Radiographic testing: Increased detection sensitivity using optimum source to object distance

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Abstract
Previous research has shown, when using a Se-75 isotope as source, that not only is the DWSI Technique as effective as the DWDI Technique for finding linear cracks in welded pipe samples, but in some instances even superior, both in the geometric unsharpness and exposure duration with an improved probability of detection for mentioned defects. (Test sample: Pipe - 50mm ID, 3.9mm wall thickness, up to 3mm weld build-up)

Conformance with ASME V Article 2 is achievable.

Conformance with EN1435 Image Quality Class A can be achieved. However, the requirements for Image Quality EN1435 Class B are not attainable due to the non-linear nature of the formula applied for determining the minimum source-to-object-distance.

Work has been carried out to improve the probability of detection by determining the minimum source-to-object-distance without negating radiographic quality using short exposure times.

Keywords: Radiographic testing, Source to object testing, Double wall single image.

Definitions:

ASME: American society of mechanical engineers
ISO: international standards organization
Ug: Geometrical unsharpness as calculated with the ASME V art. 2. formula.

\[ Ug = \frac{d \times f}{D} \]

Where: d = object to film distance
D = source to film distance
f = effective focal spot

EN 1435 Source to object distance formula

Class A: \[ \frac{f}{d} \geq 7.5 \times \sqrt{\frac{b^3}{d}} \]

Class B: \[ \frac{f}{d} \geq 15 \times \sqrt{\frac{b^3}{d}} \]

Where: f = source to object distance
b = object to film distance
d = source size
Introduction:

Conformance with ASME V Article 2 is achievable, as may be seen from the following quote it:

“ASME V article 2 paragraph T-271.2 (b)”

“For pipe diameters not exceeding 89 mm a technique may be used in which the radiation passes through two walls and the weld (material) in both walls is viewed for acceptance on the same radiograph.”

“Care should be exercised to ensure that the required geometric unsharpness is not exceeded.”

“If the geometric unsharpness cannot be met, then single-wall viewing shall be used.”

I.e. ASME V Article 2 allows double wall imaging techniques without specifying whether the image should be double-wall or single-wall unless geometric unsharpness cannot be met – if this is the case then single-wall images are mandatory!

Investigation and results:

In the following two radiographs count the number of discontinuities present.

Radiograph 1 Double wall double image source side IQI 0.25mm wire visible 0 to 4cm and 8 to 12 cm The geometrical unsharpness is 0.5mm
Radiograph 2 Double wall double image source side IQI 0.25mm wire visible 4 to 8cm and 12 to 0 cm. The geometrical unsharpness is 0.5mm

We see a tungsten inclusion some porosity and some undercut let’s compare this to some double wall single image radiographs number 3 to 8

Radiograph 3 Double wall single image source side IQI placed inside the pipe 0.20mm wire visible 0 to 4cm The geometrical unsharpness is 0.3mm
Radiograph 4 Double wall single image source side IQI placed inside the pipe 0.20mm wire visible 4 to 8cm. The geometrical unsharpness is 0.3mm
Radiograph 5 Double wall single image source side IQI placed inside the pipe 0.20mm wire visiable 8 to 12cm. The geometrical unsharpness is 0.3mm
Radiograph 6 Double wall single image source side IQI placed inside the pipe 0.20mm wire visible 12 to 0cm. The geometrical unsharpness is 0.3mm.

On radiograph 3 and 4 we can clearly see cracks that were missed on the double wall double image radiographs. This proves the acceptance of double wall single image radiography to ASME 5 art 2 for density and IQI visibility.

Conformance with EN1435 or ISO 17636 Image Quality Class A can be achieved. However, the requirements for Image Quality EN1435 ISO 17636 Image Quality Class B will be difficult due to the non-linear nature of the formula applied for determining the minimum source-to-object-distance.

Let’s investigate further:

With a Gilardoni X ray machine serial no. 22070002 with a 4.5 X 4.5 mm focal spot size

Some radiographs of the parent material of a 10mm plate butt weld were taken, on Agfa D4 film.
Radiograph no 7: 155 mm focus to object distance and 16mm object to film distance. A crack is visible above the weld and wire no 15 of the 10 FE EN pennetrameter is visible. The geometrical unsharpness is 0.66mm
Radiograph no 8: 160 mm focus to object distance and 10mm object to film distance. A crack is visible above the weld and wire no 15 of the 10FE EN pennetrameter is visible. The geometrical unsharpness is 0.4mm

Radiograph no 9: 225 mm focus to object distance and 10mm object to film distance. A crack is visible above the weld and wire no 15 of the 10FE EN pennetrameter is visible. The geometrical unsharpness is 0.28mm
Radiograph no 10: 475 mm focus to object distance and 10mm object to film distance. A crack is visible above the weld and wire no 15 of the 10 FE EN pennetrameter is visible. The geometrical unsharpness is 0.14mm

Radiograph no 11: 692 mm focus to object distance and 63mm object to film distance. A crack is visible above the weld and wire no 15 of the 10 FE EN pennetrameter is visible. The geometrical unsharpness is 0.58mm
Conclusion:

From 0.14 mm geometric unsharpness to 0.65mm geometric unsharpness no significant visible change is noticeable.

I can only conclude from this that for X-Ray machine work and most probably due to the better subject contrast geometric unsharpness less than 0.65mm is not necessary.

It is my opinion that conformance to EN 1435 class B with its overly long focal to object distance as far as geometrical unsharpness is concerned is a total waste of time.

It would be better to use a shorter focus to object distance on curved objects and to observe the 1.1mm maximum change in wall thickness.

I.e. double wall single image radiography instead of double wall double image radiography as illustrated at the start of the paper.

We saw that this is easy to apply to ASME 5 art 2 of 2010

If we have to comply with EN 12952 of 2002 for boilers on a new power station started around 2008

EN 12952-6 of 2002 sends us to EN 1435 of 1997 class A or B? for radiography.

EN 12952-6 of does not refer us to a class.

EN 12952-6 do reference EN 25817 of 1992 in its normative references however this does not refer us to a class either. So class A may do and we may develop procedure to do this.

Bibliography:

EN 12952-6 of 2002

EN 25817 of 1992

EN 1435 of 1997

ASME V art. 2 of 2010