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The Use of Witness Notches to detect Full Penetration and Soundness in Electron Beam Welds

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Objective

- Radiographic inspection of welds in pressure vessels which have features that don't allow elliptical shots
- Confirm proper electron beam and weld joint alignment

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Welded Pressure Vessel

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Weld Sample Design

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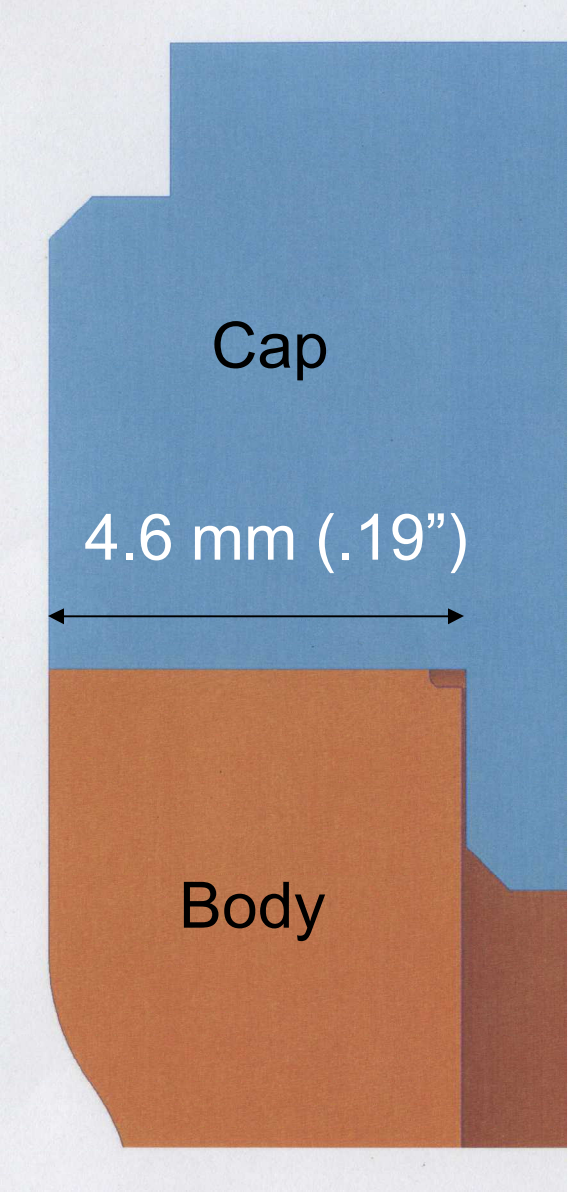
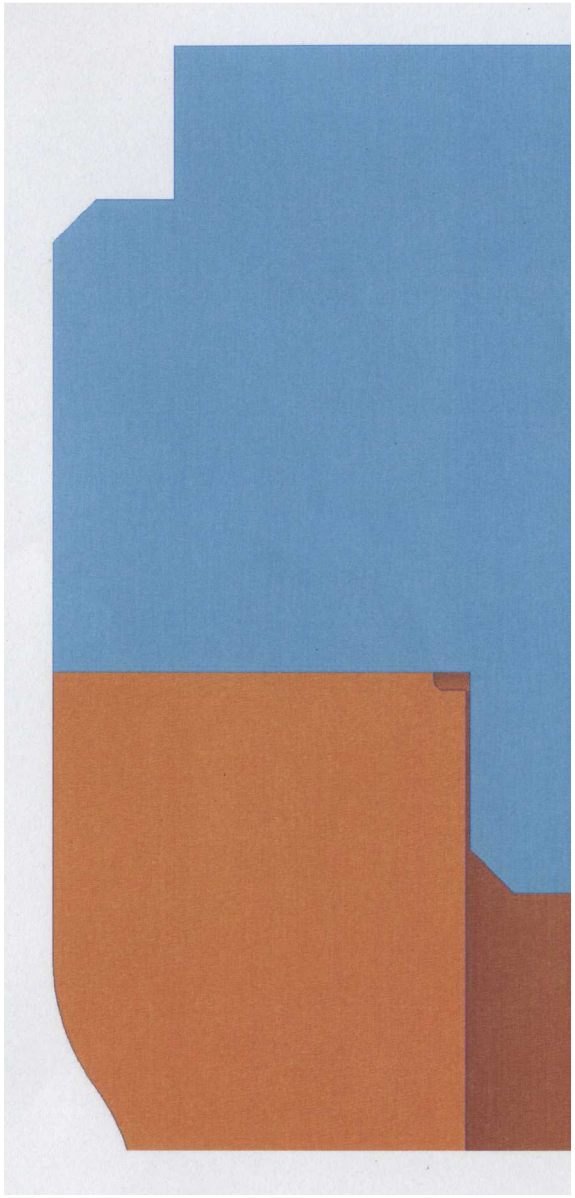
Weld Joint

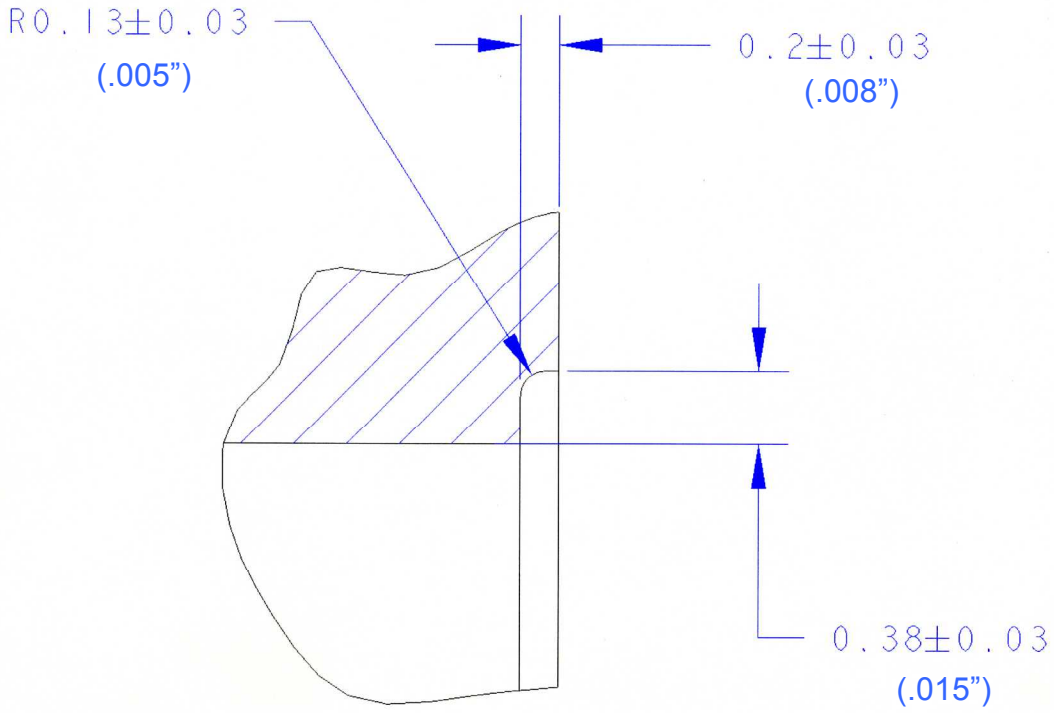


Square groove to backing step.

Sandia-designed Witness Notch

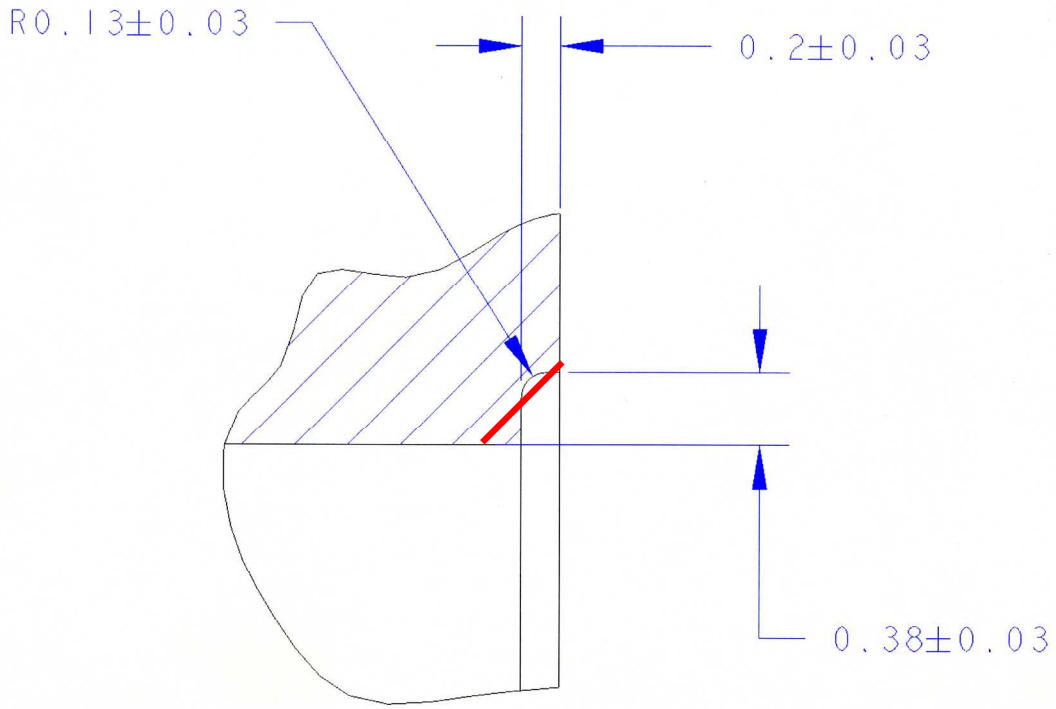


Details of this witness notch (sometimes called a “radiographic window”)



Previous Witness Notch

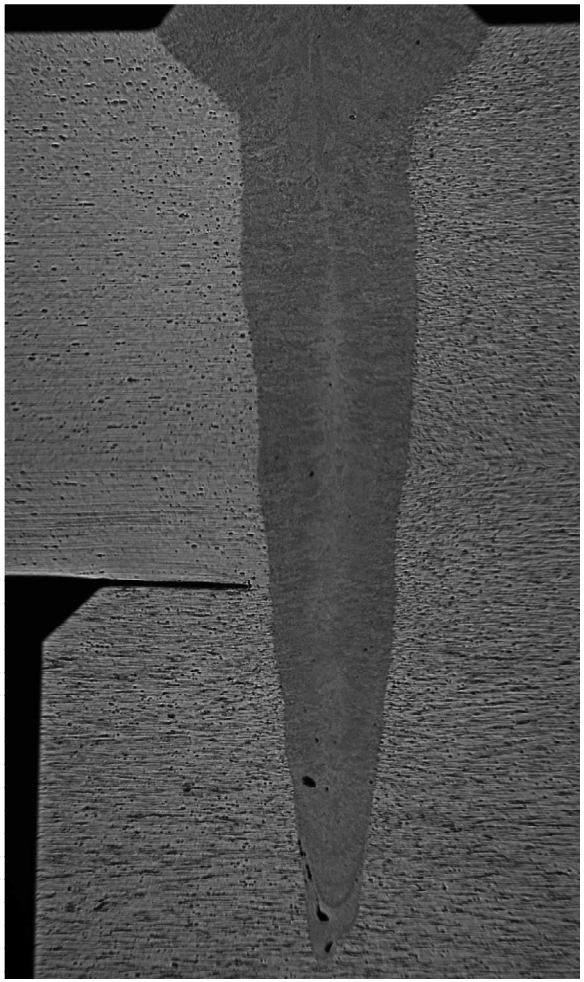
The previous witness notch design was a 0.38 mm (.015”) 45° bevel.



Characteristics of Sandia-design

- Enhances radiographic inspect ability
- The features of this witness notch can be machined today because of CNC processing centers that no longer require a custom-made form tool
- Cleaning is easier than if the notch were square, because there are no sharp corners

Welding Parameters



Beam Current	13 mA
Voltage	125 kV
Travel	500 mm/min
Circle Oscillation	0.25 mm at 1000 Hz
Focus	Sharp

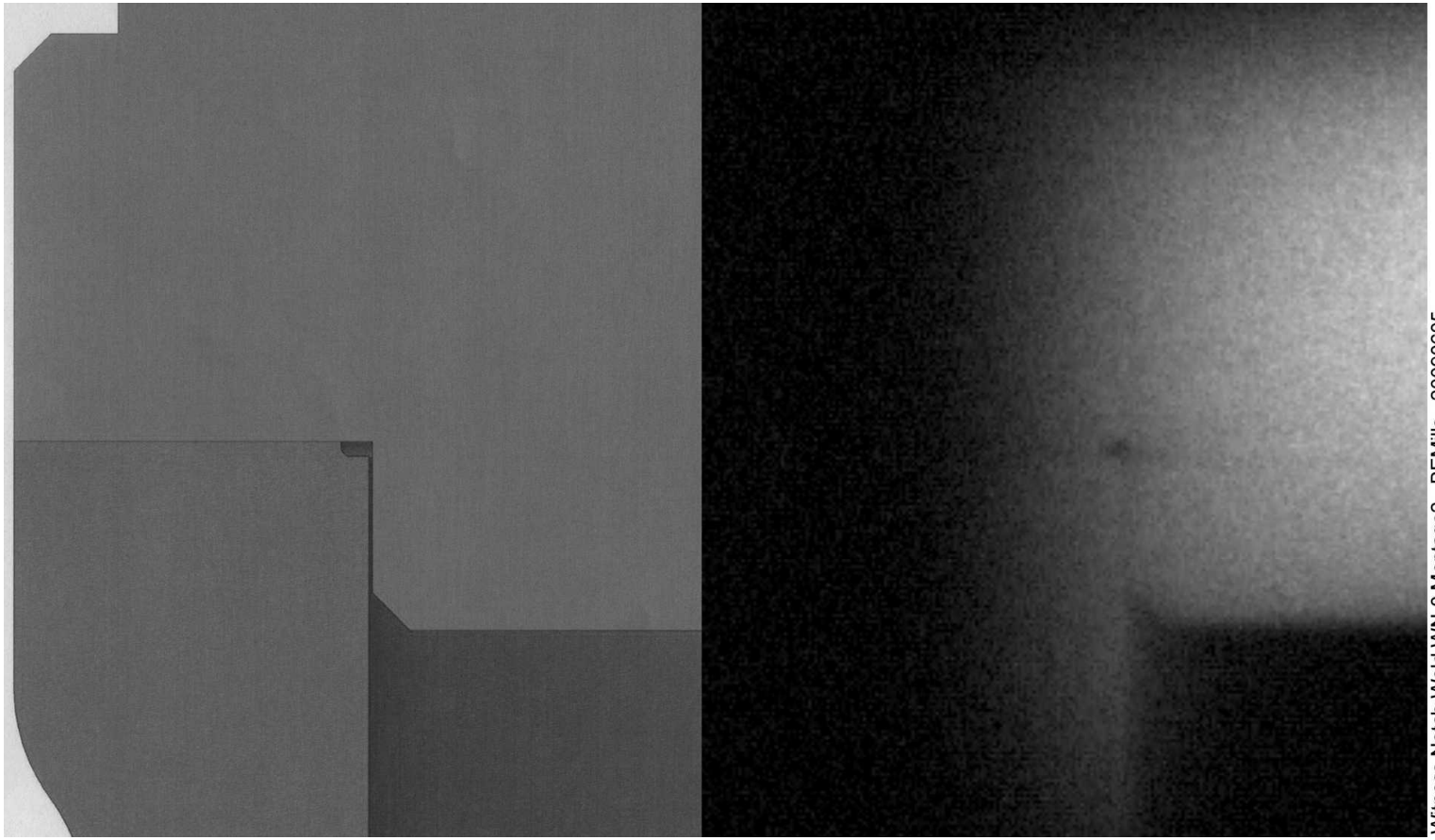
Radiographic Technique

- 450 kV x-ray generator
- 330 kV accelerating voltage
- 45 mAm (10 mA X 4.5 min.)
- 2.4 m (96”) source-to-film distance (SFD)
- 54 mm (2.125”) object-to-film distance (OFD)
- Duplicate films are taken every 30°.
- Each film shows two sides of weld 180° apart.

Un-welded

model

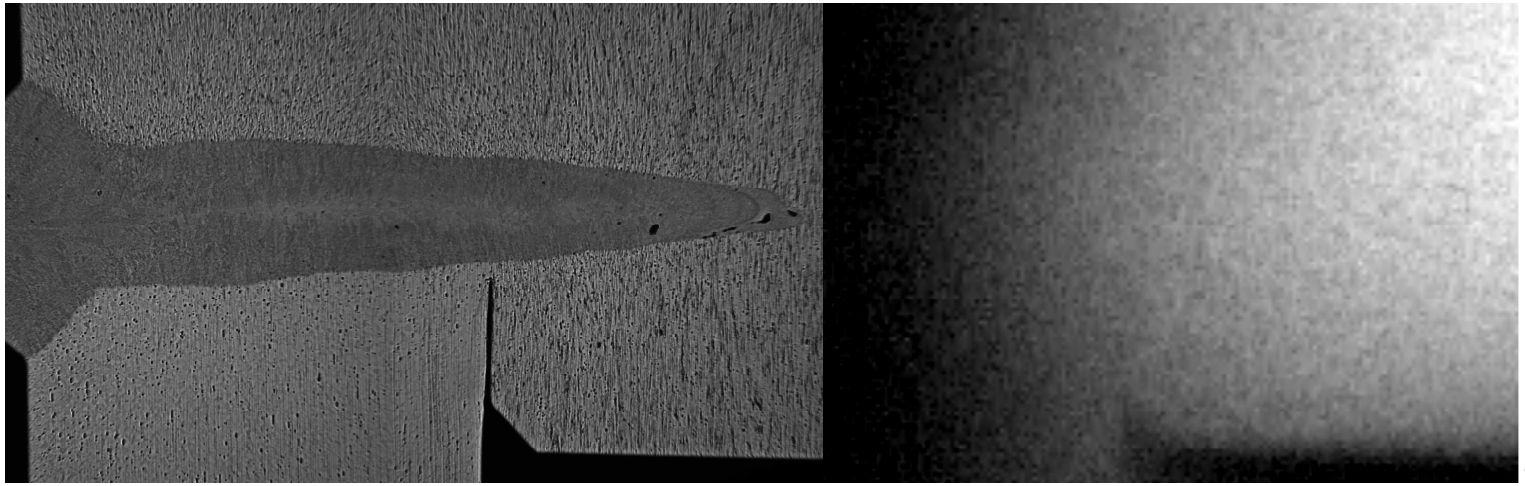
radiograph



Acceptable Weld

cross-section

radiograph



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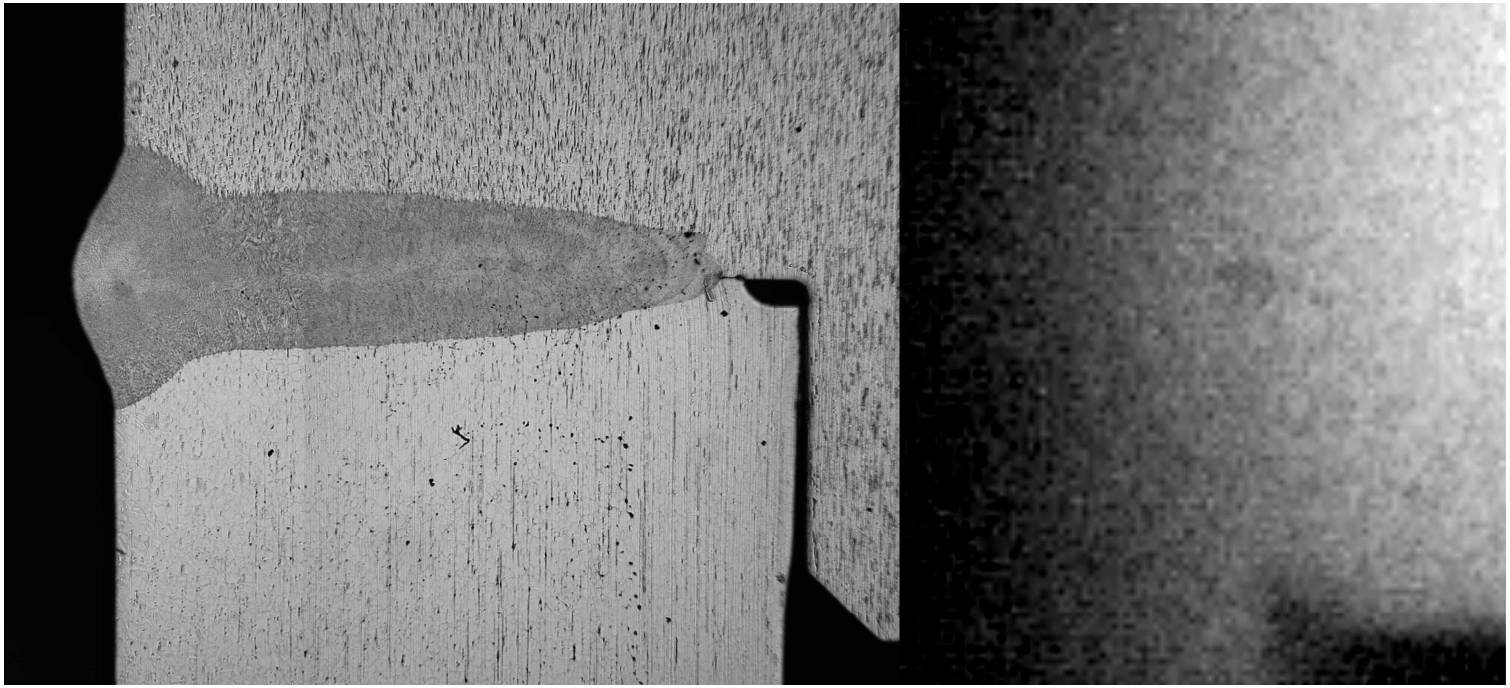
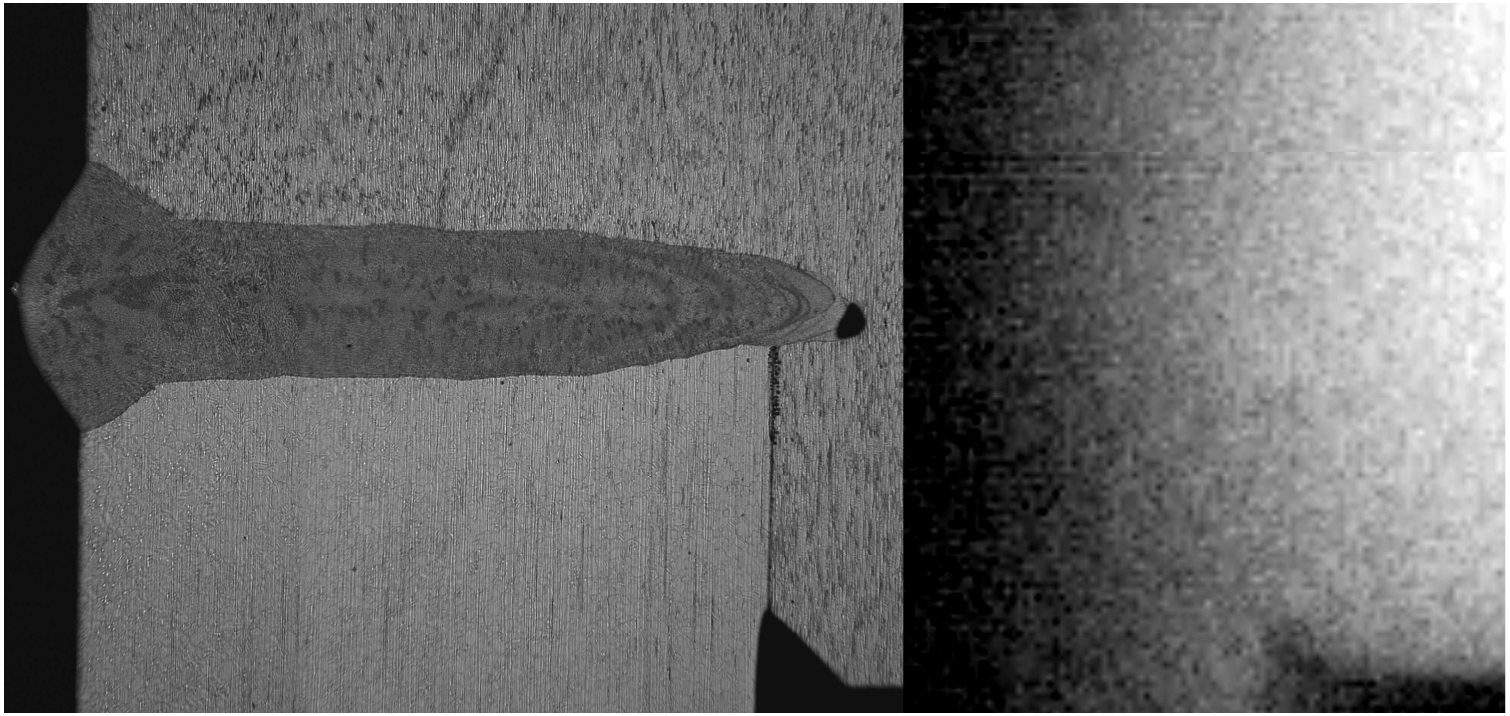
Partially-penetrated Weld



Radiograph shows witness notch.

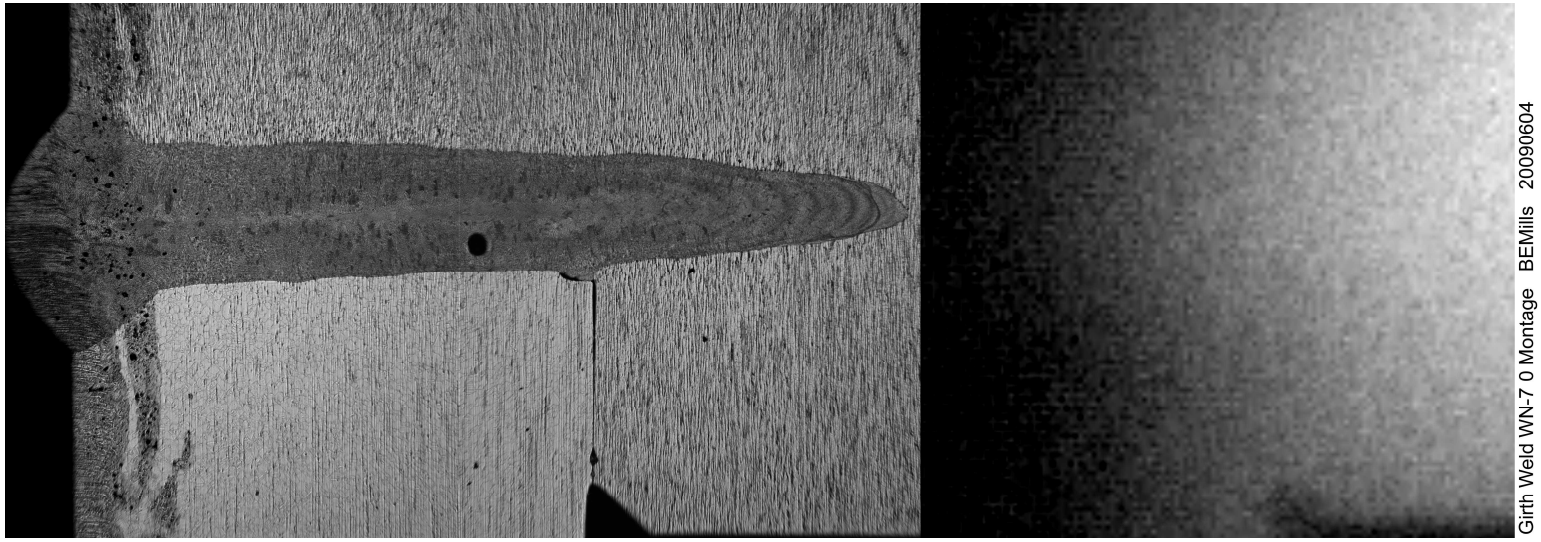
Minimally-penetrated Weld



Radiograph shows no witness notch.

0.5 mm Off-center Weld

The joint is welded and a small part of the witness notch is visible in cross-section.



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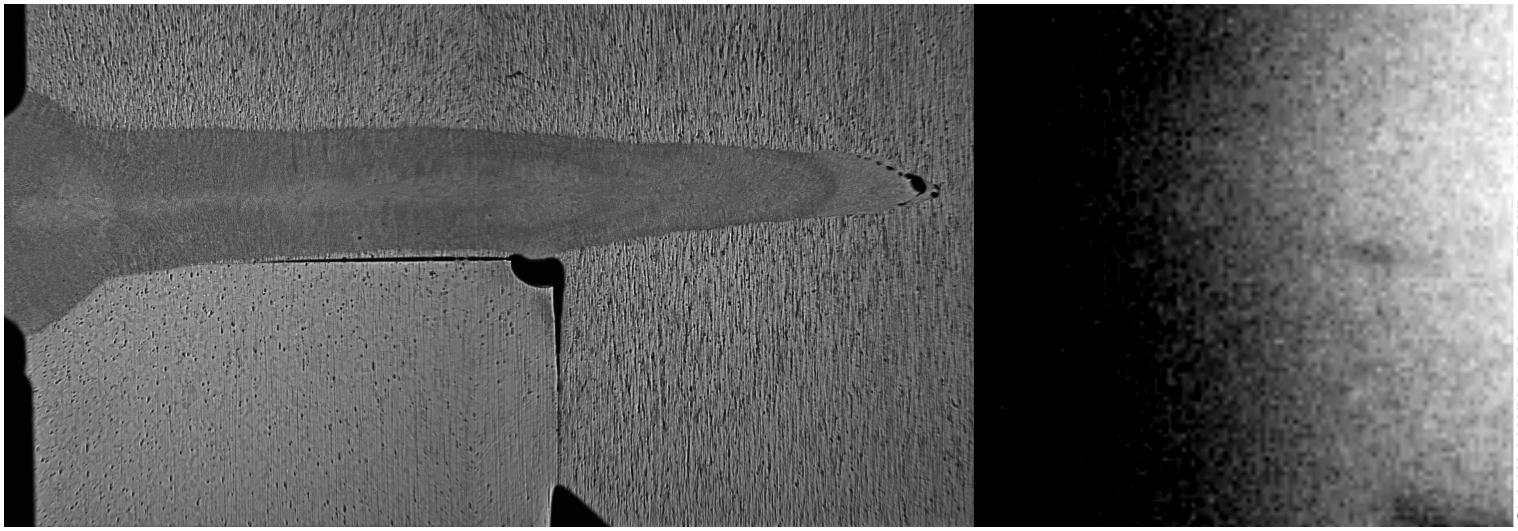
The witness notch is not visible in the radiograph.

0.6 mm Off-center Weld

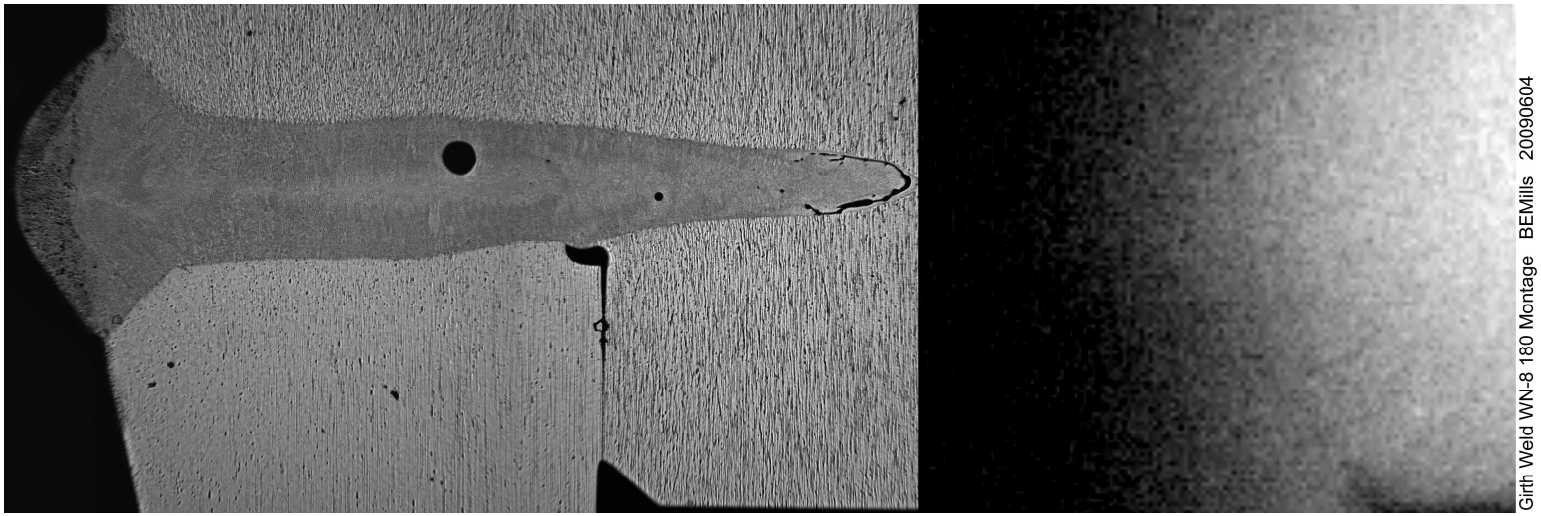
Cross-section at 0° shows the joint interface not adequately welded and the witness notch exposed.



The radiograph clearly shows both the witness notch and the joint interface.

0.6 mm Off-center Weld

Cross-section at 180° shows the joint interface welded and the witness notch exposed.



Girth Weld WN-8 180 Montage BEMills 20090604

The unfilled witness notch does not clearly shows in the radiograph, indicating that it is a localized feature.

Conclusions

- Radiography with witness notches is an excellent technique to detect proper weld depth of penetration in parts with features that don't allow elliptical shots.

- When not consumed, the witness notch is easily visible in radiographs. A partially filled notch may not be visible.

- Small voids (e.g. less than 0.25 mm or 0.01") are hard to detect.

- Welding off-center by less than 0.5 mm (0.02") can produce an acceptable joint and fill the witness notch. Control to < 0.1 mm (0.005") is easily achieved.

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