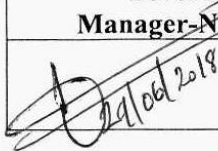
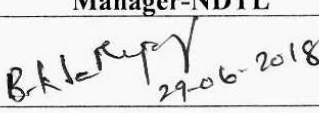
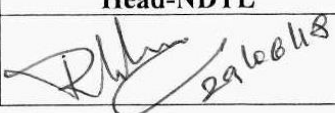


PROCEDURE FOR RADIOGRAPHIC EXAMINATION OF WELDS

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RECORD OF REVISION

Rev No	Revision Date	Revision of Details
03to 06	01-06-1983 01-03-1990	Revision details are maintained separately
07	28-03-1994	Changed for its entirety to include ASME Section VIII Div I and 2
08	01-08-1996	Revised in entirety
09	25-02-1997	ProceduresBHE:NDT:PB:RT01/01,01/02and01/03 merged with this procedure and revised in its entirety
10	10-06-1997	Revised to incorporate the revision in ASME Section V/1995-1996 Addenda. Clause 16 modified
11	11-05-1998	Clauses 2.1,6.1,10.1,22.1 and 23.1 revised
12	20-03-2000	Clauses 2.0,6.1 and Annexure I modified
13	28-12-2002	Clause 4.2.1 deleted. 8.1, 10.2, 11.1.1, 13.1, 17.4, revised. Annexure I and II modified.
14	15-03-2005	2.0, 10.2, 12.3 Modified. Annexure-I Revised. Annexure III modified.
15	28-12-2006	Clause 2.1 Revised Annexure III- Figure 6 Revised.
16	30-12-2007	Clause 2.1 Revised
17	31-12-2009	Clause 2.1 Revised. Clause 19.2 Modified. Porosity Acceptance level charts added
18	15-12-2011	Clause 2.1, 2.2 Revised Clause 6.1.1 Clause 10.3, 16.5.1, 17.2.1,17.3.1 Revised Clause 18.1.7 Added
19	30-01-2015	Clauses 2.1, 2.2., 5.2.2, 6.5.2, 11.1.1, 14.2.1, 17.4.1, Annexure-I and Annexure-II revised
20	01-01-2016	Clause 2.1 revised Clause 1.1,5.2.1,6.2.1,11.1.1,22.1 modified
21	07-10-2017	Clause 5.2.1,5.2.2,6.5.2,12.3 revised. Clause 11.1.1 (a),(b) deleted. Clause 13.1.1,20.5 added
22	28-06-2018	Clause 1.1,2.1,2.2,4.1,6.4.1,6.5,6.5.1,6.5.2,8.1,13.1,21.1 revised. Annexure III column 1 revised



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1.0 SCOPE

1.1 This procedure describes the techniques and acceptance standard for Radiographic Examination of butt welds in steel (Carbon Steel, Alloy Steel, Stainless Steel etc.) and nonferrous materials up to 200 mm thickness, of boilers (drums, headers, pipelines etc.), Pressure Vessel and Heat Exchanger components.

2.0 REFERENCE

2.1 ASME Section I, V, VIII (Divn.1 & 2) 2017 Edition.

2.2 ASME B 31.1 / 2016

3.0 SURFACE PREPARATION

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

3.2 The finished surface of all welded joints may be flush with the base material or may have reasonably uniform crowns, with reinforcement not to exceed that specified in Annexure I in each face. If there is a question regarding the surface condition of the weld when interpreting radiographs, then radiographs shall be compared to the actual weld surface for determination of acceptability.

4.0 BACK SCATTER RADIATION

4.1 A lead letter 'B' of minimum 1.5 mm thick and 13 mm height shall be attached to the back of each film holder within the area of radiograph which meets the density requirements mentioned in para 17.1 to 17.3 during each exposure to determine if back scatter is exposing the film.

4.2 Excessive back-scatter: If the image of the letter 'B' appears as lighter density than the back ground, it is an indication that protection against back scattering is insufficient and that additional Lead backing shall be used.

5.0 SYSTEM IDENTIFICATION

5.1 Each radiograph shall have a permanent identification traceable to the contract, component, and weld seam or part numbers as appropriate.

5.2 In addition BHEL symbol or manufacturer's name and the date of the radiography shall be plainly and permanently included on the radiograph.

5.2.1 This identification system does not necessarily require that the information appear as radiographic images. It can be done either by placing lead numbers during radiographic exposure or vibro etching on the radiograph. These information shall not obscure the area of interest.

5.2.2 These images will appear on all the radiographs exposed individually or by panoramic exposure.

5.3 For longitudinal welds in shells or in plate formed pipes the reference for the start of the segment shall be from one end of the weld. Sufficient overlap in the film shall be given to ensure 100% coverage in radiograph.



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- 5.4 The entire longitudinal seam shall be divided, stamped and marked into number of segments.
- 5.5 Any geometric imperfection that requires rework by surface conditioning (and not by welding) after initial radiography, the affected area shall be blended smooth with adjoining surfaces by grinding to avoid sharp notches, crevices or corners.
- 5.6.1 The blended area shall be re-radiographed with letters suffixed G1, G2, G3 etc. to the original identification number to denote the number of times the weld has undergone surface conditioning.
- 5.7 Letters R1, R2 etc will be suffixed to the original identification number, when radiographs are taken after repair by welding, to denote the number of times the weld has undergone repair.
- 5.8 Wherever retake has been performed, letters RT/(RT1), RT2 etc. will be suffixed to the original identification number.
- 6.0 EQUIPMENT AND MATERIALS
- 6.1 Film:
- 6.1.1 The film used for radiography shall be as per SE 1815 and type ASTM System Class I or II. Generally the following brands of film shall be used. Other brands of films may be used subject to the approval of Head / NDT.
- (a) Kodak-Industrex AA 400/T 200/M
 (b) Agfa Gevaert - Agfa D7/D5/D4
- 6.1.2 The exposed films shall be processed as per procedure BHE: NDT: PB: RT: 14
- 6.2 Intensifying Screens:
- 6.2.1 Lead Screens of minimum thickness as listed below will be used on the front and back side of the film to improve the quality of the radiograph depending upon radiation energy selected.
- | | | |
|------------------|-------------|-----------------|
| X-rays | upto 420 kV | 0.02 to 0.25 mm |
| Ir.192 | | 0.10 mm |
| Co.60 | | 0.20 mm |
| 4 MeV/6Mev Linac | | 0.25 mm |
- 6.2.2 All intensifying screens shall be handled carefully to avoid dents, scratches, dirt or grease on the active surface, which might cause false indications.
- 6.3 Image Quality Indicator (IQI)
- 6.3.1 IQI shall be hole type and shall conform to SE 1025 and Table T.233.1 of ASME Section V.
- 6.4 Density Monitoring
- 6.4.1 Step wedge comparison filmstrip or a densitometer shall be used to judge the radiograph density. (Refer BHE:NDT:RT:Calib:01 for filmstrip requirements)
- 6.5 Facility for Viewing of Radiographs



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- 6.5.1 The radiographs shall be viewed in a room with subdued background lighting of an intensity that will not cause troublesome reflections, shadows or glare on the radiograph.
- 6.5.2 Illuminators / radiograph viewers shall be used to view radiographs for interpretation. The illuminator shall provide a variable light source sufficient for the essential IQI hole to be visible for the density range specified and obtained in the radiograph. 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. This can be taken care by masking the region around the edges of the radiograph.

7.0 CALIBRATION

7.1 Source Size

- 7.1.1 The technical manual or written statements of the equipment manufacturer or supplier's publication documenting the actual or maximum source size or focal spot shall be acceptable as source size verification.

7.2 Step Wedge Film and Densitometer

- 7.2.1 The density of step wedge comparison films and densitometer calibration shall be verified by comparison with a standard step wedge film as per procedure BHE:NDT:RT:Calib:01.

8.0 RADIATION ENERGY

- 8.1 The radiation energy (X-rays energy up to 6 Mev, Iridium 192 and Cobalt 60) employed for any Radiographic technique shall achieve the Density and IQI image requirements.

9.0 DIRECTION OF RADIATION

- 9.1 The direction of the central beam shall be centered on the area of interest whenever practical

10.0 GEOMETRIC UNSHARPNESS (Source to Film Distance)

- 10.1 Film shall be kept in close contact with the object.
- 10.2 Table 1 may be used as a guideline for Geometric un-sharpness.

TABLE - 1

MATERIAL THICKNESS	μ_g Max.
Under 50.0 mm	0.51 mm
Over 50.0 to 75.0 mm	0.76 mm
Over 75.0 to 100.0mm	1.02 mm
Greater than 100.0 mm	1.78 mm

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

- 10.3 Minimum source to film distance shall be kept such that the geometric unsharpness of the radiograph shall be kept as low as practical within the above range, but in any case shall not exceed 1.78 mm for Power Boiler components complying with ASME Section I or 2.0 for power piping components complying with ASME B 31.1.
- 10.4 Final acceptance of Radiographs shall be based on the achievement of required IQI sensitivity.
- 11.0 EXAMINATION - FULL RADIOGRAPHY**



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11.1 Radiographic technique

11.1.1 A single-wall exposure technique shall be used for radiography whenever practical. When it is not practical to use a 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. Two methods for Double wall technique are double wall single image technique and double wall double image technique.

11.1.2 The Real Time Radioscopy examination in lieu of Radiography for Straight Tube Butt welds shall be carried out as per the procedure BHE:NDT:PB:FT 01

12.0 EXAMINATION - SPOT RADIOGRAPHY

12.0 The total length of the weld shall be divided into equal segments of length, approximately equal to 15 cms or 30 cms. The segment where the spot is marked for examination shall be radiographed with the corresponding segment numbers.

12.2 Single wall single image technique shall be used wherever possible:

12.3 One spot shall be examined on each vessel for each 15 meters increment of weld or fraction thereof per welder or welding operator. However, for identical vessels each with less than 15 meters of weld, 15 metres increments weld may be represented by one spot examination. A sufficient number of spot radiographs shall be taken to examine the welding of each welder or welding operator.

12.4 Under condition where two or more welders or welding operators make weld layers in a joint, one spot may represent the work of all welders or welding operators.

12.5 Each spot examination shall be made as soon as practicable after completion of the increment of weld length to be examined. The minimum length of spot radiography shall be 150 mm.

13.0 LOCATION OF MARKERS

13.1 Location markers made of lead that are to appear as radiographic images on the radiograph shall be placed on the part adjacent to the weld. Their locations shall be marked and stamped on the surface of the part being radiographed in such a manner that an area of interest appearing on the radiograph will be accurately located. The location markers shall provide evidence on the radiograph that complete coverage of the weld has been obtained. Location markers shall not interfere with the interpretation of the radiograph. Location markers shall be placed as given in figures (a) to (f) given in Annexure IV.

13.1.1 Single wall Viewing : Location markers shall be placed on Source side when radiographing flat components or longitudinal joints in cylindrical or conical components/curved or spherical components whose convex side is toward the source. Location markers shall be placed 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 than the inside radius. For flat components or longitudinal joints in cylindrical or conical components as an alternative location markers shall be placed on the film side when the radiograph shows coverage beyond the location markers to the extent demonstrated in Annexure IV. 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 radius of the component.



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13.2 Double wall Viewing

13.2.1 For double-wall viewing at least one location marker shall be placed on the source side surface adjacent to the weld for each radiograph - (Double Wall elliptical images with source off set for butt welds in Boiler Tubes).

14.0 SELECTION OF IQI

14.1 IQI shall be selected from either the same material group or grade as identified in SE - 1025 or from a material group or grade with less radiation absorption than the material being radiographed.

14.1.1 The designated hole IQI with essential hole shall be as specified in Annexure II / Table-5. A smaller hole in a thicker IQI or a larger hole in a thinner IQI may be substituted for any section thickness, provided equivalent Hole type IQI sensitivity as in Annexure II / Table-6 is maintained and all other requirements for radiography are met.

14.2 Weld with Reinforcement

14.2.1 The thickness on which the IQI is based is the nominal single wall thickness plus the actual weld reinforcement thickness estimated to be present on both sides of the weld (ID and OD). The values shall not exceed the maximum specified as in Annexure I / Table 2, 3 and 4.

14.2.2 Backing rings or strip are not to be considered as part of the thickness in IQI selection. The actual measurement of the weld reinforcement is not required.

14.3 Weld without reinforcement

14.3.1 The thickness on which the IQI is based is the nominal single wall thickness. Backing rings or strips are not to be considered as part of the weld thickness in IQI selection.

14.4 Welds joining dissimilar materials or welds with dissimilar filler metal

14.4.1 When the weld material 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 14.1. When the density limits of +30 % to -15% 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 IQI shall be based on the base material and be in accordance with 14.1.

15.0 PLACEMENT OF IQI

15.1 Source Side IQI

15.1.1 Wherever possible, the IQI shall be placed on the source side of the part being examined.

15.2 Film Side IQI



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- 15.2.1** Where inaccessibility prevents hand placing the IQI(s) on the source side, the IQI shall be placed on the film side in contact with the part being examined. A lead letter 'F' shall be placed adjacent to the IQI(s) but shall not mask the essential hole
- 15.3** IQI Location for welds
- 15.3.1** The IQI will be generally placed adjacent to the weld. When placed on the weld, the identification numbers, the lead letter 'F' etc. shall not fall in the area of interest, except when geometric configuration makes it impractical.
- 15.4** IQI Location for materials other than welds
- 15.4.1** The IQI with the IQI identification, letter 'F' etc. may be placed in the area of interest.
- 16.0** NUMBER OF IQI
- 16.1** For components when one or more film holders are used for an exposure, at least one IQI image shall appear on each radiograph except as outlined below:
- 16.1.1** For circumferential welds in cylindrical and spherical components, where the source is placed on the axis of the weld for a single exposure (Panoramic Exposure), at least three IQI's shall be spaced approximately 120° apart,
- (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 degree is radiographed using one or more film holders. additional film locations may be required to obtain necessary IQI spacing.
- 16.1.2** For Cylindrical or Spherical components where the source is placed on the axis of the component for a single exposure, at least three IQI(s), with one placed at each end of the span of the circumference radiographed and one in the approximate centre of the span are required under the following conditions:
- (a) When the section of the circumference, the length of which is greater than 120 degree and less than 240 degree is radiographed using just one film holder, or;
- (b) When a section or sections of circumference, where the length between the ends of the outermost sections span less than 240 deg., is radiographed using more than one film holder.
- 16.1.3** In 16.1.1 and 16.1.2 above, where sections of longitudinal welds adjoining the circumferential weld are radiographed simultaneously with 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.
- 16.1.4** In spherical components, where other welds are radiographed simultaneously with the circumferential weld, one additional IQI shall be placed on each other weld.
- 16.2** When an array of components in a circle is radiographed, at least one IQI shall show on each component image.
- 16.3** In order to maintain the continuity of records involving subsequent exposures, all radiographs exhibiting IQI that qualify the techniques permitted in 16.1.1, 16.1.2, 16.1.3 or 16.1.4 shall be retained. Annexure V may be used as guide.



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16.4 Multiple IQI

16.4.1 If the requirements of 17.2 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.

16.5 Shims under IQI

16.5.1 A shim of material radiographically similar to the weld metal shall be placed between the part and the IQI, if needed, so that the radiographic density throughout the area of interest is within minus 15% from the radiographic density through the body of IQI adjacent to the essential hole.

16.5.2 The shim dimensions shall exceed the IQI dimensions such that the outline of at least three side of the IQI image shall be visible in the radiograph.

17.0 EVALUATION

17.1 Quality of radiographs

17.1.1 All radiographs should be free from mechanical, chemical or other blemishes such as fogging, processing defects to the extent that they do not mask or are not confused with the image of any discontinuity in the area of interest of the object being radiographed.

17.2 Radiographic density

17.2.1 The transmitted film density through the radiographic image of the body of the designated hole type IQI adjacent to the essential hole or adjacent to the essential wire type IQI and the area of interest shall be 1.8 minimum for radiographs made with an X-ray source and 2.0 minimum for radiographic made with a gamma ray source.

17.2.2 In both cases the maximum density shall be 4.0. A tolerance of ± 0.05 in density is allowed for variation between the densitometer readings.

17.3 Density variation

17.3.1 If the density of radiograph anywhere through the area of interest varies by more than minus 15% or plus 30% rounded to the nearest 0.1 from the density through the body of designated hole type IQI adjacent to the essential hole within the minimum/maximum allowable density ranges specified in para 16.2.1, then an additional IQI shall be used for each exceptional area, one shall represent the lightest area and the other the darkest area of interest.

17.3.2 With shims: When shims are used, the +30% density restriction of 17.3.1 above may be exceeded, provided the required IQI sensitivity is displayed and the density limitation of 17.2 are not exceeded.

17.4 IQI Sensitivity

17.4.1 Radiography shall be performed with a technique of sufficient sensitivity to display the IQI image and 2T-hole, which are the essential indications of the image quality of the radiographs. The radiographs shall also display the identifying numbers and letters. A thinner or thicker IQI than listed in Annexure II (Table 5) may be used if an equivalent IQI sensitivity as specified in Annexure II (Table 6) is obtained.

18.0 ACCEPTANCE - FULL RADIOGRAPHY



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- 18.1 The following type of discontinuities shall be unacceptable:**
- 18.1.1 Any type of crack, zone of incomplete fusion or incomplete penetration.**
- 18.1.2 Any other elongated indication on the radiograph whose length exceeds the following:**
a) 6 mm for thickness up to 19 mm.
b) $\frac{1}{3} t$ for 't' from 19 mm to 57 mm.
c) 19 mm for 't' over 57 mm.
Where 't' is the thickness of weld excluding any allowable reinforcement. For a butt weld joining two members having different thickness 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'.
- 18.1.3 Any group of aligned indications that have an aggregate length greater than 't' in a length of 12t except when the distance between successive indication exceeds 6L where 'L' is the longest indication in the group.**
- 18.1.4 Rounded indications (whose length is less than three times the width) in excess of that shown as acceptable as in Appendix A 250 of ASME Section I or Appendix 4 of ASME Section VIII Division 1 or appendix 8 of ASME Section VIII Division 2 (all are identical), Table 7.**
- 18.1.5 For circumferential joint in pipe, tube and headers, the thickness of the weld measured between the inside surface of the weld preparation and the outside surface of the pipe or tube shall not be less than the minimum thickness permitted by the applicable material specification for the particular size and thickness of the pipe or tube used.**
- 18.1.6 The contour of the concavity shall be smooth and the resulting thickness of the weld, including reinforcement, shall be at least equal to the required thickness of the thinner section. Root concavity shown without abrupt change in density is acceptable provided it is not greater than 2.5 mm in depth or 20% of thinner of the two sections, whichever is minimum for components fabricated as per Section I and 0.8 mm or 10% for components fabricated as per Section VIII. Comparable outside reinforcement shall be provided whenever acceptable root concavity is present.**
- 18.1.7 Root concavity when there is an abrupt change in density, as indicated in the radiography, is not acceptable for power piping welds.**
- 18.2 Repaired area in a weld shall be re-radiographed using the same technique used for original radiography.**
- 19.0 ACCEPTANCE - SPOT RADIOGRAPHY**
- 19.1 Any zone of crack, lack of fusion or in-complete penetration are unacceptable.**
- 19.2 Slag inclusion or cavities whose length is greater than $\frac{2}{3}T$ or 19 mm, whichever is less, where T is the thickness of the weld excluding any allowable reinforcement is unacceptable.. For all thicknesses, indications less than 6 mm are acceptable and indications greater than 19 mm are unacceptable. For a butt weld joining two members having different thickness at the weld, 'T' is the thickness of the thinner of the two sections.**
- 19.3 If several indications within the limitation given 19.2 above exists in a line, the welds shall be judged acceptable if the sum of the larger dimensions of all such indications is not more the 'T' in a length of 6T (or proportionately, for radiographs shorter than 6T) and if the longest indications considered are separated by at least '3L' of acceptable weld metal**



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where L is the length of the longest indication. Any such indications shorter than 6 mm shall be acceptable for any plate thickness.

19.4 Rounded indications (length less than three times the width) are not a factor in the acceptability of welds not required to be fully radiographed.

20.0 EVALUATION AND RETEST: (Spot Radiography)

20.1 When radiograph of one spot is found acceptable, the entire weld increment represented by this radiograph is acceptable.

20.2 If any spot is found defective, then two additional spots shall be radiographed from the same weld increment at location away from the original spot. If additional spots are found acceptable, then the entire weld increment represented by the three radiographs is acceptable. The defective area in the first radiograph will be removed, re-welded and re-radiographed as given above.

20.3 If either of the two additional spots examined are found defective, then the entire increment of weld represented shall be radiographed and repaired or the entire weld shall be rejected.

20.4 If the entire weld is removed and re-welded based on the spot radiography result, the welded joint or weld repaired area shall be spot radiographically examined at one location in accordance with the procedure given above.

20.5 For original and additional spot selection AI Permission shall be obtained.

21.0 PERSONNEL QUALIFICATION

21.1 Personnel performing examination shall be qualified in accordance with BHE:NDT:G:CRT to at least one of the following levels.

1) Operator - Minimum Level- I 2) Radiograph Evaluation- Minimum Level-II

22.0 RECORDING AND REPORTING

22.1 BHEL's evaluation report shall be given in the format (Annexure VI) and shall be presented along with radiographs to External Inspector for review.

23.0 STORAGE:

23.1 Radiographs of Products to ASME Code Sec. I, Sec. VIII Div.1 and Div.2 and Boiler drums:

23.1.1 A complete set of radiographs with proper identification shall be preserved for a period of 5 years as in Quality Control Manual.

23.2 Radiographs of Other components:

23.2.1 Radiographs of header, pipe and tubular butt welds shall be retained and kept on file for a period of three years or till the final inspection, whichever is earlier.

23.2.2 Records such as registers and reports shall be maintained till the final inspection is completed.

24.0 SAFETY

- 24.1 Radiography shall be performed in accordance with all applicable safety requirements as specified in BHEL's Safety Procedure BHE:NDT: G:SFT.

ANNEXURE I

Table 2- MAXIMUM WELD REINFORCEMENT AS PER ASME SECTION I

Weld Thickness in mm (nominal thickness of the thinner section at the weld joint)	Circumferential welds in Pipes & Tubes (mm)	Other welds (mm)
Up to 3.0	2.5	2.5
Over 3.0 to 5.0	3.0	2.5
Over 5.0 to 13.0	4.0	2.5
Over 13.0 to 25.0	5.0	2.5
Over 25.0 to 50.0	6.0	3.0
Over 50.0 to 75.0	The greater of 6 mm or 1/8 times the width of the weld (in mm).	4.0
Over 75.0 to 100.0		5.5
Over 100.0 to 125		6.0
Over 125		8.0

TABLE 3- MAXIMUM WELD REINFORCEMENT AS PER ASME SECTION VIII-Division 1

Weld Thickness in mm (nominal thickness of the thinner section at the weld joint)	Category B & C Butt welds (mm)	Other welds (mm)
Up to 2.4	2.4	0.8
Over 2.4 to 4.8	3.0	1.5
Over 4.8 to 13.0	4.0	2.5
Over 13.0 to 25.0	5.0	2.5
Over 25.0 to 51.0	5.0	3.0
Over 51.0 to 76.0	6.0	4.0
Over 76.0 to 102.0	6.0	5.5
Over 102.0 to 127	6.0	6.0
Over 127	8.0	8.0

TABLE 4- MAXIMUM WELD REINFORCEMENT AS PER ASME SECTION VIII-Division 2

Weld Thickness in mm (nominal thickness of the thinner section at the weld joint)	Circumferential welds in Pipes & Tubes (mm)	Other welds (mm)
< 2.5	2.5	0.8
≥ 2.5 to < 5.0	2.5	1.5
≥ 5.0 to < 13.0	3.0	2.5
≥ 13.0 to < 25.0	4.0	2.5
≥ 25.0 to < 50.0	4.0	3.0
≥ 50.0 to < 76.0	4.0	4.0
≥ 76.0 to < 100.0	5.5	5.5
≥ 100.0 to < 125.0	6.0	6.0
≥ 125.0	8.0	8.0

ANNEXURE II
TABLE 5 - IQI SELECTION

IQI		
Nominal Single Wall thickness Range(mm)	Source side Desgn.	Film Side Desgn.
Up to 6.4 mm	12	10
Over 6.4 thro' 9.5	15	12
Over 9.5 thro' 12.7	17	15
Over 12.7 thro' 19.0	20	17
Over 19.0 thro' 25.4	25	20
Over 25.4 thro'38.1	30	25
Over 38.1 thro' 50.8	35	30
Over 50.8 thro'63.5	40	35
Over 63.5 thro' 101.6	50	40
Over 101.6 thro'152.4	60	50
Over 152.4 thro'203.2	80	60
Over 203.2 thro'254.0	100	80
Over 254.0 thro'304.8	120	100

Note: The radiograph should display the designated IQI and 2T-hole image

TABLE – 6 EQUIVALENT HOLE TYPE IQI SENSITIVITY (T-283 of ASME Sec.V, Article 2)

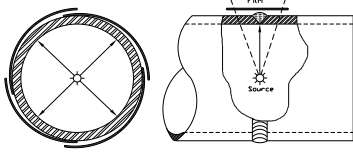
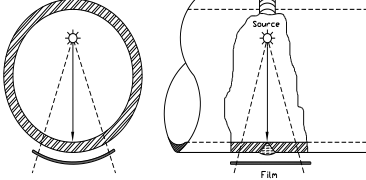
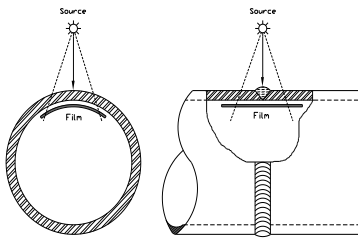
Hole Type Designation 2T - Hole	Equivalent Hole Type Designation	
	1T Hole	4T Hole
10	15	5
12	17	7
15	20	10
17	25	12
20	30	15
25	35	17
30	40	20
35	50	25
40	60	30
50	70	35
60	80	40
80	120	60
100	140	70
120	160	80
160	240	120
200	280	140

Table-7

Thickness t mm	Max size acceptable mm		Max size of non relevant indication
	Random	Isolated	
< 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	5.84	0.79
19 to 50 incl	3.96	6.35	0.79
Over 50	3.96	9.53	1.60

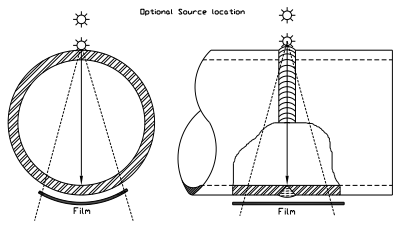
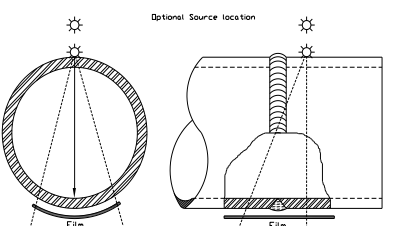
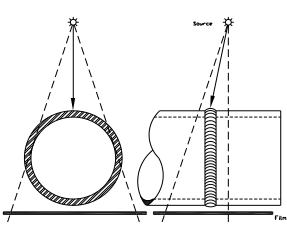
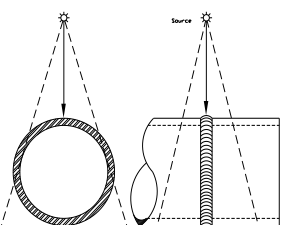
.ANNEXURE III

SINGLE WALL RADIOGRAPHIC TECHNIQUES

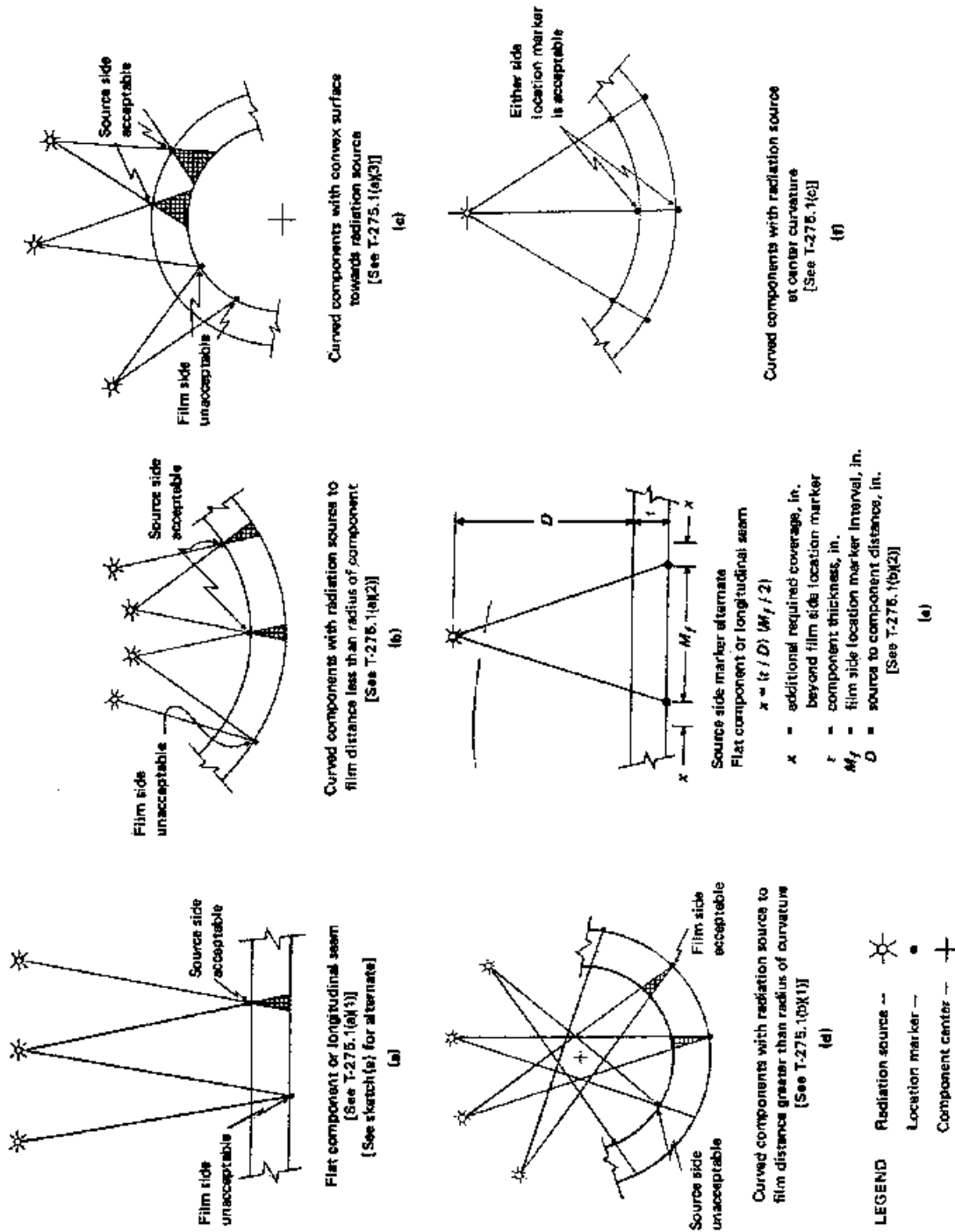
O.D	Exposure Technique	Radiograph Viewing	Source-weld-film Arrangement		IQI		Location Marker Placement
			End View	Side View	Selection	Placement	
Any	Single wall	Single wall	 1) Panoramic		Table 2	Source side (15.1)	Either side (13.0)
						Film side (15.2)	
Any	Single wall	Single wall	 2) Source inside – Film outside		Table 2	Source side (15.1)	Film side (13.0)
						Film side (15.2)	
Any	Single wall	Single wall	 3) Source outside – Film inside		Table 2	Source side (15.1)	Source side (13.0)
						Film side (15.2)	

ANNEXURE III

DOUBLE WALL RADIOGRAPHIC TECHNIQUES

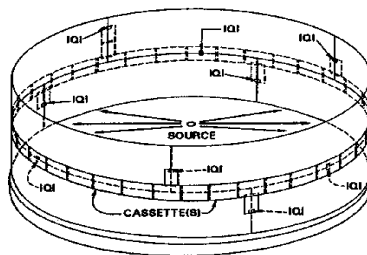
O.D	Exposure Technique	Radiograph Viewing	Source –weld-film Arrangement		IQI		Location Marker Placement
			End View	Side View	Selection	Placement	
Any	Double wall: at least 3 exposures 120° to each other for complete coverage	Single wall	 4)Double wall single image		Table 2	Source side (15.1)	Film side (13.0)
						Film side (15.2)	
Any	Double wall: at least 3 exposures 120° to each other for complete coverage	Single wall	 5)Double wall single image- source offset		Table 2	Source side (15.1)	Film side (13.0)
						Film side (15.2)	
<u>89 mm or less</u>	Double wall: at least 2 exposures 90° to each other for complete coverage	Double wall (Ellipse): Read offset source side and film side images	 6)Double wall double image		Table 2	Source side (15.1)	Either side (13.0)
<u>89 mm or less</u>	Double wall: at least 3 exposures at 60° or 120° to each other for complete coverage	Double wall: Read Super imposed source side and film side images	 7)Double wall double image- superimpose		Table 2	Source side (15.1)	Either side (13.0)

ANNEXURE IV

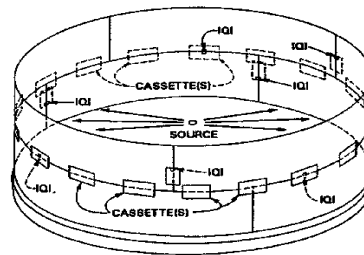


LOCATION MARKER SKETCHES

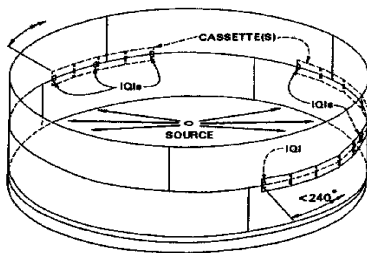
ANNEXURE V



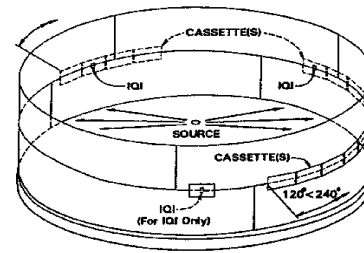
COMPLETE CIRCUMFERENCE
CYLINDRICAL COMPONENT



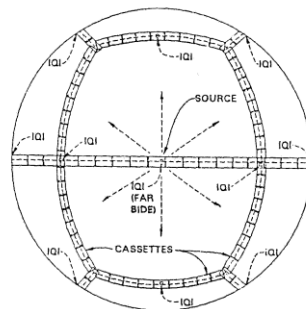
SECTION OF CIRCUMFERENCE
240 deg. OR MORE CYLINDRICAL COMPONENT
(EXAMPLE IS ALTERNATE INTERVALS)



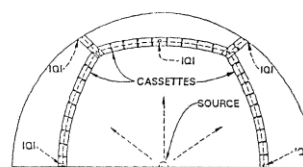
SECTION(S) OF CIRCUMFERENCE
LESS THAN 240 deg. CYLINDRICAL COMPONENT



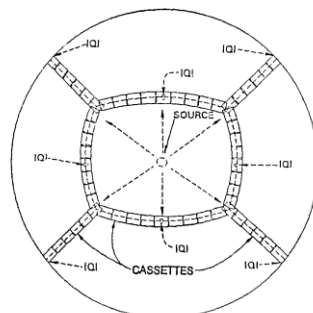
SECTION(S) OF CIRCUMFERENCE
EQUAL TO OR MORE THAN 120 deg. AND LESS THAN
240 deg. CYLINDRICAL COMPONENT



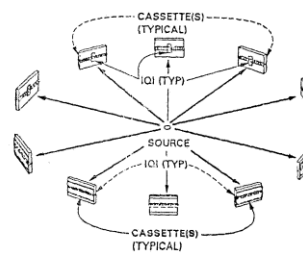
COMPLETE CIRCUMFERENTIAL
WELDS SPHERICAL COMPONENT



WELDS IN SEGMENTS OF SPHERICAL
COMPONENT



PLAN VIEW A-A



Note: Special Cases IQI Locations are Typical in All
Figures.

ARRAY OF OBJECTS IN A CIRCLE

POROSITY-ACCEPTANCE LEVEL

FIG. A-250.3.4-1 ALIGNED ROUNDED INDICATIONS

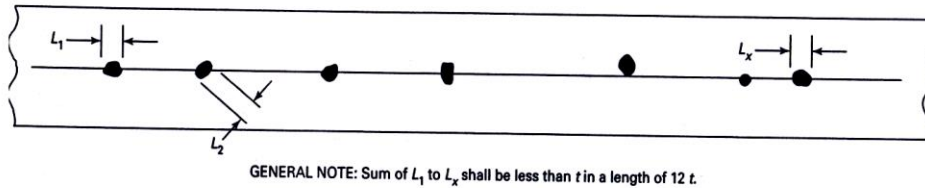
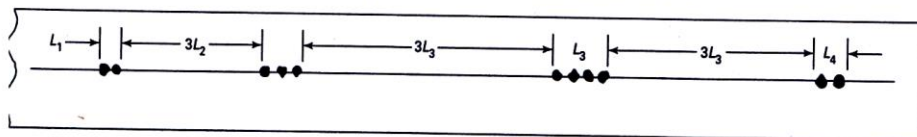


FIG. A-250.3.4-2 GROUPS OF ALIGNED ROUNDED INDICATIONS

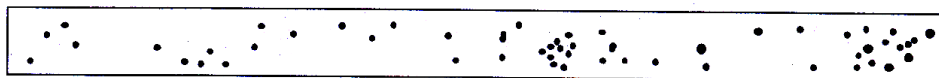


Maximum Group Length
 $L = 1/4$ in. (6 mm) for t less than $3/4$ in. (19 mm)
 $L = 1/3 t$ for $t 3/4$ in. (19 mm) to $2 1/4$ in. (57 mm)
 $L = 3/4$ in. (19 mm) for t greater than $2 1/4$ in. (57 mm)

Minimum Group Spacing
 $3L$ where L is the length of the longest adjacent group being evaluated.

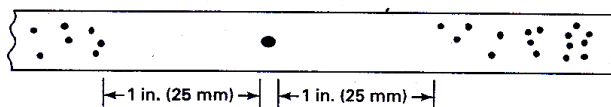
GENERAL NOTE: Sum of the group lengths shall be less than t in a length of $12 t$.

FIG. A-250.3.6-1 CHARTS FOR $t 1/8$ in. (3 mm) TO $1/4$ in. (6 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld

(a) Random Rounded Indications



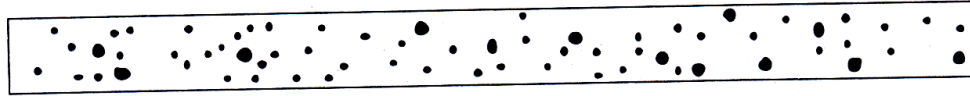
(b) Isolated Indication
(Maximum size per Table A-250.3.2)



(c) Cluster

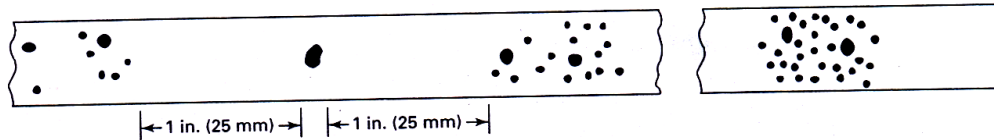
POROSITY-ACCEPTANCE LEVEL

FIG. A-250.3.6-2 CHARTS FOR t OVER $\frac{1}{4}$ in. (6 mm) TO $\frac{3}{8}$ in. (10 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld

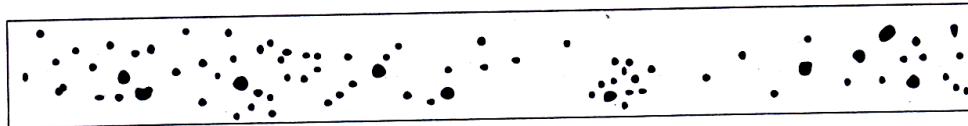
(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table A-250.3.2)

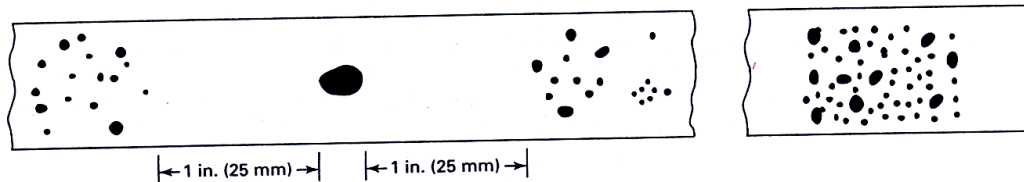
(c) Cluster

FIG. A-250.3.6-3 CHARTS FOR t OVER $\frac{3}{8}$ in. (10 mm) TO $\frac{3}{4}$ in. (19 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld

(a) Random Rounded Indications

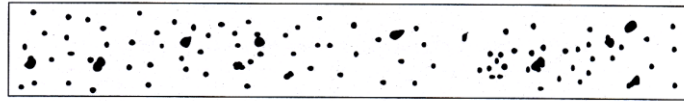


(b) Isolated Indication
(Maximum size per Table A-250.3.2)

(c) Cluster

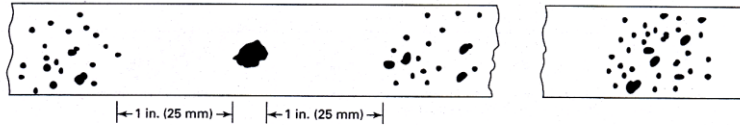
POROSITY-ACCEPTANCE LEVEL

FIG. A-250.3.6-4 CHARTS FOR t OVER $\frac{3}{4}$ in. (19 mm) TO 2 in. (50 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld.

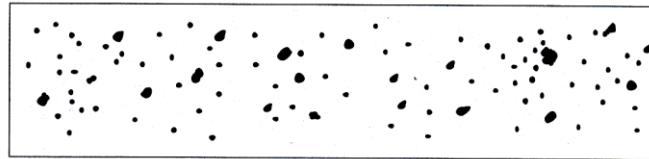
(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table A-250.3.2)

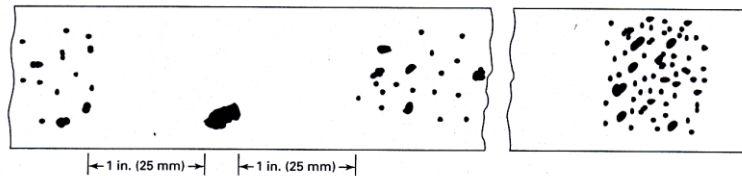
(c) Cluster

FIG. A-250.3.6-5 CHARTS FOR t OVER 2 in. (50 mm) TO 4 in. (100 mm), INCLUSIVE



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld.

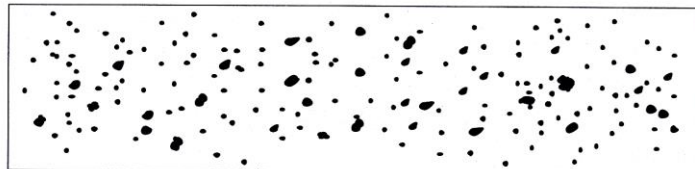
(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table A-250.3.2)

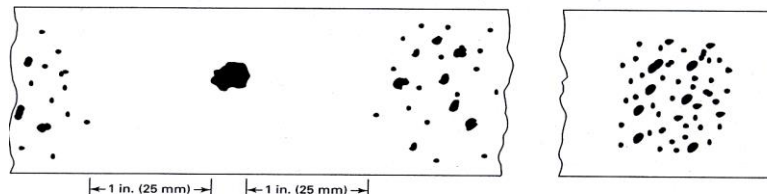
(c) Cluster

FIG. A-250.3.6-6 CHARTS FOR t OVER 4 in. (100 mm)



GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld.

(a) Random Rounded Indications



(b) Isolated Indication
(Maximum size per Table A-250.3.2)

(c) Cluster



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PROPRIETARY DATA NOT TO BE
DISCLOSED OR REPRODUCED WITHOUT
THE PERMISSION OF BHEL

ANNEXURE VI
RADIOGRAPHIC REPORT CUM REVIEW FORM

Report No.:		Date:		Ref.:		Stage of Test:	
Description:		Material:		Dia.: mm		Thickness: mm	
W.O. No.:		Drg. No.:		DU No.:			
Pb. Screen Front/Back		Welding Process:		Weld reinforcement: mm			
Source: X- Rays/ Ir. 192/ Co.60		Source Size:		Exposure: KV: mA / Ci.mts:			
Source to Object distance: mm				Source side of object to Film Distance: mm			
IQI: ASTM Hole / Wire type:		Source side /Film side		Sensitivity:		Density:	
Single/Double wall/Panoramic technique		Single/ Double wall viewing		Markers: Source / Film side			
Film Manufacturer: Agfa. / Kodak.				Film Type / Designation :			
No. of Radiographs (Exposures):		No. of films in each cassette:		Date of Evaluation:			
Procedure & Acceptance : BHE:NDT:PB / SS / VV / NU / RT							
Sl. No.	Welder No.	Radiograph No./ Joint No.	Seg. No.	Findings		Disposition (Repair/Accept)	
SAMPLE							
Operator Level I / II			Approved by : Level II / III			External Inspection Agency	