Digital Profile Radiography – Practical uses and limitations

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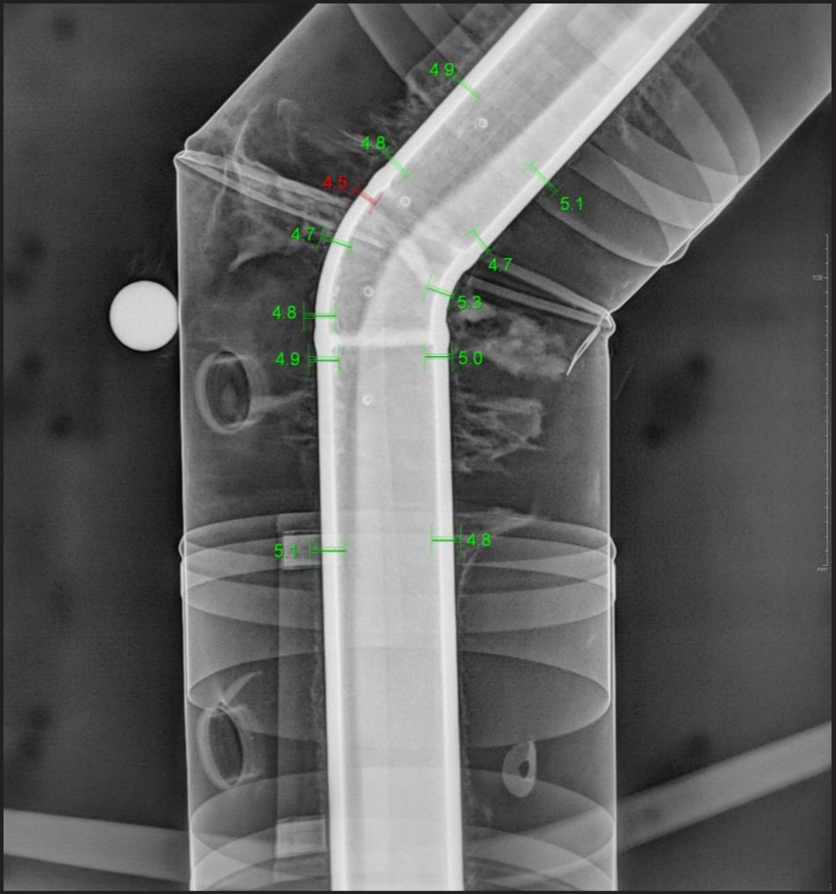
Introduction

Profile digital radiography for online piping thinning assessment has been in use in Australia since 2005 and recently is gaining significantly more acceptance/use.

Today all major refineries in Australia use digital imaging for pipe inspection.

This is helped by new international standards.

This workshop aims to explain the uses and limitations of this technology with some real world samples.



Digital Radiography – What is it?

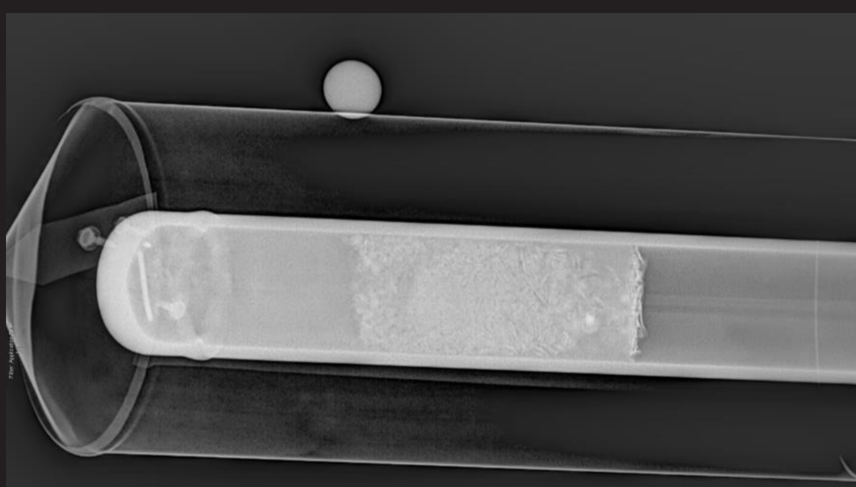
Essentially the same as conventional film radiography with the exception that the image is captured via reusable digital media instead of film, at a lower radiation dose by either a Digital Detectors Array (DDA) panel or on a Phosphor Imaging Plate (PIP or IP).

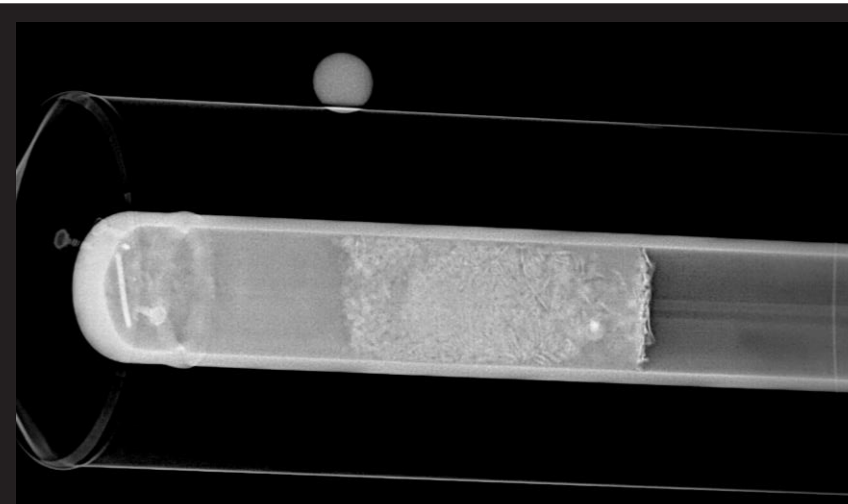
Industry separates the two mediums by calling DDA – Digital Radiography (DR) and IP – Computed Radiography (CR).

Advantages / Disadvantages

- Instant results (DDA) – no reshoots
- Fast results (CR) – easy onsite processing
- Software for wall thickness evaluation
- Easily shared (email an image)
- No chemical dark rooms
- Broader area (you get the bigger picture)
- Higher dynamic range
- Higher productivity & automated workflows
- Ability to “hunt” degradation

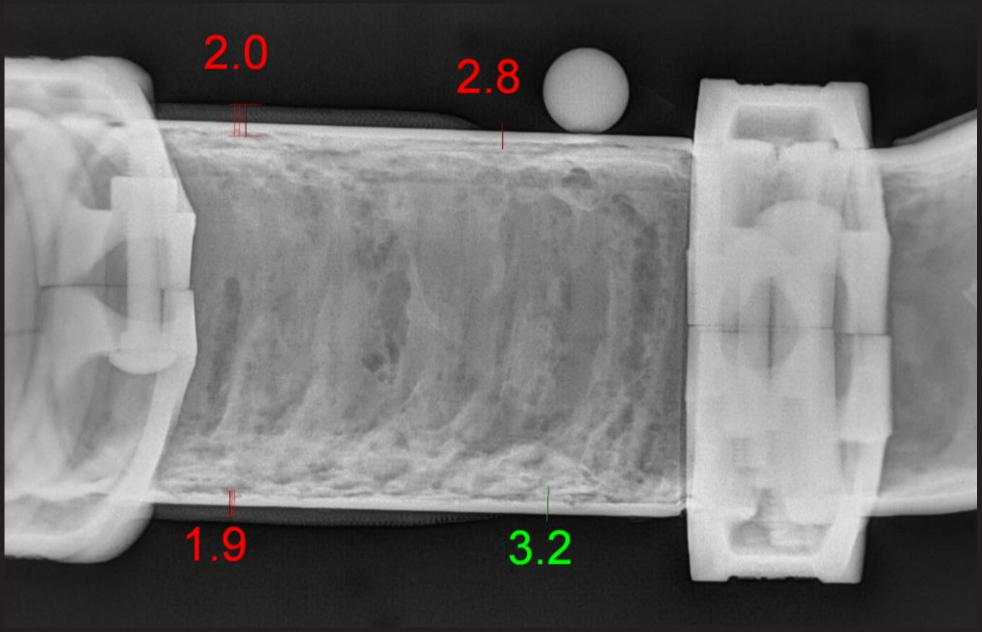
- High initial capital costs
- Restricted to smaller size pipes
- Additional training
- Radiation exclusion zones
- Digital, poor data in = poor data out
- DDA lower spatial resolution than film





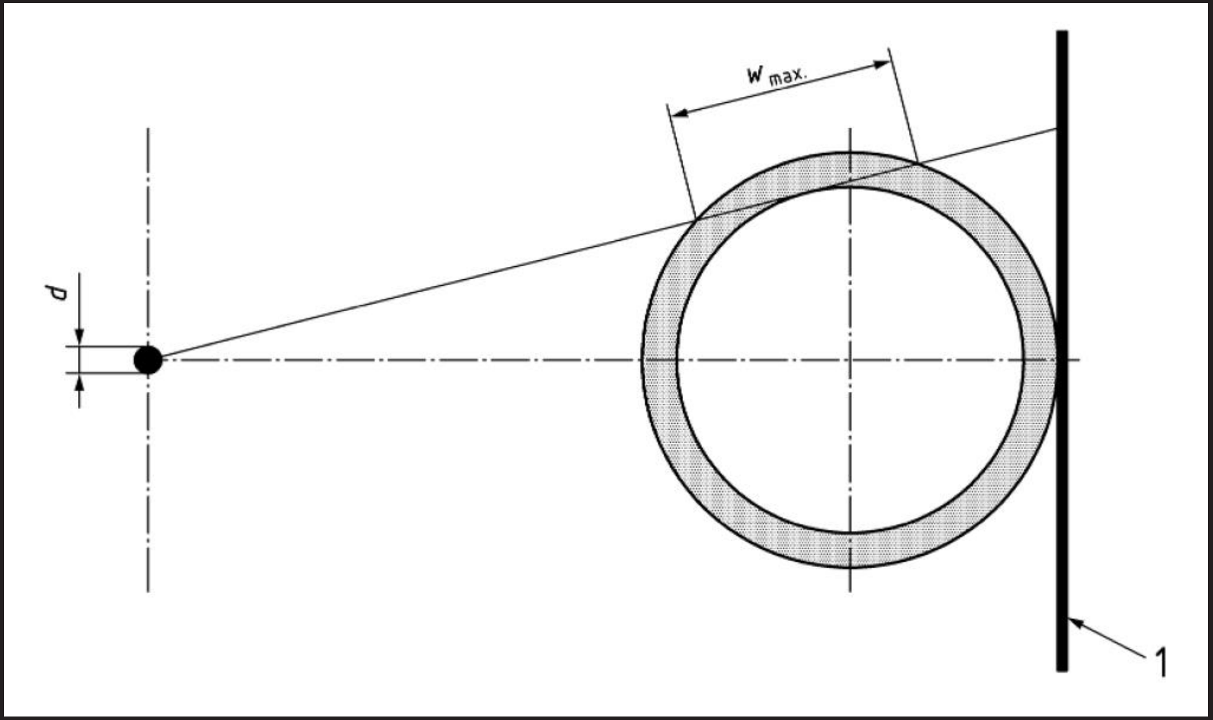
Methods of test - Standards

- BS EN 16407-1 Non-destructive testing – Radiographic inspection of corrosion and deposits in pipes X- and gamma rays Part 1: Tangential radiographic inspection
- BS EN 16407-2 Non-destructive testing — Radiographic inspection of corrosion and deposits in pipes by X- and gamma rays Part 2: Double wall radiographic inspection



Pipe Size Limitations (what is readily achievable)

You are restricted on what pipe size / schedule you can test. This restriction is due to the different penetrating power of the radiation type used which is referred to a Wmax in EN16407.1
(referred to as chord length in conventional Australian standards)



Standard prescribes maximum allowable thickness (Wmax) for different types of radiation (different penetrating power)

Table 1 — Maximum penetrated thickness range for different radiation sources for steel

Radiation source	**Limits on maximum penetrated thickness w_{max} mm** Basic (for generalized wall loss)	Improved (for pitting flaws)
X-ray (100 kV)	≤ 10	≤ 7
X-ray (200 kV)	≤ 30	≤ 20
X-ray (300 kV)	≤ 40	≤ 30
X-ray (400 kV)	≤ 50	≤ 35
Se 75	≤ 55	≤ 40
Ir 192	≤ 80	≤ 60
Co 60	≤ 120	≤ 85

The maximum penetrated thickness, w_{max}, is given by:

$$w_{max} = 2\sqrt{t(D_e - t)}$$

where

t is the nominal thickness of the pipe;

D_e is the outside diameter of the pipe.

What does this equate to for two commonly used gamma sources?

			Ir192				Se75	
		Sch40	Sch80	Sch160		Sch40	Sch80	Sch160
DN	15-65	Yes	Yes	Yes		Yes	Yes	Yes
DN	80	Yes	Yes	Yes		Yes	Yes	No
DN	90	Yes	Yes	N/A		Yes	Yes	N/A
DN	100	Yes	Yes	No		No	No	No
DN	125	Yes	Yes	No		No	No	No
DN	150	Yes	Yes	No		No	No	No
DN	200	No	No	No		No	No	No

What does this mean?

- Using Se75 for smaller exclusion zones etc gives you less scope than Ir192
- Both sources are only useable on smaller piping
- If using battery powered pulsed X-ray units again for exclusion zones/safety you are more restricted again than when using Se75
- Larger pipes need to be examined with ultrasonic or eddy current techniques

TIP: Fittings are thicker so if you have designed a PRT scope on the upper limits based on pipe size/schedule you will struggle for accurate data on the fittings (elbows, Tees etc) attached to these pipes [which is typically where you are looking with flow/direction changes]

Insulation – Internal and External pipe degradation

A key advantage of this technology is that by looking at the image you detect internal (flow/contents) degradation and/or external corrosion (CUI)

If you detect CUI at early stages you can then address the issue/s with a repair before costly replacements

EN16407-01 Standard prescribes a visual assessment of the area as well by stating on the test report the "condition of the insulation"

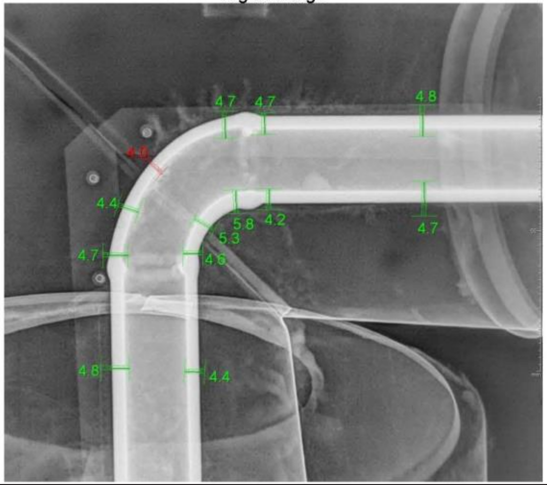
- No point in getting a satisfactory radiographic result and not being advised of degradation of the insulation that will affect the result at the next inspection
- With the right service provider you can get a visual examination of the lagging and the thickness result
- Our reports detail this and include a set up image which can double as record of condition of the recording point at time of test

REPORT NO: ARIXXXX-XX TEST DATE/S: 14 & 15/09/15

DRG No	PIP-212-005	**Image Quality**	
Line No	GS-13-1	BSR	218
Record Point No (or description)	Location 1	Grey level – Free Beam	11449
		SNRn – Centre Pipe	89
Pipe Size / Sch	DN 25 / XS	SNRn – Free Beam	119
Pipe Contents	Sniff Gas	Additional Observations:	
Insulated	Yes	Wall loss was not evident	
Insulation OD	140mm (approx.)		
Insulation Condition	Satisfactory	Minimum wall thickness detected: 4.0mm	
Exposure Time	7.5 s (4 frame average)		
SDD	570mm		
Method	Offset		

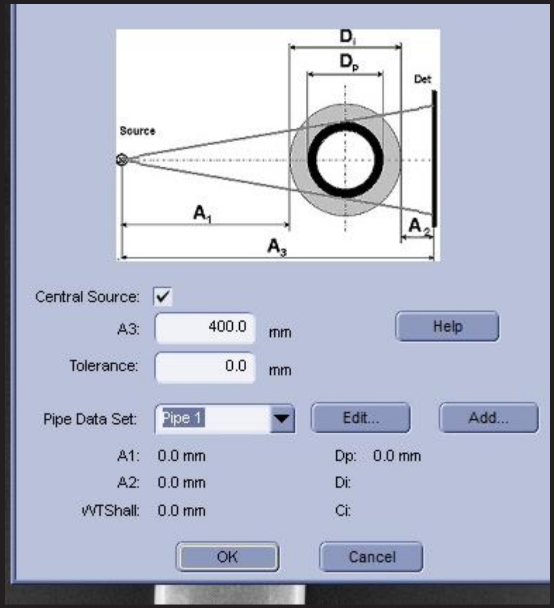
Test Arrangement

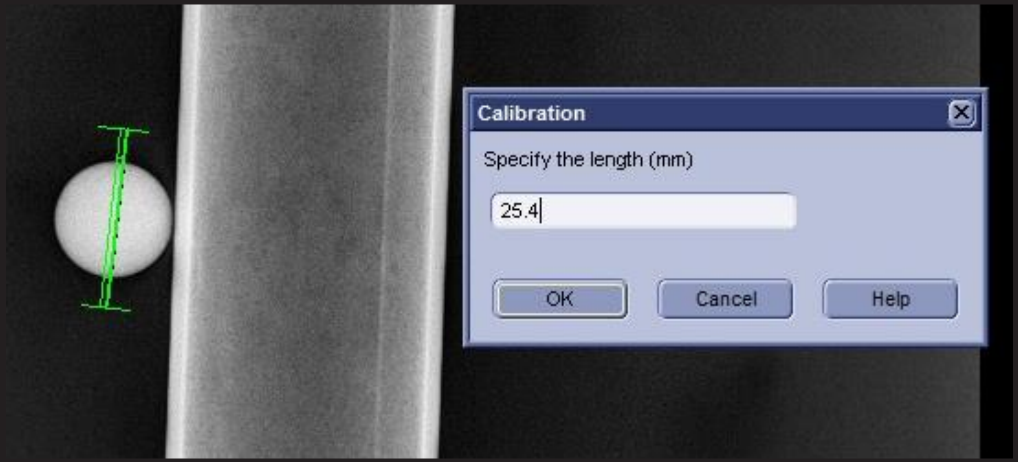
Digital Image



Order of Accuracy – Set up mistakes

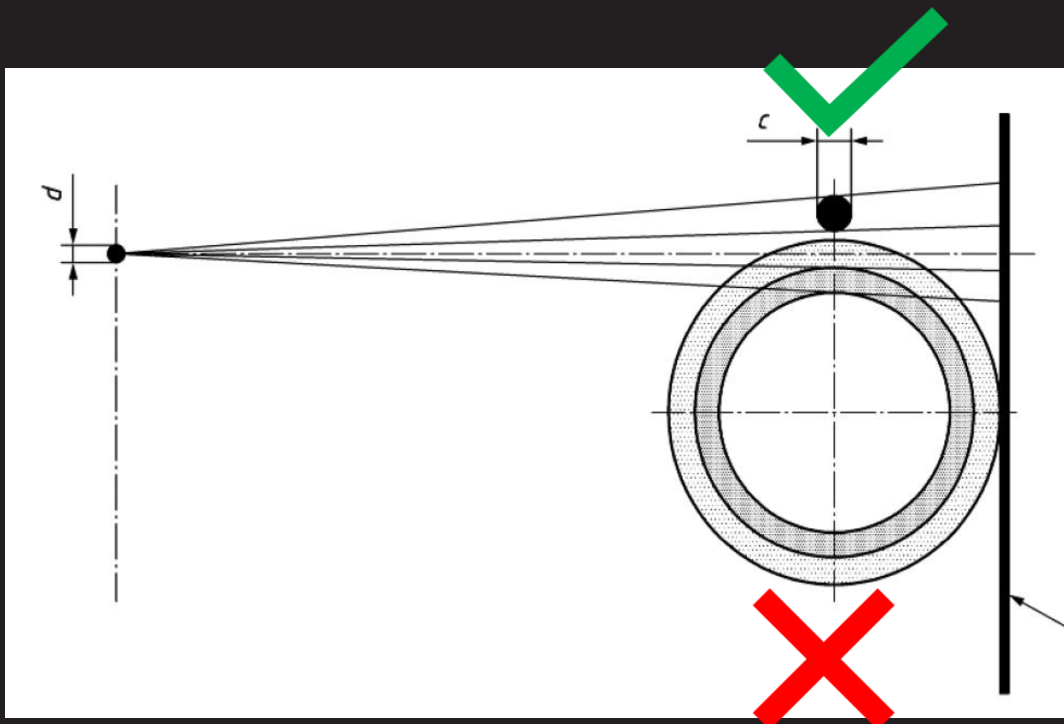
- Image Calibration – Test arrangement OR Reference Object

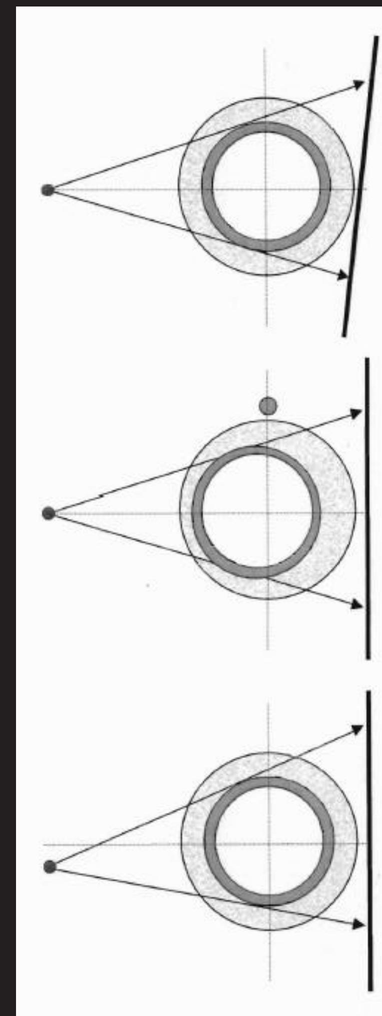




- Understand where you want to test – intrados/extrados, washout, flow/impact

Tangential Offset - Ensure you are “square” with the wall you are trying to examine





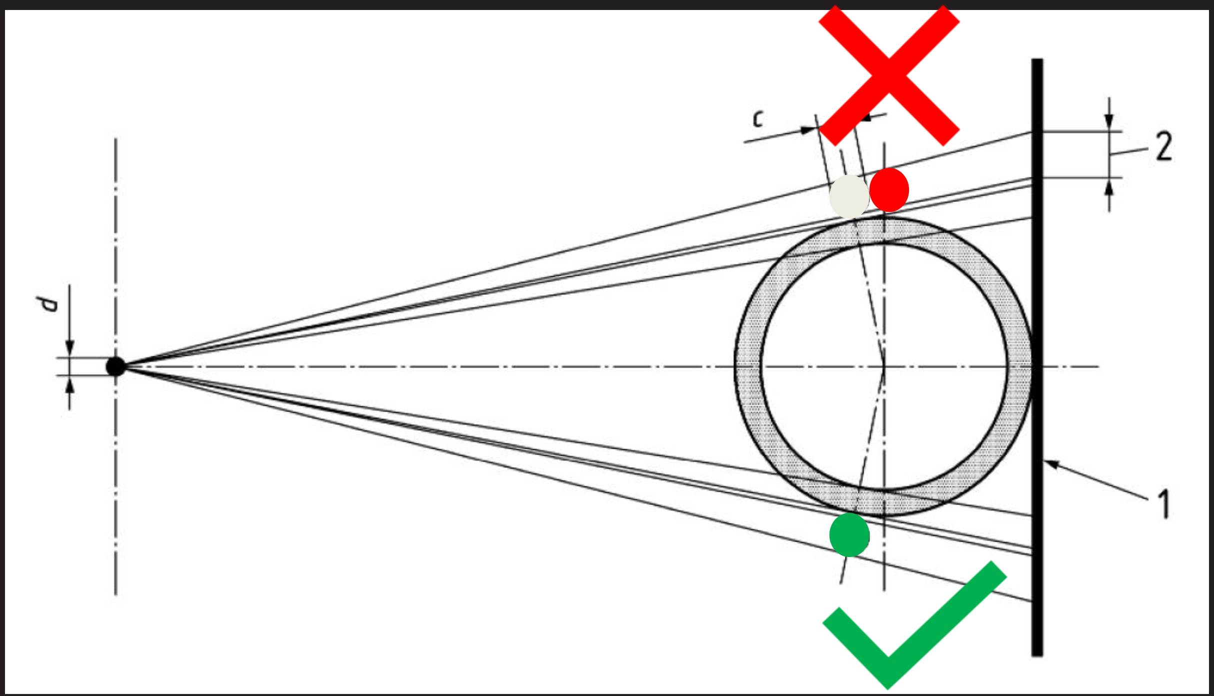
Detector Misalignment

Pipe Misalignment

Source Placement

Larger pipes don’t then go “measuring” the other side

Tangential Centerline - Ensure your source is central and your comparator ball is offset to correctly capture the enlargement (examine both sides)



Reducing The Human Factor

- All previous sources of error are human and are reducible
- Ask for ISO9712 certification such as that offered by the AINDT

AINDT

- Ask for ***specific*** ISO17025 accreditation offered by NATA

This facility complies with the requirements of ISO/IEC 17025:2005

6.01 Radiographic interpretation applicable to the following
.01 Welded joints

6.03 Wall thickness measurement and profile radiography

6.04 Radiographic imaging capability
.01 Film
.03 Image storage plates
.04 Direct imaging (digital radiography)

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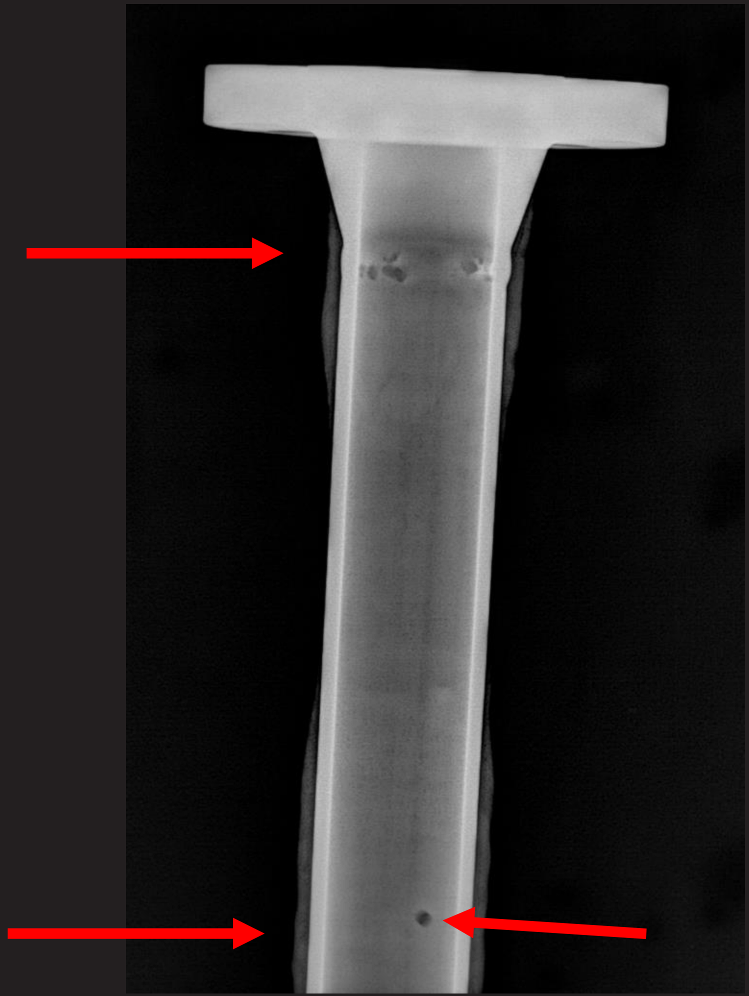
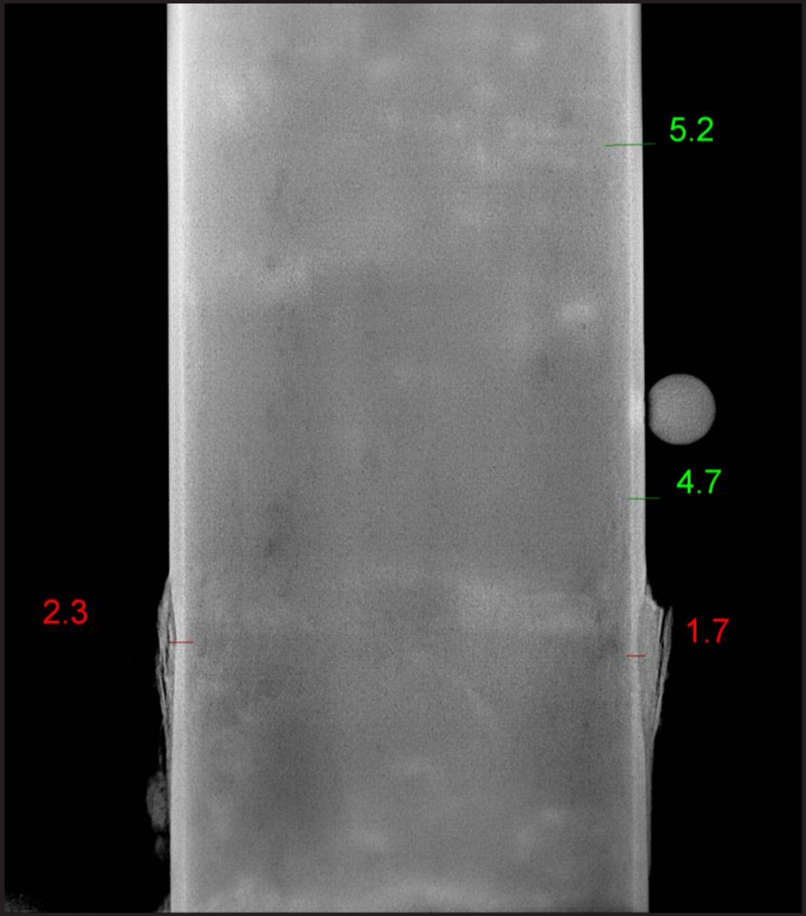
Sample Images

Wrapped Temporary Repair Pipe Test



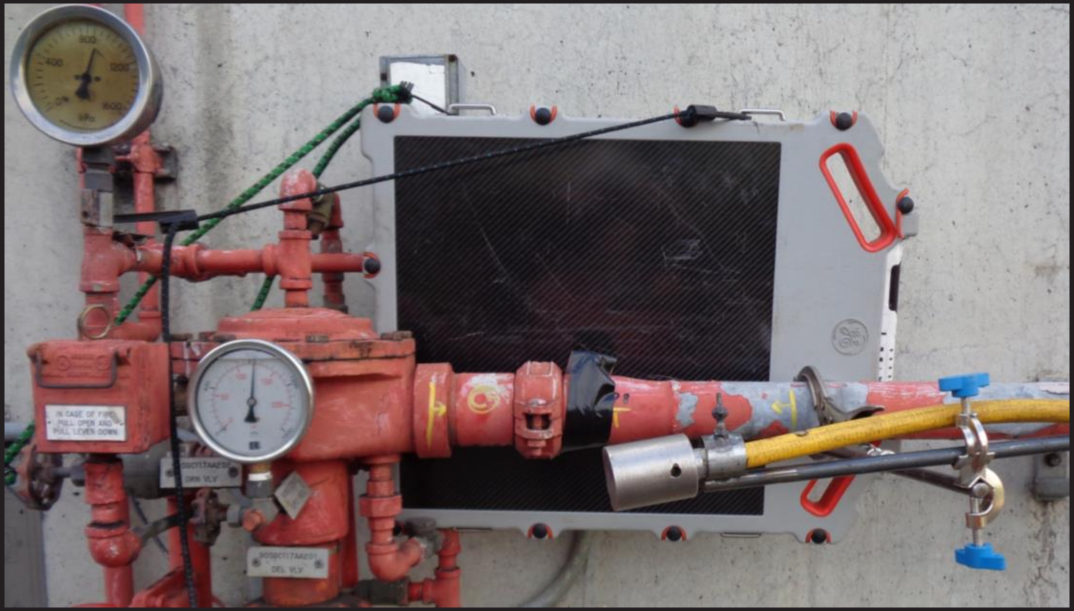
Sample Images

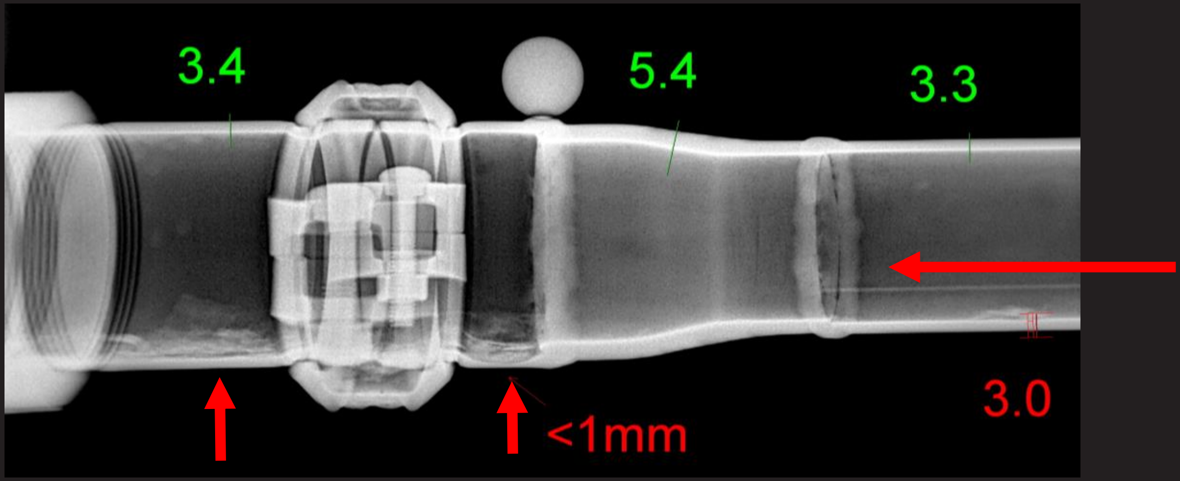
Soil Air Interface – External Corrosion Blisters



Sample Images

Bigger Picture





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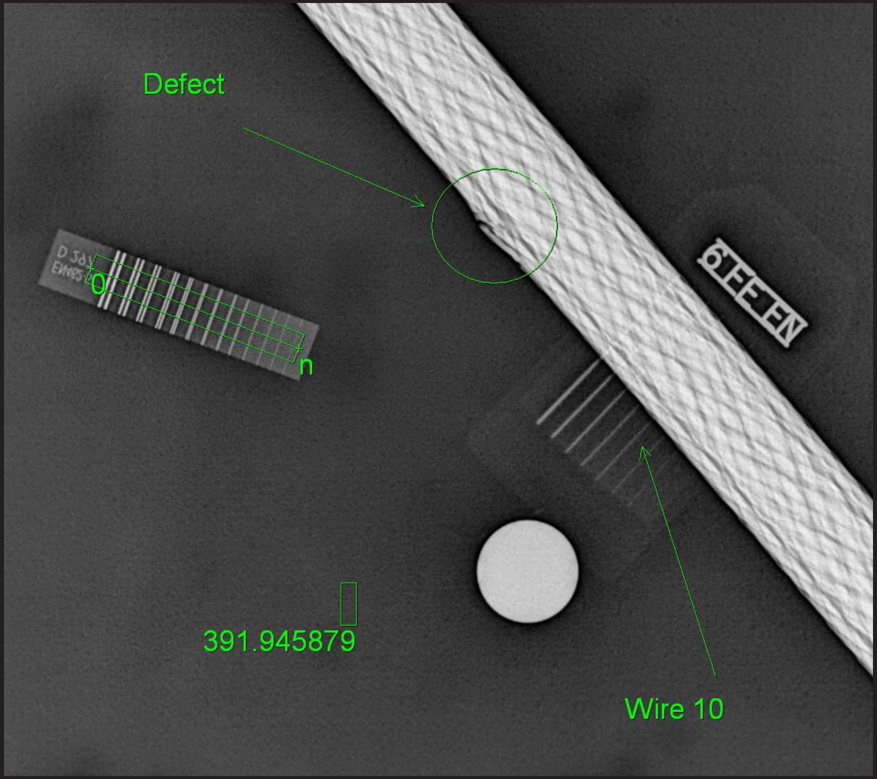
Sample Images

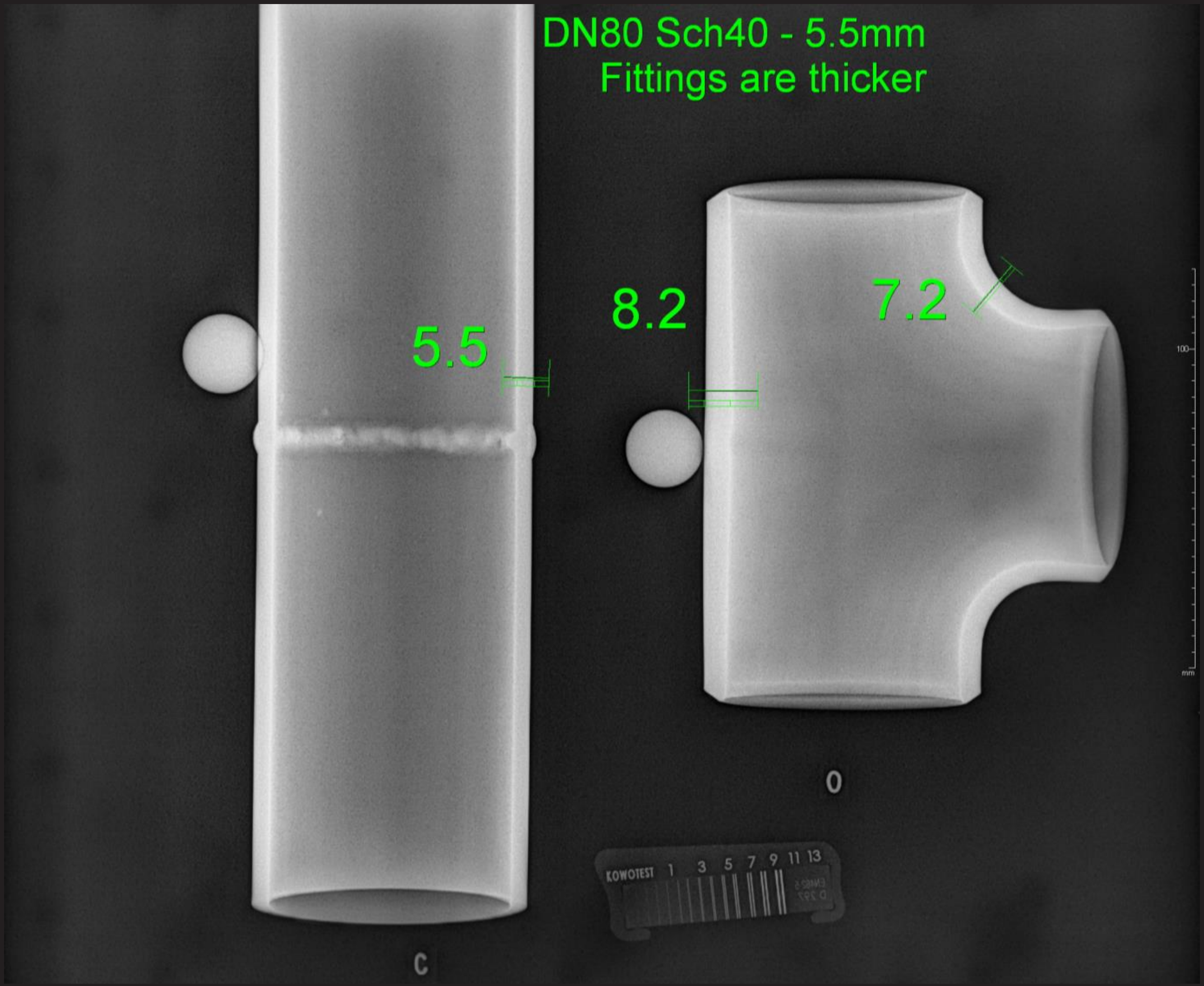
Wire Rope Trials



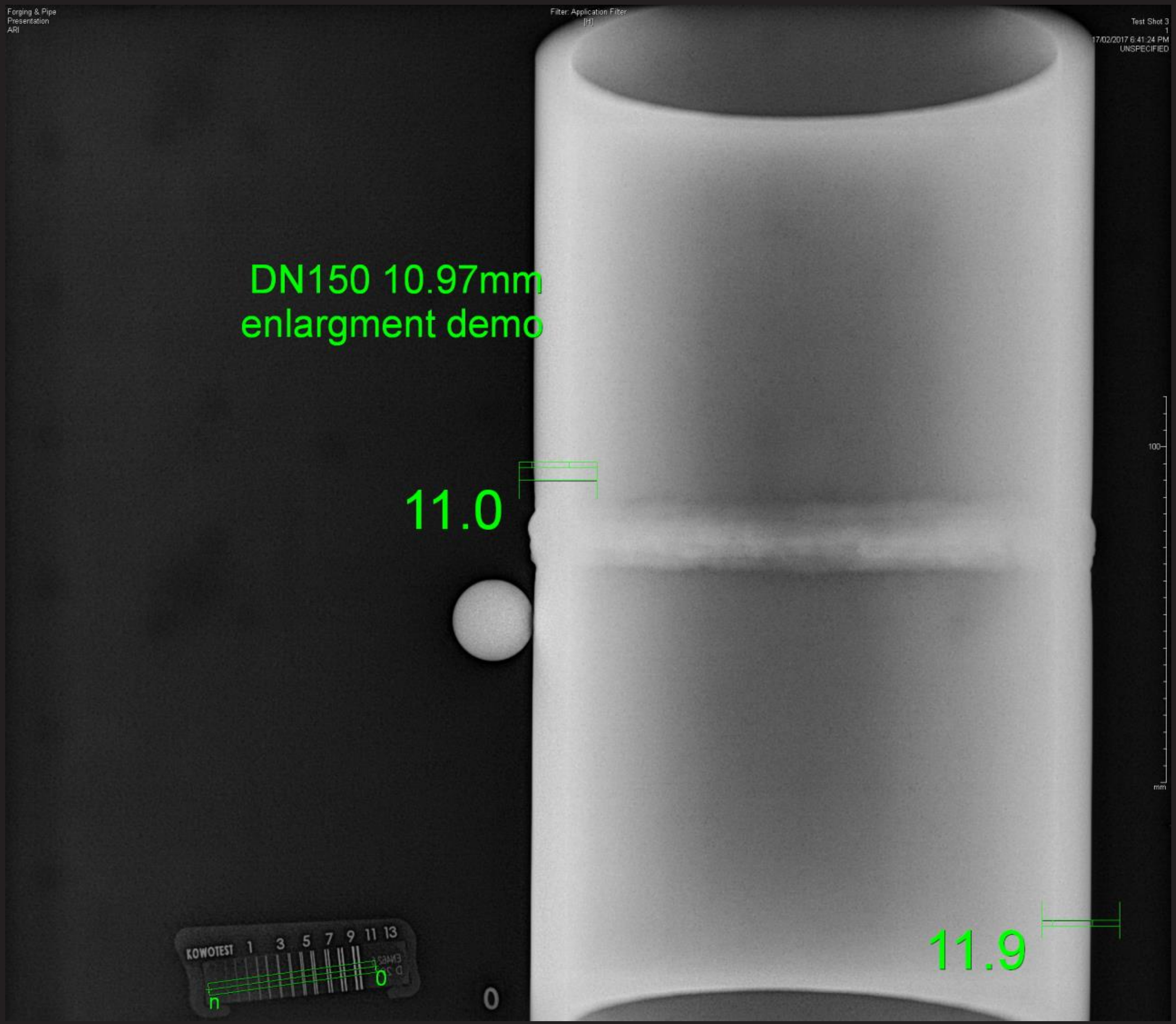
Software Demonstration

- Fittings are thicker
- Upper limit struggles
- Oxide separation wall thickness tool
- Holed
- Tangential offset opposite calibration side variations

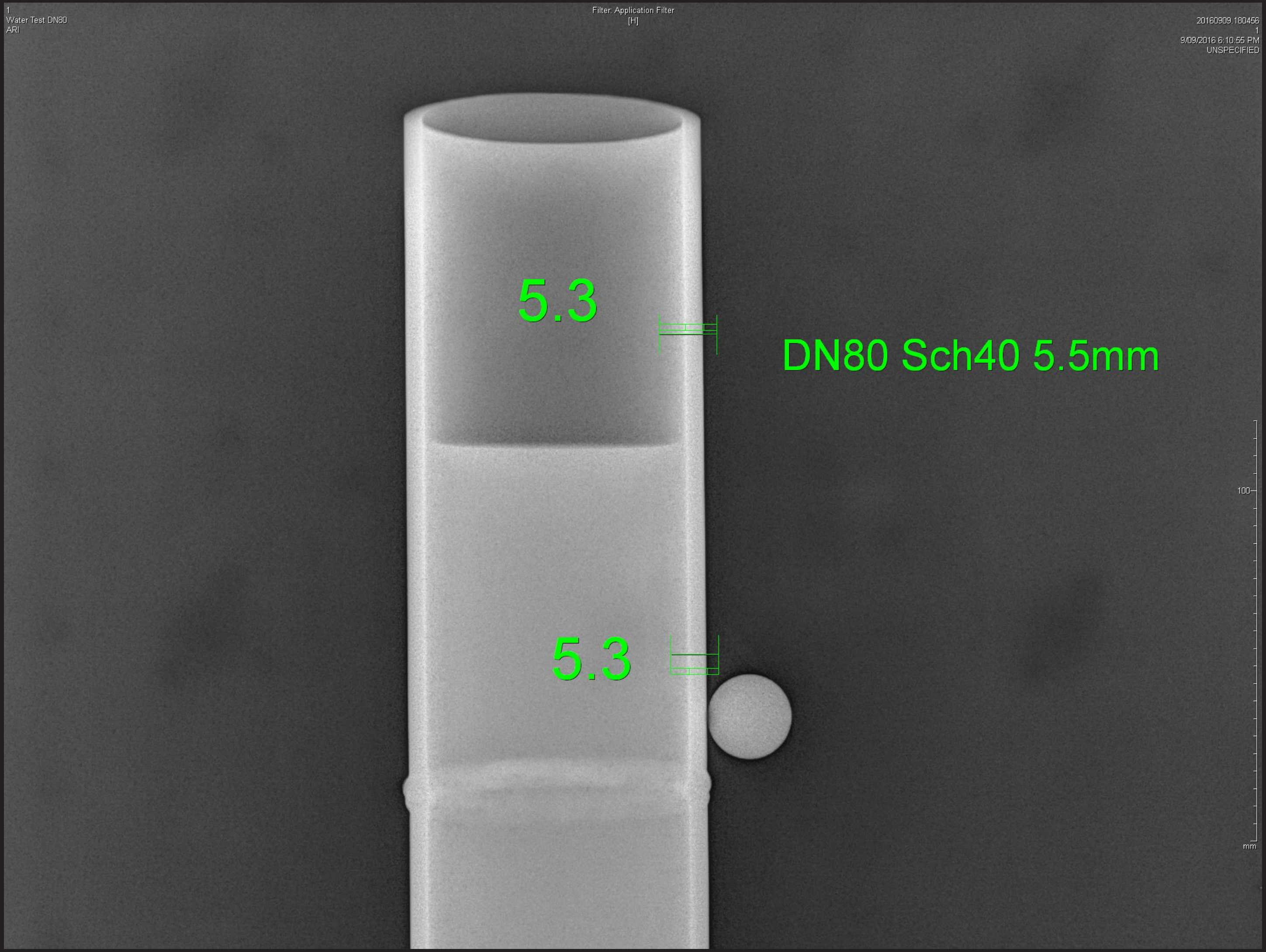
Fittings Are Thicker



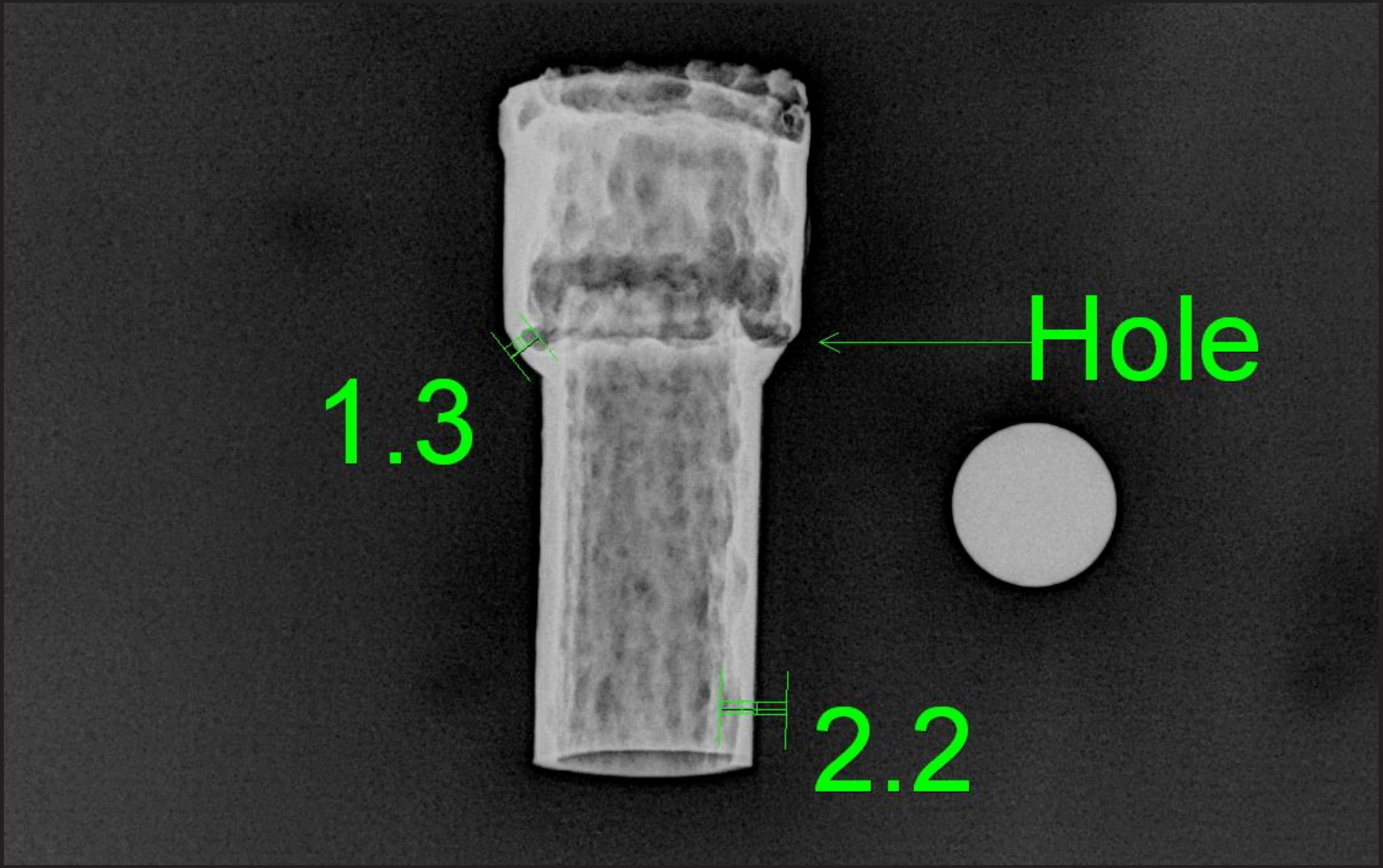
Enlargement



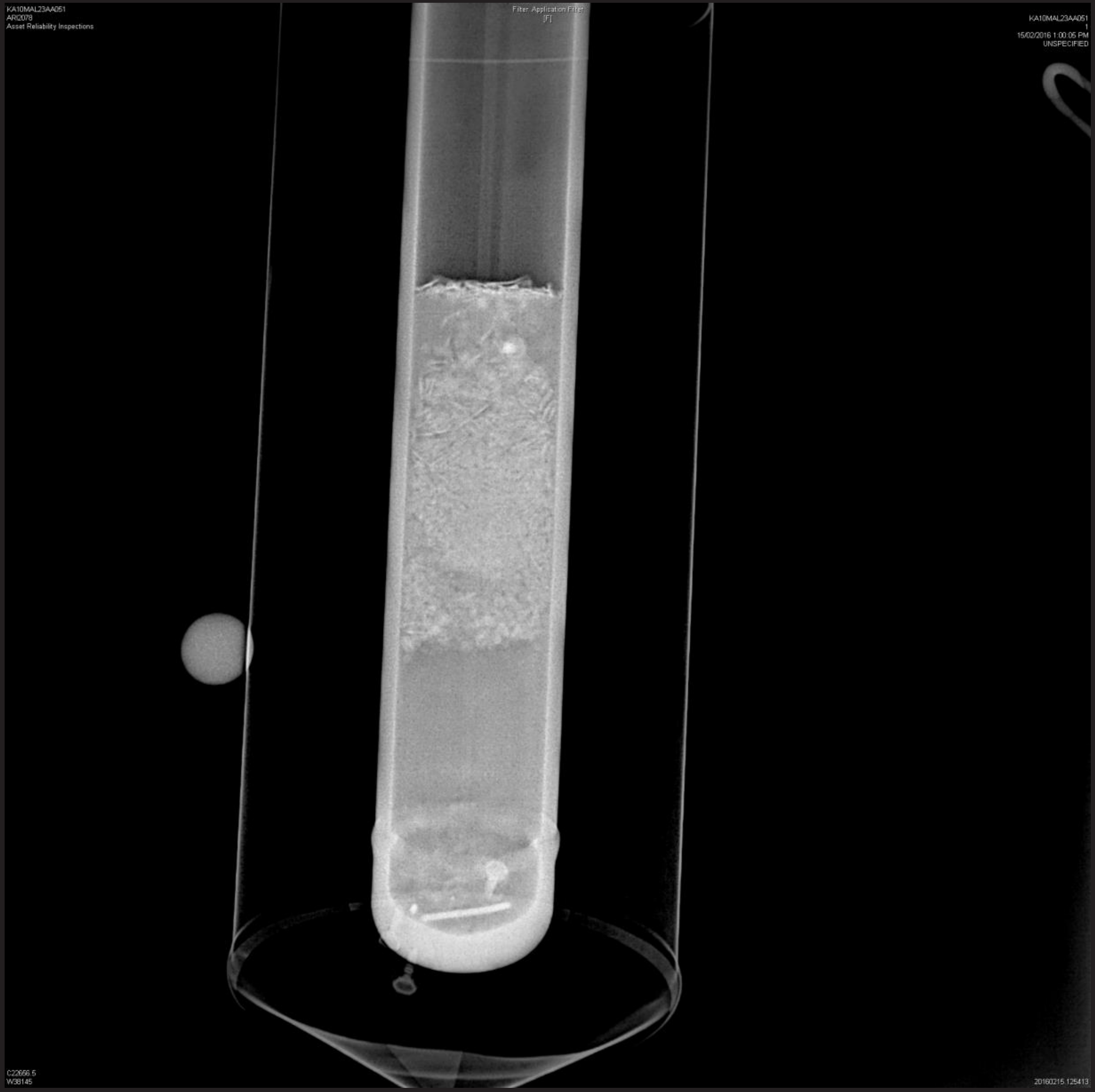
Water Filled



Oxide layer Separation



Debris Trap



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