RADIOGRAPHIC EXAMINATION PROCEDURE

1. SCOPE:
The scope of this procedure shall apply to all radiographic examinations carried out during the execution of the Tankage Re-Erection work Phase-II with a special emphasis on radiation safety.

2. PURPOSE:
The purpose of this procedure is to ensure that the radiographic images produced are acceptable quality and that all radiographic examinations are performed in a safety policy, project specifications, quality control plan (SEP-Q1-001) and applicable codes.

3. REFERENCE:
ASME V Nondestructive Examination-Boiler & pressure vessel Code
ASME B31.3 Process Piping
ASME IX Welding and Bracing Qualification
API 650 Welded Steel tanks for Oil Storage.
SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification & Certification.
API 1104 Standard for welding pipelines and related facilities.

4. RADIATION SAFETY
4.1 General
The radiographic technician (radiographer) shall be fully trained / qualified, and shall be fully aware of the hazards of radiation. Human body tissue will be severely damaged if they are over exposed to radiation and even small amount of exposure on a daily basis, with insufficient recovery periods, will eventually produce a serious deterioration in health. All possible safety precaution shall always be taken to avoid unnecessary exposure. Prior to commencing any radiation work on site, emergency procedures shall be established. All radiographic discipline personnel who are involved with working with ionizing Radiation shall
➢ Take all reasonable safety precautions.
➢ Not knowingly expose either themselves or any other person to radiation greater than is absolutely necessary for the purposes of their work.

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Make full and proper use of all personal protection equipment provided.
Report any defects to radiographic equipment to his employer immediately upon discovery.

4.2 Controlled areas
Radiography shall only be undertaken in designated and clearly identified "controlled areas".
These areas shall be identified and sealed by the use of the following as a minimum
- Radiation tape Barriers-which surround and seal off the controlled area in its entirety.
- Radiation Hazard Warning Signs in English.
- The sign shall be a minimum size of 450 x 450 mm.
- These shall be positioned every 30 meters around the periphery of the controlled area.
- Flashing yellow lights to indicate radiation hazard area, these shall be positioned adjacent to warning signs.

Under no circumstances shall non radiographic discipline (unclassified) personnel cross or enter the barriers to a controlled area.
Any infringement of this safety rule / regulations concerning controlled areas will result in the immediate removal of the individual concerned and expulsion from the Tankage Project.

4.3 Radioactive isotope
The container in which radioactive isotopes are housed shall be lockable and sealed. They shall be manufactured from expended uranium or similar materials, to international safety standards.
These containers shall be re-certified as safe to use every of 26 months (maximum).The senior radiographic technician on site shall hold the keys at all times (other than usage).The whereabouts of all radioactive isotopes on site shall be logged and known at all times.

5. QUALIFICATION OF EXAMINATION PERSONNEL
The qualification of examination personnel shall be in accordance with SNT-TC-1A or an alternative system specifically accepted by owner.

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6. EQUIPMENT AND MATERIALS

6.1 Film
Radiographs shall be made using industrial radiographic films that are available to meet the required quality of radiographs. AGFA /KODAK made D4 or equivalent film to be used for 6 mm to 19 mm thick materials.

6.2 Identifying screen
The function of the lead intensifying screens is to reduce exposure times by the emission of electrons and secondary radiation in reaction to the primary radiation source and at the same time reduce film fogging by acting as a filter for the absorption of back scattered radiation.
The lead screens used shall be clean and in good condition, with a thickness of 0.125 mm (front) and 0.25 mm (rear), and shall be in direct contact with the radiographic film.

6.3 IQI (Image Quality Indicator)
Pentameter shall be either the hole type or the wire type and shall consist of those in Table 1 for hole type and those in Table 2 for wire type.

6.4 Radiation source
Iridium 192 will be used as a radiation source.
### Table 1. Hole Type IQI Designation, Thickness and Hole Diameters, in

<table>
<thead>
<tr>
<th>Penetrator Designation</th>
<th>Penetrator Thickness</th>
<th>1T Holes Diameter</th>
<th>2T Holes Diameter</th>
<th>4T Holes Diameter</th>
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</thead>
<tbody>
<tr>
<td>5</td>
<td>0.005</td>
<td>0.010</td>
<td>0.020</td>
<td>0.040</td>
</tr>
<tr>
<td>7</td>
<td>0.007</td>
<td>0.010</td>
<td>0.020</td>
<td>0.040</td>
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<tr>
<td>10</td>
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<td>0.010</td>
<td>0.020</td>
<td>0.040</td>
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<tr>
<td>12</td>
<td>0.012</td>
<td>0.012</td>
<td>0.025</td>
<td>0.050</td>
</tr>
<tr>
<td>15</td>
<td>0.015</td>
<td>0.015</td>
<td>0.030</td>
<td>0.060</td>
</tr>
<tr>
<td>17</td>
<td>0.017</td>
<td>0.017</td>
<td>0.035</td>
<td>0.070</td>
</tr>
<tr>
<td>20</td>
<td>0.020</td>
<td>0.020</td>
<td>0.040</td>
<td>0.080</td>
</tr>
<tr>
<td>25</td>
<td>0.025</td>
<td>0.025</td>
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<td>0.100</td>
</tr>
<tr>
<td>30</td>
<td>0.030</td>
<td>0.030</td>
<td>0.060</td>
<td>0.120</td>
</tr>
<tr>
<td>35</td>
<td>0.035</td>
<td>0.035</td>
<td>0.070</td>
<td>0.140</td>
</tr>
<tr>
<td>40</td>
<td>0.040</td>
<td>0.040</td>
<td>0.080</td>
<td>0.160</td>
</tr>
<tr>
<td>45</td>
<td>0.045</td>
<td>0.045</td>
<td>0.090</td>
<td>0.180</td>
</tr>
<tr>
<td>50</td>
<td>0.050</td>
<td>0.050</td>
<td>0.100</td>
<td>0.200</td>
</tr>
<tr>
<td>60</td>
<td>0.060</td>
<td>0.060</td>
<td>0.120</td>
<td>0.240</td>
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<tr>
<td>80</td>
<td>0.080</td>
<td>0.080</td>
<td>0.160</td>
<td>0.320</td>
</tr>
<tr>
<td>100</td>
<td>0.100</td>
<td>0.100</td>
<td>0.200</td>
<td>0.400</td>
</tr>
<tr>
<td>120</td>
<td>0.120</td>
<td>0.120</td>
<td>0.240</td>
<td>0.480</td>
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<td>0.160</td>
<td>0.320</td>
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<tr>
<td>200</td>
<td>0.200</td>
<td>0.200</td>
<td>0.400</td>
<td>……</td>
</tr>
</tbody>
</table>

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Table 2. Wire IQI Designation and Wire Diameters, in

<table>
<thead>
<tr>
<th>ASTM Set</th>
<th>Wire Diameter</th>
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<tbody>
<tr>
<td>A</td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>0.008</td>
</tr>
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<tr>
<td></td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>0.016</td>
</tr>
<tr>
<td>B</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>0.032</td>
</tr>
<tr>
<td></td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>0.050</td>
</tr>
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<td>0.063</td>
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<tr>
<td></td>
<td>0.080</td>
</tr>
<tr>
<td></td>
<td>0.100</td>
</tr>
<tr>
<td></td>
<td>0.126</td>
</tr>
<tr>
<td>C</td>
<td>0.160</td>
</tr>
<tr>
<td>D</td>
<td>0.200</td>
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<tr>
<td></td>
<td>0.250</td>
</tr>
<tr>
<td></td>
<td>0.320</td>
</tr>
</tbody>
</table>

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7. PROCESSING REQUIREMENTS

7.1 Quality of radiographs

All radiographs shall be free from mechanical, chemical or other artifacts to the extent that they cannot mask or be confused with the image of any discontinuity in the object being radiographed. Such artifacts include but are not limited to:

[a] Fogging
[b] Processing defects such as water or chemical marks.
[c] Scratches, Finger marks, crimps, static smudges or tears.
[d] Loss of details due to poor film Contrast.
[e] False indication due to defective screens.

7.2 Processing Manual (According to SE-94)

7.2.1 Preparation:–

No more film should be processed that can be accommodated with a minimum separation of ½”. Hangers are loaded and solutions stirred before starting development.

7.2.2 Start of development:–

Start the timer and place the films into the developer tank. Separate to a minimum distance of ½” and agitate in two directions for about 15 seconds.

7.2.3 Development:–

Normal development is 5 to 8 minutes at 68°F (20°C).

7.2.4 Agitation:–

Shake the film horizontally and vertically, ideally for a few seconds each minute during development. This will help develop evenly.

7.2.5 Rinsing:–

Rinse the films with vigorous agitation in clear water.

7.2.6 Fixing:–

The films must not touch one another in the fixer. Agitate the hangers vertically for about 10 seconds and again at the end of the first minute, to ensure uniform and rapid fixation. Keep them in the fixer until fixation is complete (i.e. at least twice the clearing time), but not more than 15 minutes in relatively fresh fixer. Frequent agitation will shorten the time of fixation.

7.2.7 Fixer Neutralizing:–

Use hypo eliminator or fixer neutralizer between fixation and washing.

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7.2.8 Washing:-
Washing is very slow below 60° F(16° C). When washing at temperature above 85° F(30° C), care should be exercised not to leave films in the water too long. The films should be washed in batches without contamination from new film brought over from the fixer. If pressed for capacity, as more films are put in the wash, Partially washed film should be moved in the direction of the inlet.

7.2.9 Wetting Agent:-
Dip the film for approx. 30 seconds in a wetting agent added clear water.

7.2.10 Drying:-
Take Precaution to tighten film on hangers, so that it cannot touch in the dryer. Too hot a Drying temperature at low humidity can result in uneven drying and should be avoided.

8. Examination Procedure:-

8.1. 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 irregularities cannot mask or be confused with the image of any discontinuity.

8.2. RT request
Upon completion and visual acceptance of a weld that is subject to radiography, the controlling engineer shall make a request for radiographic examination. The request shall be entered into the schedule for radiographic examination and forwarded to the radiographic technicians for execution.

8.3. Controlled area
Radiography shall only be performed at such times as the work site is clear of all non radiographic discipline personnel and the area of exposure shall be designated a ‘controlled area’
Prior to commencing exposure of the isotope, all safety precautions and requirements as stated in 4.0 radiation safety shall be implemented.
The area in which the isotope is to be exposed shall be treated as a 'controlled area' and only classified personnel may enter.

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The boundaries of this ‘controlled area’ shall be identified with radiation tape barriers, warning signs (in both English and Hindi) and flashing lights.

8.4. Marking on the weld
The radiographer shall identify the weld to be radiographed and mark the weld.

8.5. Film identification
Each radiograph shall be uniquely identified by means of lead numbers and letters. The lead letters and numbers shall not encroach into the weld area and shall not interfere with the interpretation of the radiograph in any way. The following information shall be displayed on each radiographic film as a minimum:
--- Project name
--- Company name
--- Line number, drawing number or piece number.
--- Weld number
--- Repair identification number(where applicable)
--- Welder identification number
--- Date of radiograph
--- Joint thickness and diameter

8.6. Location markers
Location markers, which are to appear as radiographic images on the film, shall be placed on the part, not on the exposure holder. Their location 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 radiographed to be accurately traceable to its location on the part.

8.7. Direction of radiation
The direction of the central beam of radiation should be centered on the area of interest whenever practical.
8.8. Film handling
Care shall be taken to ensure that both exposed and unexposed films are kept segregated and are stored in such a manner as that they shall not be subjected to radiation, excessive heat, dirt, fumes, etc.

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

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

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

[b] Double wall viewing
For welds in components 3.1/2 in. or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld in both walls is viewed for acceptance on the same radiograph.
For double wall viewing, only a source side penetrrometer shall be used.

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

[2] As alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed.
When complete coverage is required, a minimum of three exposures taken at either 60 deg. To 120 deg. To each other shall be made for each joint.
8.10. Geometric unsharpness

Unless otherwise specified in the applicable job order or Contract, the geometric unsharpness shall not exceed the following limits:

<table>
<thead>
<tr>
<th>Material</th>
<th>Ug Maximum (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (in.)</td>
<td></td>
</tr>
<tr>
<td>Under 2</td>
<td>0.020</td>
</tr>
<tr>
<td>2 trough 3</td>
<td>0.030</td>
</tr>
<tr>
<td>Over 3 trough 4</td>
<td>0.040</td>
</tr>
<tr>
<td>Greater than 4</td>
<td>0.070</td>
</tr>
</tbody>
</table>

8.11. IQI Selection

The designed hole penetrameter with essential hole or designed wire diameter shall be as specified in Table 3.

8.11.1. Weld with reinforcements

The thickness on which the penetrameter is based is the nominal single wall thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing Code Section.

Backing rings or strips are not be considered as part of the thickness in penetrameter selection.

The actual measurement of the weld reinforcement is not required.

8.11.2. Weld without reinforcements

The thickness on which the penetrameter is based is the nominal single wall thickness.

Backing rings or strips are not to be considered as part of the thickness in penetrameter selection.

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Design:

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### Table.3 IQI Selection

<table>
<thead>
<tr>
<th>Normal Single-wall Material Thickness Range, in.</th>
<th>Penetrator</th>
<th>Source Side</th>
<th>Film side</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hole Type Designation</td>
<td>Essential Hole</td>
<td>Wire Diameter, in</td>
</tr>
<tr>
<td>Up to 0.25 incl.</td>
<td>12</td>
<td>2T</td>
<td>0.008</td>
</tr>
<tr>
<td>Over 0.25 through 0.375</td>
<td>15</td>
<td>2T</td>
<td>0.010</td>
</tr>
<tr>
<td>Over 0.375 through 0.50</td>
<td>17</td>
<td>2T</td>
<td>0.013</td>
</tr>
<tr>
<td>Over 0.50 through 0.75</td>
<td>20</td>
<td>2T</td>
<td>0.016</td>
</tr>
<tr>
<td>Over 0.75 through 1.00</td>
<td>25</td>
<td>2T</td>
<td>0.020</td>
</tr>
<tr>
<td>Over 1.00 through 1.50</td>
<td>30</td>
<td>2T</td>
<td>0.025</td>
</tr>
<tr>
<td>Over 1.50 through 2.00</td>
<td>35</td>
<td>2T</td>
<td>0.032</td>
</tr>
<tr>
<td>Over 2.00 through 2.50</td>
<td>40</td>
<td>2T</td>
<td>0.040</td>
</tr>
<tr>
<td>Over 2.50 through 4.00</td>
<td>50</td>
<td>2T</td>
<td>0.050</td>
</tr>
<tr>
<td>Over 4.00 through 6.00</td>
<td>60</td>
<td>2T</td>
<td>0.063</td>
</tr>
<tr>
<td>Over 6.00 through 8.00</td>
<td>80</td>
<td>2T</td>
<td>0.100</td>
</tr>
<tr>
<td>Over 8.00 through 10.00</td>
<td>100</td>
<td>2T</td>
<td>0.126</td>
</tr>
<tr>
<td>Over 10.00 through 12.00</td>
<td>120</td>
<td>2T</td>
<td>0.160</td>
</tr>
<tr>
<td>Over 12.00 through 16.00</td>
<td>160</td>
<td>2T</td>
<td>0.250</td>
</tr>
<tr>
<td>Over 16.00 through 20.00</td>
<td>200</td>
<td>2T</td>
<td>0.320</td>
</tr>
</tbody>
</table>

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8.11. Placement of penetrameters

8.11.1. Source side penetrameter(s)
The penetrameter(s) shall be placed on the source side of the part being examined, except for the condition described in 8.11.2.

8.11.2. Film side penetrameter(s)
Where inaccessibility prevents hand placing the penetrameter(s) on the source side, the penetrameter(s) shall be placed on the film side in contact with the part being examined.
A lead letter "F", at least as high as the penetrameter indication number(s), shall be placed adjacent to or on the penetrameter(s), but shall not mask the essential hole where hole penetrameters are used.

8.11.3. Penetrameter location for welds—hole penetrameters
The penetrameter(s) may be placed adjacent to or on the weld. The identification number(s) and, when used, the lead letter "F" shall not be in the area of interest.

8.11.4. Penetrameter location for welds—wire penetrameters
The penetrameter(s) shall be placed on the weld so that the length of the wires is perpendicular to the length of weld. The identification number(s) and, when used, the lead letter "F" shall not be in the area of interest.

8.12. Number of penetrameters
For components where one or more film holders are used for an exposure, at least one penetrameter image shall appear on each radiographed except as outlined in 8.12.2.

8.12.1. Multiple penetrameters
If the requirements of 9.3.2 are met by using more than one penetrameter, 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.

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8.12.2. Special cases

1. For cylinder vessels 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 circumstance, at least three penetrameters shall be spaced approximately 120 deg. apart.

2. For cylinder vessels where the source is placed on the axis of the object and four or more film holders are used for a single exposure of a section of the circumference, at least three penetrameters shall be used. One penetrameter shall be in the approximate center of the section exposed and one at each end. When the section of the circumference exposed exceeds 240 deg., the rules of [1] above apply. Additional film locations may be required to obtain necessary penetrameter spacing; otherwise at least one penetrameter image shall appear on each radiograph.

3. For spherical vessels, where the source is located at the center of the vessel and one or more film holders are used for a single exposure of a complete circumstance, at least three penetrameters shall be spaced approximately 120 deg. apart. For other welds radiographed simultaneously, one additional parameter shall be placed on each other weld.

4. For segments of spherical vessels where the source is located at the center of the vessel and four or more film holders are used for a circumferential weld, at least three penetrameters shall be used. One penetrameter shall be in the approximate center of the portion exposed and one at each end. When the portion exposed exceeds 240 deg., the rules of [3] above apply. Additional film locations may be required to obtain necessary penetrameter spacing; otherwise, at least one penetrameter image shall appear on each radiograph.

8.13. Shims

A shim of material radiographically similar to the weld metal shall be placed between the part and the penetrameter, if needed, so that the radiographic density throughout the area of interest is no more than minus 15% from the radiographic density through the penetrameter. The shim dimensions shall exceed the penetrameter dimensions such that the outline of at least three sides of the penetrameter image shall be visible in the radiograph.

<table>
<thead>
<tr>
<th>Prepared by</th>
<th>Concurred by</th>
<th>Approved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTRACTOR</td>
<td>Hindustan Petroleum Crop. Ltd.</td>
<td>Hindustan Petroleum Crop. Ltd</td>
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<td>Design:</td>
<td>Name:</td>
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<tr>
<td>Design:</td>
<td></td>
<td>Design:</td>
</tr>
</tbody>
</table>
9. EVALUATION

9.1. Quality of radiographs

All radiographs shall be free of mechanical, chemical, handling related or other blemishes to the extent that they do not mask and are not confused with the image of any discontinuity in the area of interest of the object being radiographed. If any doubt exists as to the true nature of an indication exhibited by the film, the radiograph shall be rejected and re-shot.

9.2. Viewing facilities for radiographs

Viewing facilities shall provide subdued background lighting of an intensity that will not cause troublesome reflections, shadows or glare on the radiograph. Equipment used to view radiographs for interpretation shall provide a variable light source sufficient for the designated wire to be visible for the specified density range.

9.3. Radiographic density

9.3.1 Density Limitations

The transmitted film density through the radiographic image of the body of appropriate hole penetrameter or adjacent to the designated wire of a wire penetrameter and the area of interest shall be 2.0 minimum and 4.0 maximum.

9.3.2 Density variation

[a] General

If the density of the radiograph anywhere through the area of interest varies by more than minus 15% or plus 30% from the density through the body of the hole penetrameter or adjacent to the designated wire of a wire penetrameter within density limitations, then an additional penetrameter shall be used for each exceptional area or areas and the radiograph taken.

[b] With Shims

When shims are used the plus 30% density restriction of [a] above may be exceeded, provided the required penetrameter sensitivity is displayed and the density limitation are not exceeded.

9.4. IQI sensitivity

Radiography shall be performed with a technique of sufficient sensitivity to display the hole penetrameter image and the specified hole, or the designated wire of a wire penetrameter, which are essential indication of the image quality of the radiograph. The quality levels required using wire Penetrameters shall be equivalent to the 2-2T level of method E 142/ or practice E1025, ASME Sec V Article 22 for hole type penetrameters. The table T-276 Article 2 Sec V Provides a list of various hole type IQI’s and the diameter of the wires of corresponding EPS (Equivalent Penetrameter Sensitivity) with the applicable 2T holes in the IQI.
9.4. Excessive scatter
A lead letter “B” shall be attached to the back of each film holder during each exposure to determine if backscatter radiation is exposing the film. 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.

10. ACCEPTANCE CRITERIA
Radiographs shall be interpreted only in those areas in which Penetrameter(s) have established that a suitable radiographic technique has been used. The following acceptance criteria shall be applied according to applicable code section.
[a] ASME B 31.3
[b] ASME Sec VIII Div 1 UW- 51 or UW- 52
[c] ASME Sec VIII Div.2 AI-510
[d] API 650 XI th Edition cl.8.1.5

11. RECORDS
The following radiographic records shall be maintained as agreed upon between the client and Visual
11.1 Sketch
11.2 Weld repair documentation
11.3 Film used
11.4 Thickness of material
11.5 Source to film distance
11.6 Film interpretation record shall contain as the minimum following information
11.6.1. Disposition of each radiograph (acceptable or rejected)
11.6.2. If rejected, cause for rejection (slag, crack, Porosity, LOP,LOF etc)
11.6.3. Surface indication verified by visual examination (grinding marks, weld ripple, spatter etc.)
11.6.4. Signature of the film interpreter

12. ATTACHMENTS
12.1 Sketch showing location markers and arrow markers
12.2 Radiation warning Sign Board.
12.3 Sample radiographic Report.

Prepared by
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