CASE STUDIES OF GUIDED WAVE TESTING USING MAGNETOSTRICTIVE TRANSDUCER ARRAYS

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GUIDED WAVE IMAGING WITH MAGNETOSTRICTIVE ARRAYS

Inspection approach

- Flexible magnetostrictive transducer (MsT) arrays support guided wave inspection of hard-to-access structures using SH0 and higher order guided waves.
- Multichannel acquisition records full matrix capture (FMC) data.
- The total focusing method (TFM) reconstructs images to locate corrosion and other reflectors.

Field applications

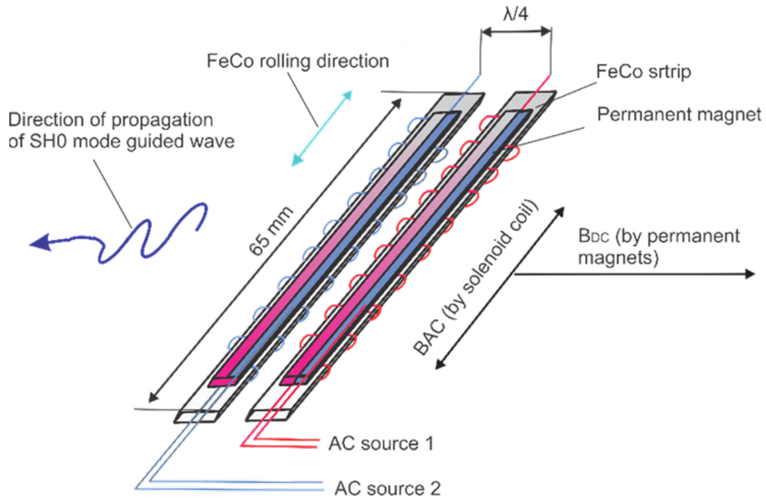
- Concrete pipe supports and buried piping
- Buried monopoles, anchor rods and H-shaped anchors
- Storage tank bottoms, walls and welded supports

Case studies span minor corrosion through severe wall loss.

MAGNETOSTRICTIVE TRANSDUCER DESIGN

- A coil-generated dynamic field and a permanent magnet-generated bias field drive the magnetostrictive response in FeCo strips.
- Two independently driven strips per segment provide direction control.
- The same probe operates over 20–250 kHz.
- Automated frequency sweeps compare inspection responses at multiple frequencies.
- Testing requires shear-wave couplant.
- No other consumables are needed.

Wiedemann Effect MsT Transducer



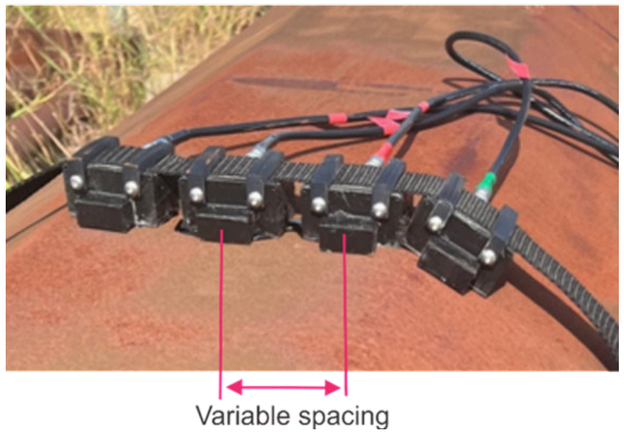
Bracelet MsT probe on 4'' OD lightning pole



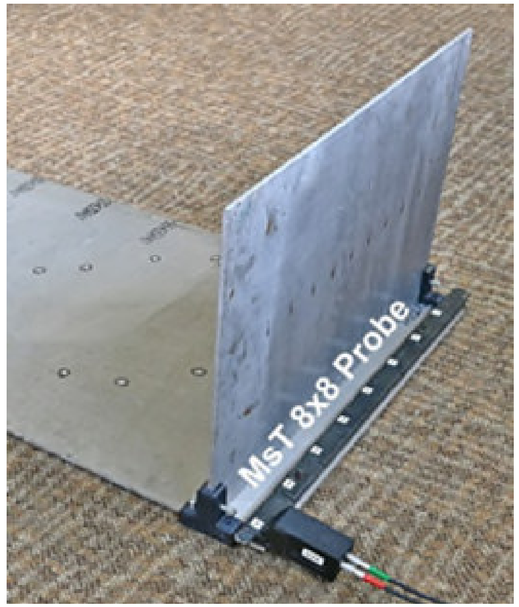
Bracelet MsT probe on 10'' OD pipe

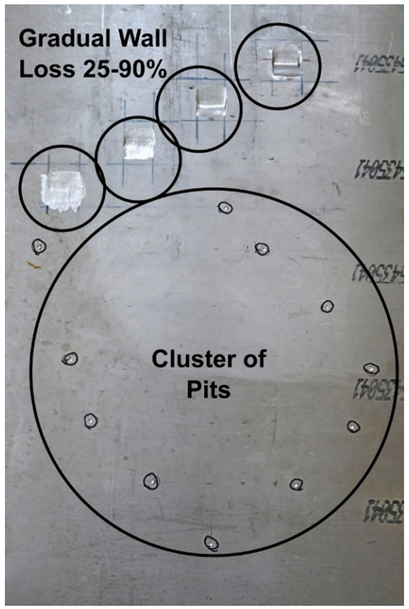


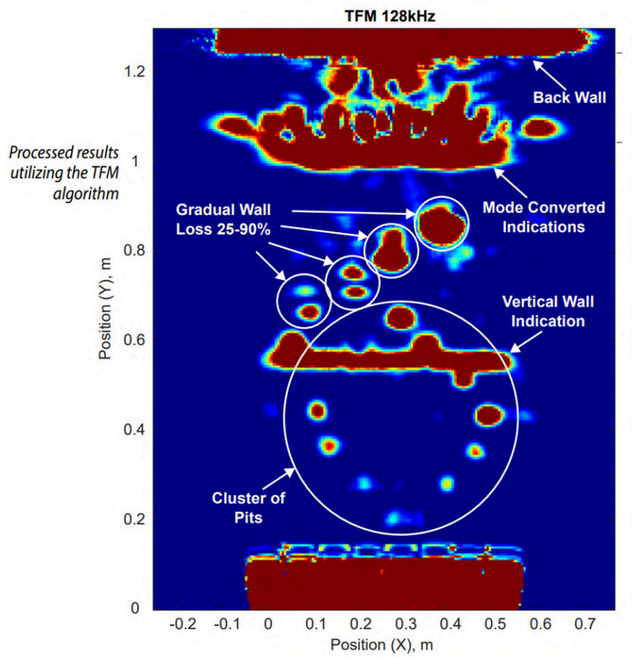
Probe array mount on octagonal pole surface



DEFECT IMAGING IN PLATES USING MST 8×8 AND FMC/TFM

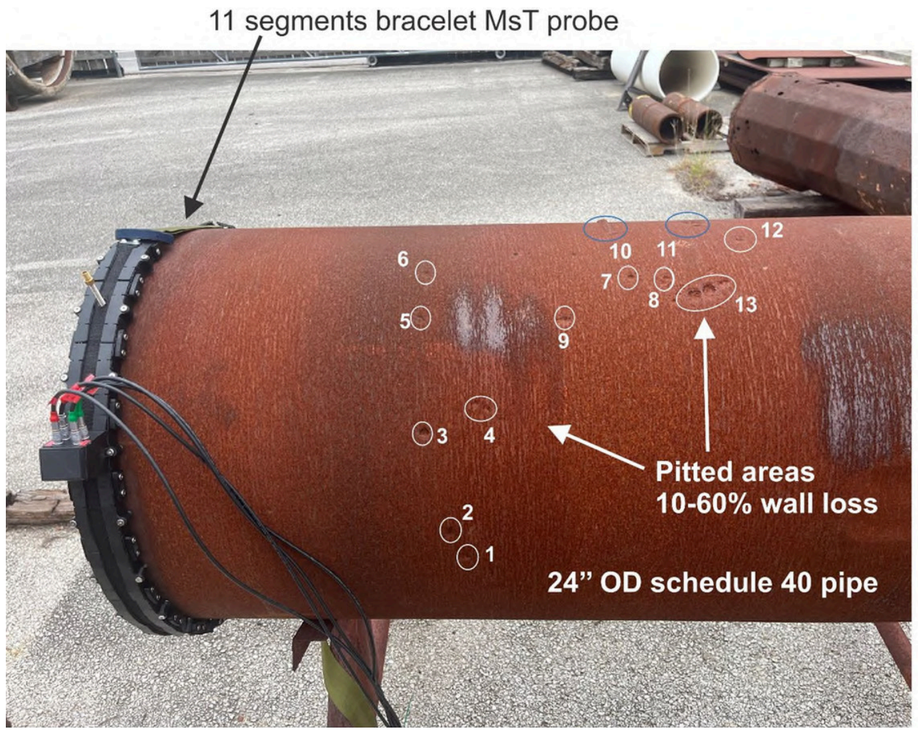


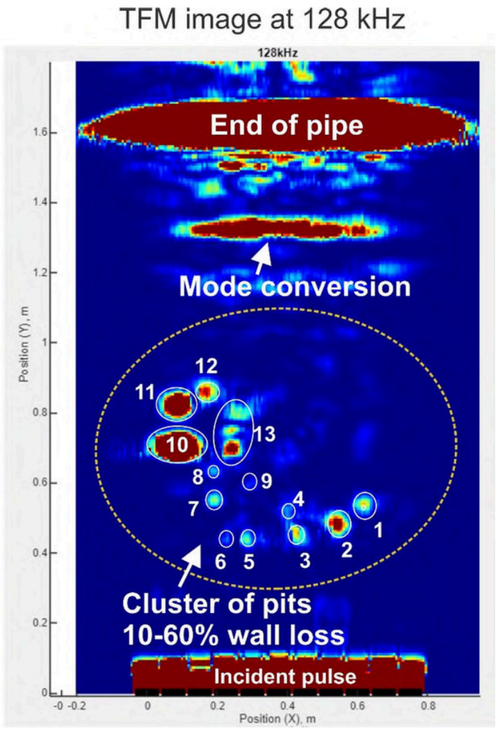




- Tank mockup: 6.4 mm (0.25 inch) thick aluminum plate representing the tank bottom with an attached vertical plate representing the wall
- Plate MsT 8x8 probe positioned on tank mockup outside the wall
- The bottom plate had a series of anomalies, including 4 mm (0.16 inch) diameter 25% deep drilled holes and gradual wall loss defects, with maximum wall loss of 25% to 90%
- The probe demonstrated outstanding sensitivity to simulated pitting corrosion and gradual wall loss defects, as well as the ability to map the defect locations.

NATURALLY FORMED PITTING CORROSION IN 24 IN. OD PIPE



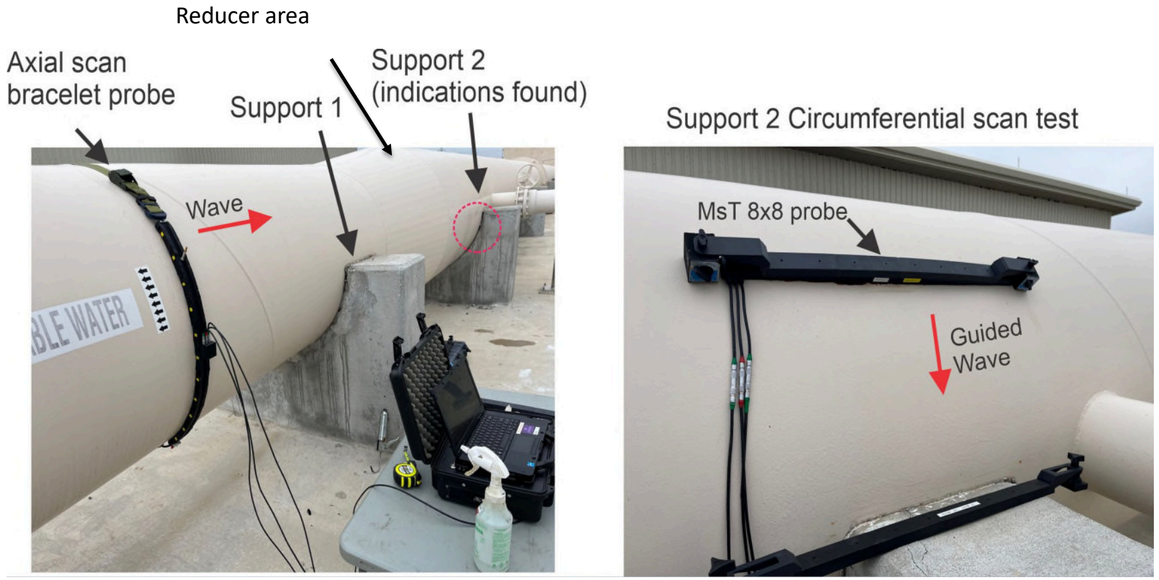


List of indications

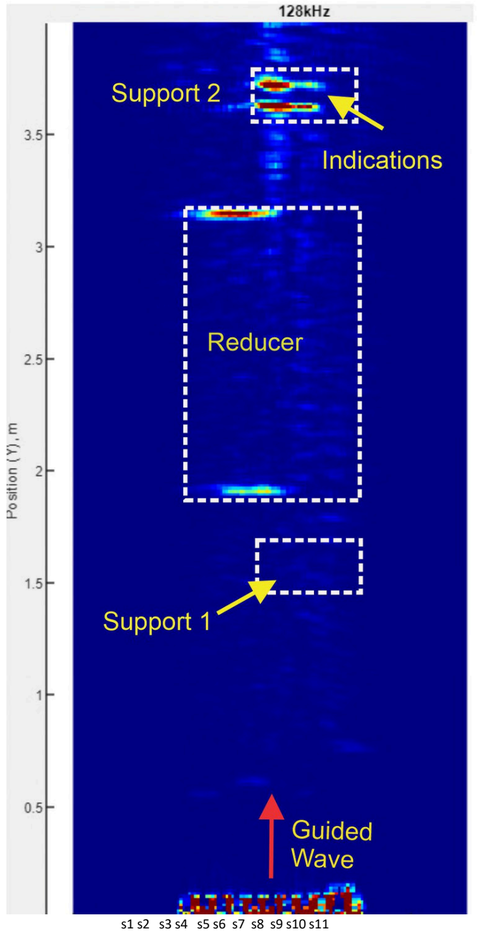
N	Diameter	Depth
11	25 mm (1 inch)	60%
12	12 mm (0.47 inch)	28%
5	6 mm (0.23 inch)	10%
2	12 mm (0.47 inch)	42%
8	7 mm (0.27 inch)	14%

- 13 anomalies were naturally formed in this pipe sample
- TFM image produced a map of pit distribution and a realistic image of pit geometry
- This information can be used to estimate cross-sectional area of defects to help improve the depth estimate accuracy

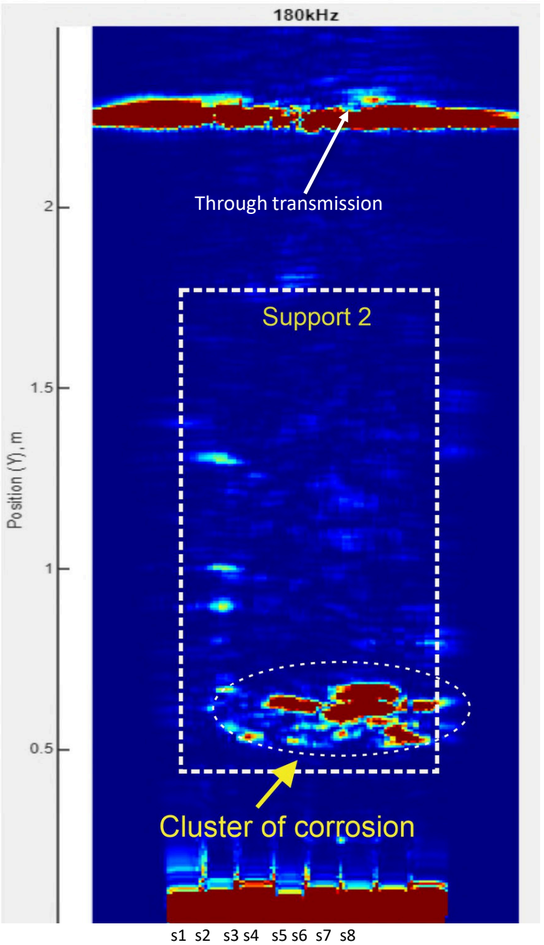
CUPS: CONCRETE PIPE SUPPORT AXIAL AND CIRCUMFERENTIAL SCANS



Results of axial scan

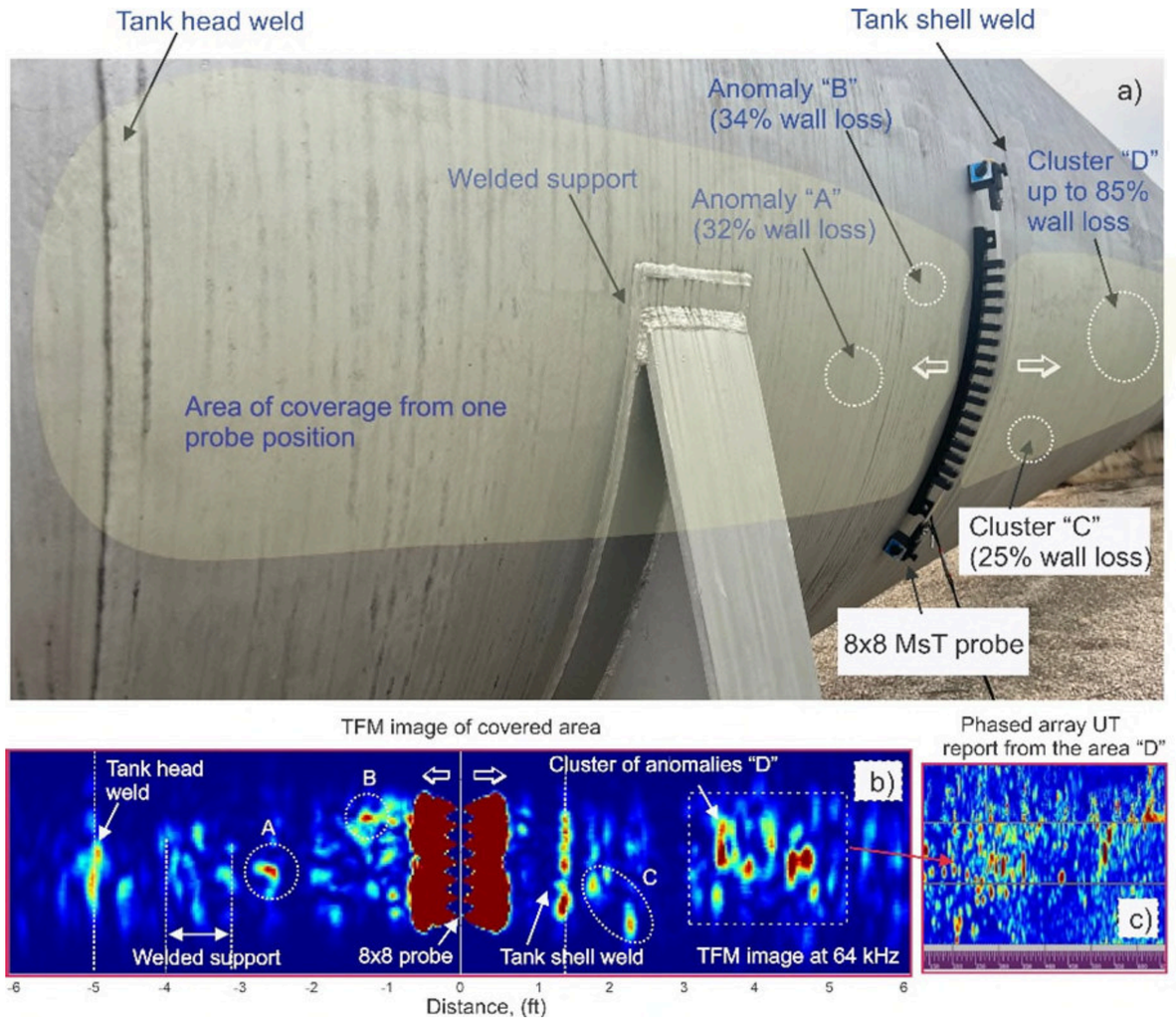


Results circumferential scan



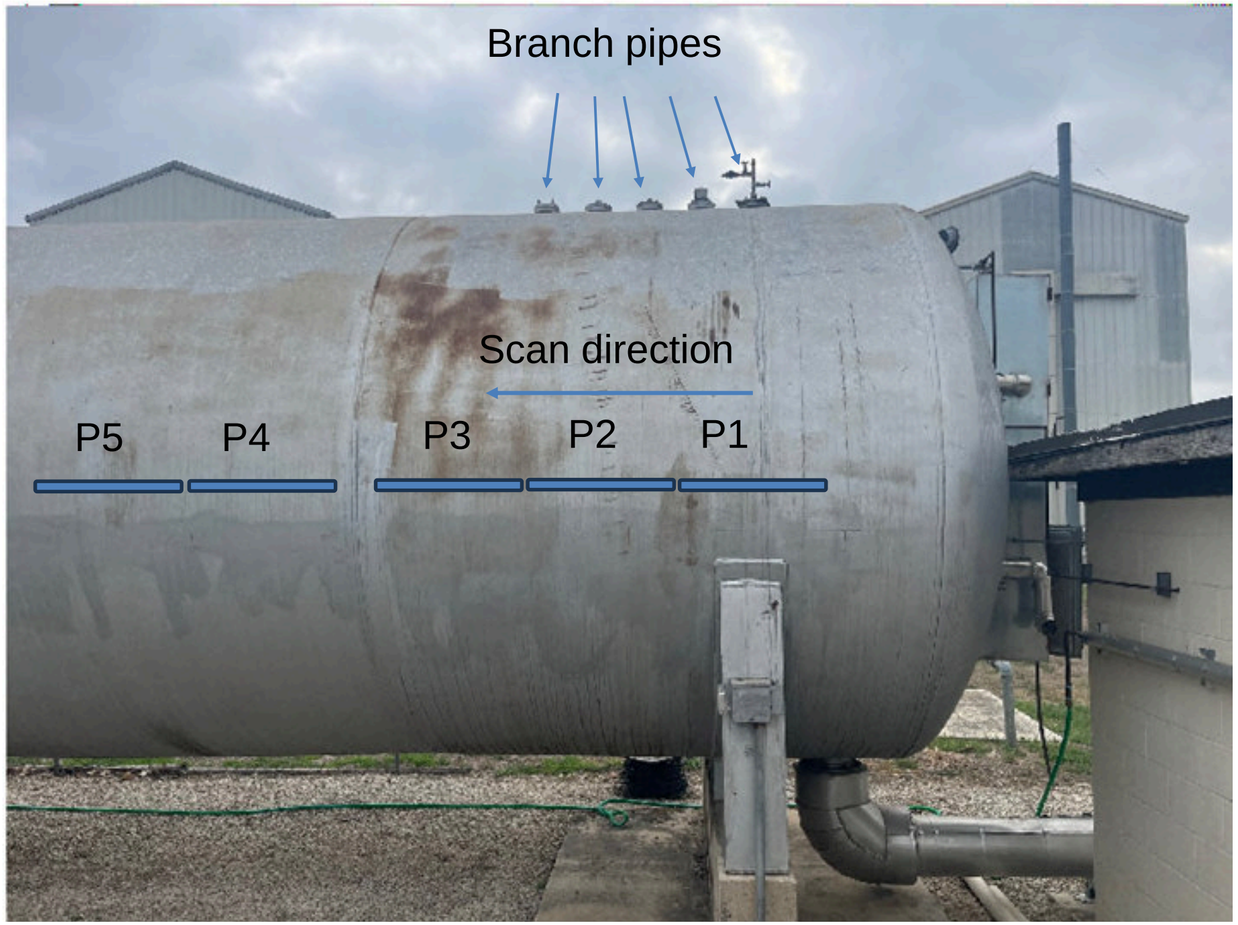
- 42 in (1.07 m) OD carbon steel pipe 10 mm (0.4 in) wall.
- An 11-segment bracelet scanned axially across two concrete supports.
- An 8 × 8 MsT array scanned around support 2 and found a corrosion cluster 0.5 m (20 in) from the probe.

CORROSION BENEATH A WELDED TANK SUPPORT

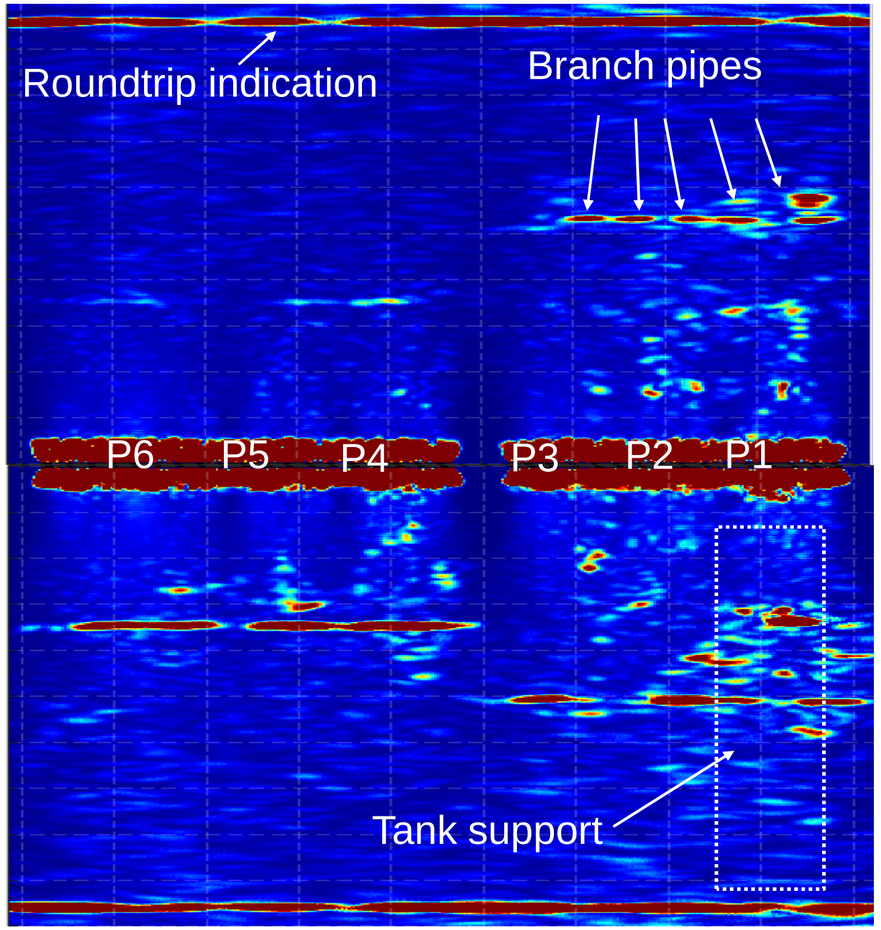


- 40-year-old tank with a 9.5 mm (0.375 in) wall and verified wall loss up to 90%.
- Guided waves covered 6 ft in each direction and detected both welds and four suspected corrosion clusters.
- Phased array UT confirmed up to 85% wall loss in cluster D. The deepest damage aligned with the TFM map.
- The inspection covered the area beneath the welded support. Severe corrosion can limit the backwall reflection needed for phased array UT defect characterization.

TFM MAPPING ACROSS A STORAGE TANK



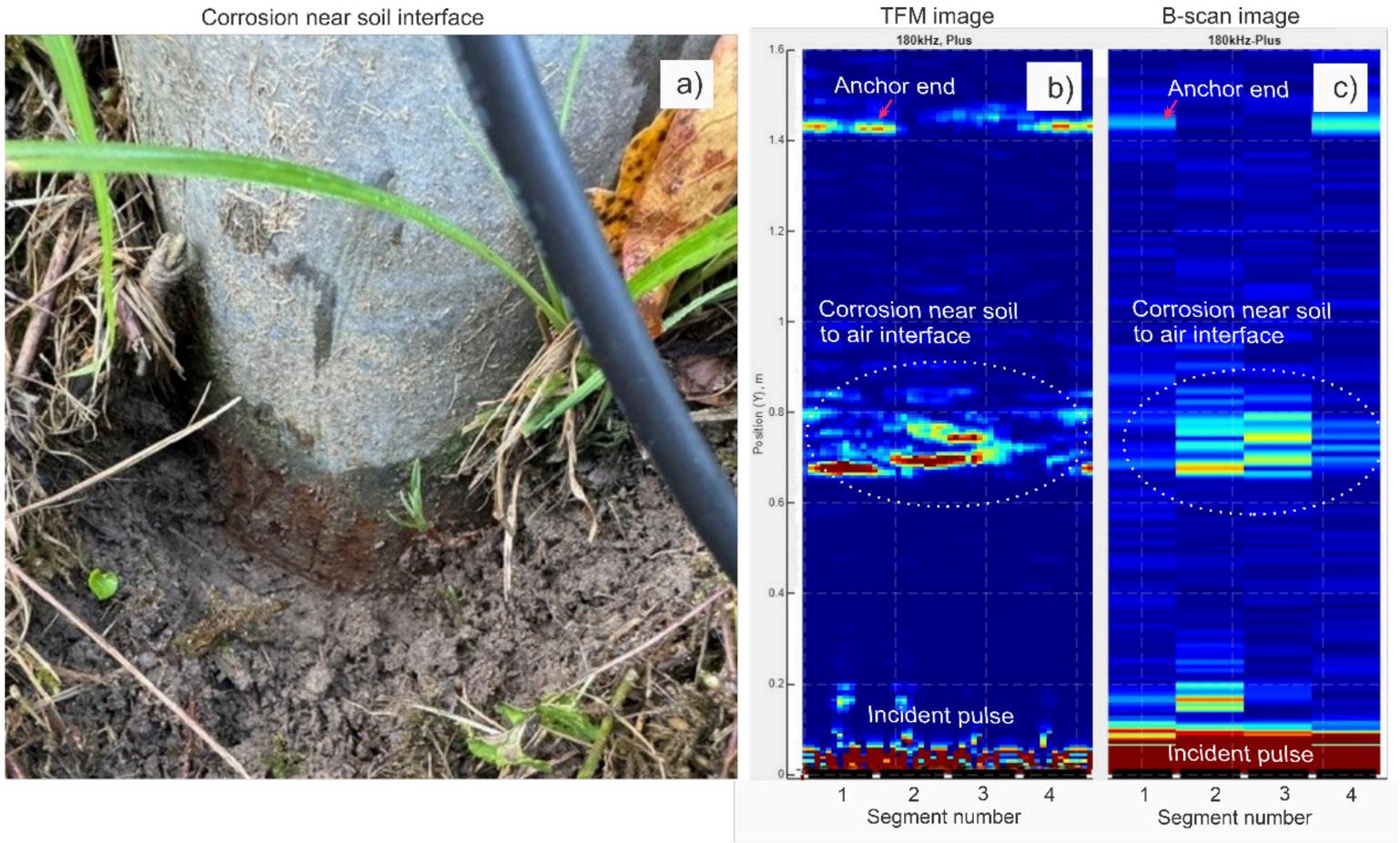
Successive MsT 8x8 probe positions



Combined TFM images

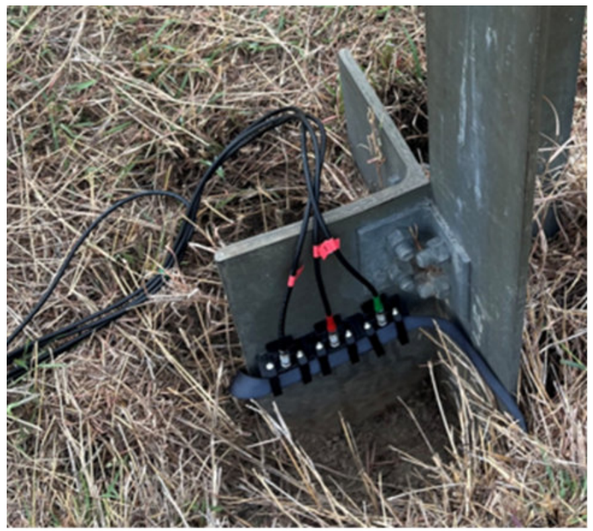
LIGHTNING POLES: CORROSION AT THE GROUND LINE

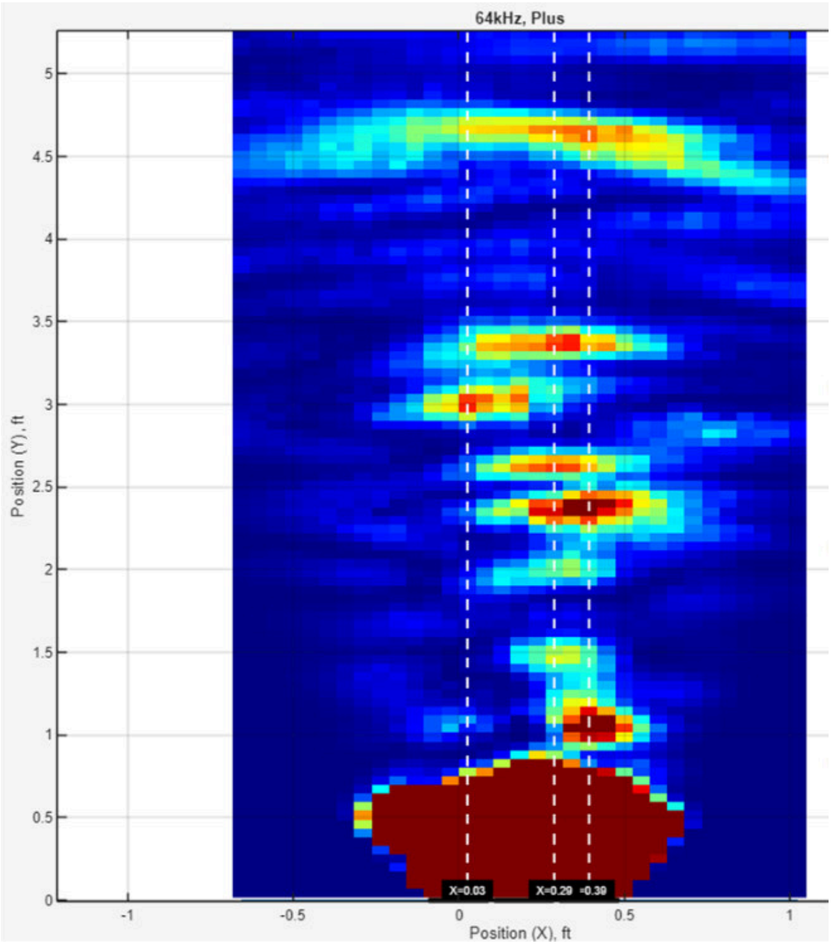
- 102 mm (4 in.) OD lighting pole
- Four-segment MsT array
- Discoloration at the soil interface suggested corrosion.
- At 180 kHz, TFM improved localization compared with the B-scan.
- The pole-end reflection remained visible.



FMC/TFM IMAGING OF A BURIED ANCHOR

Three plate probes on the accessible anchor surface





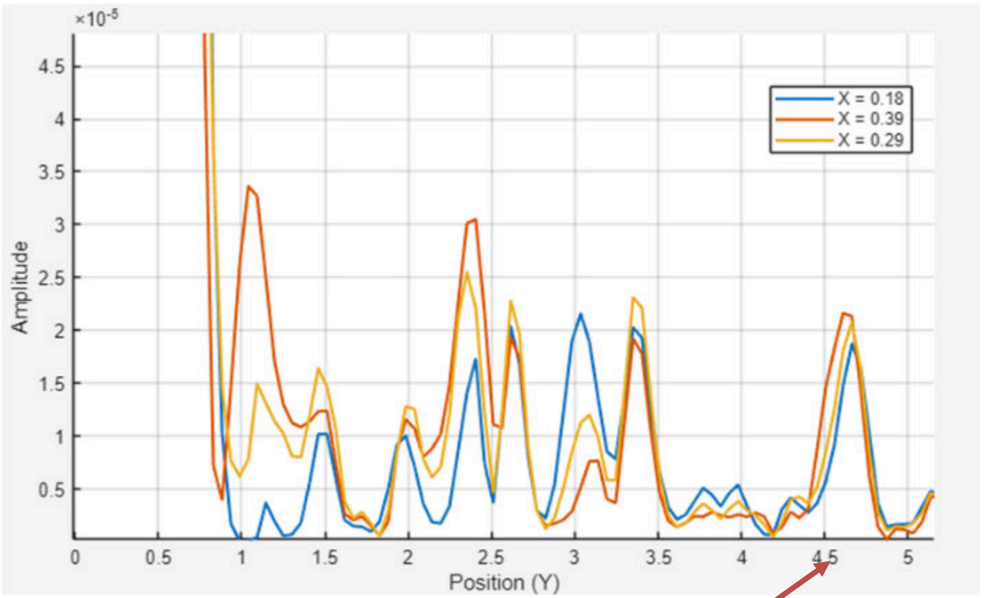
Full Matrix Capture (FMC)

Data acquisition using three plate probes.

TFM reconstruction

Imaging the buried section.

Amplitude profiles



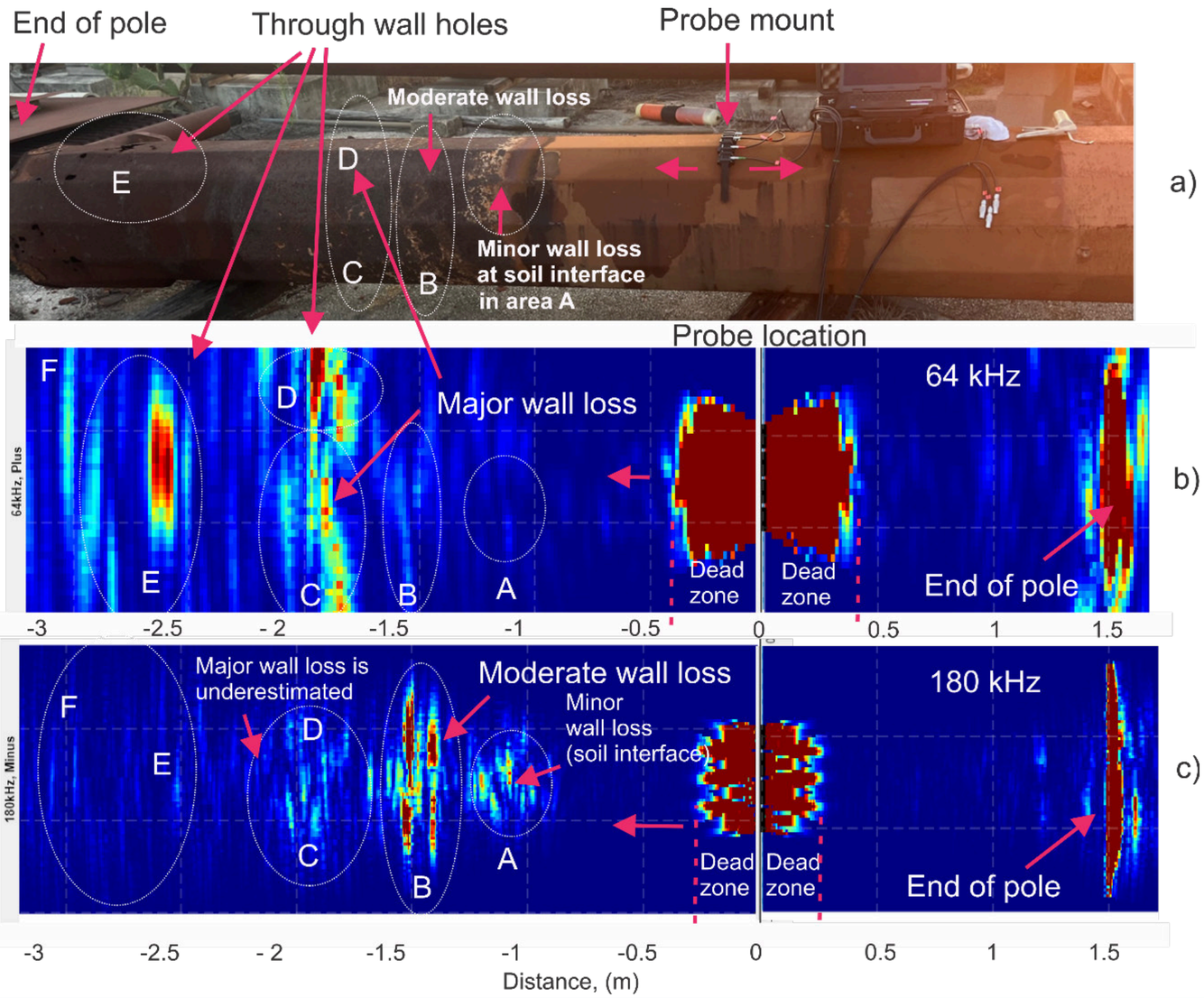
Anchor end at ≈4.6 ft

Several indications appear between ≈1.0 and 3.4 ft.

FREQUENCY SELECTION FOR CORROSION IMAGING

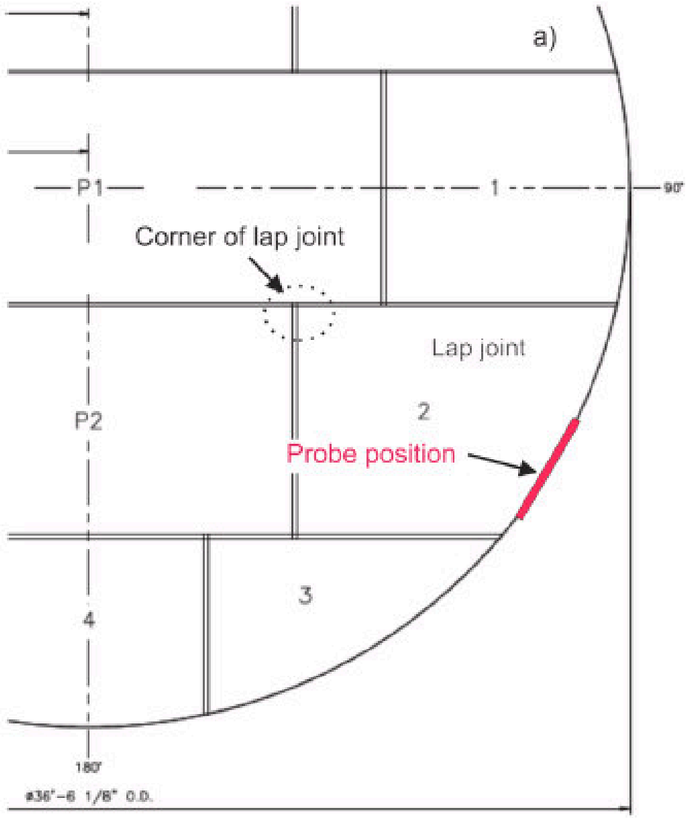
Retired multisided pole

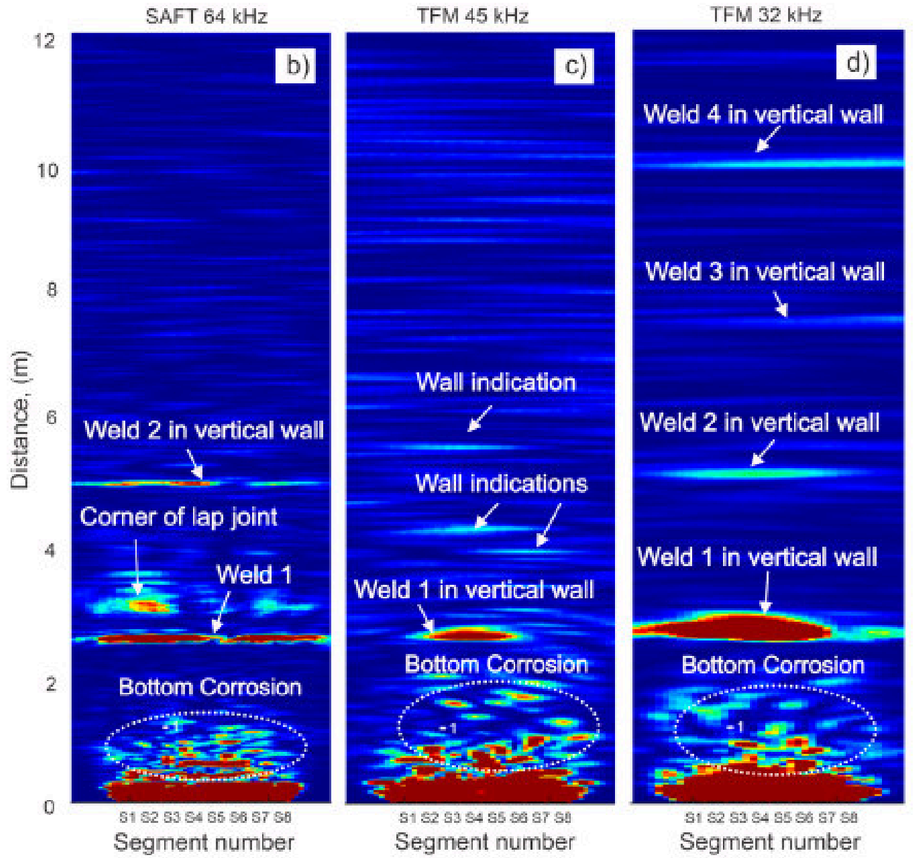
- Wall loss increases from the soil interface toward the end of pole.
- 180 kHz: clearer indications from minor and moderate wall loss in areas A and B.
- 64 kHz: stronger detection of major wall loss in areas C and D, consistent with lower attenuation.
- **The frequencies provide complementary sensitivity to corrosion severity.**



ANOMALIES IN A LAP-WELDED TANK BOTTOM

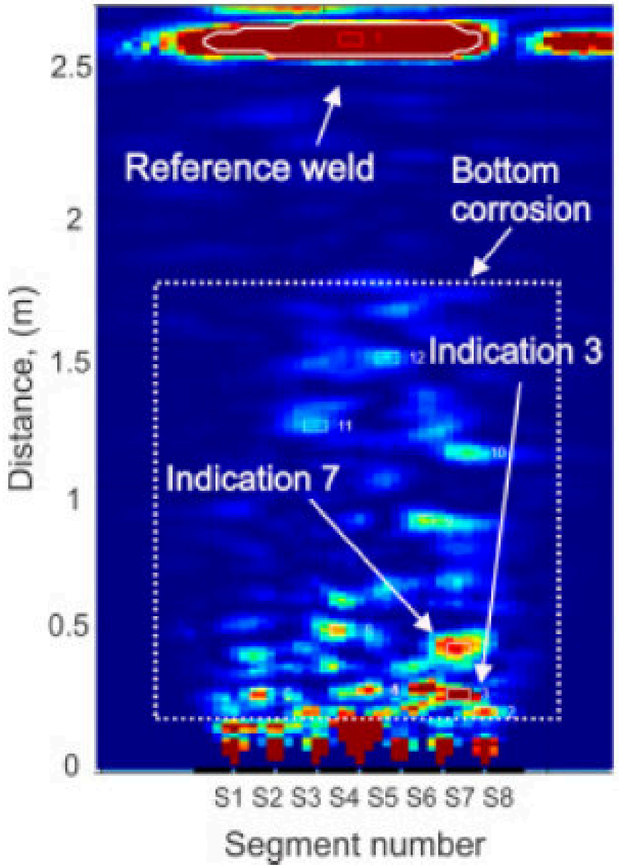






- Probe position and reconstructed images at 64, 45 and 32 kHz.
- Data can be acquired from a tank skirt as narrow as 0.5 inches (13 mm).

TANK-BOTTOM INDICATION RANKING AT 64 KHZ

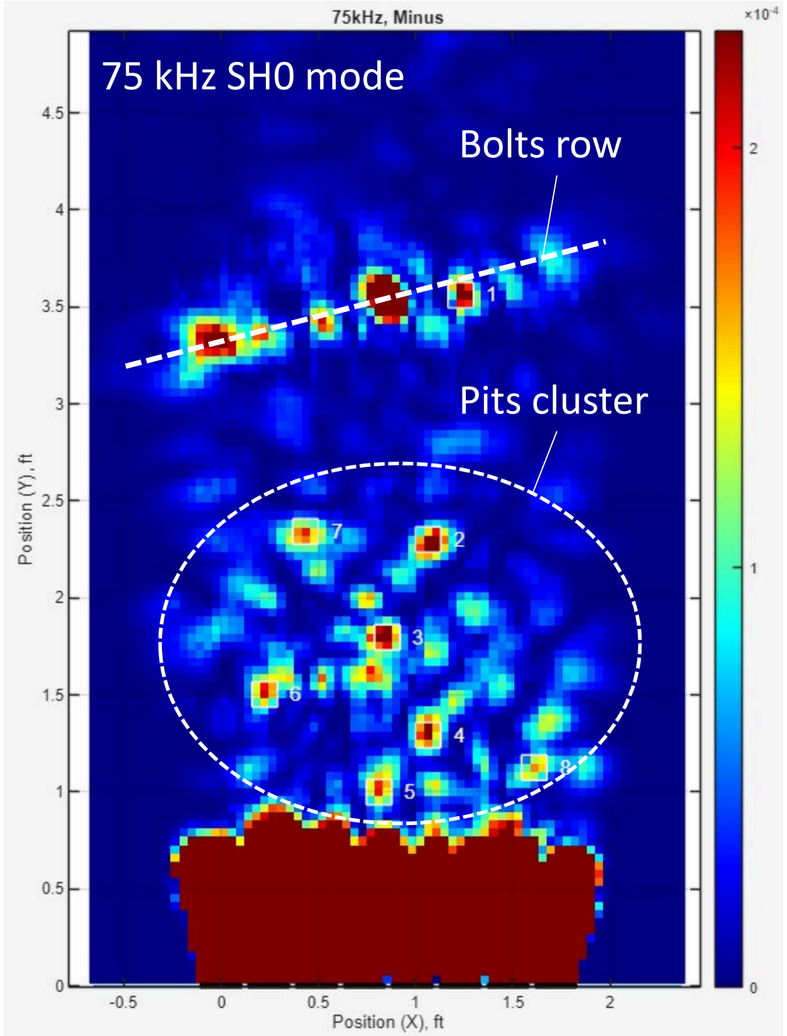


N	Type	Peak Amp, %	Circ. Position, m	Axial position, m	Span X, cm	Span Y, cm	Ranking
1	Reference weld	20	0.2	2.6	53.0	1.0	N/A
2	Indication 2	21	0.5	0.2	1.0	0.6	Moderate
3	Indication 3	57	0.4	0.3	1.0	1.0	Severe
4	Indication 4	21	0.3	0.3	0.8	0.8	Moderate
5	Indication 5	21	0.3	0.3	0.8	0.8	Moderate
6	Indication 6	22	0.1	0.3	0.6	0.8	Moderate
7	Indication 7	23	0.4	0.4	1.3	1.8	Moderate
8	Indication 8	18	0.2	0.5	0.8	1.1	Moderate
9	Indication 9	14	0.4	0.9	1.8	1.0	Minor
10	Indication 10	13	0.5	1.1	1.4	0.8	Minor
11	Indication 11	8	0.2	1.2	1.3	1.4	Minor
12	Indication 12	9	0.3	1.5	1.0	1.1	Minor

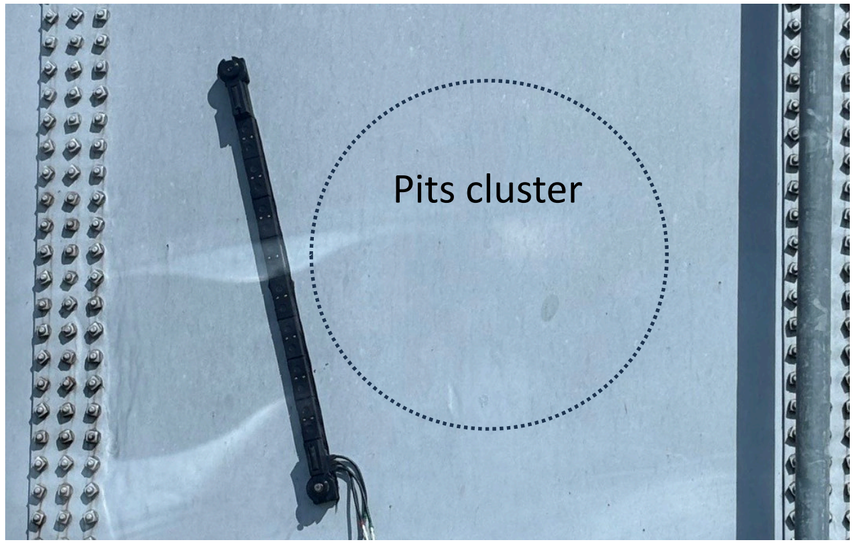
Reference weld and suspect indications

The report lists peak amplitude, position, indication span and relative ranking.

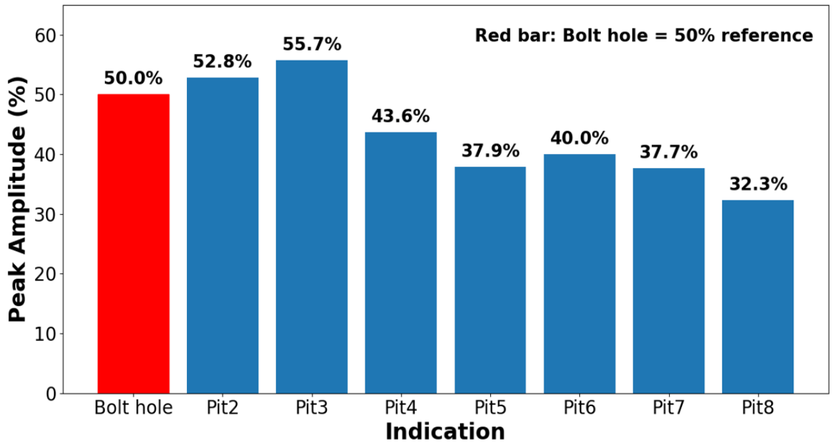
PITTING INDICATIONS IN A BOLTED TANK WALL



40-year-old water storage tank with a 0.25'' CS wall



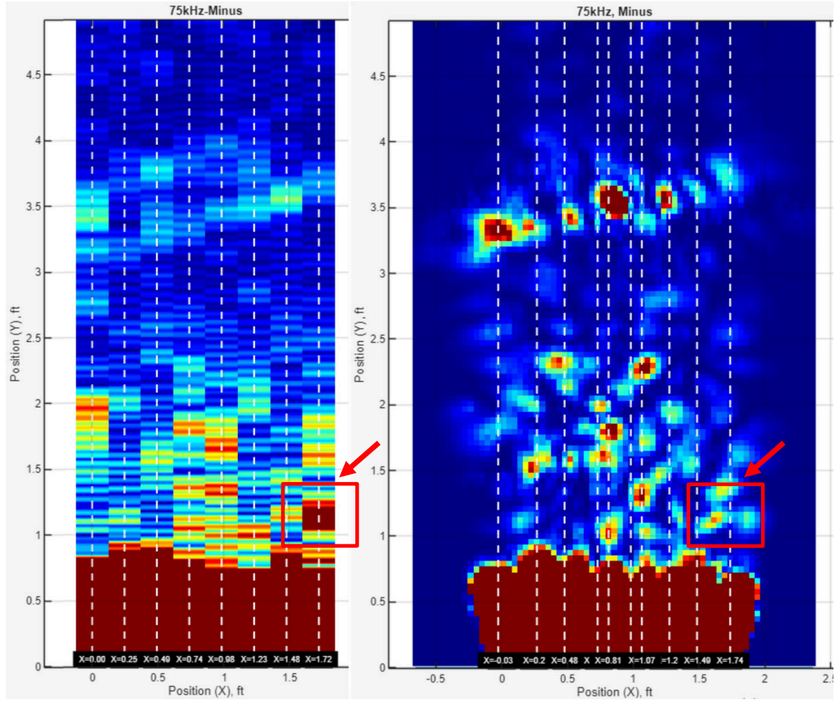
TFM Indication Peak Amplitude



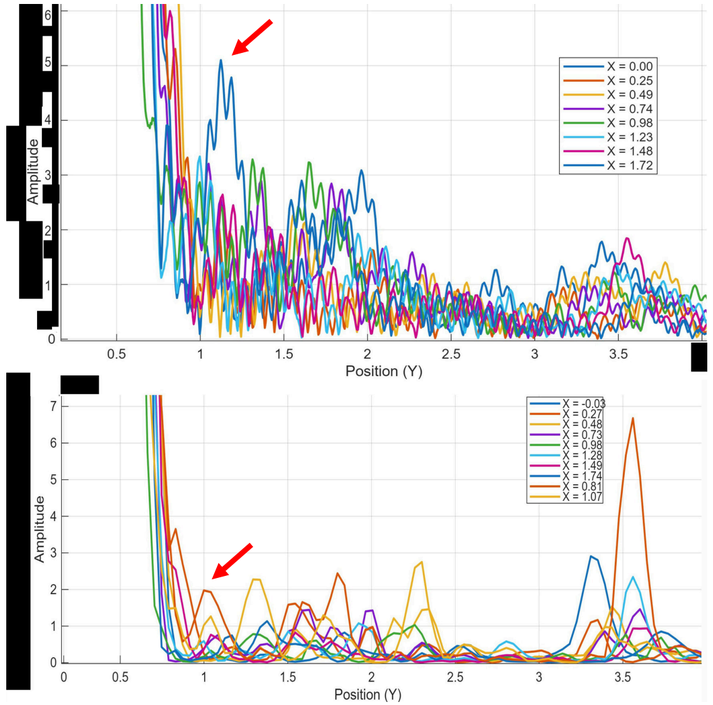
PROBE ARRAY EDGE EFFECTS IN BOLTED TANK WALL INSPECTION

B-scan

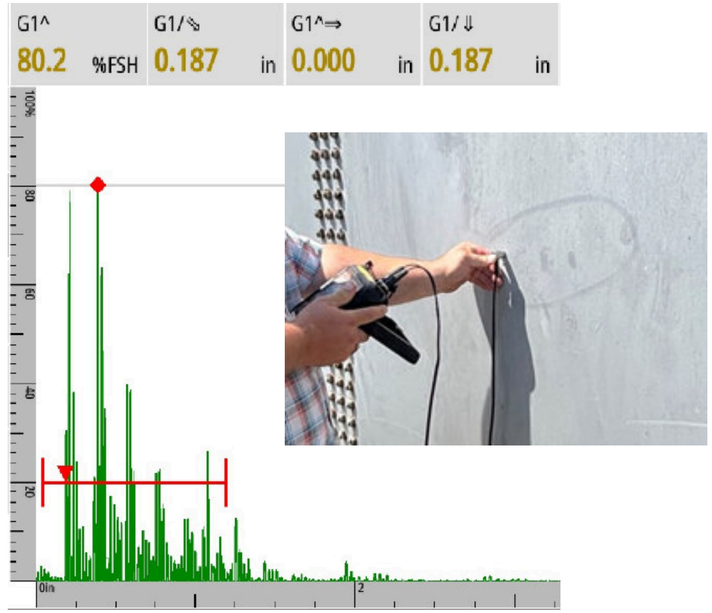
TFM image



Measured / TFM-derived A-scans



Manual UT: up to 50% wall loss



- TFM sensitivity decreases near edge segments (1 and 8) because fewer array segments contribute to the reconstruction.
- Red arrows mark the same indication near Segment 8 in the B-scan, TFM image, and corresponding A-scan profiles.
- Manual UT in the indicated area confirmed wall loss of up to 50%.

CONCLUSIONS

- Flexible magnetostrictive arrays demonstrated corrosion detection and mapping in inaccessible regions, including pipe supports, buried poles, and aboveground storage tank walls and bottoms.
- A-scan, B-scan, and TFM processing provided complementary methods for anomaly detection, localization, and mapping.
- TFM provided detailed corrosion imaging; however, location-dependent amplitude normalization is required to compensate for sensitivity variations and coherent-summation effects.

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