Recent advances in Pulsed Eddy Current inspection of corrosion under insulation near pipe flanges

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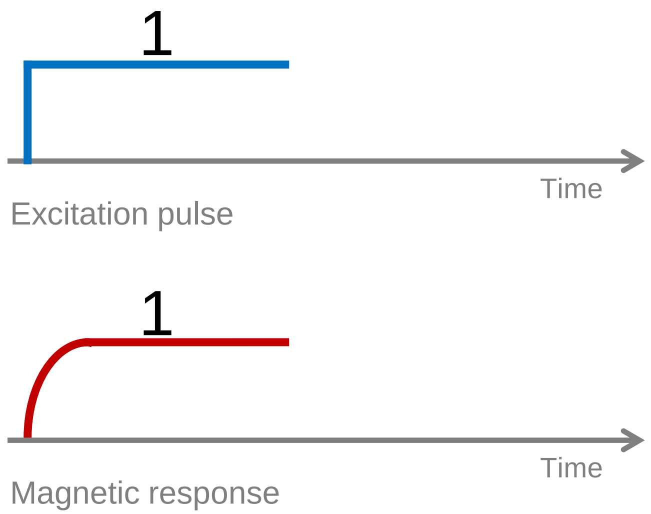
Content

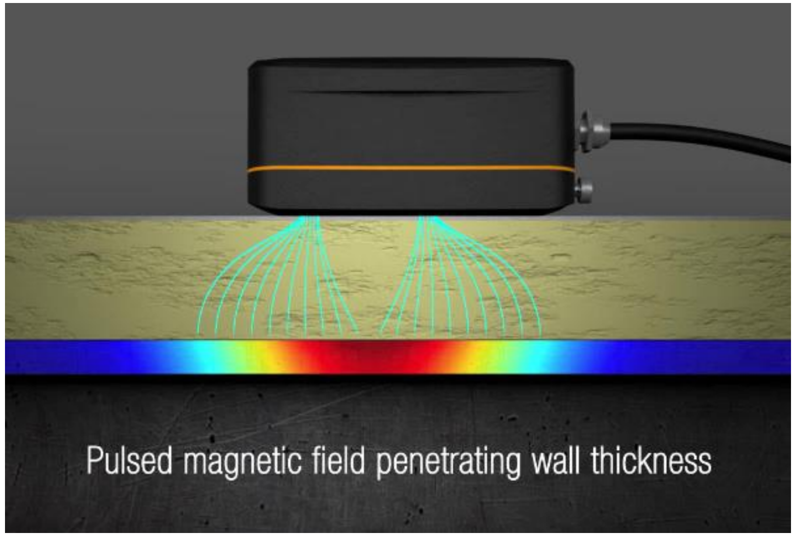
- Pulsed Eddy Current (PEC) Working Principle
- Signal representation and interpretation
- Limitations of PEC
- Compensated wall thickness evaluation
- Mass effect correction
- Conclusion and Future development

PEC Working Principle (1/3)

PEC consists in the analysis of the transient eddy current inside a conductive component following a sharp electromagnetic transition. There are 3 phases:

1. The emission phase (the pulse) during which the probe injects magnetic fields that penetrate and stabilize in the component thickness

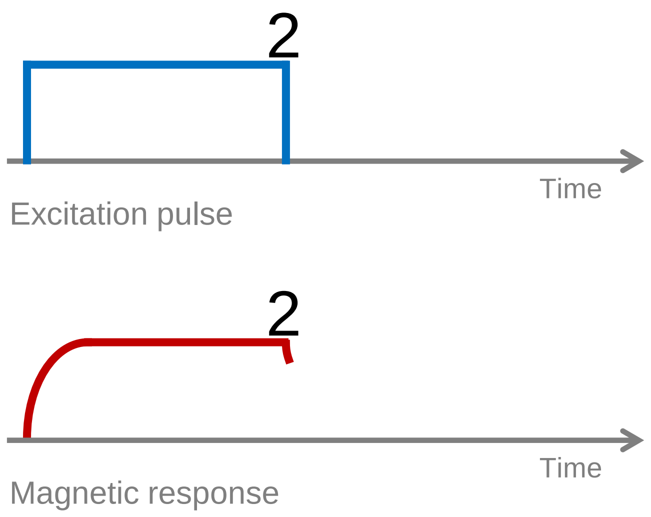


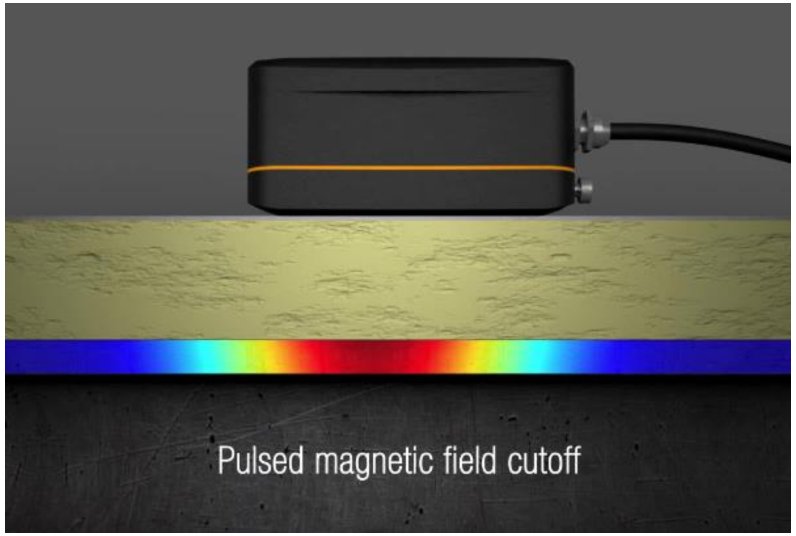


PEC Working Principle (2/3)

PEC consists in the analysis of the transient eddy current inside a conductive component following a sharp electromagnetic transition. There are 3 phases:

2. The cut-off phase which induces strong eddy currents into the component when the magnetic field emission is stopped abruptly

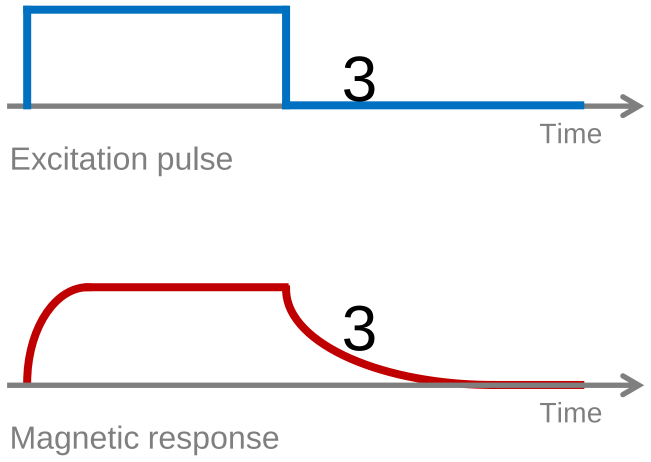


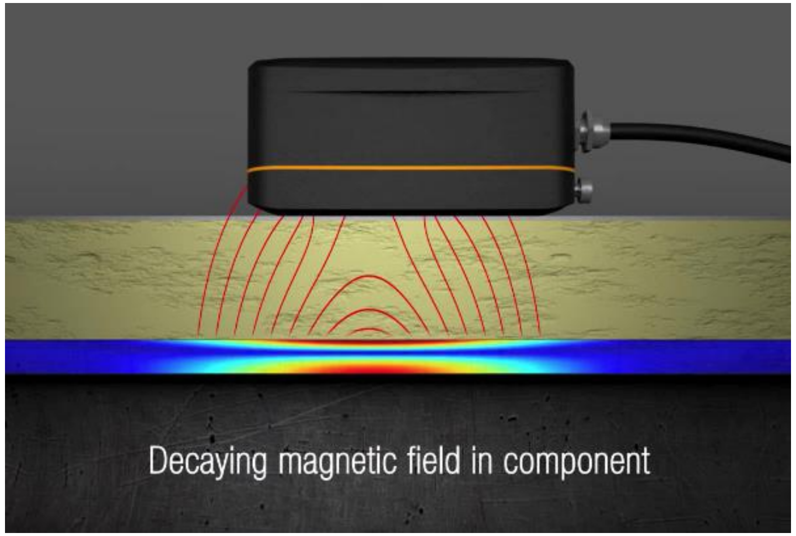


PEC Working Principle (3/3)

PEC consists in the analysis of the transient eddy current inside a conductive component following a sharp electromagnetic transition. There are 3 phases:

3. The reception phase during which magnetic sensors measure the decay of the magnetic field as eddy currents diffuse into the material thickness

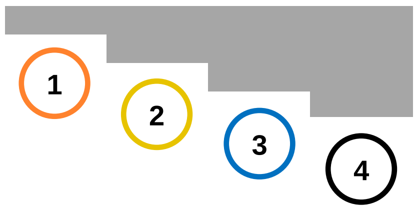


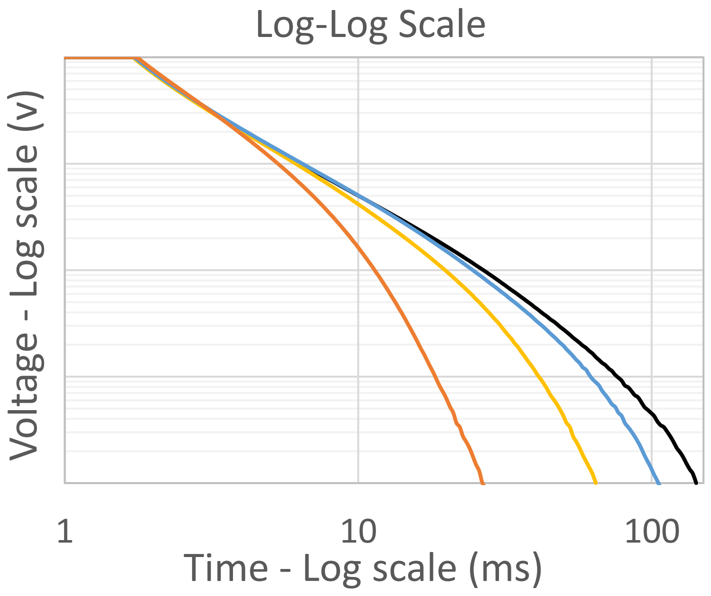


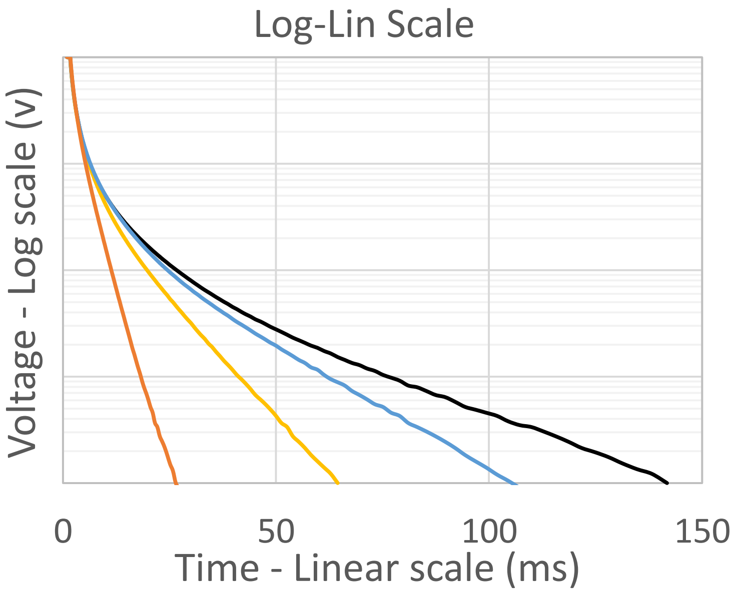
A-Scan in Reception Phase

Thinner wall thicknesses change the shape of the A-scan

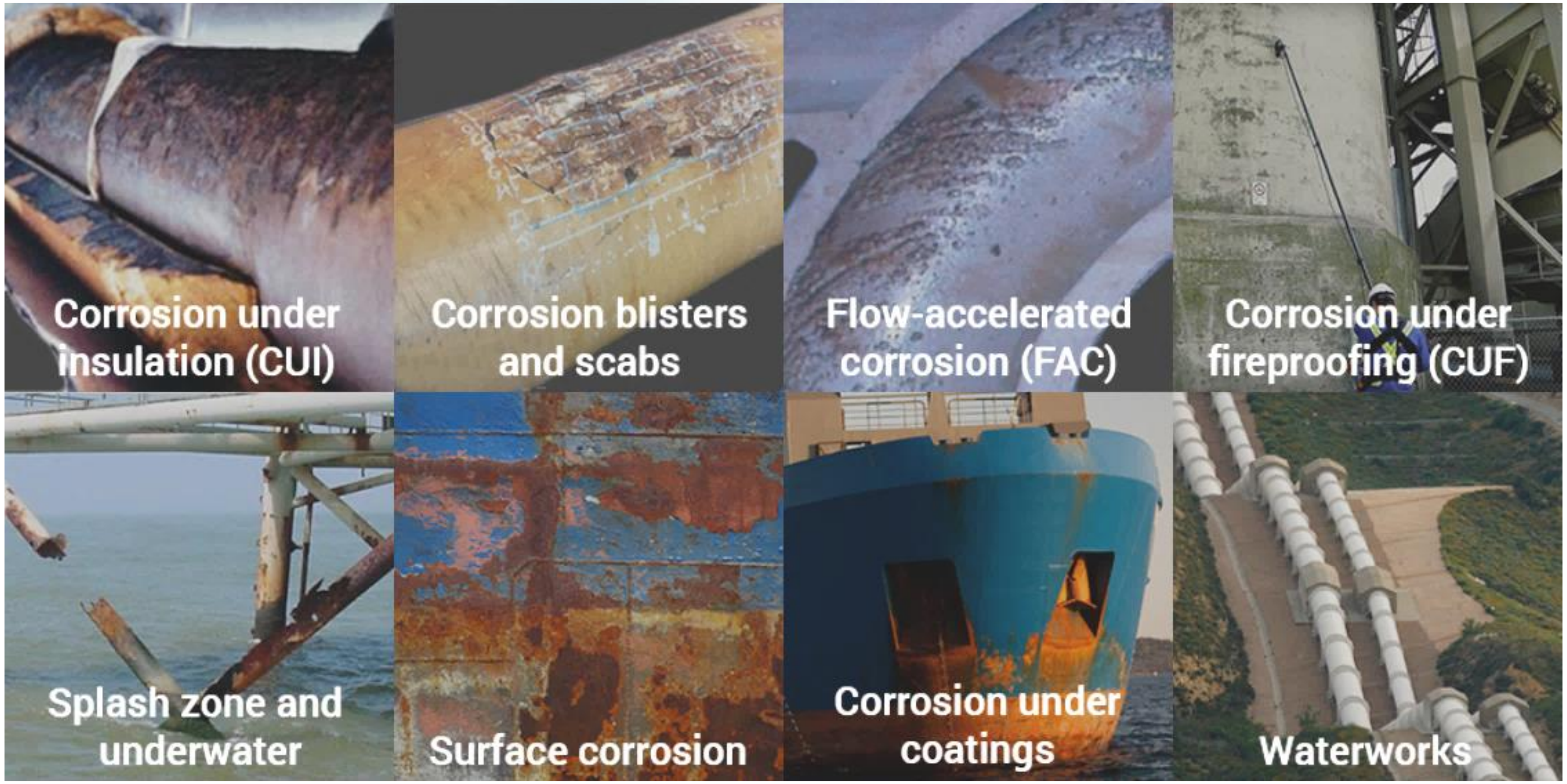
- Shorter eddy current diffusion time
- Quicker signal drop in a Log-Log scale
- Different slope in a Log-Lin scale







Applications Suitable for PEC



What Pulsed Eddy Currents do well

Detection of corrosion in presence of high lift-off which can come from:

- Protective coating
- Insulation
- Corrosion product
- Marine growth
- Concrete
- Repair wrap

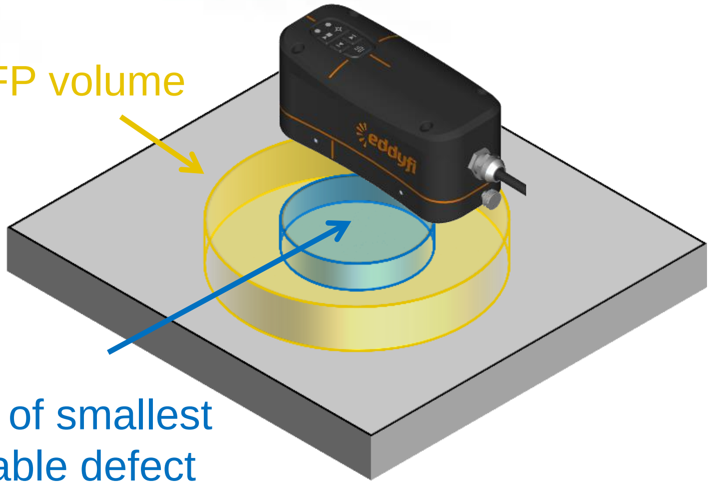
Penetrates thick wall

Works through weather jacket and / or thin metallic coating

Main Limitations

Minimum detectable volume loss is fairly large

- Current probe detect volume loss that covers about 15% of the probe footprint



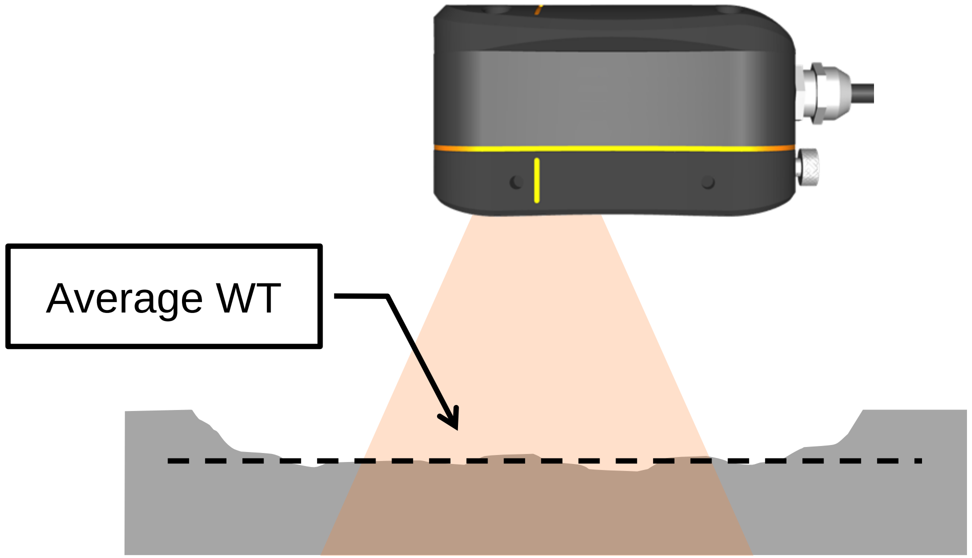
Provide an average WT measurement within the footprint of the probe

- Depth sizing underestimation for small indication

Impact of the Average WT Measurement

Large corrosion

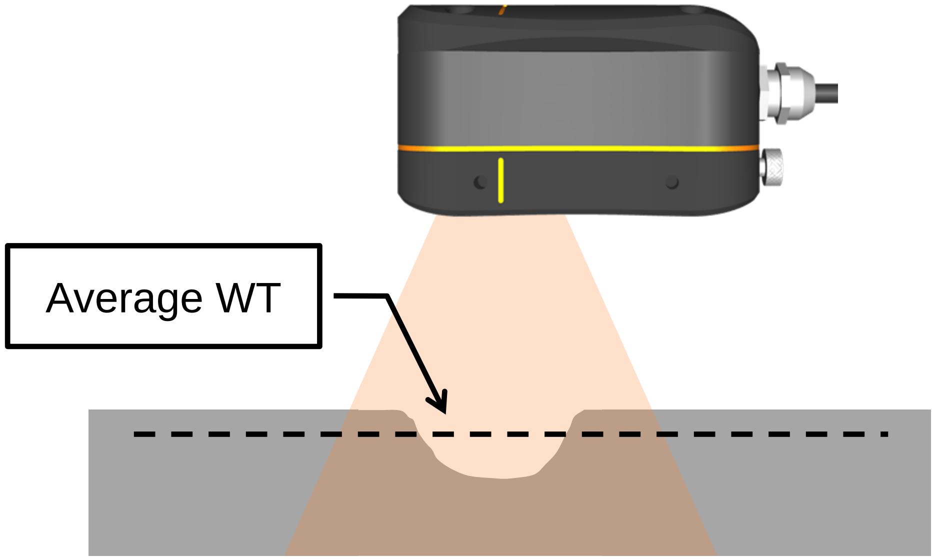
(larger than averaging area)



Good sizing accuracy

Small corrosion

(smaller than averaging area)

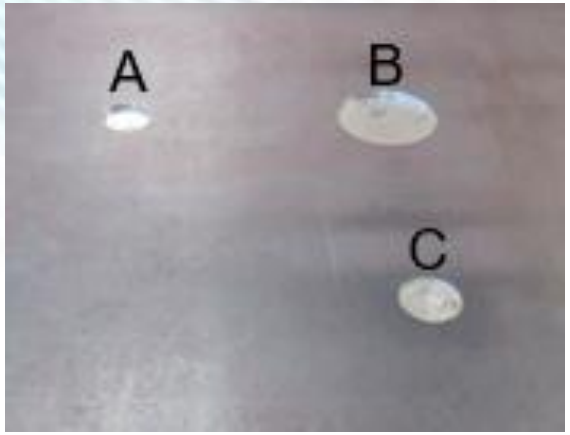


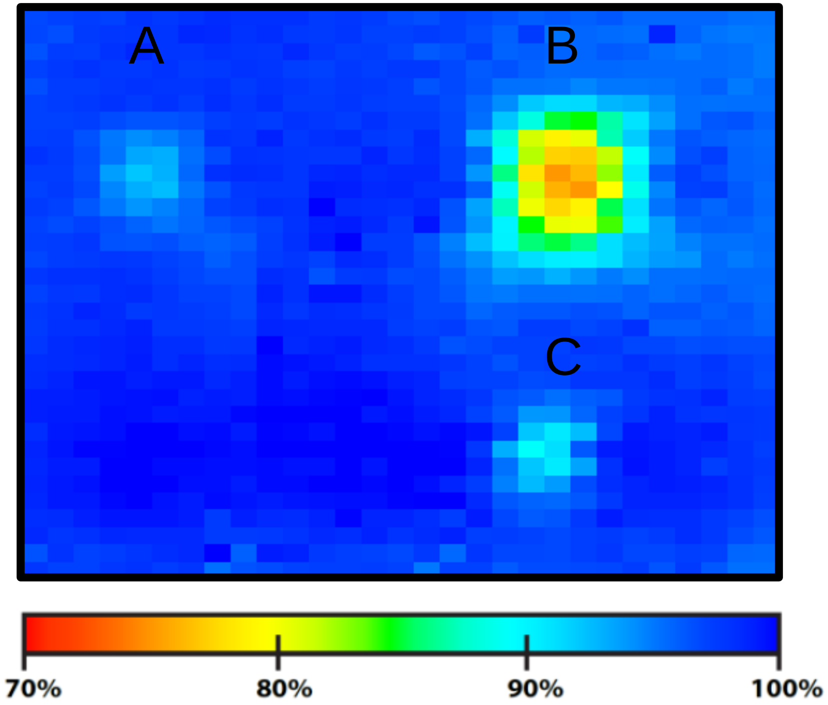
Undersizing of the flaw!

Example of Flaw Undersizing

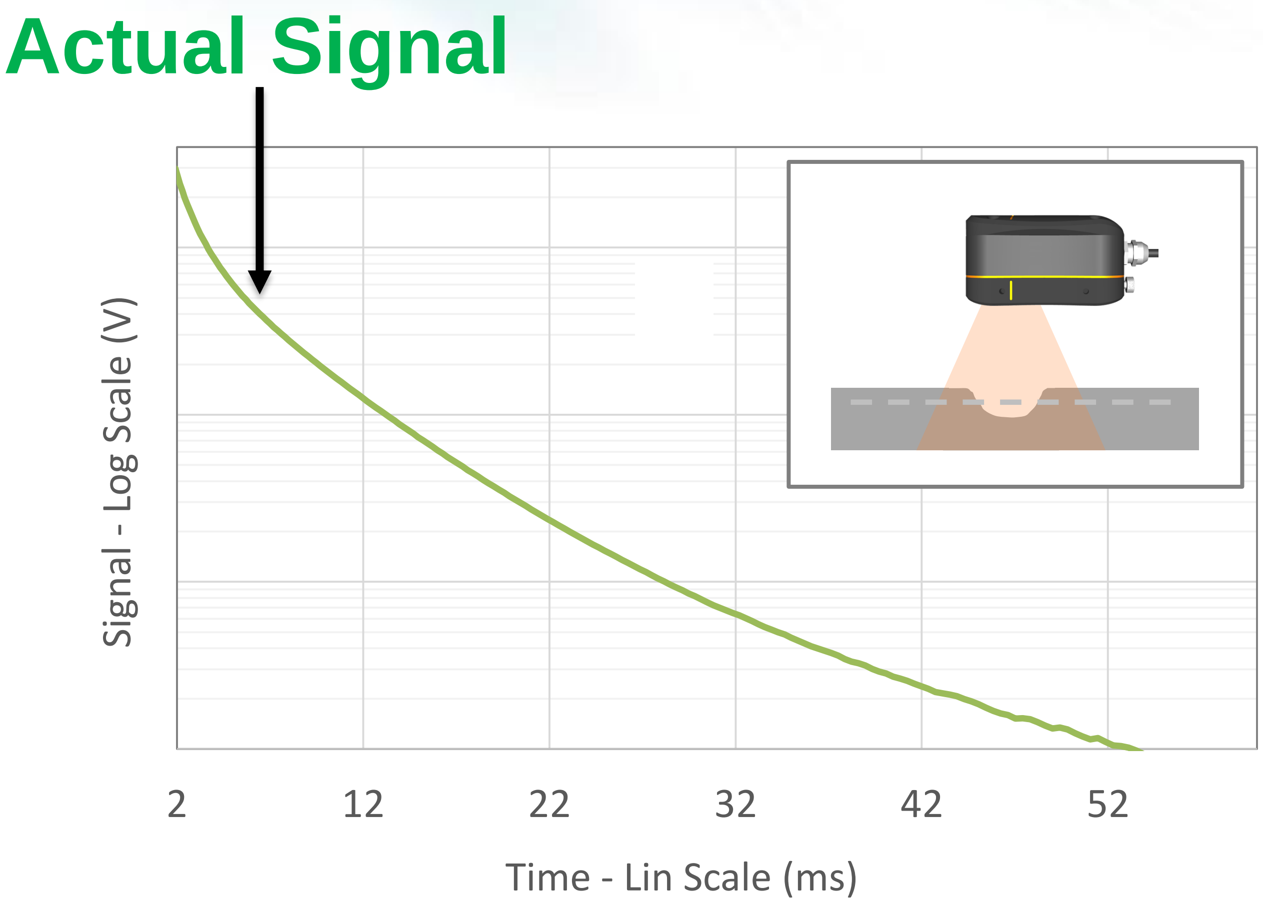
Lab mockup sample – Flat bottom holes	
Plate WT	0.5'' (12.7 mm)
Insulation height	2'' (50.8 mm)

Defect	Diameter	Real WT	Average WT
A	3''	66%	89.5%
B	6''	33%	66.8%
C	3''	33%	85.7%



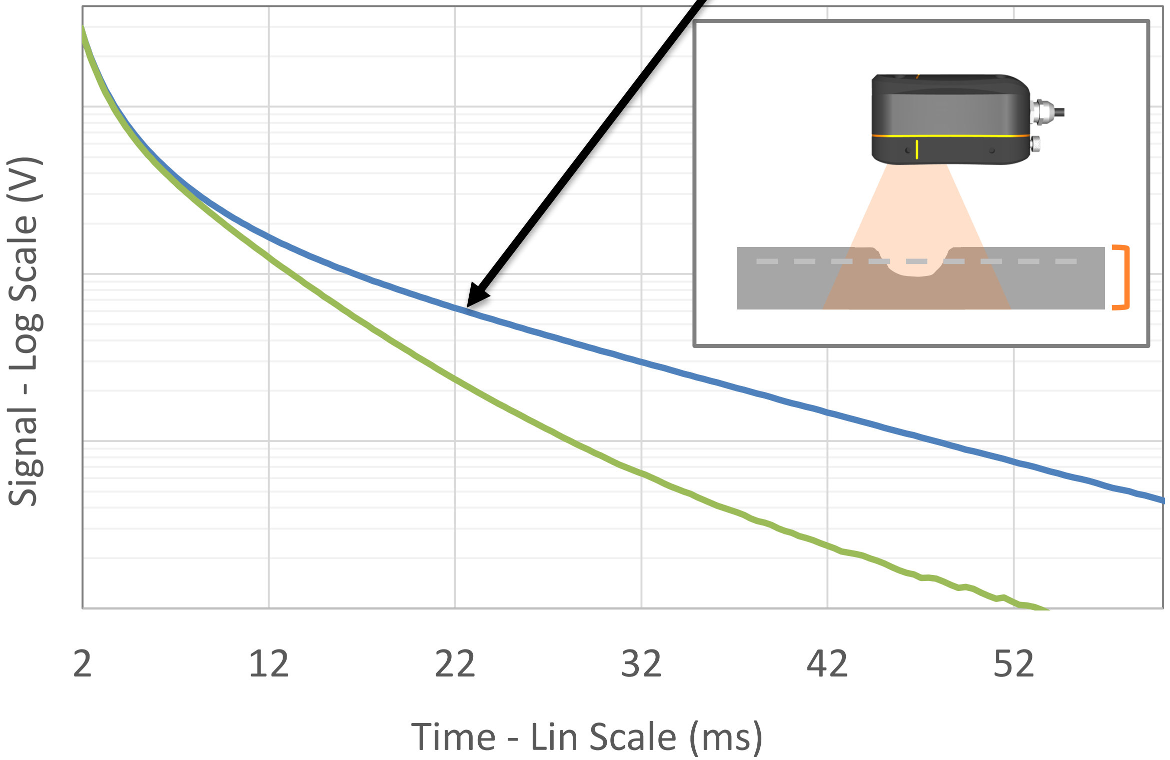


A-scan from Defect Smaller than Footprint



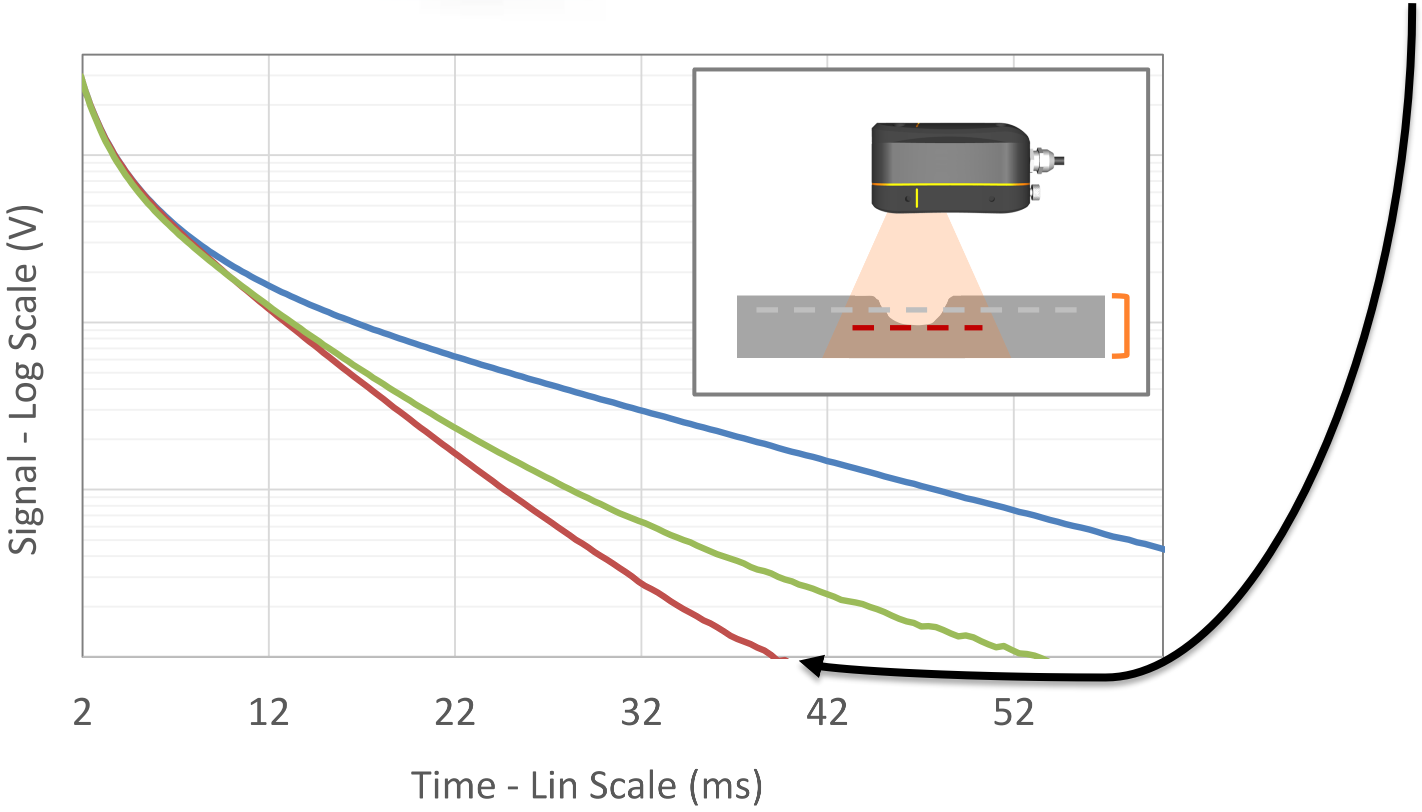
A-scan from Defect Smaller than Footprint

Actual Signal = contribution of **Nominal**



A-scan from Defect Smaller than Footprint

Actual Signal = contribution of **Nominal** + **Defect**

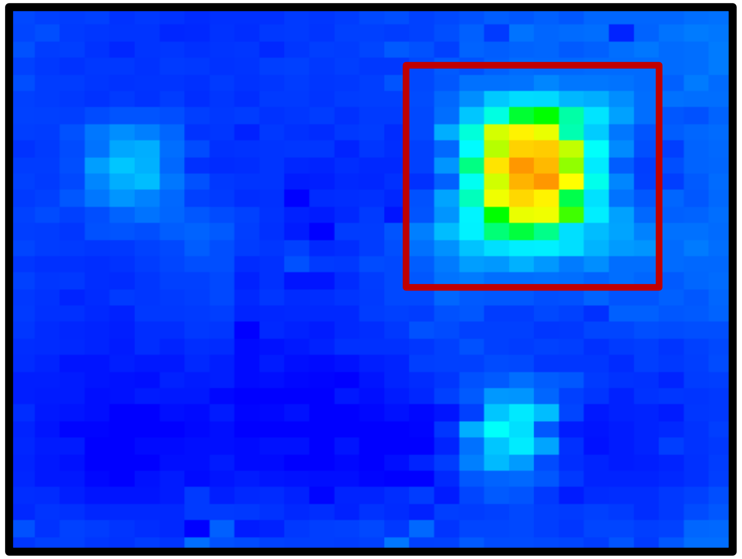


Compensated Wall Thickness

Goal: Isolate the defect contribution from the signal

How it works:

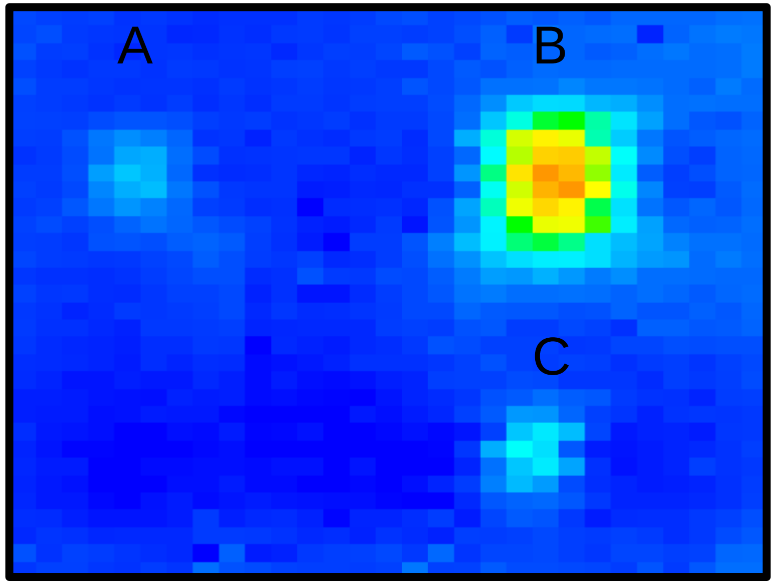
- Analyze a defective region rather than a single point
- Fit an analytical equation on each data point
- Find a defect contribution ratio
- Calculate a compensated WT



Results of CWT

Lab mockup sample – Flat bottom holes	
Plate WT	0.5'' (12.7 mm)
Insulation height	2'' (50.8 mm)

Defect	Diam.	Real WT	Average WT	Comp. WT
A	3''	66%	89.5%	**67.1%**
B	6''	33%	66.8%	**36.7%**
C	3''	33%	85.7%	**39.8%**



Mass effect

Mass effect is a strong signal contribution from large metallic masses near the probe

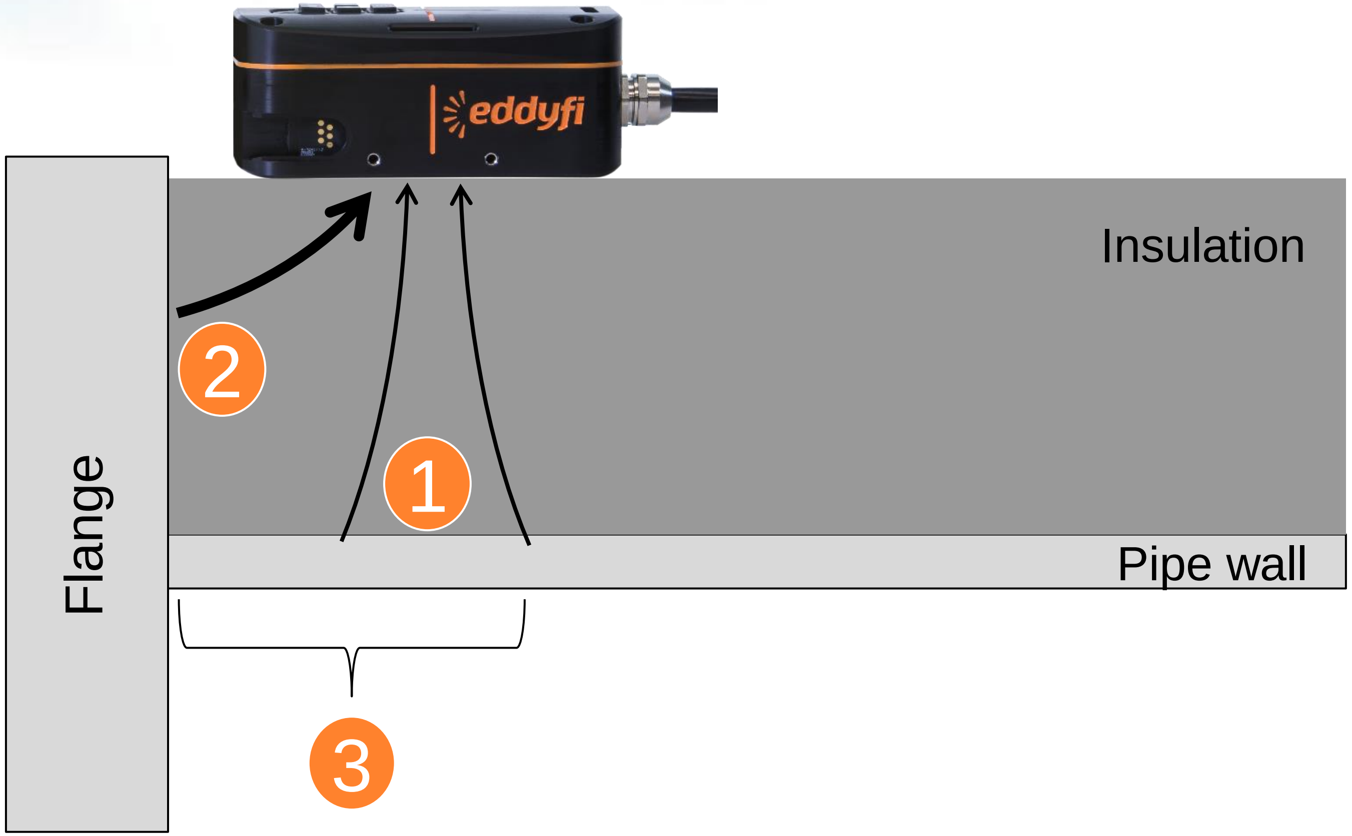
- Pipe saddles
- Supports
- Welded I-beams
- T-pipes
- Nozzles

Mass effect

When the probe approaches a mass, the strong and slow mass signal hides the signal from the pipe

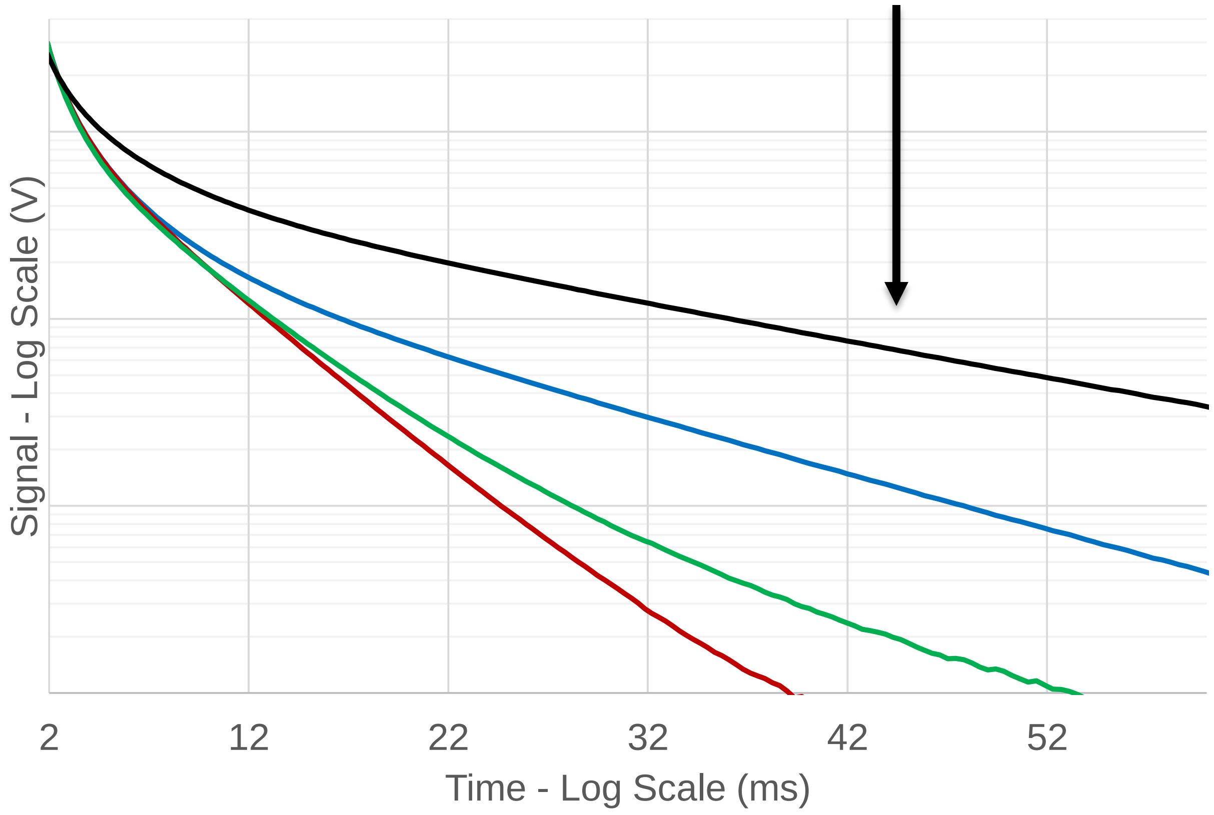
1. Pipe wall: Far + Thin
   → Weak, fast-decaying signals
2. Flange: Close + Thick
   → Strong, slow-decaying signals
3. Within one FP distance, flange signal hides pipe signal

This results in an **increasing** measured wall thickness.



A-scan from mass effect

New dominant contribution from mass

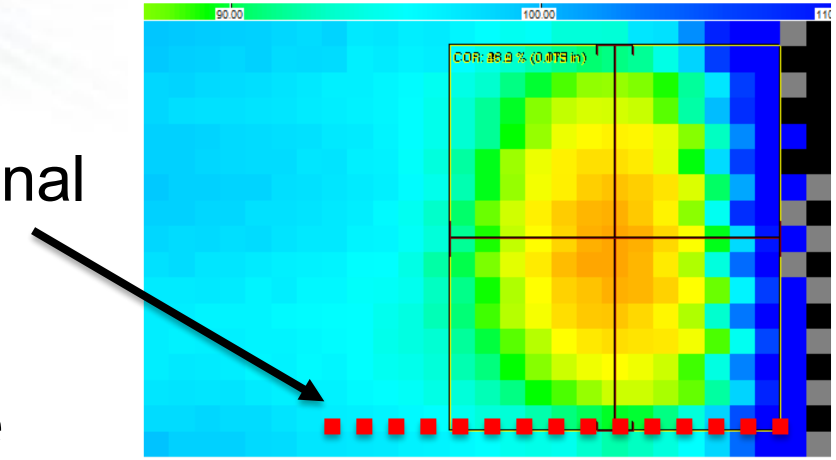


CWT is blinded by mass signal unless a proper correction is applied

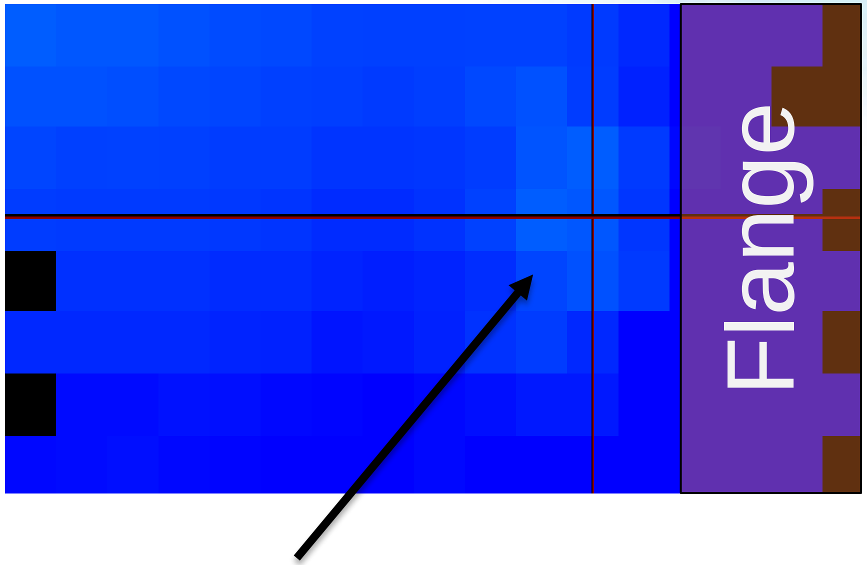
CWT with mass effect correction

Concept of mass effect correction:

1. Identify a “reference line” mainly influenced by nominal and mass
2. Analysis of this reference line allows to estimate the contribution of the mass only
3. Apply CWT technique by including the mass contribution in the fitting procedure



Example: small defect near flange



Defect barely visible here

7in OD, STD pipe
with small defect milled at 1in from flange

- Average measured WT before compensation is heavily undersized as this defect is much smaller than the probe footprint
- Uncorrected CWT is blinded by mass
- Correction allows for accurate defect sizing

Insulation thickness	Defect length	Defect width	Real WT	Average WT	Compensated WT without correction	Compensated WT with correction
2 inch	2 inch	0.75 inch	24%	96%	Blinded	**26.1%**

Conclusions and future developments

PEC is an efficient screening technique to detect corrosion in several CUI applications.

The Compensated WT algorithm addresses the main weakness of PEC: undersizing of small flaws

The new correction for mass effects enables CWT near metallic masses like flanges, nozzles etc.

Future development:

- Reduce footprint size
- Improve A-scan analysis to further enhance sizing of defects smaller than footprint
- Further improve robustness and accuracy of CWT in presence of mass effects.