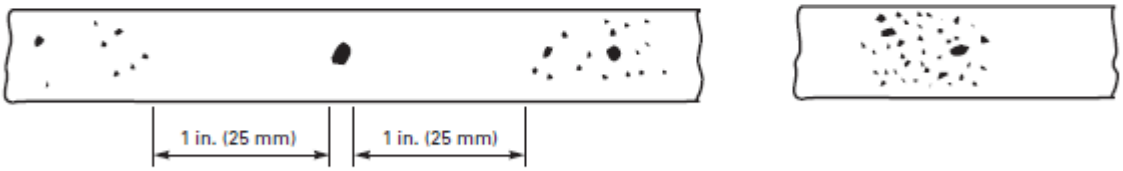
(b) Isolated Indication [See Note (2)] (c) Cluster

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

Figure 4-4
Charts for t Over $\frac{1}{4}$ in. to $\frac{3}{8}$ in. (6 mm to 10 mm), Inclusive



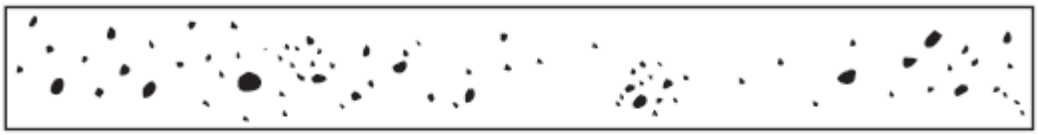
(a) Random Rounded Indications [See Note (1)]



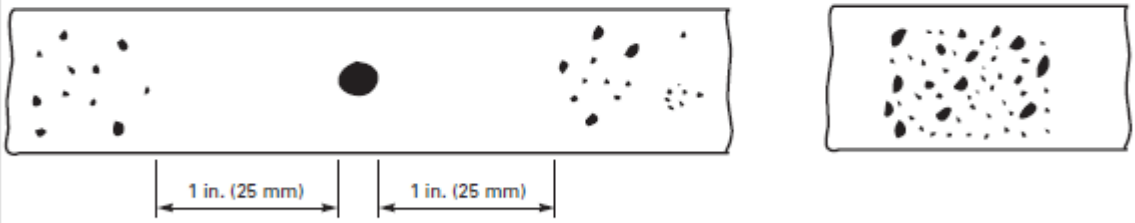
(b) Isolated Indication [See Note (2)] (c) Cluster

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. to $^3/_4$ in. (10 mm to 19 mm), Inclusive



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



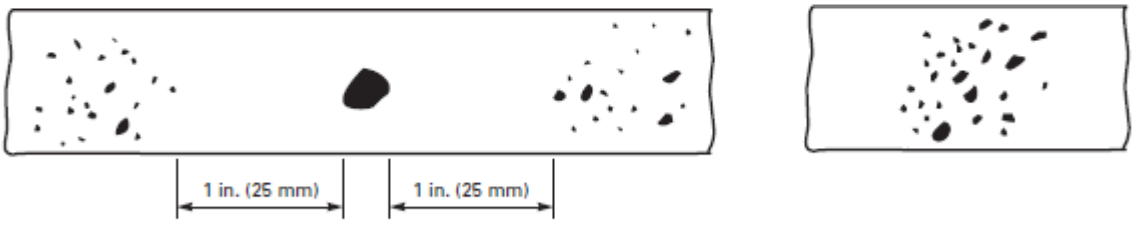
(b) Isolated Indication [See Note (2)]

(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.

Figure 4-6
Charts for t Over $^3/_4$ in. to 2 in. (19 mm to 50 mm), Inclusive

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

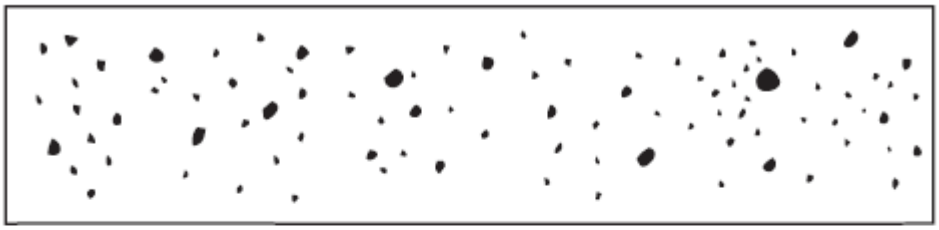


(b) Isolated Indication [See Note (2)]

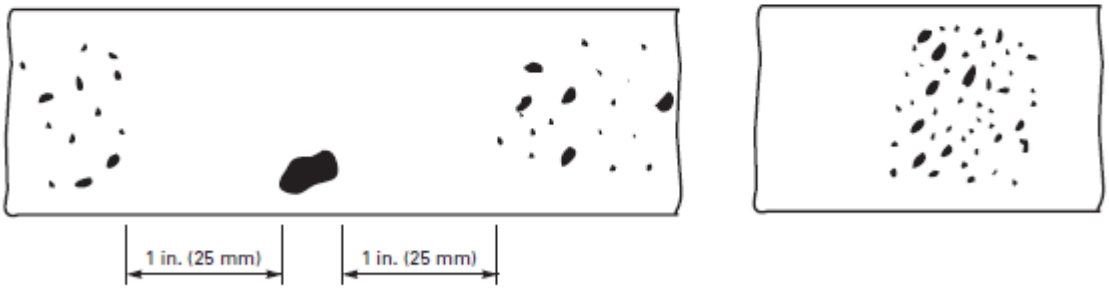
(c) Cluster

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. to 4 in. (50 mm to 100 mm), Inclusive



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

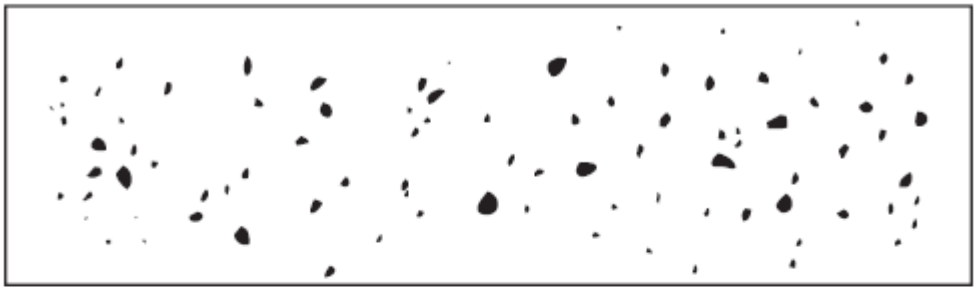


(b) Isolated Indication [See Note (2)]

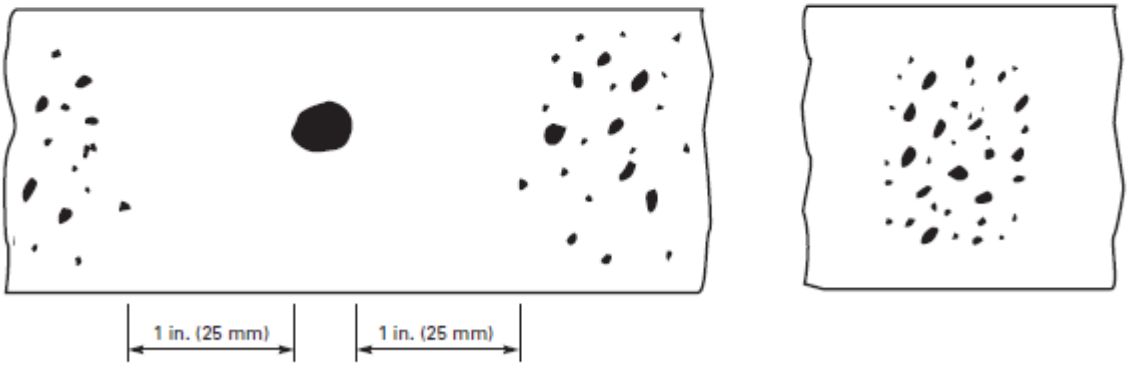
(c) Cluster

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.

Attachment 2 UW-52 SPOT EXAMINATION OF WELDED JOINTS

NOTE: Spot radiographing of a welded joint is recognized as an effective inspection tool. The spot radiography rules are also considered to be an aid to quality control. Spot radiographs made directly after a welder or an operator has completed a unit of weld proves that the work is or is not being done in accordance with a satisfactory procedure. If the work is unsatisfactory, corrective steps can then be taken to improve the welding in the subsequent units, which unquestionably will improve the weld quality.

Spot radiography in accordance with these rules will not ensure a fabrication product of predetermined quality level throughout. It must be realized that an accepted vessel under these spot radiography rules may still contain defects which might be disclosed on further examination. If all radiographically disclosed weld defects must be eliminated from a vessel, then 100% radiography must be employed.

(a) Butt-welded joints that are to be spot radiographed shall be examined locally as provided herein.

(b) Minimum Extent of Spot Radiographic Examination

(1) One spot shall be examined on each vessel for each 50 ft (15 m) increment of weld or fraction thereof for which a joint efficiency from column (b) of Table UW-12 is selected. However, for identical vessels or parts, each with less than 50 ft (15 m) of weld for which a joint efficiency from column (b) of Table UW-12 is selected, 50 ft (15 m) increments of weld may be represented by one spot examination.

(2) For each increment of weld to be examined, a sufficient number of spot radiographs shall be taken to examine the welding of each welder or welding operator. Under conditions where two or more welders or welding operators make weld layers in a joint, or on the two sides of a double-welded butt joint, one spot may represent the work of all welders or welding operators.

(3) Each spot examination shall be made as soon as practicable after completion of the increment of weld to be examined. The location of the spot shall be chosen by the Inspector after completion of the increment of welding to be examined, except that when the Inspector has been notified in advance and cannot be present or otherwise make the selection, the Manufacturer may exercise his own judgment in selecting the spots.

(4) Radiographs required at specific locations to satisfy the rules of other paragraphs, such as UW-9(d), UW-11(a)(5)(-b), and UW-14(b), shall not be used to satisfy the requirements for spot radiography.

(c) Standards for Spot Radiographic Examination.

Spot examination by radiography shall be made in accordance with the technique prescribed in UW-51(a). The minimum length of spot radiograph shall be 6 in. (150 mm). Spot radiographs may be retained or be discarded by the Manufacturer after acceptance of the vessel by the Inspector. The acceptability of welds examined by spot radiography shall be judged by the following standards:

(1)Welds in which indications are characterized as cracks or zones of incomplete fusion or penetration shall be unacceptable.

(2) Welds having indications characterized as slag inclusions or cavities are unacceptable when the indication length exceeds 2/3t, where t is defined as shown in UW-51(b)(2). For all thicknesses, indications less than 1/4 in. (6 mm) are acceptable, and indications greater than 3/4 in. (19 mm) are unacceptable. Multiple aligned indications meeting these acceptance criteria are acceptable when the sum of their longest dimensions indications does not exceed t within a length of 6t (or proportionally for radiographs shorter than 6t), and when the longest length L for each indication is separated by a distance not less than 3L from adjacent indications.

(3) Rounded indications are not a factor in the acceptability of welds not required to be fully radiographed.

(d) Evaluation and Retests

(1) When a spot, radiographed as required in (b)(1) or (b)(2) above, is acceptable in accordance with (c)(1) and (c)(2) above, the entire weld increment represented by this radiograph is acceptable.

(2) When a spot, radiographed as required in (b)(1) or (b)(2) above, has been examined and the radiograph discloses welding which does not comply with the minimum quality requirements of (c)(1) or (c)(2) above, two additional spots shall be radiographically examined in the same weld increment at locations away from the original spot. The locations of these additional spots shall be determined by the Inspector or fabricator as provided for the original spot examination in (b)(3) above.

(-a) If the two additional spots examined show welding which meets the minimum quality requirements of (c)(1) and (c)(2) above, the entire weld increment represented by the three radiographs is acceptable provided the defects disclosed by the first of the three radiographs are removed and the area repaired by welding. The weld repaired area shall be radiographically examined in accordance with the foregoing requirements of UW-52.

(-b) If either of the two additional spots examined shows welding which does not comply with the minimum quality requirements of (c)(1) or (c)(2) above, the entire increment of weld represented shall be rejected. The entire rejected weld shall be removed and the joint shall be rewelded or, at the fabricator's option, the entire increment of weld represented shall be completely radiographed and only defects need be corrected.

(-c) Repair welding shall be performed using a qualified procedure and in a manner acceptable to the Inspector. The rewelded joint, or the weld repaired areas, shall be spot radiographically examined at one location in accordance with the foregoing requirements of UW-52.

Attachment 3 API Standard 610 / ISO 13709

Unless otherwise specified, inspection methods and acceptance criteria shall be in accordance with those in Table 15 as required by the material specification.

If additional radiographic, ultrasonic, magnetic-particle or liquid-penetrant examination of the welds or materials is specified by the purchaser, the methods and acceptance criteria shall also be in accordance with the standards shown in Table 15.

Alternative standards may be proposed by the vender or specified by the purchaser.

Table 15 – Materials inspection standards

Type of inspection	Methods	Acceptance criteria	
		For fabrications	For castings
Radiography	ASME BPVC, Section V, Articles 2 and 22	ASME BPVC, Section VIII, Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography)	ASME BPVC, Section VIII, Division 1, Appendix 7
Ultrasonic inspection	ASME BPVC, Section V, Articles 5 and 23	ASME BPVC, Section VIII, Division 1, Appendix 12	ASME BPVC, Section VIII, Division 1, Appendix 7
Liquid-penetrant inspection	ASME BPVC, Section V, Articles 6 and 24	ASME BPVC, Section VIII, Division 1, Appendix 8	ASME BPVC, Section VIII, Division 1, Appendix 7
Magnetic-particle inspection	ASME BPVC, Section V, Articles 7 and 25	ASME BPVC, Section VIII, Division 1, Appendix 6	ASME BPVC, Section VIII, Division 1, Appendix 7
Visual Inspection (all surfaces)	ASME BPVC, Section V, Article 9	In accordance with the material specification and the manufacturer's documented procedures	MSS SP-55

Attachment 4 ASME B31.3 Severe Cyclic Condition

Type of Weld: Girth, Milter Groove & Branch Connection
Longitudinal Groove

Weld Imperfection	Measure	Limits
Crack	Extend of imperfection	Zero (no evident imperfection)
Lack of Fusion	Extend of imperfection	Zero (no evident imperfection)
Incomplete Penetration	Extend of imperfection	Zero (no evident imperfection)
Rounded Indications	Size and distribution of rounded indications	See BPV Code, Section VIII, Division 1, Man. Appendix 4; see § UW-51 above
Internal slag inclusion, tungsten inclusion, or elongated indication	Individual length Individual width Cumulative length	≤ T_w/3 ≤2.5 mm (3/32 in.) and T_w/3 ≤T_w in any 12 *Tw* weld length
Undercutting	Extend of imperfection	Zero (no evident imperfection)
Surface porosity or exposed slag inclusion	Extend of imperfection	Zero (no evident imperfection)
Surface finish	Surface roughness	≤500 min. Ra in acc. with ASME B46.1
Concave surface	Depth of surface concavity	Total joint thickness, incl. weld reinf., ≥T_w
Weld reinforcement or internal protrusion	Height of reinforcement or internal protrusion	for T_w mm (in.) / Height mm (in.) ≤ 6 (1/4) / ≤ 1.5 (1/16) > 6 (1/4), ≤ 13 (1/2) / ≤ 3 (1/8) > 13 (1/2), ≤ 25 (1) / ≤ 4 (5/32) > 25 (1) / ≤ 5 (3/16)

.

Attachment 5 ASME B31.3 Normal and Category M Fluid Service

Type of Weld: Girth, Milter Groove & Branch Connection

Weld Imperfection	Measure	Limits
Crack	Extend of imperfection	Zero (no evident imperfection)
Lack of Fusion	Extend of imperfection	Zero (no evident imperfection)
Incomplete Penetration	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
Rounded Indications	Size and distribution of rounded indications	- for T_w ≤ 6 mm (1/4 in.), Limit see BPV Code, Section VIII, Div. 1, Man. Appendix 4; see § UW-51 above - for T_w > 6 mm (1/4 in.), Limit is 1.5 x bigger
Internal slag inclusion, tungsten inclusion, or elongated indication	Individual length Individual width Cumulative length	≤ T_w/2 ≤ 3 mm (1/8 in.) and T_w/2 ≤ 4T_w in any 150 mm (6 in.) weld length
Undercutting	Depth of undercut	≤ 1 mm (1/32 in.) and ≤ T_w/4
Surface porosity or exposed slag inclusion	Extend of imperfection	Zero (no evident imperfection)
Surface finish	Surface roughness	N/A
Concave surface	Depth of surface concavity	Total joint thickness, incl. weld reinf., ≥T_w
Weld reinforcement or internal protrusion	Height of reinforcement or internal protrusion	for T_w mm (in.) / Height mm (in.) ≤ 6 (1/4) / ≤ 1.5 (1/16) > 6 (1/4), ≤ 13 (1/2) / ≤ 3 (1/8) > 13 (1/2), ≤ 25 (1) / ≤ 4 (5/32) > 25 (1) / ≤ 5 (3/16) .

Type of Weld: Longitudinal Groove

Weld Imperfection	Measure	Limits
Crack	Extend of imperfection	Zero (no evident imperfection)
Lack of Fusion	Extend of imperfection	Zero (no evident imperfection)
Incomplete Penetration	Extend of imperfection	Zero (no evident imperfection)
Rounded Indications	Size and distribution of rounded indications	- for T_w ≤ 6 mm (1/4 in.), Limit see BPV Code, Section VIII, Div. 1, Man. Appendix 4; see § UW-51 above - for T_w > 6 mm (1/4 in.), Limit is 1.5 x bigger
Internal slag inclusion, tungsten inclusion, or elongated indication	Individual length Individual width Cumulative length	≤ T_w/2 ≤ 3 mm (1/8 in.) and T_w/2 ≤ 4T_w in any 150 mm (6 in.) weld length
Undercutting	Extend of imperfection	Zero (no evident imperfection)
Surface porosity or exposed slag inclusion	Extend of imperfection	Zero (no evident imperfection)
Surface finish	Surface roughness	N/A
Concave surface	Depth of surface concavity	Total joint thickness, incl. weld reinf., ≥T_w
Weld reinforcement or internal protrusion	Height of reinforcement or internal protrusion	for T_w mm (in.) / Height Mm (in.) ≤ 6 (1/4) / ≤ 1.5 (1/16) > 6 (1/4), ≤ 13 (1/2) / ≤ 3 (1/8) > 13 (1/2), ≤ 25 (1) / ≤ 4 (5/32) > 25 (1) / ≤ 5 (3/16) .

Attachment 6 ASME B31.1 at temperatures > 175°C (350°F)

Type of Weld: Branch Connections

Weld Imperfection	Measure	Limits
Crack	Extend of imperfection	Zero (no evident imperfection)
Lack of Fusion	Extend of imperfection	Zero (no evident imperfection)
Incomplete Penetration	Extend of imperfection	Zero (no evident imperfection)
Rounded Indications	Size and distribution of rounded indications	See BPV Code, Section I, Appendix A-250; see below
Internal slag inclusion, tungsten inclusion, or elongated indication	Individual length Individual width Cumulative length	max. Length mm (in.) / Thickness *t* mm (in.) 6 (1/4) / ≤ 19 (3/4) 1/3 *t* / 19 (3/4) < *t* ≤ 57 (2 1/4) 19 (3/4) / > 57 (2 1/4)
Group of indications in line	Aggregated length	*t* in a length of 12*t,* except where the distance between the successive indications exceed 6L where L is the longest indication in the group
Undercutting	Extend of imperfection	> 1 mm (1/32 in.) deep
Root concavity	Depth of surface concavity	When there is an abrupt change in density, as indicated on the radiograph
Weld reinforcement	Extend of imperfection	Thickness base metal *t* mm (in.) / max. thickness of reinforcement mm (in.): > 400°C (750°F) / 175°C-400°C (350°F-750°F) ≤ 3 (1/8) / 2 (1/16) / 2.5 (3/32) 3 (1/8) < *t* ≤ 5 (3/16) / 2 (1/16) / 3 (1/8) 5 (3/16) < *t* ≤ 13 (1/2) / 2 (1/16) / 4 (5/32) 13 (1/2) < *t* ≤ 25 (1) / 2.5 (3/32) / 5 (3/16) 25 (1) < *t* ≤ 50 (2) / 3 (1/8) / 6 (3/16) > 50 (2) / 4 (5/32) / The greater of 6 (1/4) or 1/8 times the width of the weld

Attachment 7 ASME BPVC Section I

A-250 ACCEPTANCE STANDARD FOR RADIOGRAPHICALLY DETERMINED ROUNDED INDICATIONS IN WELDS

A-250.1 Applicability of These Standards. These standards are applicable to ferritic, austenitic, and nonferrous materials.

A-250.2 Terminology.

A-250.2.1 Rounded Indications. Indications with a maximum length of three times the width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, conical, or irregular in shape and may have tails. 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.

A-250.2.2 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.

A-250.2.3 Thickness t . t is the thickness of the weld, excluding any allowable reinforcement. For a butt weld joining two parts 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 fillet weld throat shall be included in t .

A-250.3 Acceptance Criteria.

A-250.3.1 Image Density. Density within the image of the indication may vary and is not a criterion for acceptance or rejection.

A-250.3.2 Relevant Indications (See Table A-250.3.2 for Examples). Only those rounded indications which exceed the following dimensions shall be considered relevant:

(a) 1/10t	for t less than 1/8 in. (3 mm)
(b) 1/64 in. (0.4 mm)	for t 1/8 in. (3 mm) to 1/4 in. (6 mm), inclusive
(c) 1/32 in. (0.8 mm)	for t 1/4 in. (6 mm) to 2 in. (50 mm), inclusive
(d) 1/16 in. (1.6 mm)	for t greater than 2 in. (50 mm)

A-250.3.3 Maximum Size of Rounded Indication (See Table A-250.3.2 for Examples). The maximum permissible size of any indication shall be 1/4t , 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 1/3t , or 1/4 in. (6 mm), whichever is less. For t greater than 2 in. (50 mm) the maximum permissible size of an isolated indication shall be increased to 3/8 in. (10 mm).

A-250.3.4 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 A-250.3.4-1). The length of groups of aligned rounded indications and the spacing between the groups shall meet the requirements of Figure A-250.3.4-2.

A-250.3.5 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.

A-250.3.6 Rounded Indication Charts. The rounded indications characterized as imperfections shall not exceed that shown in the charts.

The charts in Figures A-250.3.6-1 through A-250.3.6-6 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 chart for each thickness range represents 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 on the radiograph, but are typical of the concentration and size of indications permitted.

A-250.3.7 Weld Thickness t Less Than 1/8 in. (3 mm). 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.

A-250.3.8 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 of weld.

Table A-250.3.2
Maximum Permissible Size of Rounded Indication
(Examples Only)

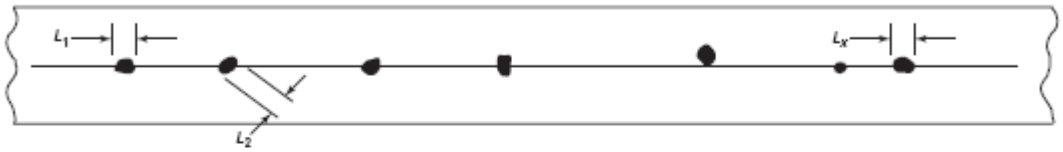
U.S. Customary Units

Thickness t, in.	Maximum Size of Acceptable Rounded Indication, in.		Maximum Size of Nonrevelant Indication, in.
	Random	Isolated	
Less than 1/8	1/4t	1/3t	1/10t
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

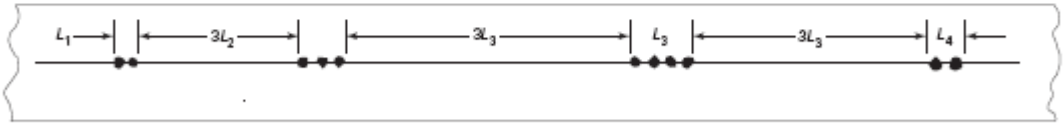
Thickness t, mm	Maximum Size of Acceptable Rounded Indication, mm		Maximum Size of Nonrevelant Indication, mm
	Random	Isolated	
Less than 3	1/4t	1/3t	1/10t
3	0.79	1.07	0.38
5	1.19	1.60	0.38
6	1.60	2.11	0.38
8	1.98	2.64	0.79
10	2.31	3.18	0.79
11	2.77	3.71	0.79
13	3.18	4.27	0.79
14	3.61	4.78	0.79
16	3.96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

Figure A-250.3.4-1
Aligned Rounded Indications



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

Figure A-250.3.4-2
Groups of Aligned Rounded Indications



Maximum Group Length
L = 1/4 in. (6 mm) for t less than 3/4 in. (19 mm)
L = 1/3 t 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)

Minimum Group Spacing
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.