



**PLANT STANDARD
HYDERABAD**

HY0850170

Rev. No. 12

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NDE PROCEDURE FOR RADIOGRAPHIC EXAMINATION OF WELDS

1.0 SCOPE:

This standard covers the procedure and acceptance standard to be employed for the radiographic examination of welds and shall be followed whenever called for as a part of design requirement or code requirement.

1.1 This standard is based on ASME: Sec. V Article - 2, ASME: Sec. VIII Division 1 & 2.

2.0 PERSONNEL QUALIFICATION:

The personnel conducting the examination shall be qualified according to NDE Written Procedure QMI: 008.

3.0 SELECTION OF RADIATION ENERGIES:

3.1 For X-Ray : Less than 19 mm of steel

For Ir-192 : Minimum 19 mm of steel

For Co-60 : Minimum 38 mm of steel

The minimum recommended thicknesses may be reduced when radiation energy employed for any Radiographic Technique shall be achieve the density and IQI image requirements.

4.0 FILMS:

Radiographs shall be made using Industrial Radiographic films. Following films or its equivalent shall be used.

- | | |
|--------------------|-----------------------|
| 1. Agfa Gaevert | - D7 / D4 |
| 2. Kodak Industrex | - AA - 400 / MX - 125 |

5.0 WELD WITH REINFORCEMENT:

The thickness on which the IQI (Image Quality Indicator) is based on the nominal single wall thickness plus the actual weld reinforcement not to exceed the maximum permitted as shown below. Backing rings or strips are not to be considered as part of the thickness in IQI selection.

Revisions: Radiography report rev. no.03 incorporated. Technique chart modified.			Issued : STANDARDS ENGINEERING DEPARTMENT		
Rev. No. 12	Amd. No.	Reaffirmed:	Prepared:	Approved:	Date:
Dt. JUN. 06	Dt.	Year:	LEVEL-III	GM (Q)	April, 1983



5.1 For welds as per ASME Sec VIII Division –I

Material Nominal Thickness	MAXIMUM REINFORCEMENT	
	Circumferential Joint Pipe and Tubing	Others
Less than 2.40mm (3/32)	2.40mm (3/32)	0.8mm (1/32)
2.40 to 4.8mm incl. (3/32 to 3/16)	3.20mm (1/8)	1.6mm (1/16)
Over 4.8 to 12.7mm incl.(3/16 to ½)	4mm (5/32)	2.40mm (3/32)
Over 12.7 to 25.4mm incl.(½ to 1)	4.80mm (3/16)	2.40mm (3/32)
Over 25.4 to 51mm incl. (1 to 2)	6mm (¼)	3.20mm (1/8)
Over 51 to 76.2mm incl. (2 to 3)	6mm (¼)	4mm (5/32)
Over 76.2 to 101.6mm incl. (3 to 4)	6mm (¼)	5.6mm (7/32)
Over 101.6 to 127mm incl. (4 to 5)	6mm (¼)	6mm (¼)
Over 127 mm (5)	7.9mm (5/16)	7.9mm (5/16)

5.2 For welds as per ASME Sec VIII Division – II

Material Nominal Thickness	MAXIMUM REINFORCEMENT	
	Circumferential Joint Pipe and Tubing	Others
Less than 2.40mm (3/32)	2.40mm (3/32)	0.8mm (1/32)
2.40 to 4.8mm incl. (3/32 to 3/16)	2.40mm (3/32)	1.6mm (1/16)
Over 4.8 to 12.7mm incl.(3/16 to ½)	3.2mm (1/8)	2.40mm (3/32)
Over 12.7 to 25.4mm incl.(½ to 1)	4.00mm (5/32)	2.40mm (3/32)
Over 25.4 to 50.8mm incl. (1 to 2)	4mm (5/32)	3.20mm (1/8)
Over 50.8 to 76mm incl. (2 to 3)	4mm (5/32)	4mm (5/32)
Over 76 to 101.6mm incl. (3 to 4)	5.6mm (7/32)	5.6mm (7/32)
Over 101.6 to 127mm incl. (4 to 5)	6mm (¼)	6mm (¼)
Over 127 mm (5)	7.9mm (5/16)	7.9mm (5/16)

- Inch sizes are adopted (with in brackets).

5.3 Weld Surface Preparation:

The weld ripples or weld surface irregularities on both the inside (where accessible) and outside shall be removed by any suitable process to such a degree that the resulting radiographic image due to any surface irregularities can not mask or be confused with the image of any discontinuity. The finished surface of all butt welded joints may be flush with the base material or may have reasonably uniform crowns.

6.0 IMAGE QUALITY INDICATORS (IQI):

Image quality indicators (IQI) shall be either the hole type or the wire type and meet the requirements of SE 1025 (For Hole Type) and SE 747 (For Wire Type). Its thickness and dia shall be as per appendix I & II respectively. Image Quality Indicators shall be selected from either the same alloy material group or grade as identified in SE 1025 and



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SE 747 or from an alloy material group or grade with less radiation absorption than the material being radiographed.

6.1 IQI Selection:

Radiography shall be performed with a technique of sufficient sensitivity to display the hole IQI image and the 2T hole, or the essential wire of a wire IQI. The radiographs shall also display the IQI identifying numbers and letters. If the designated hole IQI image and 2T hole, or essential wire, do not show on any film in a multiple film technique, but do show in composite film viewing, interpretation shall be permitted only by composite film viewing. The designated hole IQI or essential wire shall be specified in table-I. A thinner or thicker hole type IQI may be substituted for any section thickness listed in table-II. Provided an equivalent IQI sensitivity is maintained. Equivalent IQIs shall be selected from Appendix I for hole type and Appendix II for wire type

6.2 Placement of IQIs:

Source-Side IQIs: IQIs shall be placed on the source side of the part being examined. The IQIs (Hole type) may be placed adjacent to or on the weld. The IQIs (Wire type) shall be placed on the weld so that the length of the wires is perpendicular to the length of the weld. The identification numbers and, when used, the lead letter "F" shall not be in the area of interest, except when geometric configuration makes it impractical.

Film-side IQIs: Where inaccessibility prevents hand placing the IQIs on the source side, the IQIs 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 IQIs, but shall not mask the essential hole where hole IQIs are used.

6.3 Number of IQIs:

When one or more film holders are used for an exposure, at least one IQI image shall appear on each radiograph. For cylindrical components where the source is placed on the axis of the component for a single exposure, atleast three IQIs spaced approximately 120 deg. apart are required.

6.4 Shims Under Hole IQI's:

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 through out the area of interest is no more than minus 15% from (lighter than) the radiographic density through the IQI. The shim dimensions shall exceed the IQI dimensions such that the outline of at least three sides of the IQI image shall be visible in the radiograph.



7.0 IDENTIFICATION OF RADIOGRAPHS:

A system shall be used to produce permanent identification on the radiograph traceable to the contract, component, weld or weld seam, or part number as appropriate. In addition the manufacturers symbol or name and the date of the radiograph shall be plainly and permanently included in the radiograph. 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. The letter 'R' shall be used to designate a radiograph of a repair area and may include 1,2, ---- etc for the number of repairs.

7.1 Location Markers:

Location markers (See fig. 2) which are to appear as radiographic images on the film shall be placed on the part not on the cassette. Their location, shall be placed on the part, not on the exposure holder/cassette. Their locations shall be permanently marked on the surface of the part being radiographed when permitted, or on a map, in a manner permitting the area of interest on a radiograph to be accurately traceable to its location on the part, for the required retention period of the radiograph. Evidence shall also be provided on the radiograph that the required coverage of the region being examined has been obtained.

7.2 Sharpness of Radiographic Image:

7.3 Source to Object Distance (S.O.D):

The minimum distance 'd' from the weld being radiographed to the source of radiation is determined from:

$$d = Ft / Ug, \text{ where}$$

F= effective source size

Ug= geometric unsharpness

t=thickness of the weld

7.4 Geometric Unsharpness Limitation:

The geometric unsharpness of the radiograph shall not exceed the following:

<u>Material thickness</u>	<u>Ug Maximum</u>
Under 51mm (2")	0.51mm (0.020")
51 through 76.2mm (2 to 3")	0.76mm (0.030")
Over 76.2 through 101.6mm (3 to 4")	1.02mm (0.040")
Greater than 101.6mm (4")	1.78mm (0.070")



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8.0 RADIOGRAPHIC DENSITY:

The transmitted film density through the radiographic image of the body of the appropriate hole IQI or adjacent to the designated wire of a wire IQI and the area of interest shall be 1.8 minimum for single film viewing for radiographs made with X-ray and 2 minimum for radiographs made with gamma ray source. For composite viewing of multiple film exposures, each film of the composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for either single or composite viewing. A tolerance of 0.05 in density is allowed for variations between densitometer readings

If the density of the radiograph any where through the area of interest varies by more than minus 15% or plus 30% from the density through the body of the hole IQI or adjacent to the designated wire of a wire IQI with in the minimum / maximum allowable density specified above then an additional IQI shall be used for each exceptional area or areas and the radiograph retaken.

8.1 Monitoring density limitations of Radiographs:

Either a densitometer or step wedge comparison film shall be used for judging film density requirements. The density of step wedge comparison films and densitometer calibration shall be verified by comparison with a calibrated step wedge film traceable to a national standard. The step wedge calibration films may be used within one year upon opening.

9.0 INTENSIFYING SCREENS:

Lead screens shall be used in all gamma ray radiography. For x-ray, Lead Screens shall be used wherever they improve the quality of the radiograph. Copper screens of suitable thickness may be used in conjunction with Cobalt - 60 isotope to improve sensitivity.

9.1 Radiographic technique:

A single wall exposure technique shall be used for radiography when ever 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.

a) Single wall technique:

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

b) Double wall technique:

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



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

II) For welds in components 3.5 inch (89mm) or less in nominal outside diameter a technique may be used in which the radiation passes through two walls and the weld materials in both walls is viewed for acceptance on the same radiograph. For double wall viewing only a source side IQI shall be used. Care should be exercised to ensure that the required geometric unsharpness is not exceeded. With the geometric unsharpness requirement can not be met, then single wall viewing shall be used.

III) For welds, the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source side and film side portions of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90° to each other shall be made for each joint.

IV) As an alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are super imposed. When complete coverage is required a minimum of three exposures taken at either 60° or 120° to each other shall be made for each joint.

Additional exposures shall be made if the required radiographic coverage can not be obtained using the minimum number of exposures indicated above.

10.0 BACK SCATTER RADIATION:

Suitable lead backing shall be used to avoid back scatter. A lead symbol 'B' with minimum dimensions 13 mm (½") in height and 1.6 mm (1/16") in thickness shall be attached to the back of each film holder during each exposure to determine if back scatter radiation is exposing the film.

10.1 Excessive Scatter:

If there is any question about the adequacy of protection from back scatter radiation, 3.2 mm (1/8") thick letter "B" should be attached to the back of the cassette or film holder, and a radiograph made in the normal manner. If the image of this symbol appears on the radiograph that as a lighter density than background, it is an indication protection against Back Scattered radiation is insufficient and the radiograph shall be considered unacceptable and that additional precaution must be taken. A dark image of the 'B' on a lighter background is not a cause for rejection.

11.0 CHEMICAL PROCESSING AND QUALITY OF RADIOGRAPH:

The chemical processing of the film shall conform to the best standard of photographic chemical processing or recommendations of the manufacturers. Processing time,



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temperatures of various baths, degree of agitation and qualities shall be as recommended by the manufacturer of the films and / or chemicals.

All radiographs shall be free from excessive mechanical, chemical or other processing defects such as fogging, streaking watermarks, strains, dirtiness, tears and scratches that could interfere with proper interpretation of the radiograph

11.1 Procedure:

Radiography shall be carried out as per approved Technique for radiography examination of welds as shown in Appendix III

12.0 ACCEPTANCE STANDARD:

12.1 For welds as per ASME Sec VIII, Division – I

Welds that are shown by radiography to have any of the following type of discontinuities shall be unacceptable.

12.1.1 For 100% Radiography:

- a) Any indication of crack or zone of incomplete fusion or incomplete penetration.
- b) Any other elongated indication which has a length greater than
 - i) 6 mm (1/4 in.) for T up to 19mm (3/4 in.)
 - ii) 1/3 T for T from 19 to 57mm (3/4 in. to 2 ¼ in.)
 - iii) 19mm (3/4 in.) for T over 57mm (2 ¼ in.)

(Where T is the thickness of the weld excluding any allowable reinforcement or for a butt weld joining two members having different thicknesses at weld, T is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness & the throat of the fillet shall be included in T)

- c) Any group of aligned indications in line that have an aggregate length greater than T in a length of 12 T except when the distance between successive indication exceed 6L, where L is the longest indication in the group.
- d) Rounded Indication in excess that of shown in porosity chart, ASME: Sec VIII Div.I

12.1.2 For Spot Radiography:

- a) Any type of crack or zone of incomplete fusion or incomplete penetration.
- b) Any other elongated indication which has a length greater than 2/3 T, where T is the thickness of the weld excluding any allowable reinforcement or for a butt weld joining two members having different thicknesses at weld, T is the thinner of these two thicknesses.

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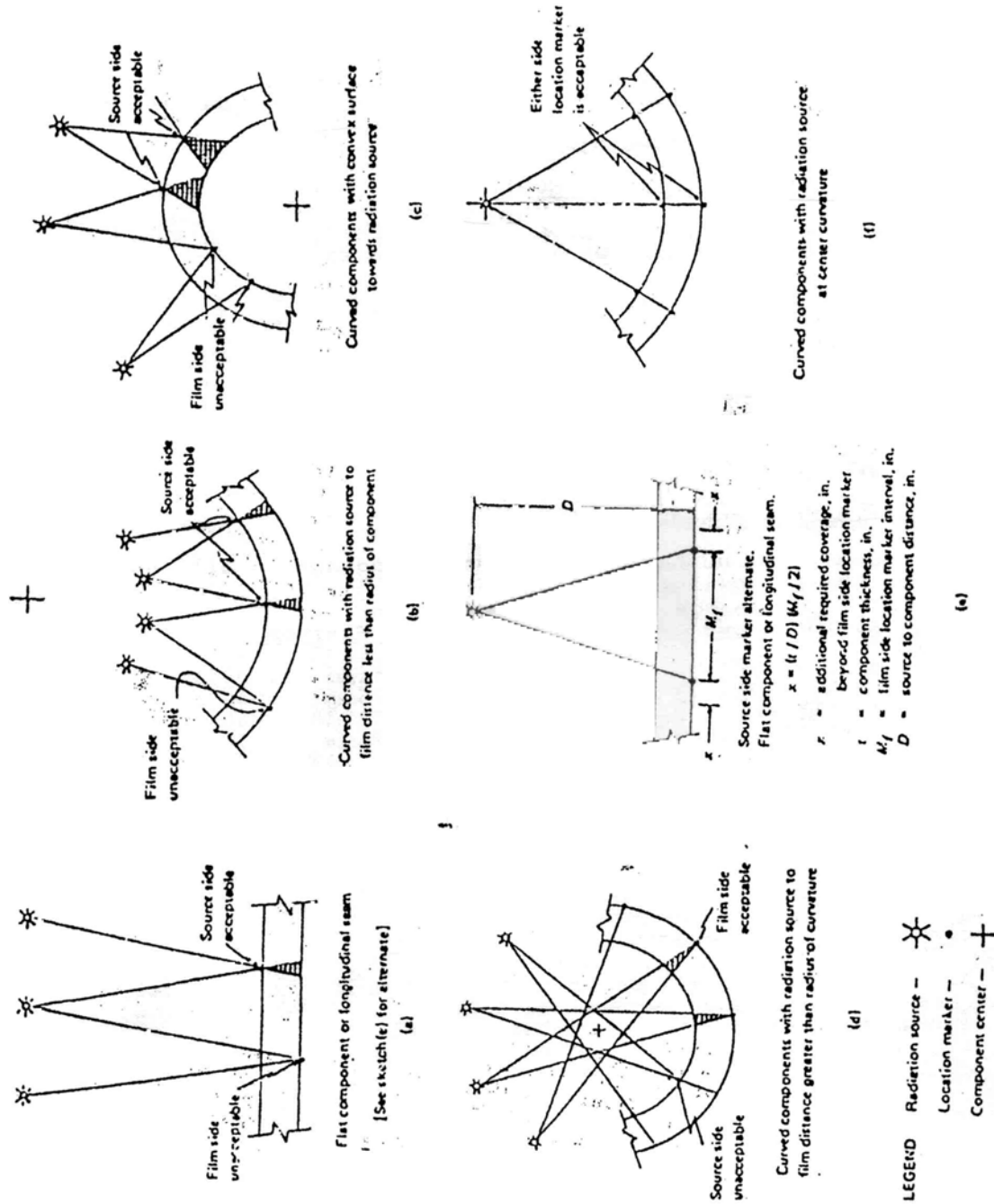


FIG. 2 - LOCATION MARKER SKETCHES

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- c) If several indications with in the above limitations exist in line, the weld shall be judged acceptable if the sum of the longest dimension of all such indications is not more than T in a length of 6 T (or proportionately for radiographs shorter than 6 T) and if the longest indications considered are separated by atleast 3L of acceptable weld metal where L is the length of the longest indication. The maximum length of acceptable indication shall be $\frac{3}{4}$ in. (19 mm). Any such indications shorter than $\frac{1}{4}$ in. (6 mm) shall be acceptable for any plate thickness.
- d) Rounded indications are not a factor in the acceptability of welds, not to be fully radiographed.

12.1.3 For welds as per ASME Sec. VIII Division – II

Sections of welds that are shown by radiography to have any of the following type of defects are unacceptable.

- a) Any indication of crack or zone of incomplete fusion or incomplete penetration.
- b) Any elongated inclusion, such as a slag which has length greater than
 - i) 6 mm (1/4 in.) for T up to 19mm (3/4 in.)
 - ii) 1/3 T for T from 19 to 57mm (3/4 in. to 2 1/4 in.)
 - iii) 19mm (3/4 in.) for T over 57mm (2 1/4 in.)

(Where T is the thickness of the weld excluding any allowable reinforcement or for a butt weld joining two members having different thicknesses at weld, T is the thinner of these two thicknesses. If a full penetration weld includes a fillet wild, the thickness & the throat of the fillet shall be included in T)

- c) Any group of aligned indications in line that have an aggregate length greater than T in a length of 12 T except when the distance between successive indication exceed 6L, where L is the longest indication in the group.
- d) Rounded Indication in excess that of shown in porosity chart, ASME: Sec VIII Div.II

13.0 REPORTS AND RECORDS:

A report describing the radiographic technique (Annexure III) and the procedure followed along with a detailed analysis of the result of the radiographic examination shall be prepared in the form INSP-085 and shall be signed by minimum of Level II personnel qualified as per NDE written procedure QMI 008.

- 13.1** A complete set of radiographs and reports for each job shall be retained by BHEL until the data report has been signed by the AI and all the NDE reports and radiographs are to be retained till MDR is signed by AI as per ASME Sec. VIII, Div-I and for 5 years, in case of ASME Sec. VIII, Div.-II.

**TABLE I****MATERIAL THICKNESS AND IQI DESIGNATIONS**

Nominal Single-wall Material Thickness Range	IQI			
	Source Side		Film Side	
	Hole Type Designa- tion	Wire Type Essential Wire	Hole Type Designation	Wire Type Essential Wire
Up to 6.4mm (0.25") incl.	12	5	10	4
Over 6.4mm through 9.5mm (0.25 to 0.375")	15	6	12	5
Over 9.5mm through 12.7mm (0.375 to 0.50")	17	7	15	6
Over 12.7mm through 19mm (0.50 to 0.75")	20	8	17	7
Over 19mm through 25.4mm (0.75 to 1.00")	25	9	20	8
Over 25.4mm through 38.1mm (1.00 to 1.50")	30	10	25	9
Over 38.1mm through 50.8mm (1.50 to 2.00")	35	11	30	10
Over 50.8mm through 63.5mm (2.00 to 2.50")	40	12	35	11
Over 63.5mm through 101.6mm (2.50 to 4.00")	50	13	40	12
Over 101.6mm through 152.4mm (4.00 to 6.00")	60	14	50	13
Over 152.4mm through 203.2mm (6.00 to 8.00")	80	16	60	14
Over 203.2mm through 254mm (8.00 to 10.00")	100	17	80	16
Over 254mm through 304.8mm (10.00 to 12.00")	120	18	100	17
Over 304.8mm through 406.4mm (12.00 to 16.00")	160	20	120	18
Over 406.4mm through 508mm (16.00 to 20.00")	200	21	160	20



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TABLE - II

EQUIVALENT HOLE TYPE IQI SENSITIVITY

Hole type designation 2T hole	Equivalent hole type designations	
	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

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APPENDIX - I

HOLE TYPE IQI DESIGNATION, THICKNESS AND HOLE DIAMETERS

IQI Designation	IQI Thickness		1T Hole Diameter		2T Hole Diameter		4T Hole Diameter	
	Mm	in	mm	in	mm	in	Mm	In
5	0.13	0.005	0.25	0.010	0.51	0.020	1.02	0.040
7	0.19	0.0075	0.25	0.010	0.51	0.020	1.02	0.040
10	0.25	0.010	0.25	0.010	0.51	0.020	1.02	0.040
12	0.32	0.0125	0.32	0.012	0.64	0.025	1.27	0.050
15	0.38	0.015	0.38	0.015	0.76	0.030	1.52	0.060
17	0.44	0.0175	0.44	0.0175	0.89	0.035	1.78	0.070
20	0.51	0.020	0.51	0.020	1.02	0.040	2.03	0.080
25	0.64	0.025	0.64	0.025	1.27	0.050	2.54	0.100
30	0.76	0.030	0.76	0.030	1.52	0.060	3.05	0.120
35	0.89	0.035	0.89	0.035	1.78	0.070	3.56	0.140
40	1.02	0.040	1.02	0.040	2.03	0.080	4.06	0.160
45	1.14	0.045	1.14	0.045	2.29	0.090	4.57	0.180
50	1.27	0.050	1.27	0.050	2.54	0.100	5.08	0.200
60	1.52	0.060	1.52	0.060	3.05	0.120	6.10	0.240
70	1.78	0.070	1.78	0.070	3.56	0.140	7.11	0.280
80	2.03	0.080	2.03	0.080	4.06	0.160	8.13	0.320
100	2.54	0.100	2.54	0.100	5.08	0.200	10.16	0.400
120	3.05	0.120	3.05	0.120	6.10	0.240	12.19	0.480
140	3.56	0.140	3.56	0.140	7.11	0.280	14.22	0.560
160	4.06	0.160	4.06	0.160	8.13	0.320	16.26	0.640
200	5.08	0.200	5.08	0.200	10.16	0.400	--	--
240	6.10	0.240	6.10	0.240	12.19	0.480	--	--
280	7.11	0.280	7.11	0.280	14.22	0.560	--	--

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APPENDIX - II

WIRE IQI DESIGNATION AND WIRE DIAMETERS

Set	Wire Diameter		Wire identity
	mm	inch	
A	0.08	0.0032	1
	0.10	0.004	2
	0.13	0.005	3
	0.16	0.0063	4
	0.20	0.008	5
	0.25	0.010	6
B	0.25	0.010	6
	0.33	0.013	7
	0.41	0.016	8
	0.51	0.020	9
	0.64	0.025	10
	0.81	0.032	11
C	0.81	0.032	11
	1.02	0.040	12
	1.27	0.050	13
	1.60	0.063	14
	2.03	0.080	15
	2.54	0.100	16
D	2.54	0.100	16
	3.20	0.126	17
	4.06	0.160	18
	5.08	0.200	19
	6.35	0.250	20
	8.13	0.320	21

* Inch sizes are adopted.

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BHEL HYDRABAD	TECHNIQUE CHART	TECHNIQUE NO
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TECHNIQUE FOR RADIOGRAPHIC EXAMINATION

A) NAME OF THE JOB:

B) JOINT DETAILS:

C) NO OF EXPOSURES:

D) SOURCE:

E) FOCAL SPOT/SOURCE SIZE:

F) MATERIAL

THICKNESS:)

REINFORCEMENT:

G)SOURCE TO OBJECT DISTANCE:

H) DISTANCE FROM SOURCE SIDE OF OBJECT TO FILM:

I) FILM:

DENSITY:

SENSITIVITY REQUIRED:

SCREEN:

SCREEN THICK :

J) NO. OF FILMS IN EACH FILM HOLDER:

K) SINGLE/DOUBLE WALL EXPOSURE :

L) SINGLE/DOUBLE WALL VIEWING:

SHOOTING SKETCH

PREPARED BY:

Level-II

Date

APPROVED BY:

Level-III

Date

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