BIT Inspection Technology

(NDT/ Weld Inspection Training / Consultancy/ Flaw Specimen Manufacturer)

Technical Justification

Doc. no. BIT/TJ/ 002

1. Abstract

This Technical Note evaluates the practical possibilities of achieving "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"**. Refer, ASME Sec. V, **para. T-282.2**

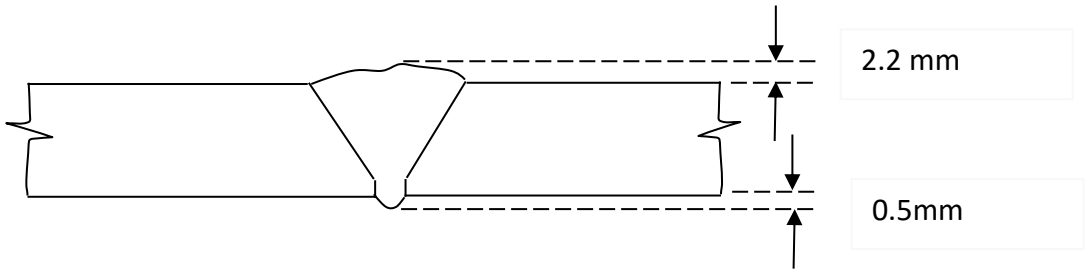
2. Weld Sample Details

Size of weld sample	-	300mm (length) x 300mm (width) x 12.4mm (Thick)
Material	-	Carbon Steel
Welding Process	-	GTAW / SMAW

3. Code Reference used

- ASME Section V
- AWS D1.1: 2015
- ASME B 31.3, High Pressure Piping - Table K341.3.2

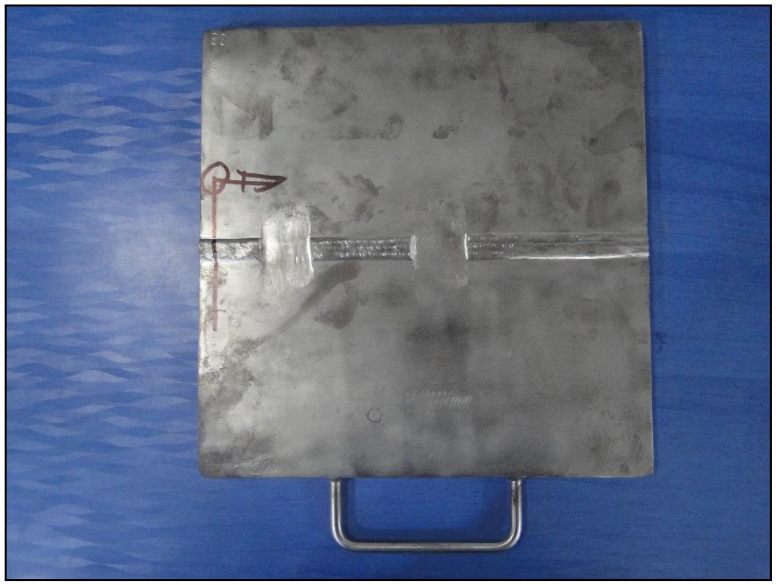
4. Weld Profile

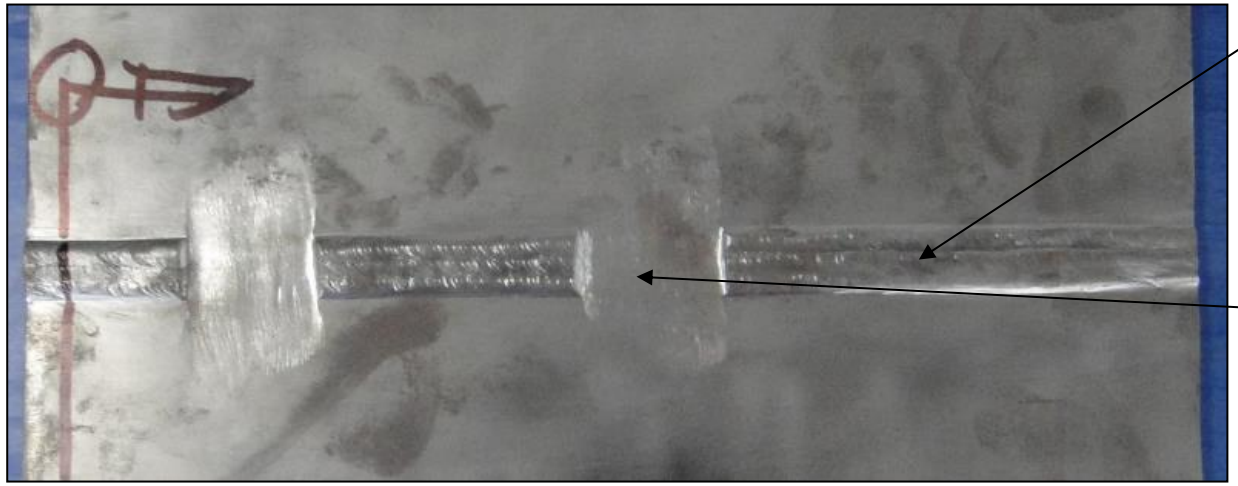


Weld reinforcement allowed by Code for Visual Inspection of 12.4mm wall thickness groove weld in butt joint

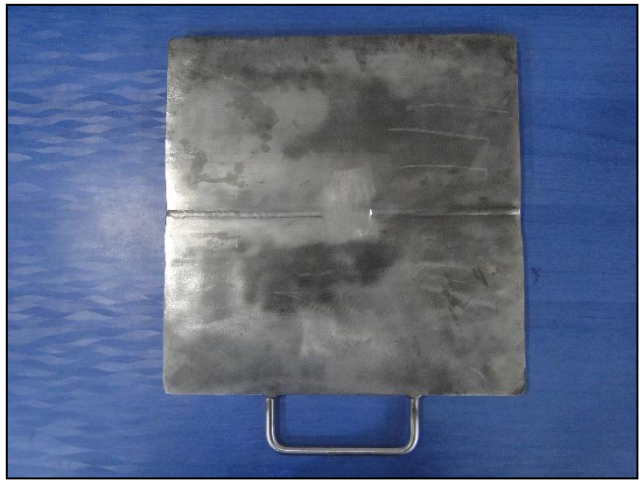
Parameter	AWS D1.1: 2015	ASME B 31.3, High Pressure Piping - Table K341.3.2	Actual reinforcement in the sample
Cap reinforcement height in mm	3	3	2.2
Root reinforcement height in mm	3	3	0.5

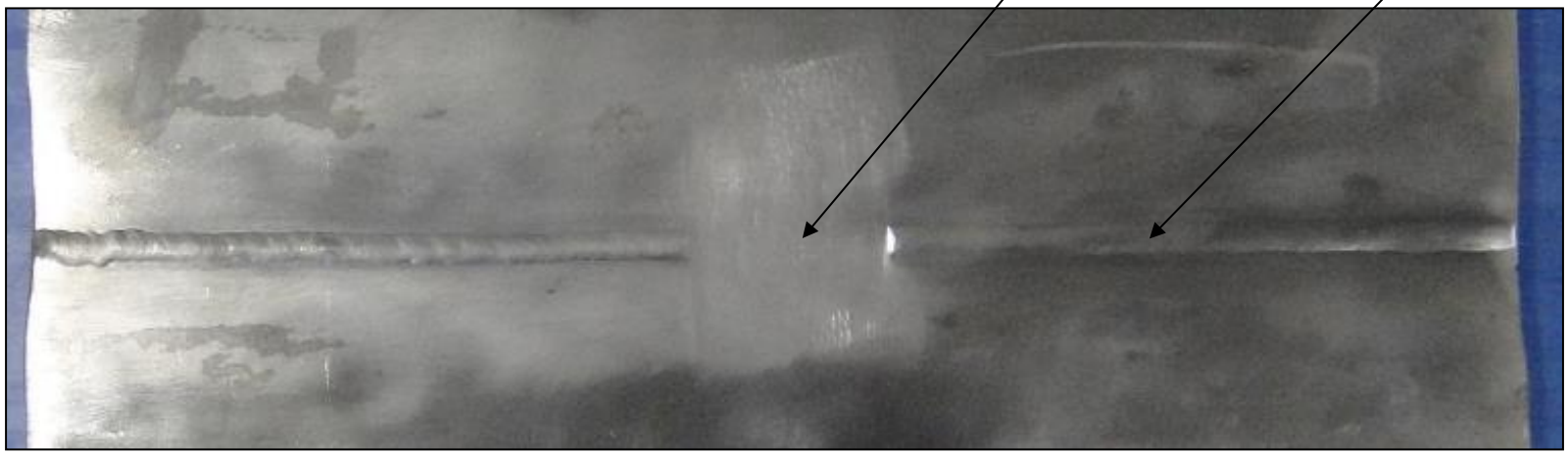
Cap Side:

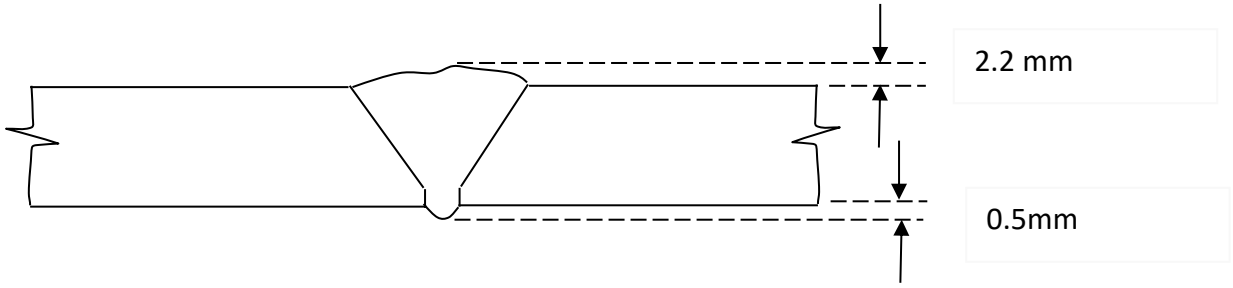




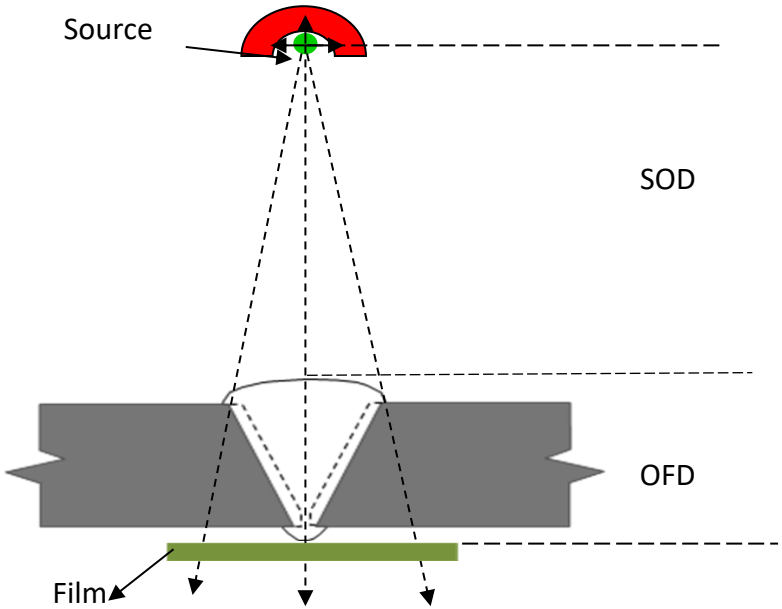
Root Side:




No Root weld reinforcement
Root weld reinforcement


2.2 mm
0.5mm

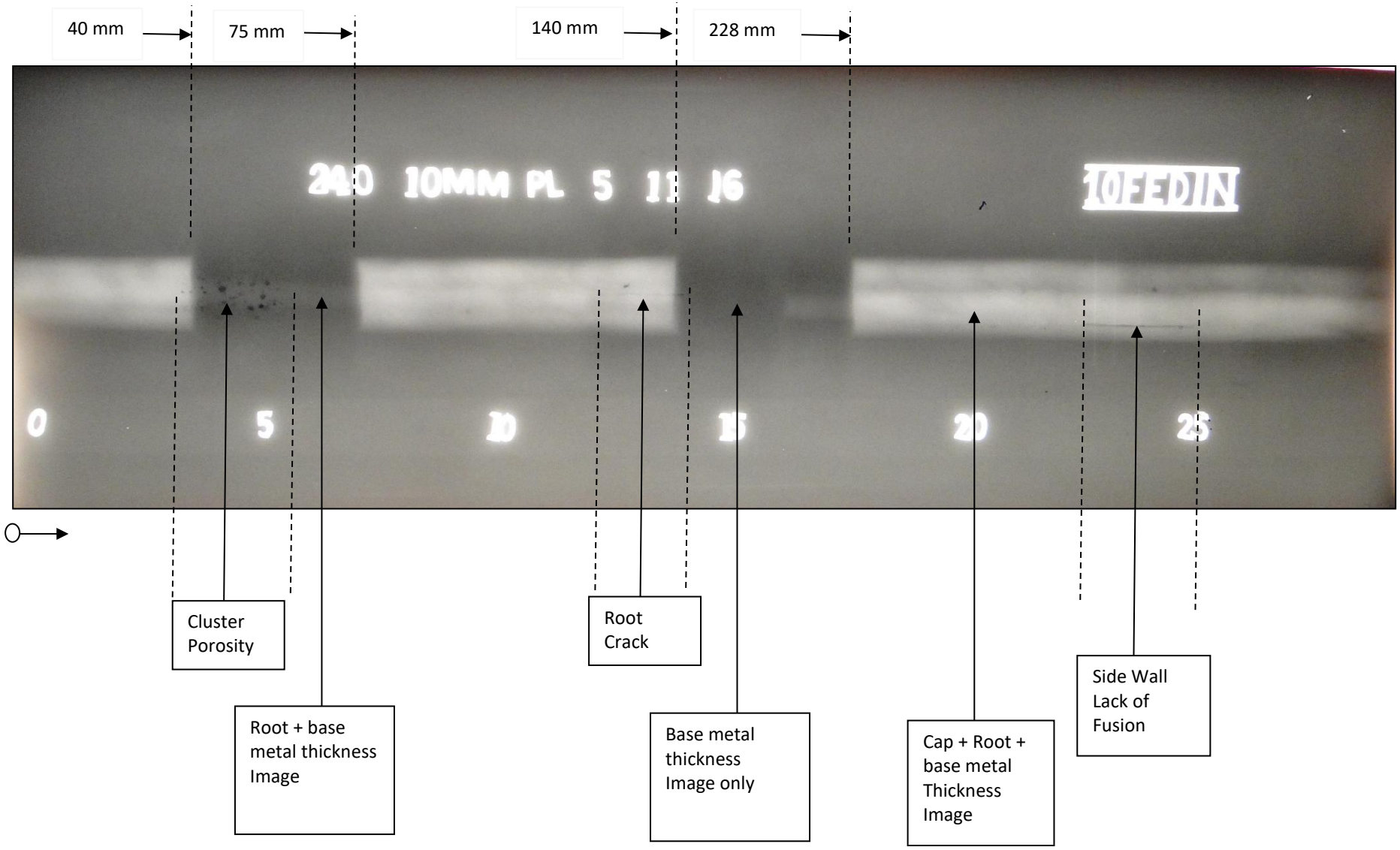
5. Radiographic Technique used



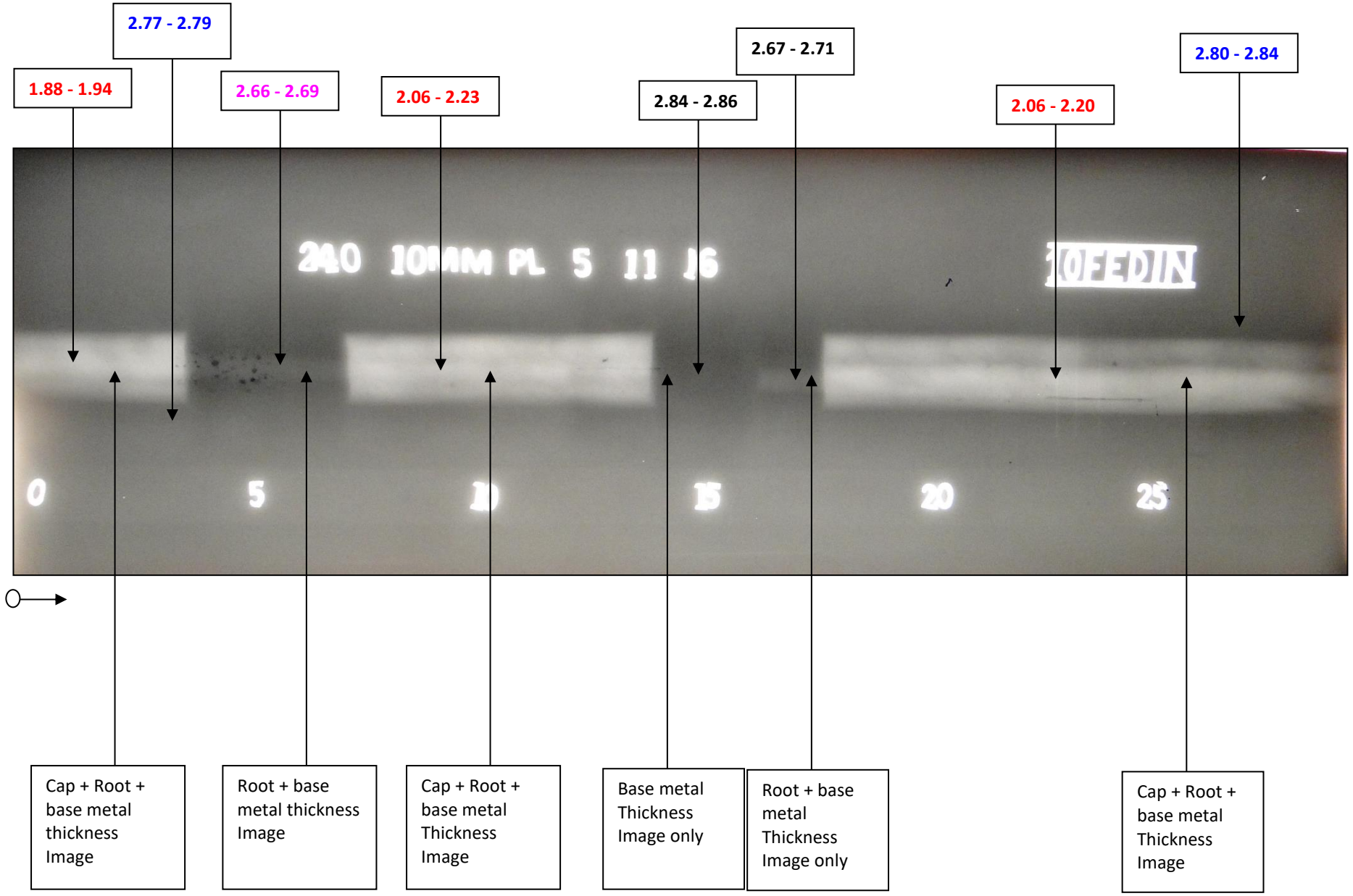
Technique used	-	SWSI
Source to film distance	-	600 mm
Source focal spot size	-	2 x 2 mm
Effective Focal Spot Size (EFSS)	-	2.8 mm
Achieved geometric un-sharpness (Ug)	-	EFSS x OFD / SOD = 2.8 x (12.4 + 2.2 + 0.5) / 585 = **0.072 mm**

6. Radiographic Film Image of Sample used

Film Type - Kodak AA400
Size - 300 mm x 80 mm

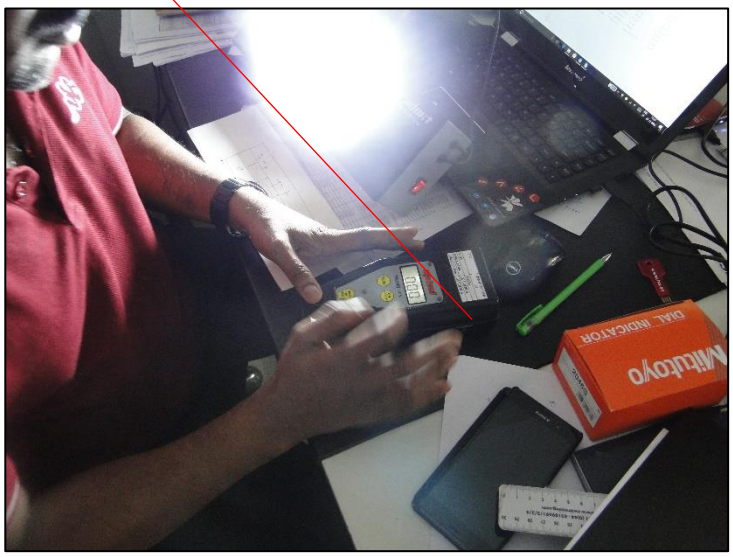


7. Radiographic Density Measurement (Range)



8. Densitometer

Model - Optel - Trans - 4V
Sr. No. - J-3233



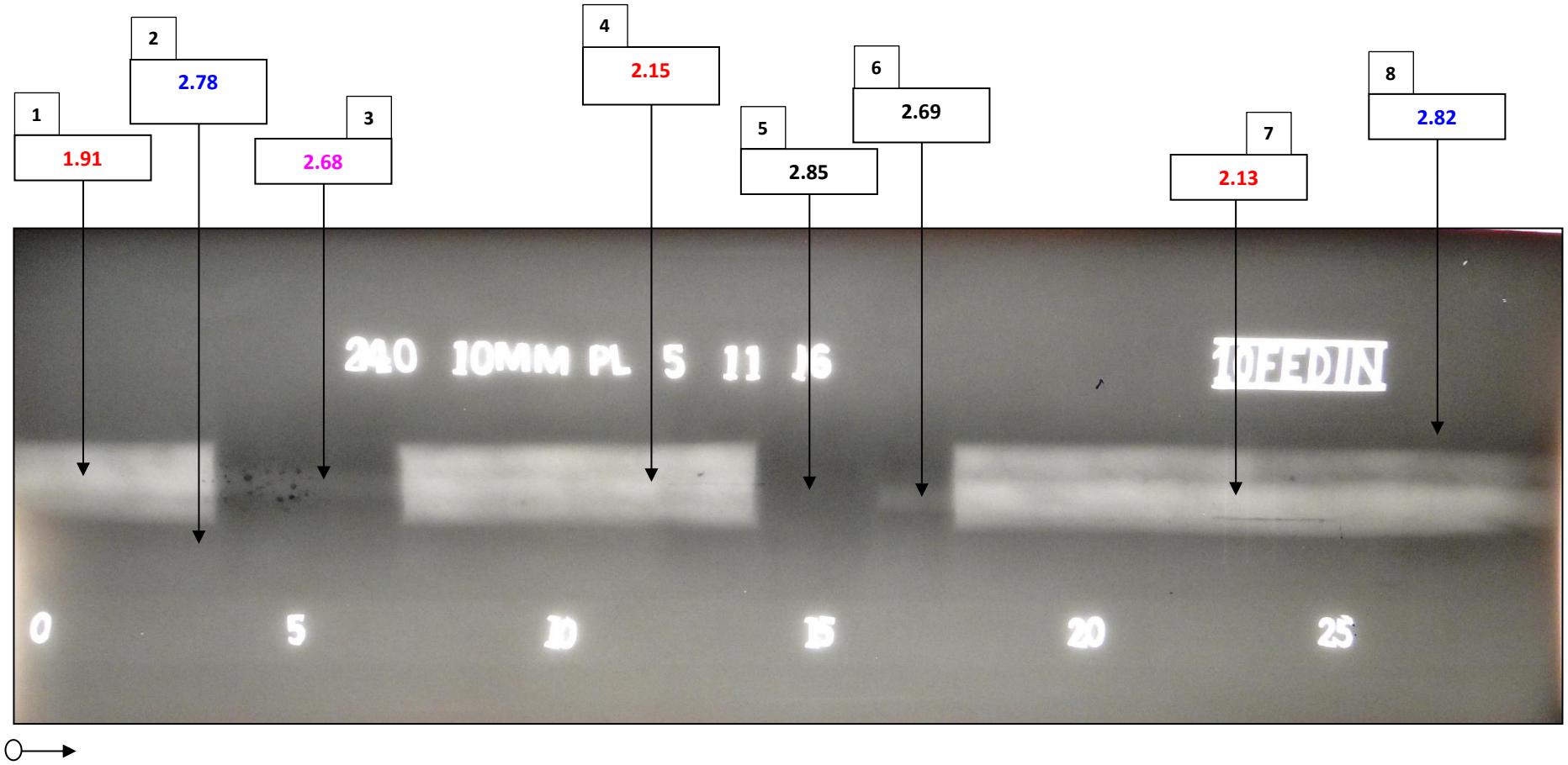
9. Sensitivity Achieved

- 5th wire clearly visible in 10 FE DIN, IQI set = 0.16 mm
- Penetrated thickness = Base metal thickness + Cap reinforcement + Root reinforcement = 12.4 + 2.2 + 0.5
- % of Sensitivity Achieved = 0.16 / (12.4 + 2.2 + 0.5) x 100 = **1.06%**

10. Intended Defect Detectability

Type of defect intended in the Sample Specimen	Status of detection
Cluster Porosity	Detected
Root Crack	Detected
Side Wall of Fusion	Detected

11. Radiographic Density Measurement (Average)



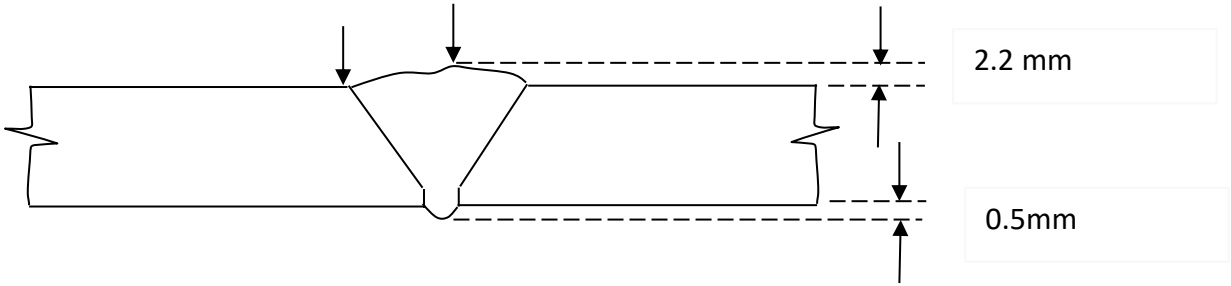
Location		Density Measurement	Density variation in % with reference to the **Ref. Point**	Remarks
1	Weld with root and cap reinforcement	1.91	- 10.3 %	
2	HAZ (Parent Metal)	2.78	**+ 30.5 %**	Note - 3
3	Weld with root reinforcement and without cap reinforcement	2.68	+ 25.8 %	Note - 2
4	Weld with root and cap reinforcement	2.15	+ 0.94 %	
5	Weld without root and cap reinforcement	2.85	**+ 33.8 %**	Note - 2
6	Weld with root reinforcement and without cap reinforcement	2.69	+ 26.3 %	Note - 2
7	**Ref. point** (Note -1) - Weld with root and cap reinforcement	2.13	0	
8	HAZ (Parent Metal)	2.82	**+ 32.4 %**	Note - 3

Note - 1: **Ref. Point:** The location of the radiograph (weld with root and cap) **at adjacent to the essential wire of a wire-type IQI.** % of density variation calculated reference to this point.

Note - 2: Considered all the possibilities of weld metal deposit during manufacturing which were influences density variation, for example

- Weld metal fill without excess weld deposit at both side root & cap (**Location 5** simulates). In general, possibilities are expected due to internal concavity with coincidence of weld metal filled just up to the base metal thickness at cap side.
- Weld metal fill up to base metal thickness at cap side (without cap reinforcement) - **Location 3 & 6** simulates

Note - 3: Very often major density variation expected between center of the weld and parent material (HAZ), as shown in the below sketch due to excess weld metal at cap and root.



12. Summery

1) The sample specimen fabricated and achieved better weld profile within visual acceptance criteria. **Refer para. 4**

Parameter	AWS D1.1: 2015	ASME B 31.3, High Pressure Piping - Table K341.3.2	Actual reinforcement in the sample
Cap reinforcement height in mm	3	3	**2.2**
Root reinforcement height in mm	3	3	**0.5**

2) Applied proper technique,

- SWSI
- Achieved better geometric un-sharpness (Ug) - **0.072 mm** (ASME Code allows up to 0.51mm maximum). **Refer para. 5**
- Used X - ray to achieve better image quality

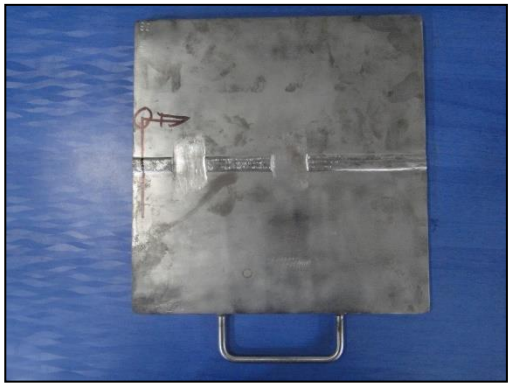
3) Achieved better radiographic image quality,

- % of Sensitivity Achieved : **1.06 %** (Most of the Code / Standard expects 2 % or better). **Refer para. 9**
- Range of density Achieved : **1.91 - 2.85** (Most of the Code / Standard expects 1.8 to 4.0). **Refer para. 11**

4) Intended Defect Detectability,

- All the 3 intended defects are detected **Refer para. 10**

Type of defect intended in the Sample Specimen	Status of detection
Cluster Porosity	Detected
Root Crack	Detected
Side Wall of Fusion	Detected



13. Practical Difficulties to achieve density variation within limit specified in the Code

- Even though after applied stringent fabrication / radiographic technique and achieved better image quality, **but failed** to achieve density variation within limit due to area of interest covers wide range of location, which were influence variation in radiographic density due to **absorption difference between base metal and weld with both cap & root reinforcement.**

- This difficulties faced particularly in **X-ray radiograph**, because of **higher contrast image** achievable by X-ray.

- This difficulties will further raised if the **components are curved**, for example piping radiograph involved particularly with DWSI and DWDI techniques.

- In general, this difficulties are not much in **Gamma –ray radiograph**, because of **lesser contrast image** achievable by gamma -ray

14. Recommendation

When this practical difficulties exist due to,

- **Fabrication difficulties** like weld reinforcement height achieved at higher side of acceptable range

- **Curvature effect of component**, which results density variation

If above inherent difficulties are exist and difficult to avoid, then try with

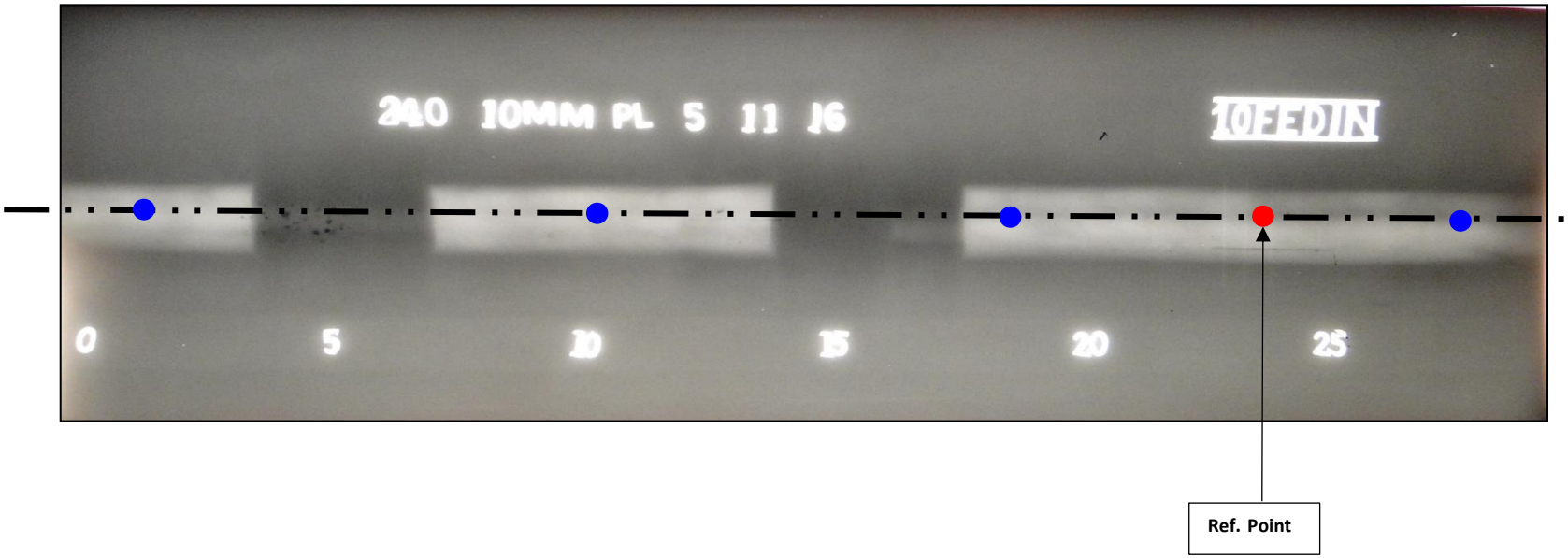
Proper Exposure Technique like selection of optimized energy level (Kv) should be balanced between required **contrast** (absorption difference) **and latitude** (covering wide range of thickness in the single exposure).

Practical difficulties to be studied properly and raised through Technical Note and justify the case in front of Client.

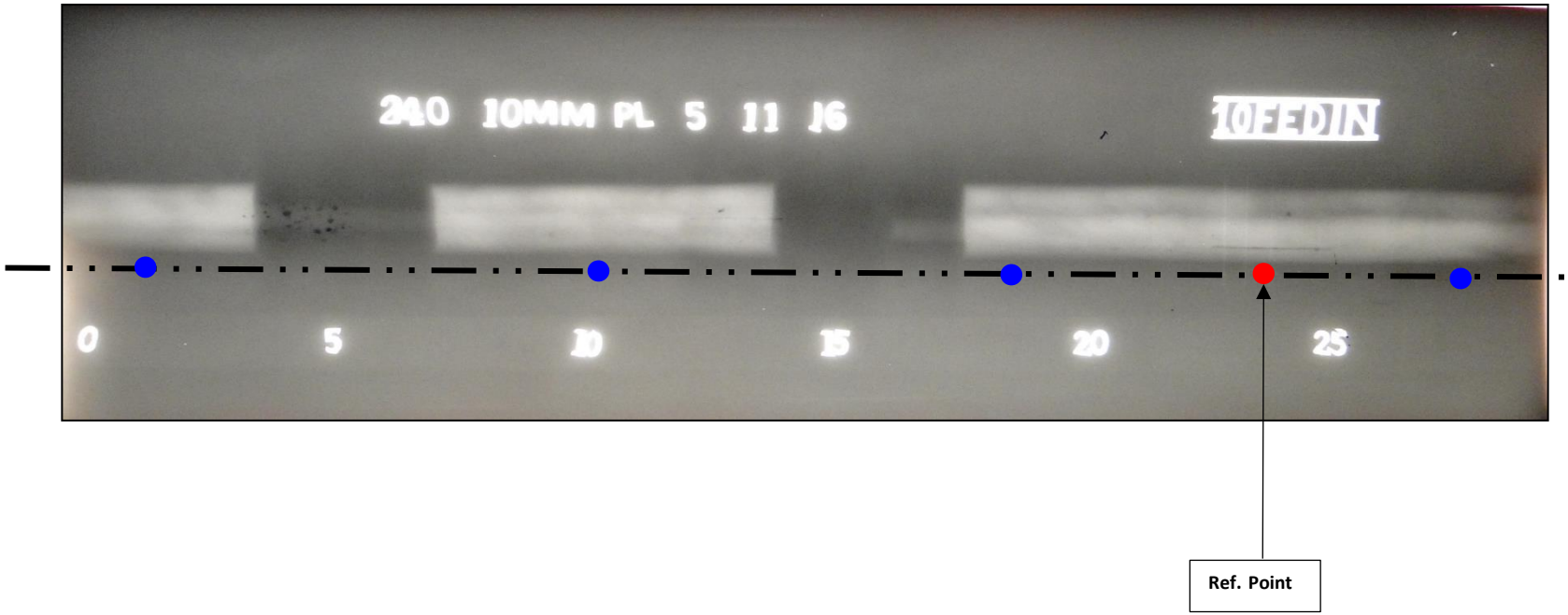
In this case, recommended to

- Compare the density variation along the same absorption thickness, as shown in the image in next page for both base metal and weld metal.
- Range of radiographic density shall be **between 2.0 to 3.0 for Base Metal (HAZ)**

For **Weld Metal:**



For **Base Metal:**



Evaluated by

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PCN Co-ordinator

BIT Inspection Technology Pvt Ltd,

BINDT's ATO & AQB for PCN scheme

ASNT NDT Level III RT, UT, PT, MT, VT, ET
PCN NDT Level III UT, PT, MT, RT / Level II RI
ISO 9712 NDT level 3 III UT, RT, VT (Multi-sector)
CSWIP 3.2 / AWS - SCWI

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