Evaluation and Protection of Industrial Structures and Systems by NDT

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NDT in Canada
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Québec City, Québec

Cost of Corrosion/Deterioration

- Global cost of corrosion 2.5 trillion USD (3.4% of the global GDP)
  - This accounts for only direct costs as a result of corrosion
  - Production losses, downtime, environmental risks are additional cost
- Corrosion control and mitigation practices can save up to 35% of this (875 billion USD globally)

NACE IMPACT Study (2016)
International Measures of Prevention, Application, and Economics of Corrosion Technologies

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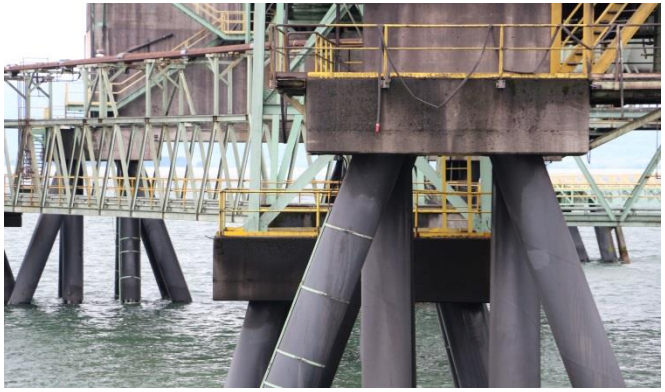
Examples of Deterioration



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Concrete Deterioration

- Protective surface film due to the natural alkalinity of concrete.
- Aggressive exposures to sulphates and chlorides lead to spalling and delamination of concrete

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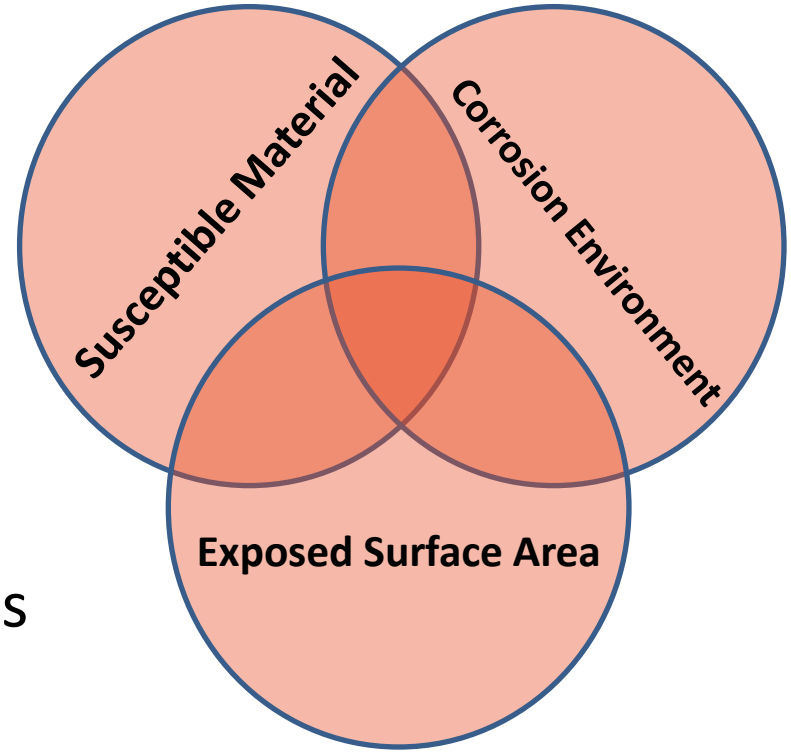
Corrosion Prevention and Monitoring Technologies

Prevention:

- Coatings and Linings
- Corrosion inhibitors
- Cathodic Protection

Monitoring:

- Electrical Resistance Monitoring
- Linear Polarization Measurements
- Field Corrosion Testing (coupons)
- Ultrasonic Testing (UT)
- Ground Penetrating Radar (GPR)



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Concrete Degradation Inspection

Acid Attack

- Due to CAPEX restraints the client did not install acid resistant coatings or design drainage for acid solution.
- Warm acid solution drain over the concrete floor.
- Loss of concrete and rebar in the supporting concrete piers.

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NDT Inspection

- Limit the extent of repair
- Ground Penetrating Radar (GPR)
  - Concrete degradation, poor bonding of RC
- Impact Echo (IE)
  - Voids/cracks within concrete
- Schmidt Hammer
  - Strength/hardness of concrete

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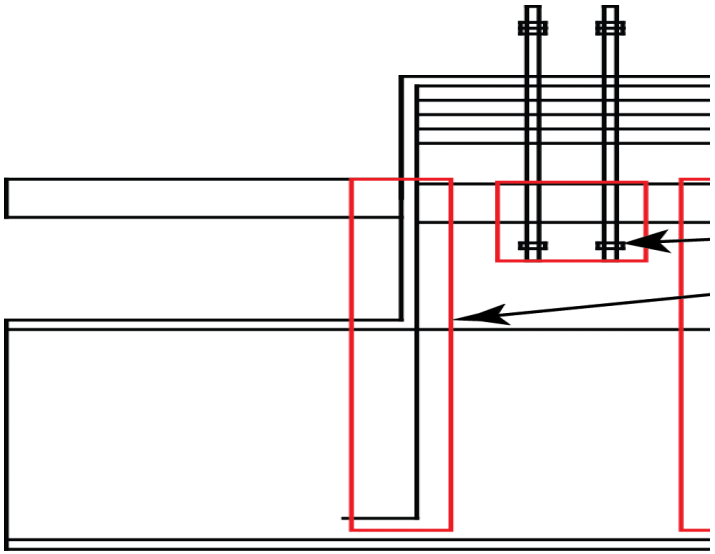
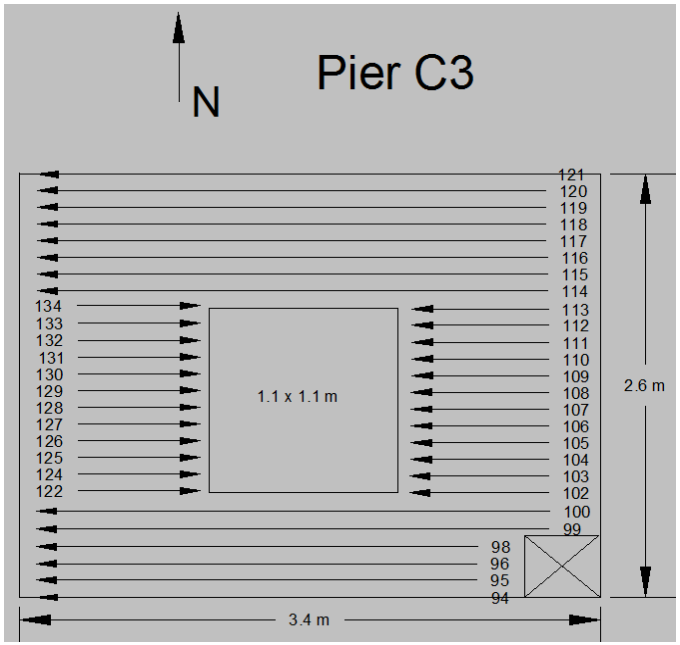
NDT Inspection

- GPR Scans
- Different antennae for piers and slabs





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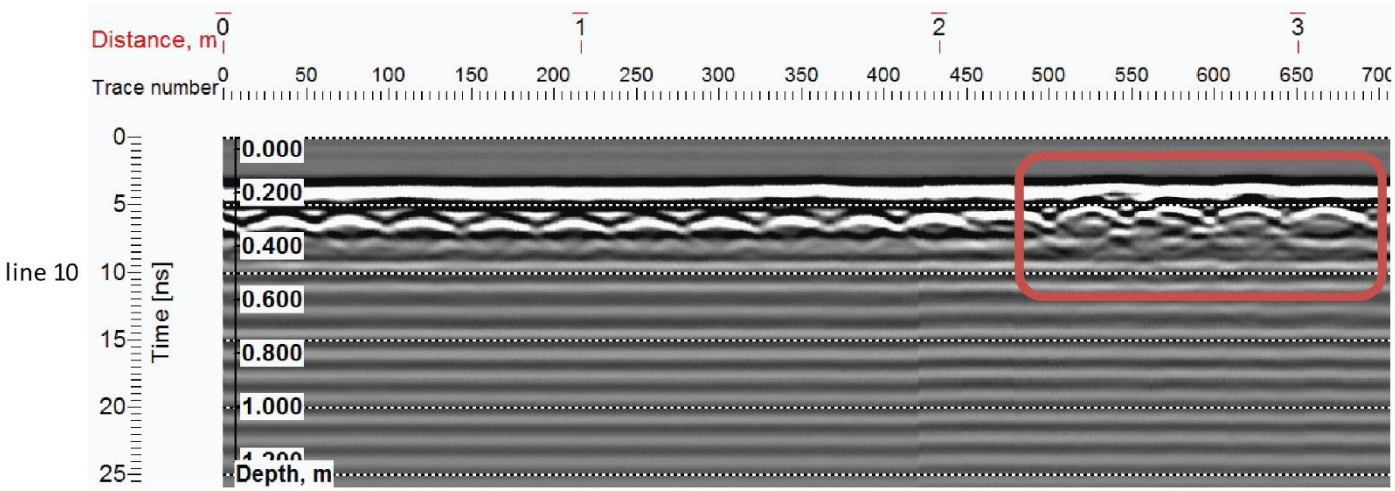

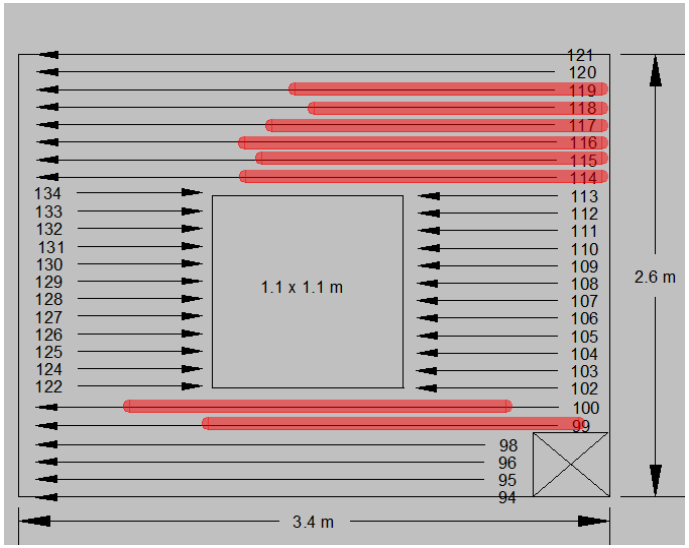

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- Impact Echo
- Couplant required
- Calibration on site
- Concrete velocity differed by 6%
- Total reflection of signals due to major separation or delamination within the pier
- Partial reflection due to cracks and voids

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NDT Inspection

Pier C3

West Face			South Face			East Face			North Face		
NW			SW			SE			NE		NW
18	17	16	15	14	13	12	11	10	9	8	7
30	29	28	27	26	25	24	23	22	21		19

Pier C6

West Face			South Face			East Face			North Face		
NW			SW			SE			NE		NW
18	17	16	15	14	13	12	11	10	9	8	7
30	29	28	27			24	23	22	21	20	19

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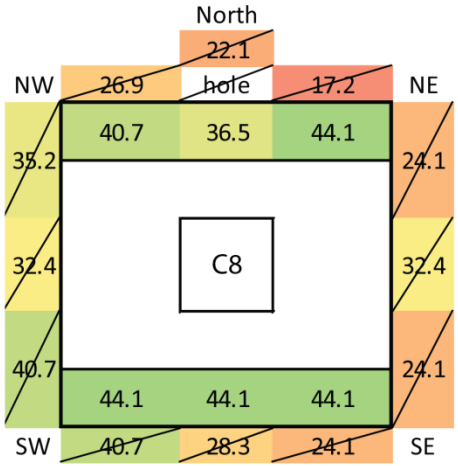
NDT Inspection

- Schmidt Hammer



West Face			South Face			East Face			North Face		
NW			SW			SE			NE		NW
37.2	34.5	43.1	43.1	37.2	44.8	46.2	39.6	31.0	34.5	28.3	39.6
28.3	31.0	39.6	47.6	46.2	49.0	43.1	43.1	39.6	37.2	31.0	34.5

hole

Pier C8

Scale
10
15
20
25
30
35
40
45
50
55

Legend: Slab

Pier

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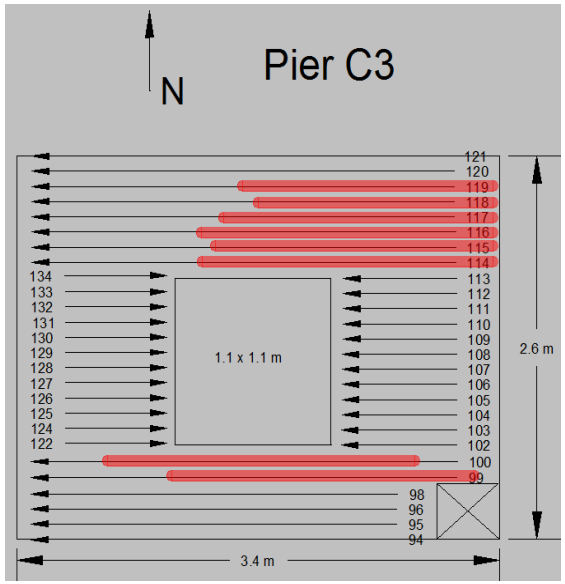
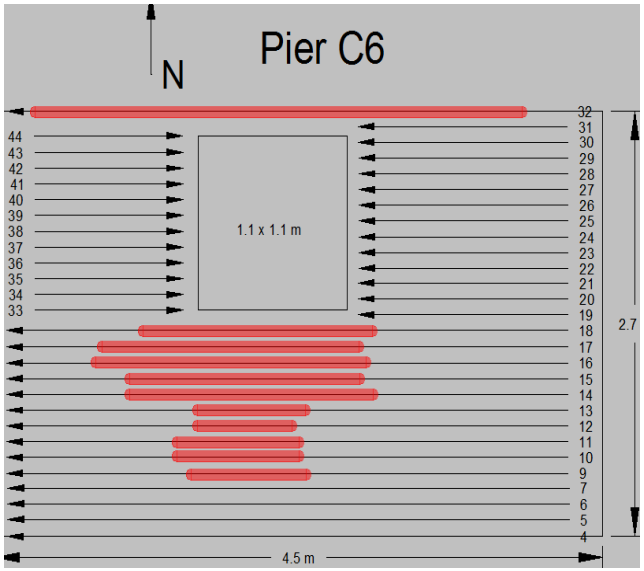
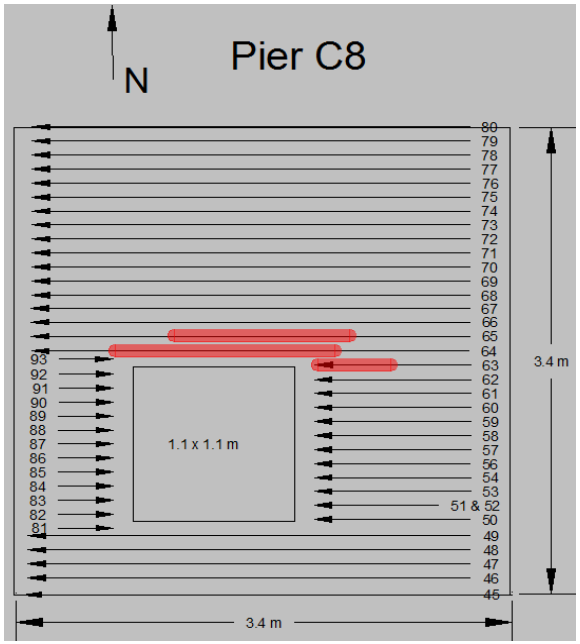
NDT Inspection







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NDT Inspection

- 3-phased repair

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Fibreglass Pipe (FRP) Inspection

Infrared & Ultrasonic Inspection of Fibreglass Pipes

- Initial visual inspection to determine limitations to inspections.
- Top: Degradation due to weathering and UV exposure. The loose fibreglass filaments become airborne during surface preparation.
- Bottom: Broken nozzle of the fire-suppression system on a SO_2 line.

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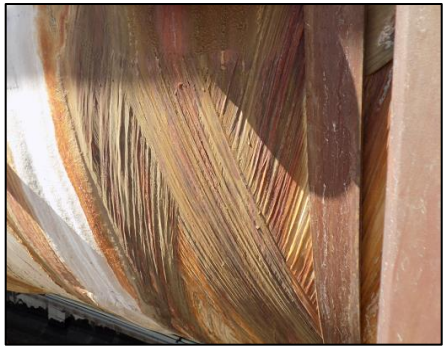
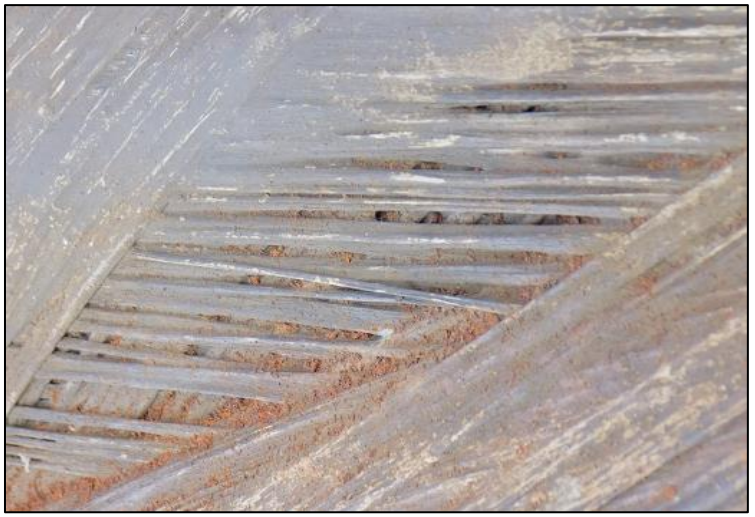
IR & UT Inspection of Fibreglass Pipes

- Hand-made fibreglass ducts vs. factory manufactured



- Uneven initial wall thicknesses, poorly bonded layers, and excess/insufficient epoxy



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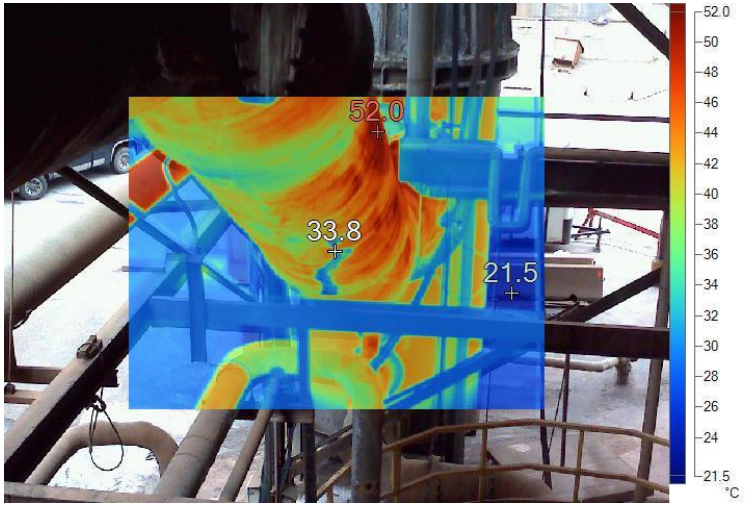
IR & UT Inspection of Fibreglass Pipes

- Infrared thermography to find hot and cold spots along the length of the inspection area → prioritize ultrasonic inspection locations



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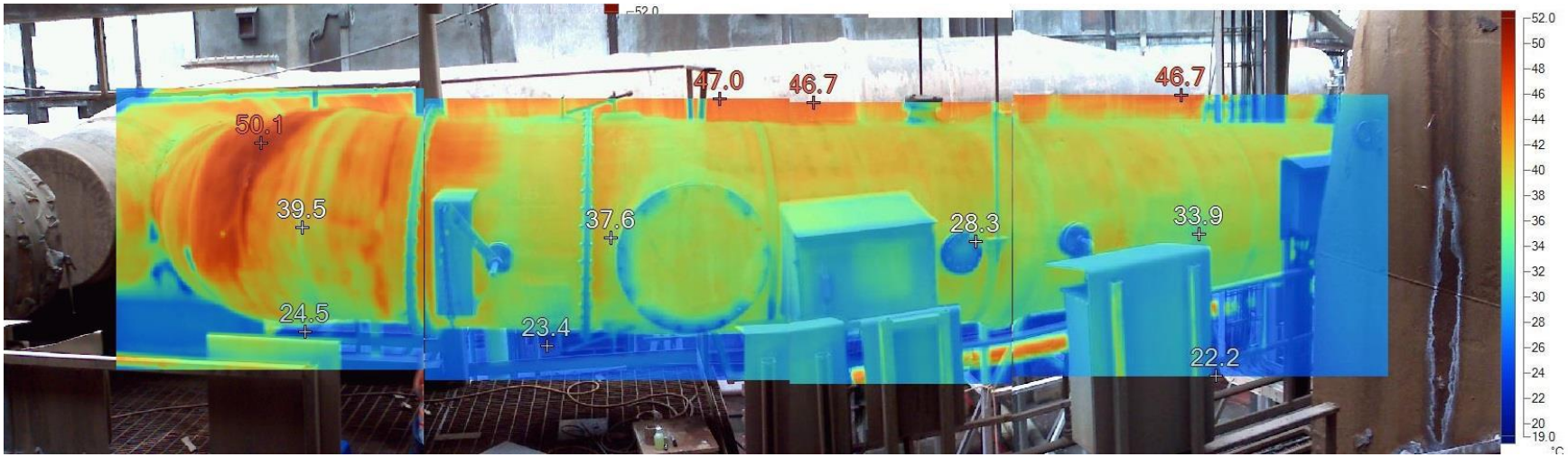
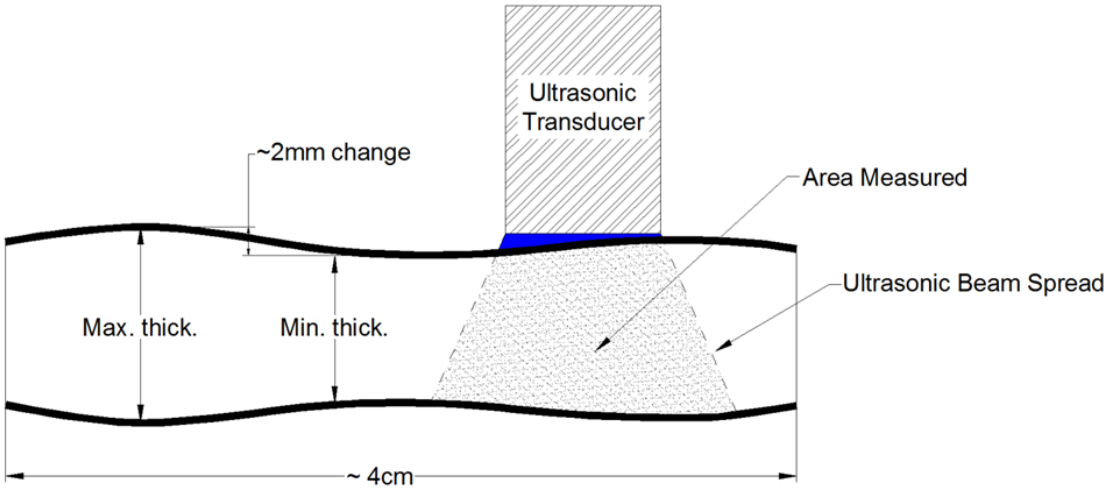
IR & UT Inspection of Fibreglass Pipes

Hot spots:

- Wall thinning
- Delaminations
- Loss of internal insulation
- Poor manufacture quality



IR & UT Inspection of Fibreglass Pipes



- Irregularities cause poor surface contact, multiple back-wall reflectors and variable wave speeds → Accuracy Reduction
- Measurements presented as a range showing minimum, maximum, and average thickness values

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Conclusion

- Preventive Measures and Monitoring can save operational cost and maintenance cost
- NDT inspection to quantify/limit the area of repair
- Periodic inspection or continuous monitoring to determine the optimal time for maintenance → reduce operational downtime and production lost

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Thank you!

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