

Oversizing of radiographic indications during the interpretation of radiographs of small bore boiler tubes, using the elliptical methods

Preamble:

Why:

Effects on Outages:

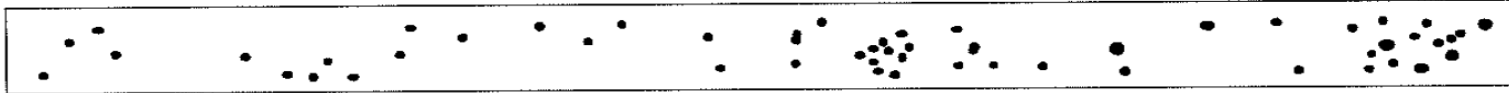
Implementation:

Conclusion:

- Generally, during planned outages on ESKOM plant, a large number of weldments are created with regards the replacement of boiler and economiser tubing.
- This has led to high repair rates due to both time constraints as well as difficult working conditions. The added oversizing of volumetric flaws, particularly porosity has the effect of impacting on turnaround delays.
- Code requirements for boiler repair work differs from EN designed boilers to ASME designed boilers. EN requires a 10% coverage whereas ASME does not specifically require radiography on boiler replacement tube welds.

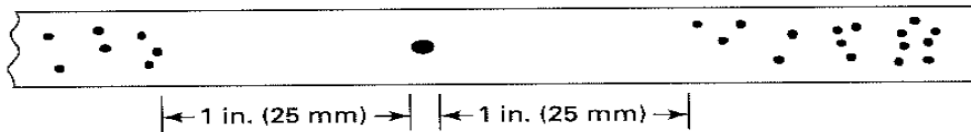
- Pore dimensions are relatively critical, particularly when conducting interpretation in accordance with EN requirements. For materials ranging from 3mm upwards, the limitation for pore dimensions (Maximum) is $0,3 \times$ the thickness.
- ASME allows pores of 1,07mm for 3mm walls and 1,6mm for wall thicknesses of 5mm.
- Very rarely is there a rejection for any other form of volumetric indication. Linear fusion type indications are obviously common as well.

Figure A-250.3.6-1
Charts for $t \frac{1}{8}$ in. (3 mm) to $\frac{1}{4}$ in. (6 mm), Inclusive

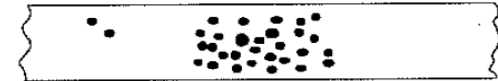


GENERAL NOTE: Typical concentration and size permitted in any 6 in. (150 mm) length of weld

(a) Random Rounded Indications

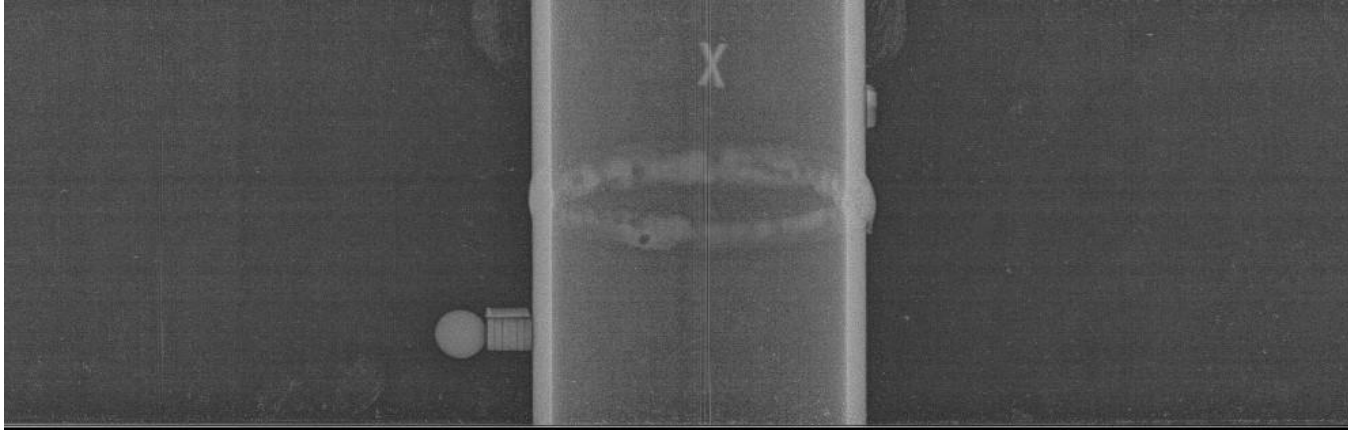


(b) Isolated Indication
(Maximum size per Table A-250.3.2)

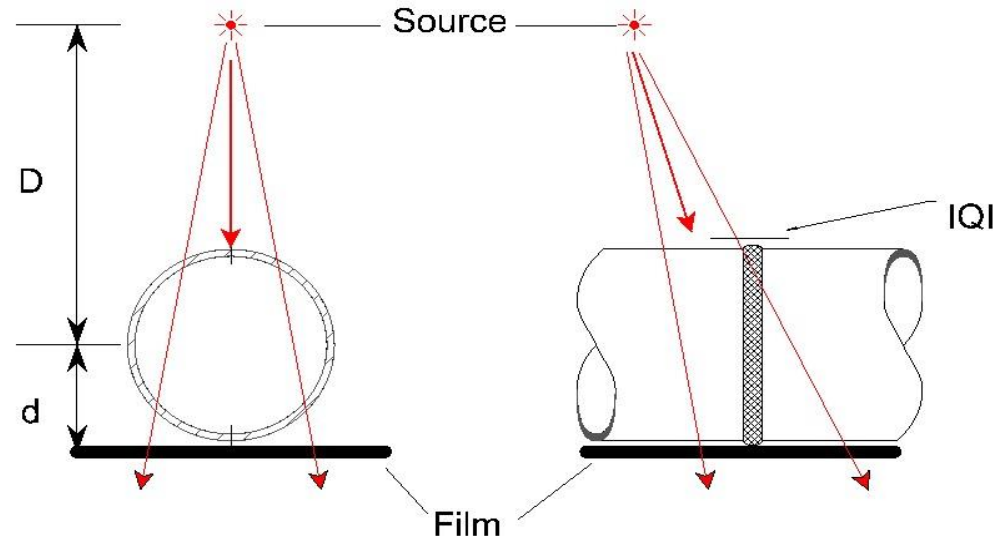


(c) Cluster

ASME 1 Porosity charts for thin walled materials



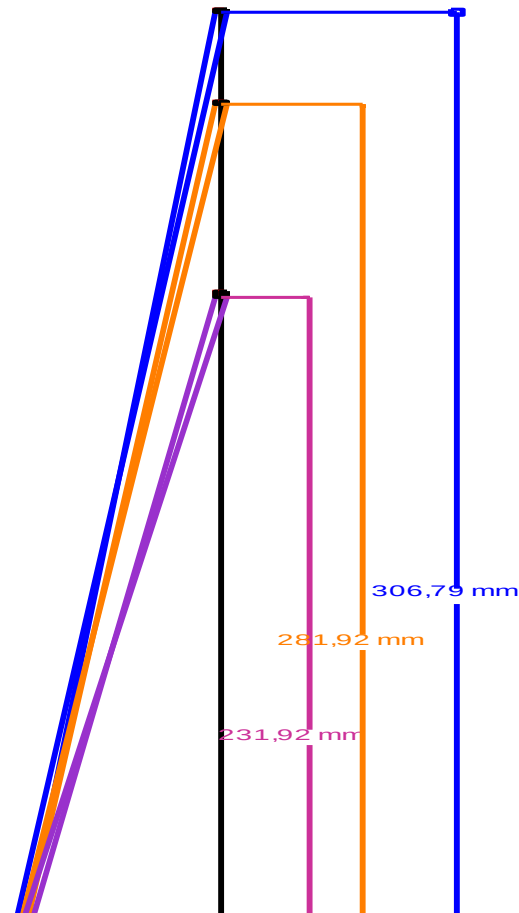
A typical elliptical image from a boiler tube weld. The upper portion of the weld is projected and rendered wider than actuality. This image is a near perfect ellipse, often the images rendered in a shut down environment are more distorted when referencing the elliptical image, due to accessibility issues



A prescribed graphic of an elliptical radiographic setup, the angle of offset from the normal can vary, dependant on tube wall thickness. The thicker the tube, the more the offset will be to achieve an ellipse without image overlap.



A pore simulation used to illustrate the effect of the dimensional enlargement of the rounded image due to projection – a 70% enlargement using a 1x2mm Ir₁₉₂ source at an SFD of 350mm.



Pore projection dimensional enlargement as a result of the effects of the projection. A variance is also affected by SFD changes.

- As can be seen from the previous image, the degree of enlargement through projection is also affected by changes to the SFD of the radiographic setup.
- Variances of between 30% to 40% enlargement are realised by merely increasing the SFD by 75mm.

Pore projected dimensions on various thicknesses of tubes and outer diameters based on an SFD of 300mm for EN Based interpretations

Tube OD (mm)	Wall Thickness 3,8mm - max. pore size permitted	Wall Thickness 3,8mm - max. pore size projected	Wall Thickness 4,0mm - max. pore size permitted	Wall Thickness 4,0mm - max. pore size projected	Wall Thickness 4,2mm - max. pore size permitted	Wall Thickness 4,2mm - max. pore size projected	Wall Thickness 4,4mm - max. pore size permitted	Wall Thickness 4,4mm - max. pore size projected	Wall Thickness 4,6mm - max. pore size permitted	Wall Thickness 4,6mm - max. pore size projected	Wall Thickness 4,8mm - max. pore size permitted	Wall Thickness 4,8mm - max. pore size projected	Wall Thickness 5,0mm - max. pore size permitted	Wall Thickness 5,0mm - max. pore size projected
38mm OD	1,14mm	1,64mm	1,2mm	1,71mm	1,26mm	1,78mm	1,32mm	1,85mm	1,38mm	1,92mm	1,44mm	1,99mm	1,5mm	2,06mm
45mm OD		1,75mm		1,82mm		1,89mm		1,96mm		2,03mm		2,10mm		2,18mm
50mm OD		1,81mm		1,89mm		1,96mm		2,04mm		2,11mm		2,18mm		2,26mm
55mm od		1,89mm		1,97mm		2,04mm		2,12mm		2,19mm		2,27mm		2,34mm
60mm od		1,98mm		2,05mm		2,13mm		2,21mm		2,28mm		2,36mm		2,43mm

Recommended projected pore sizes for isolated pores on radiographs in accordance with the Requirements of EN 5817.

Pore projected dimensions on various thicknesses of tubes and outer diameters based on an SFD of 300mm for ASME 1 Based interpretations

Tube OD (mm)	Wall Thickness 3 to 4,9mm - max. pore size permitted	Wall Thickness 3 to 4,9mm - max. pore size projected	Wall Thickness 5 to 6mm - max.pore size permitted	Wall Thickness 5 to 6mm - max. pore size projected
38mm OD	1,07mm	1,56mm	1,6mm	2,18mm
45mm OD		1,66mm		2,3mm
50mm OD		1,73mm		2,38mm
55mm od		1,81mm		2,47mm
60mm od		1,89mm		2,56mm

Recommended pore sizes for projected pores in accordance with the requirements of ASME 1

Justification for allowing the acceptance of larger pore sizes On small bore boiler tubes

ESKOM have conducted an exercise using FEA to analyse the critical flaw sizes pertaining to the safe working of the boilers, with particular reference to pores in the boiler and economiser tube welds. This survey concluded that a pore if evident could run through 360° of the circumferential butt weld with only a thin section of the remnant wall being evident. The basis of this study was also a study conducted towards the establishment of an acceptance criteria for the replacement of radiographic testing By the PAUT discipline. With this in mind, the implementation of a projected flaw size of increased size being allowable for elliptical images containing pores is justifiable.