



LOSS PREVENTION THROUGH
IMPROVED INSPECTIONS

Automated Weld Overlay Repairs of Large Damaged Equipment

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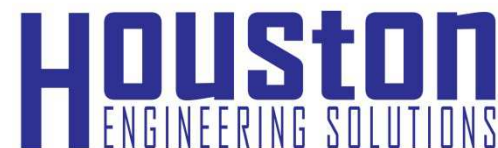
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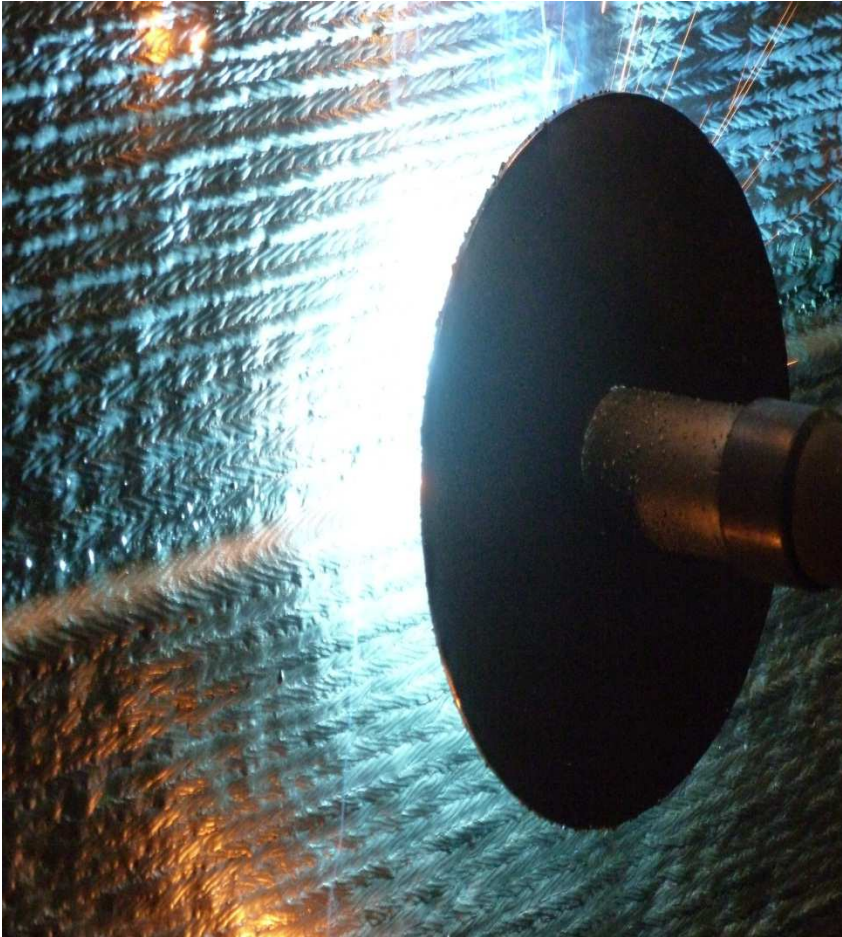
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Overview

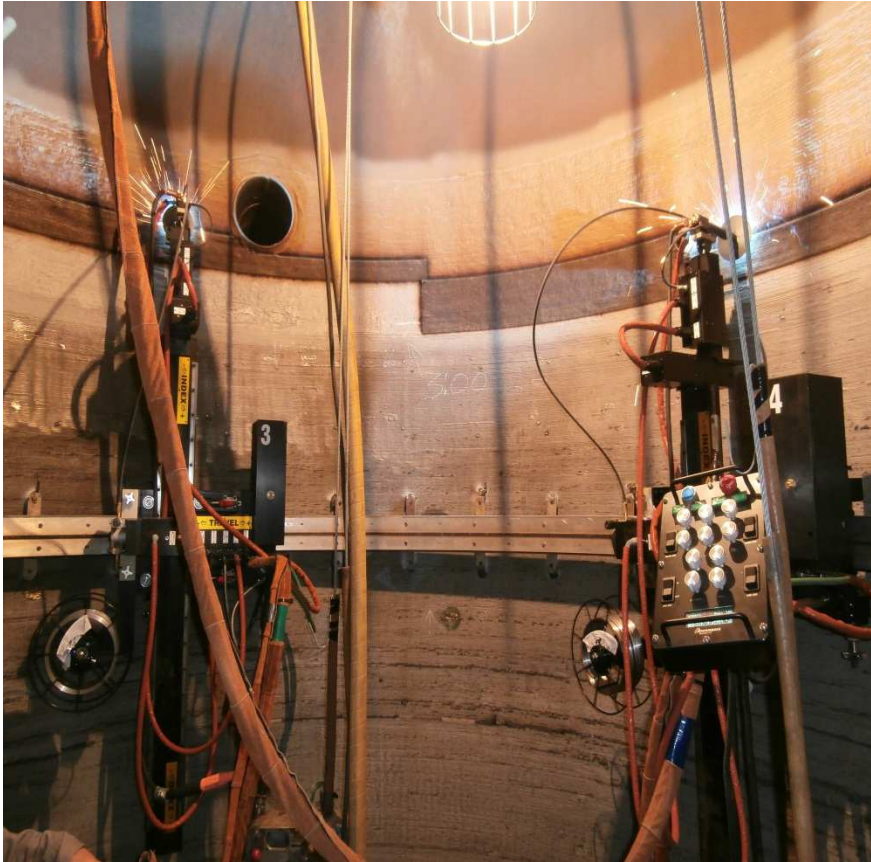
- The application process
 - Automated weld overlay
 - Equipment
 - Challenges
 - Case studies
- QA Research program
- Summary

Automated Weld Overlay



- Fully Fused Surface Protection for Pressure Vessels
- Cost Effective Long Term Solution, Short Timeframe
- Alloy Selection for Erosion/Corrosion Needs

Advanced Equipment



- Weld Process Control – Locked In Parameters
- Fail Safe with Error Diagnosis
- Inter-machine System Compatibility
- Fewer Components
- Versatility

Challenges



Coke Drum Seam Repair

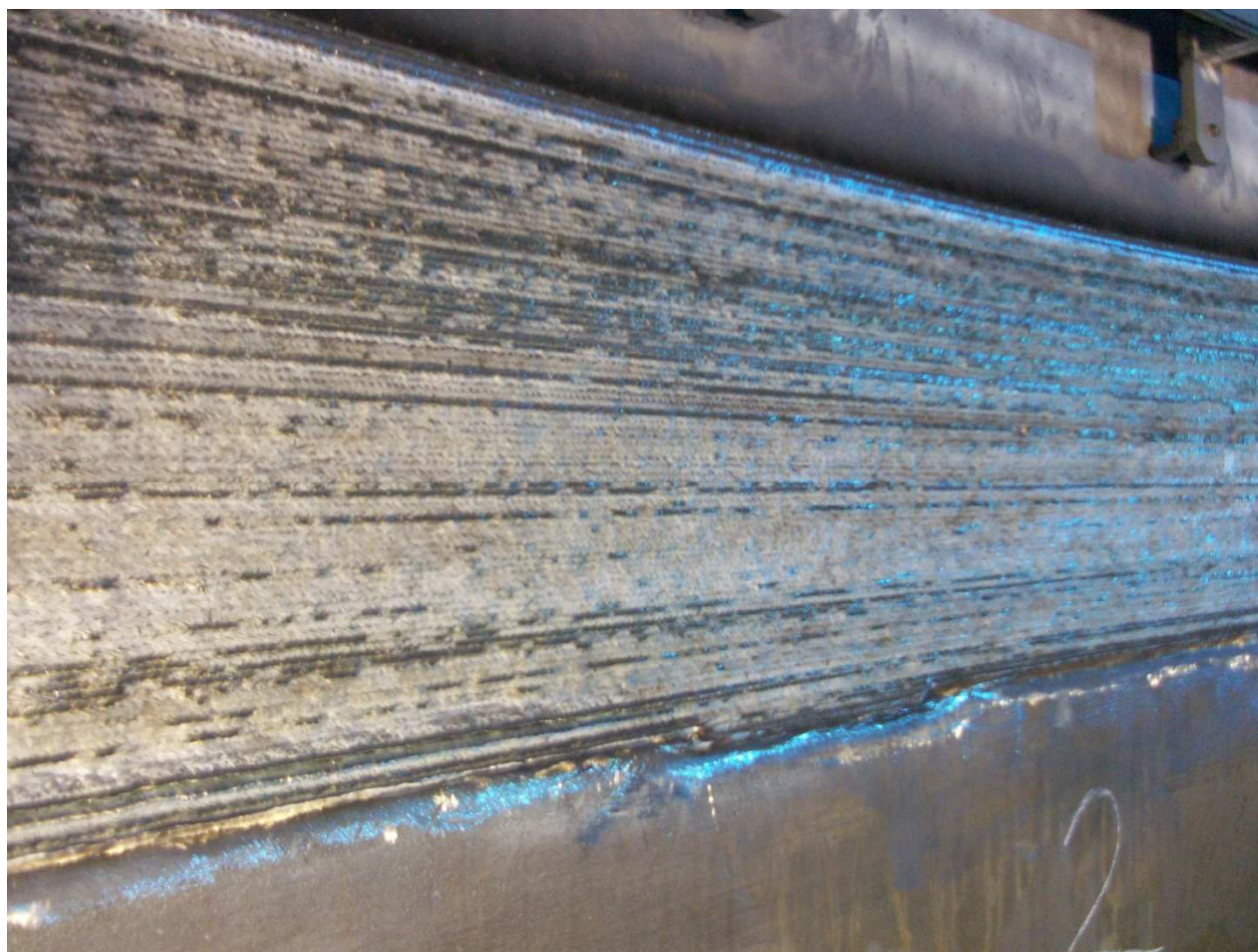


- Inspection
- Temper-bead WPS
- Surface Preparation
- Heat Input
- Machine Location - Distortion

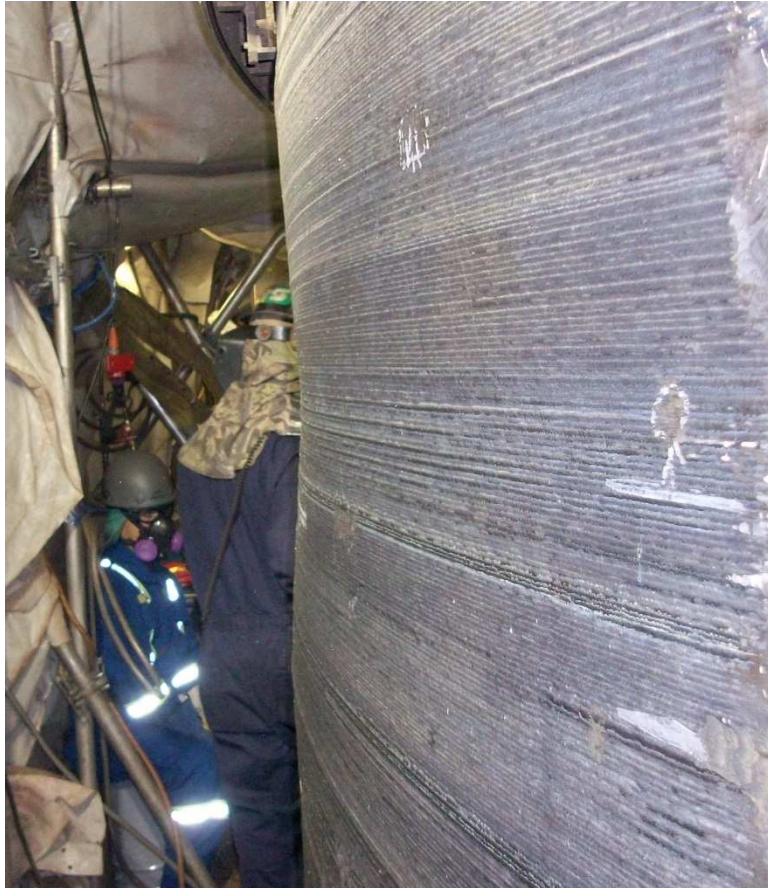
First Layer



Second Layer



Bulge Repair



QA Research Program

WHY?

- Verify adequacy of weld overlay for structural applications.
- Quantify as-welded properties.
- Improve the ability to model the overlay and predict consequences.

OBJECTIVES

- Test Program
 - Characterize and obtain key mechanical properties of as-welded overlay.
 - Examine the bond between the weld overlay and base metal.
 - Determine the impact of the weld overlay process on base metal.
 - Compare fatigue strength of unrepaired and repaired plates.
- Finite element analysis
 - Compare simulation of weld overlay results and plate distortion measurements.
 - Calibrate weld simulation process to improve the accuracy of predicting distortion and residual stresses.

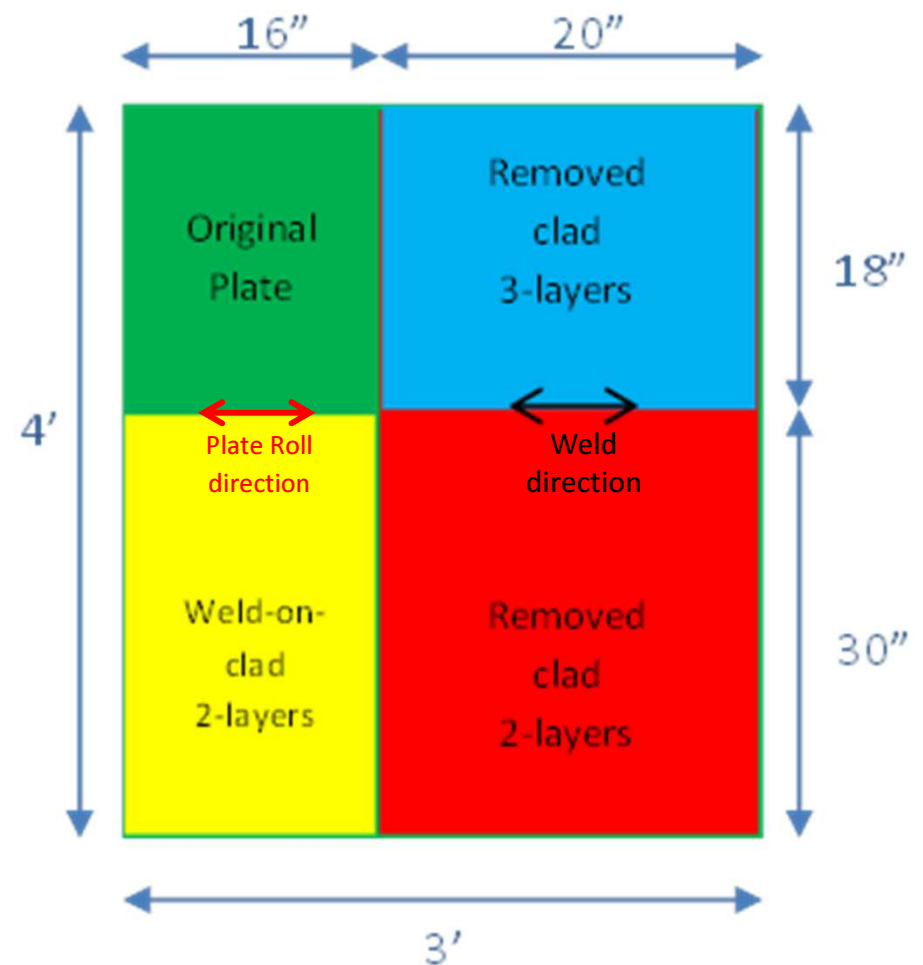
TEST PLATE

Clad carbon steel plate:

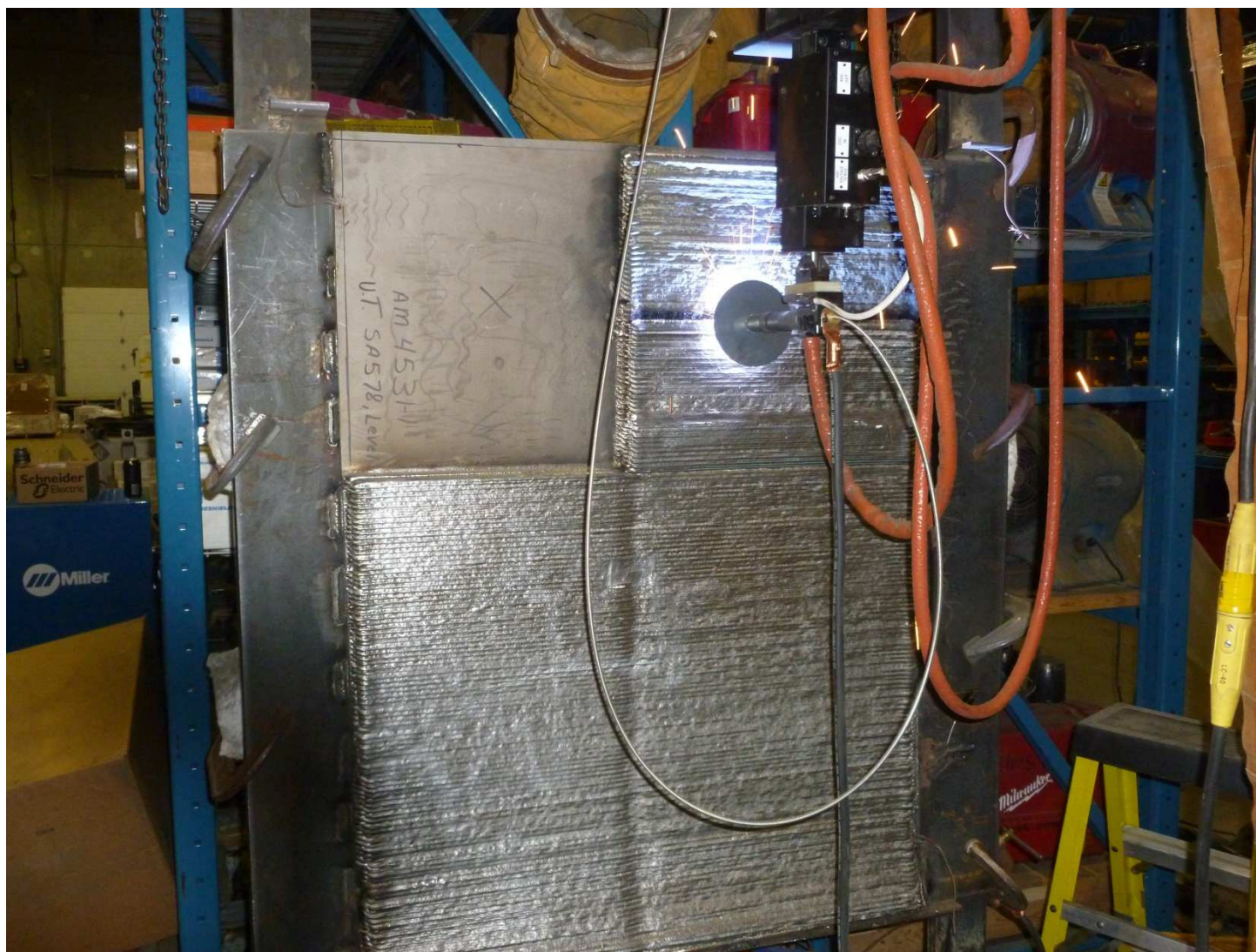
- 3' x 4' x 5/8"
- A36 base metal
- 304L SS clad
- Tensile 67.2 ksi
- Yield 41.5 ksi, 36% in 2"

Weld overlay:

- Inconel 625
- Two or three 3/16" layers
- Weld on base metal or clad



AUTOMATED WELDING



TEST SCOPE

- Tensile Testing
- Metallographic Examination
- Hardness Survey
- Fracture Toughness
- Crack Growth
- Chemical Analysis
- Fatigue Testing

Tensile Testing

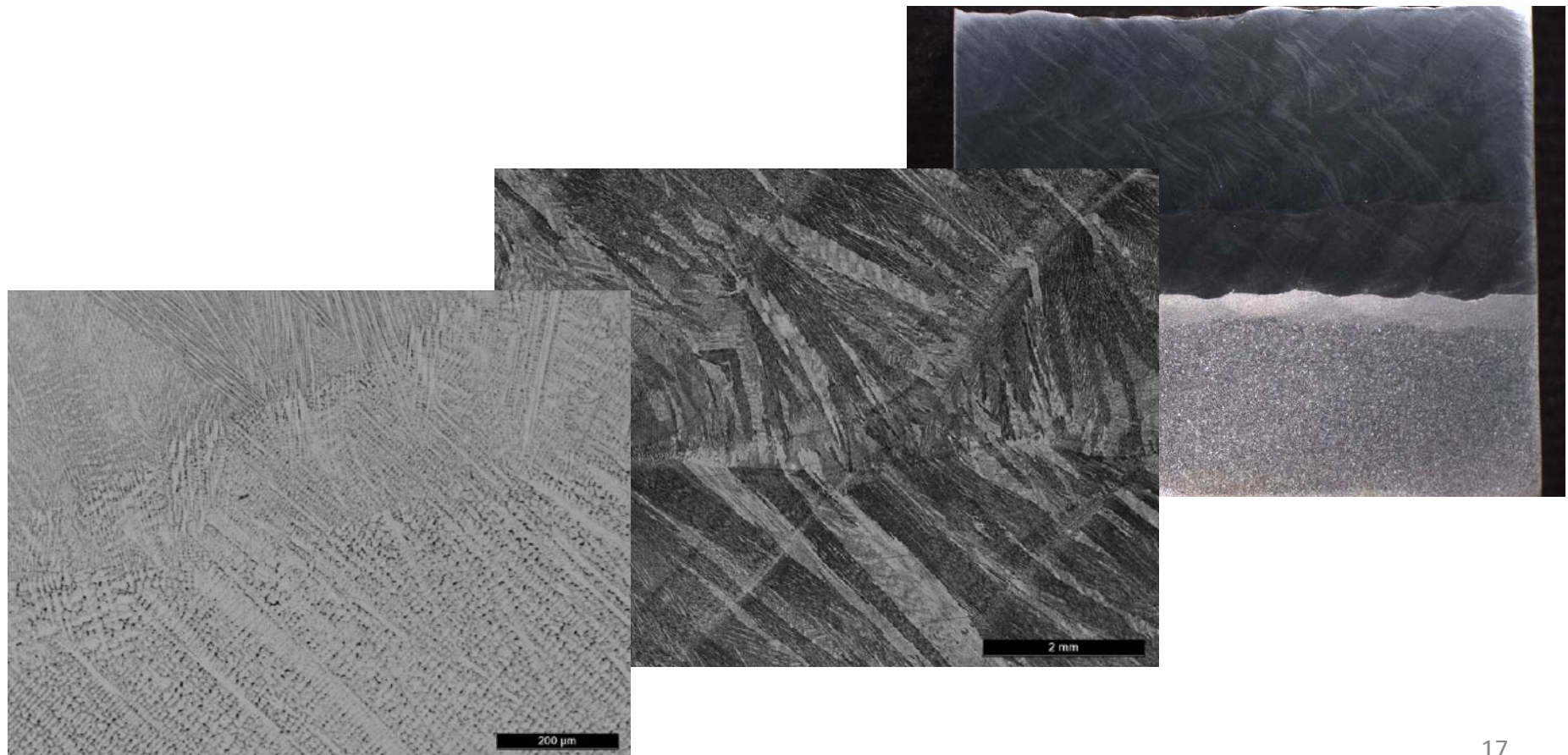
Stress-strain curves

- Room Temperature
- High Temperature



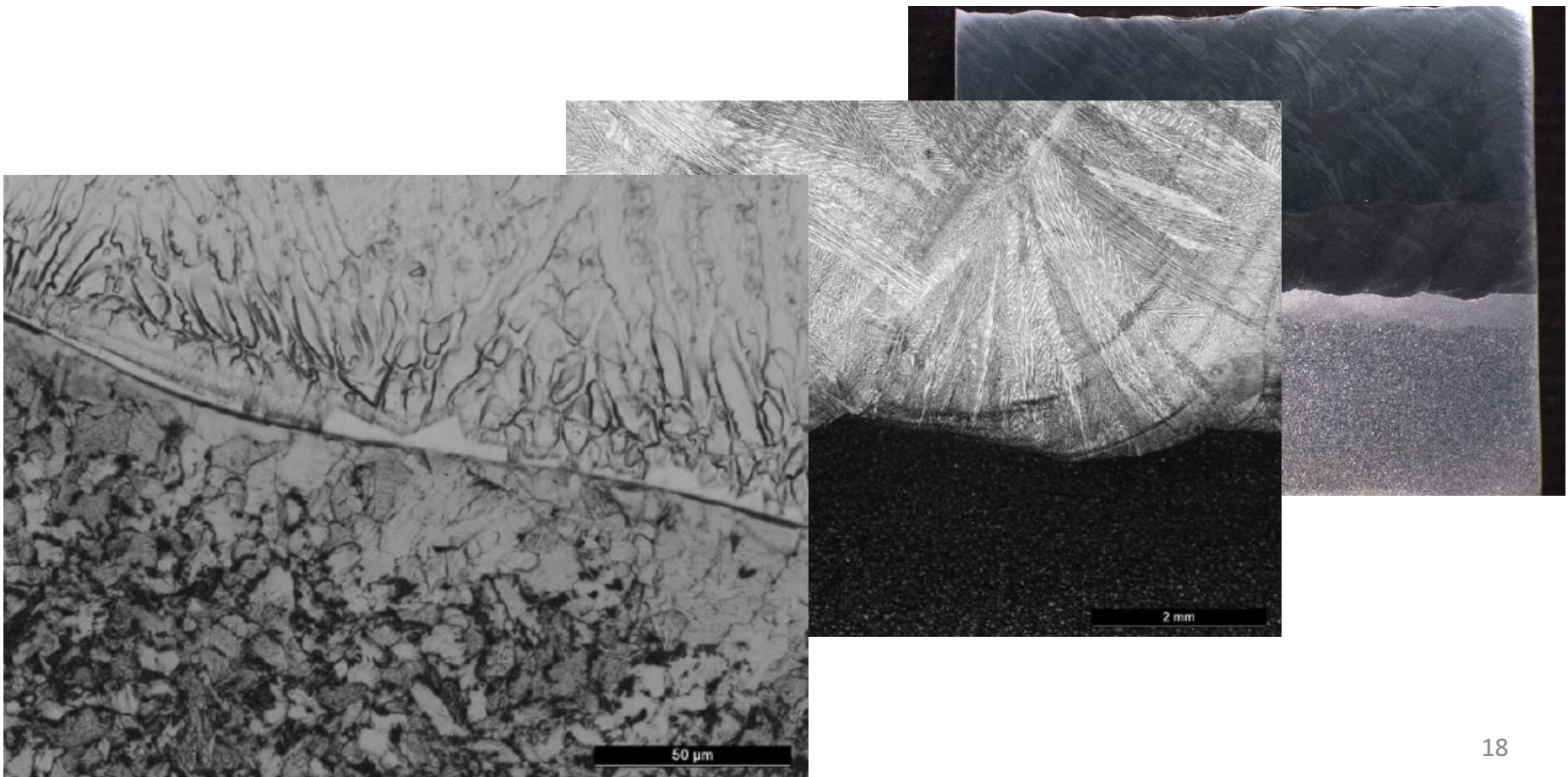
Metallographic Examination

Bond quality between the layers.



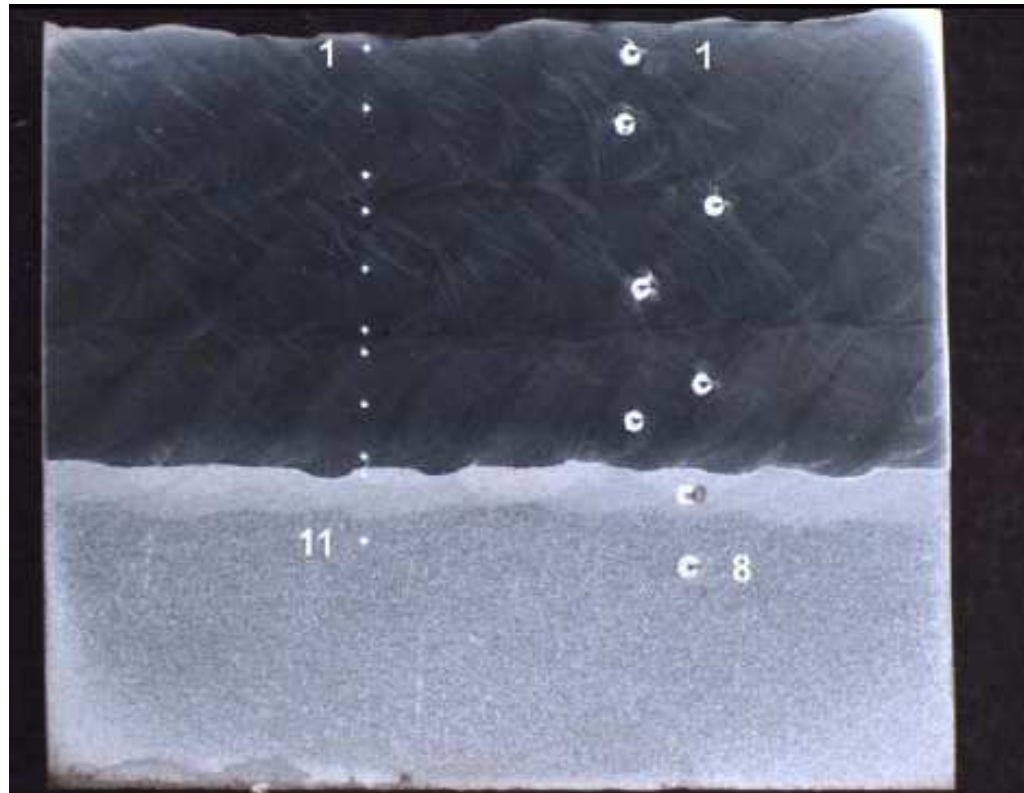
Metallographic Examination

Bond quality between base metal and weld.



Hardness Survey

Hardness and microhardness measurements.

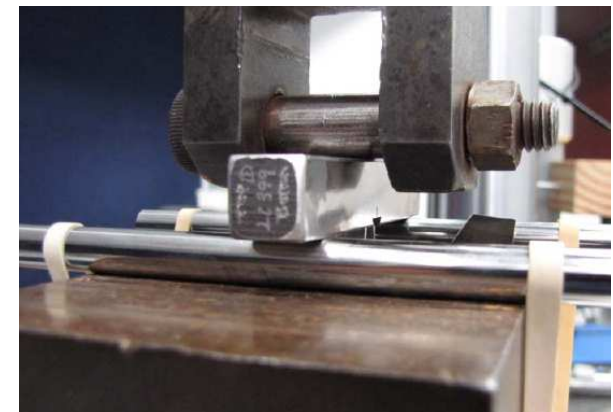
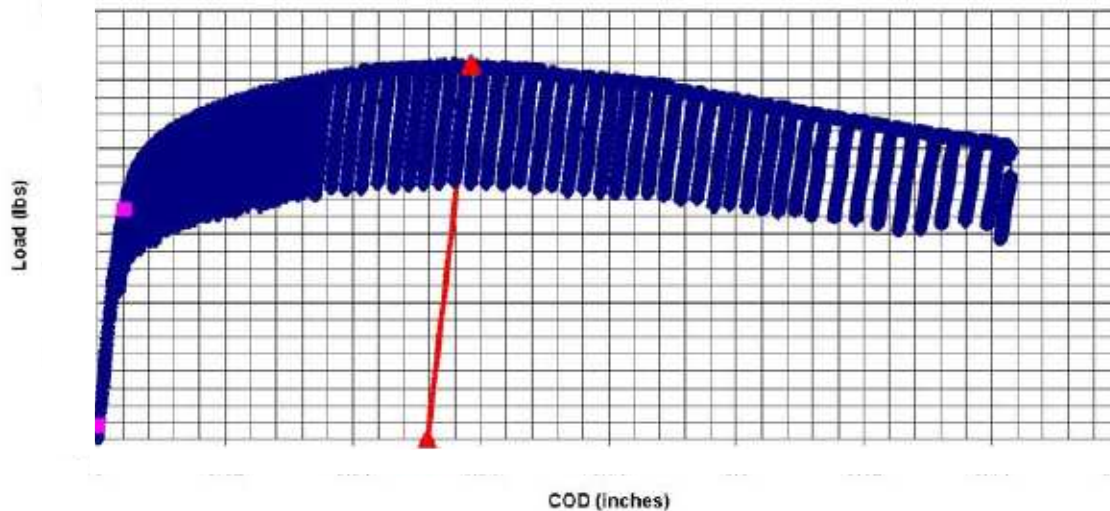


Fracture Toughness

These tests are conducted to quantify the ability of the as-welded overlay to resist cracks.



Load v Clip Gage Displacement

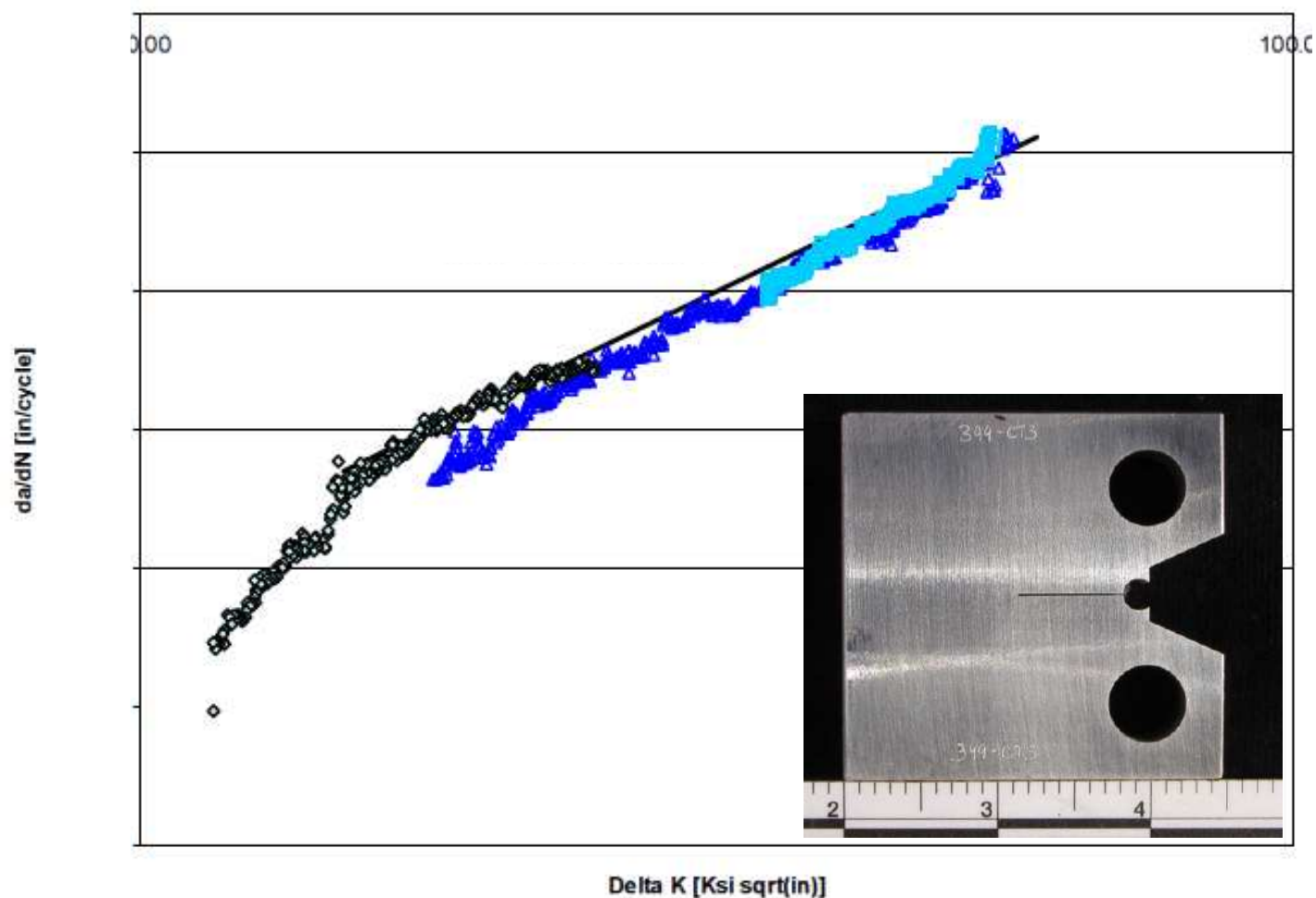


Charpy V-Notch Impact Testing



Fatigue Crack Growth

Crack propagation rates in through-wall & circumferential directions.



Chemical Analysis

This analysis is conducted to determine the chemistry of the three layers and compare them to nominal composition.

Fatigue Testing

Isothermal tests at room temperature.



Summary

- Automated weld overlay can be used to provide consistent high-quality repairs to large equipment.
- On-going test program provides unique material properties of as-welded overlays that can be used in structural applications.
- Distortion from weld overlay repairs can be predicted with higher accuracy using test results.

QUESTIONS?

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