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Advanced Welding Repair and Remediation Methods for In-Service Pipelines

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Joining Technical Workshop
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Outline

- Basics of welding repair and remediation for in-service pipelines
- DOT/PRCI project "Advanced Welding Repair and Remediation Methods for In-Service Pipelines"
- Technological needs for in-service welding

Introduction

- In-service maintenance and repair continues to be an area in which there is much interest
- Repair of corrosion damage
  - As pipelines become older, more repairs are required
  - “Rust Never Sleeps” - Neil Young
- Installations of hot-tap branch connections
  - More branch connections required as the result of open access and common carrier practices
  - “On and off ramps for the energy highway”
- Economic and environmental incentives

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Pipeline Repair and Maintenance

- Full-encirclement repair sleeves
  - Type A - For reinforcement only
    - Can have non-welded ends, but ends are often welded to prevent further corrosion
  - Type B - Capable of containing pressure
    - Must have welded ends
- "Hot-tap" branch connections
  - Connect alternative supply or additional customer
- Welding performed "in-service"

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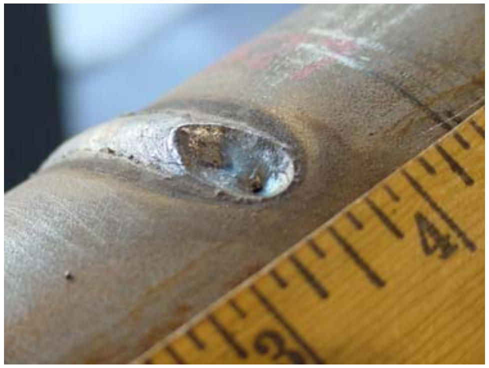
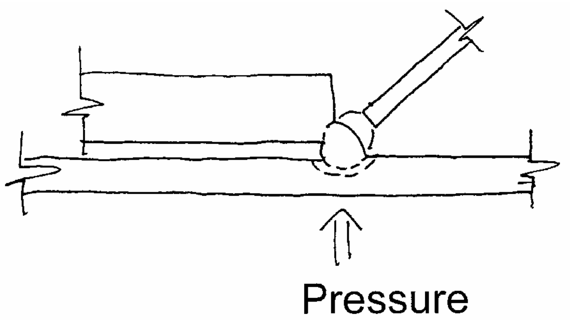
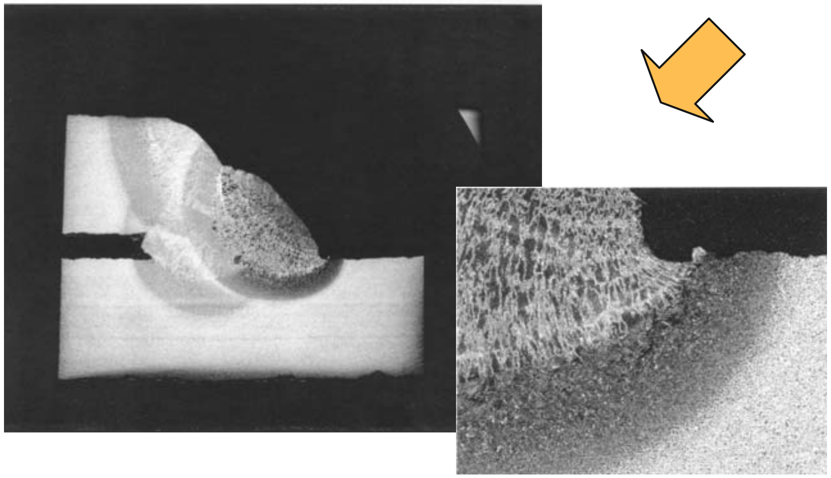
In-Service Welding Concerns

- Repair crew safety
  - Avoiding “burnthrough” or “blowout”
- Resulting integrity of the pipeline
  - Avoiding hydrogen cracking







Avoiding Burnthrough

- Avoid excessively high heat input (i.e., excessively slow travel speed) when welding onto thin-wall, low flow rate pipelines
- Burnthrough risk is extremely remote if wall thickness is 0.25 in. (6.4 mm) or greater, provided that low-hydrogen electrodes and normal welding practice is used
- For a given heat input level, the use of smaller diameter electrodes (lower current levels) is safer

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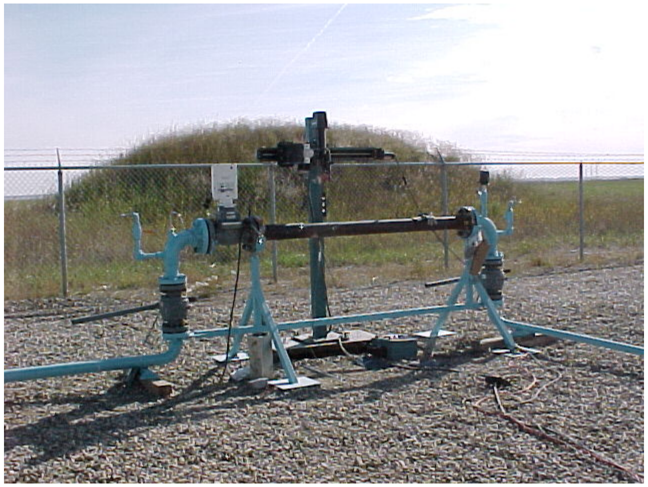
Project Work Pertaining to Burnthrough

- Improved burnthrough prediction methods
- Burnthrough limits for thin-wall applications
- Effect of pressure



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Avoiding Hydrogen Cracking

- Eliminate, or reduce below a threshold level, at least one of the conditions necessary for its occurrence
  - Limit hydrogen in the weld by proper use of low-hydrogen electrodes
  - Develop and use procedures that limit the formation of crack-susceptible microstructure
  - Limit stress acting on the weld

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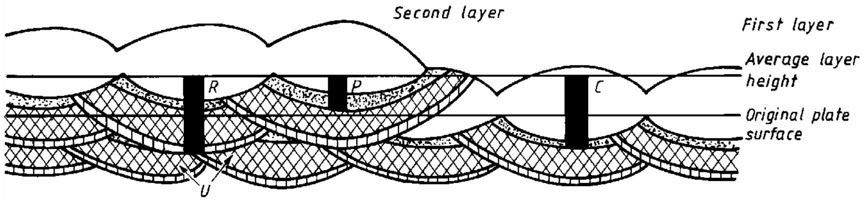
Welding Procedure Options

- Heat input control procedures
  - Sufficiently high to overcome ability of flowing contents to remove heat from pipe wall
    - May represent a burnthrough risk if pipe wall is thin
- Temper bead procedures
  - Rely on heat from subsequent passes to temper and refine HAZ of previous passes



- Preheat
  - Slow weld cooling rate somewhat
  - Allow hydrogen diffusion following welding

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Project Work Pertaining to Hydrogen Cracking

- Predicting required welding parameters
  - Thermal analysis computer modeling
  - Heat-sink capacity measurement
- Procedure qualification methods
- Qualification and selection of procedures (GSP)
- Alternative process
- Application of preheating
- Factors that affect hydrogen levels
- HAZ hardness limits/metallurgical factors

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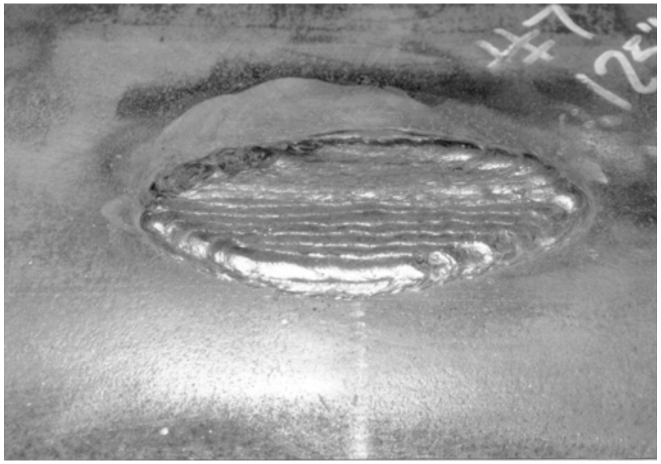
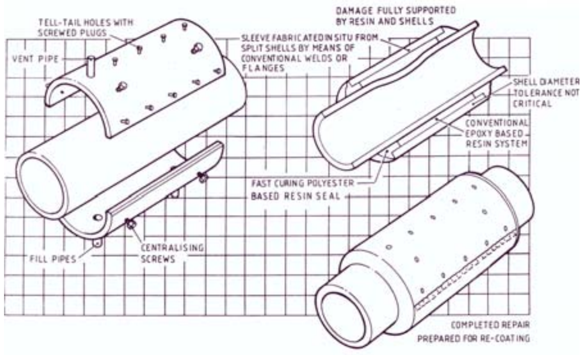
Other Pipeline Repair Methods

- Weld deposition repair
- Epoxy-filled shells
- Composite repairs
  - Glass/carbon fiber
  - Dry/wet lay-up





TYPICAL EPOXY REPAIR OF A DAMAGED PIPE

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Advanced Welding Repair and Remediation Methods

- Current DOT/PRCI funded project
- Incentives
  - For large diameter pipelines, manual welding is time-consuming
    - Greater risk of operator error
  - For higher strength pipelines, precise weld bead placement may be required to ensure effective tempering by subsequent passes

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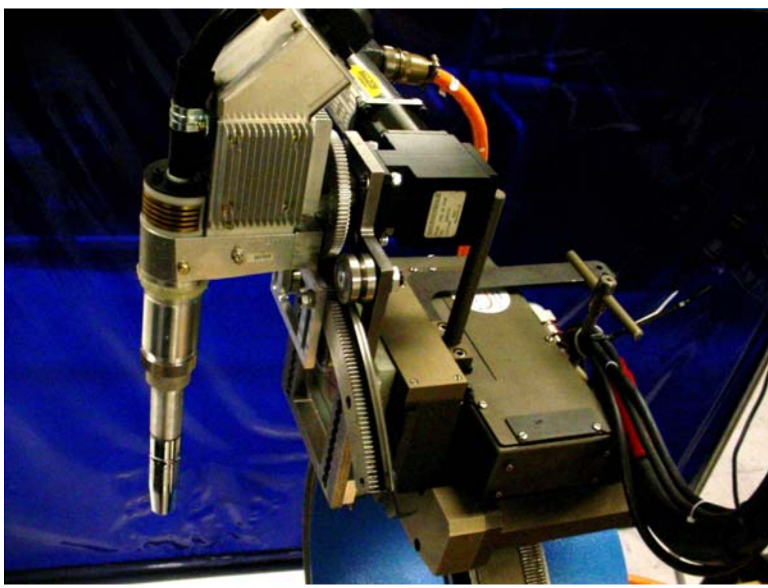
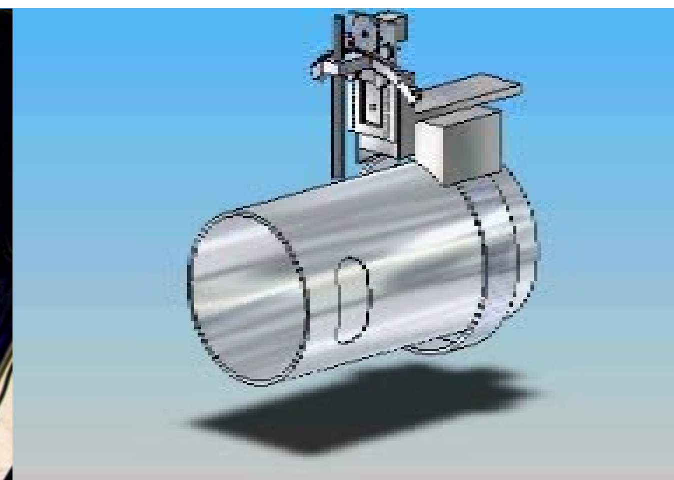
Advanced Welding Repair and Remediation Methods

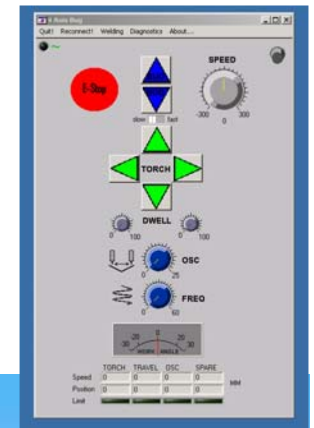
- Major objectives
  - Develop an automated in-service welding system
  - Implement real-time adaptive control system
  - Evaluate system performance through laboratory trials
  - Validate the system by qualifying procedures and performing field trials

Design and Build Automated Welding System

- Mechanized sleeve welding
  - Longitudinal groove welds
  - Circumferential fillet welds
- Mechanized weld deposition repair







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Real-Time Adaptive Control

- Mechanized sleeve welding
  - Locate weld joint
  - Identify gaps
  - Track weld joint/previous weld bead
  - Automatically adjusts welding parameters in real time to ensure effective joint filling
- Mechanized weld deposition repair
  - Map corrosion damage
  - Determine bead placement for effective filling
  - Track previous weld bead
  - Automatically adjusts welding parameters

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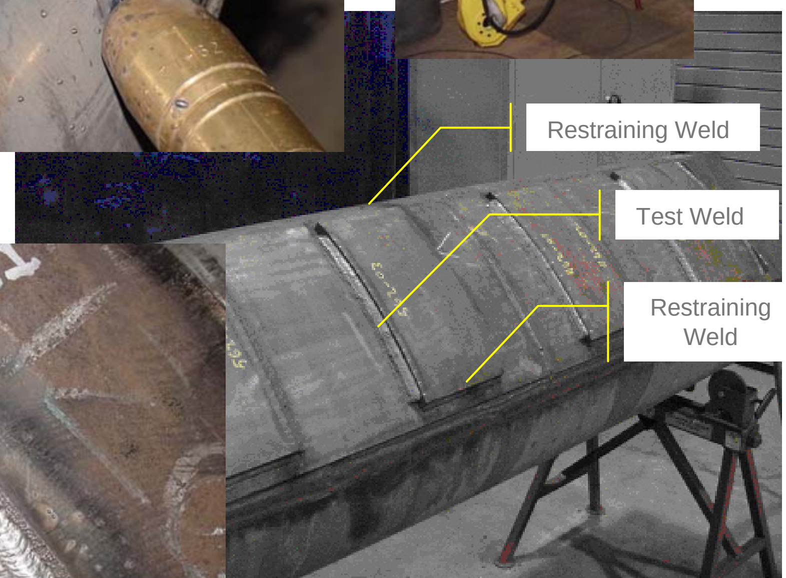
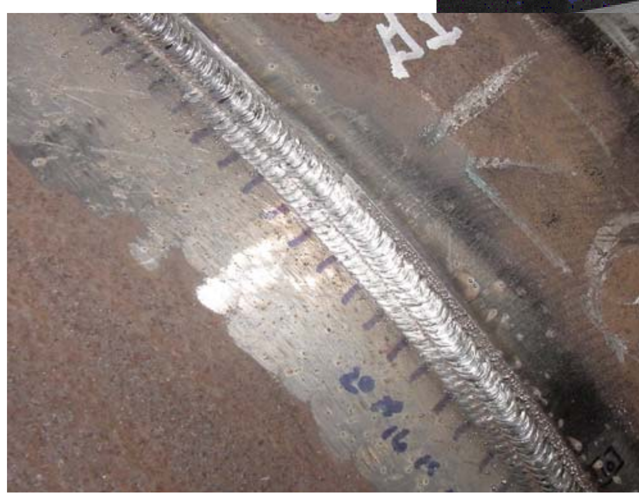
Laboratory Development and Evaluation

- System trials
- Weldability trials
  - X80, 0.75-in. WT
  - X100, 0.75-in. WT
    - TransCanada/BP
  - X120, 0.85-in. WT
    - Exxon
  - Simulated in-service conditions
  - GMAW
  - FCAW





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Technological Needs for In-Service Welding

- Advanced applications
  - Weldability issues
  - Design issues
    - Weld metal strength
- General applications
  - Pre-weld planning
  - Industry standards considerations
  - In-the-ditch application
- Others to be identified and prioritized by working group

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Pipeline Repair and Remediation Summary

- Pipelines are and will continue to be vital arteries for energy flow
- In-service repair and remediation continues to be an area in which there is much interest
- Concerns when welding onto in-service pipelines
- Techniques available to address many of these concerns
- Some concerns remain and require further effort to resolve

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The Need for Repair and Remediation Technology?

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