Long Seam ERW R&D PHMSA Update

2014 PRCI Research Exchange Atlanta, GA

Steve Nanney
US DOT / PHMSA
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Overview

- The Setting – US Pipeline Infrastructure
- Long Seam R&D – Why?
- Phases 1 and 2 – Status Update
- Phase 1 – Findings
- Phase 2 - Overview

Aging Infrastructure (% by Decade in USA)

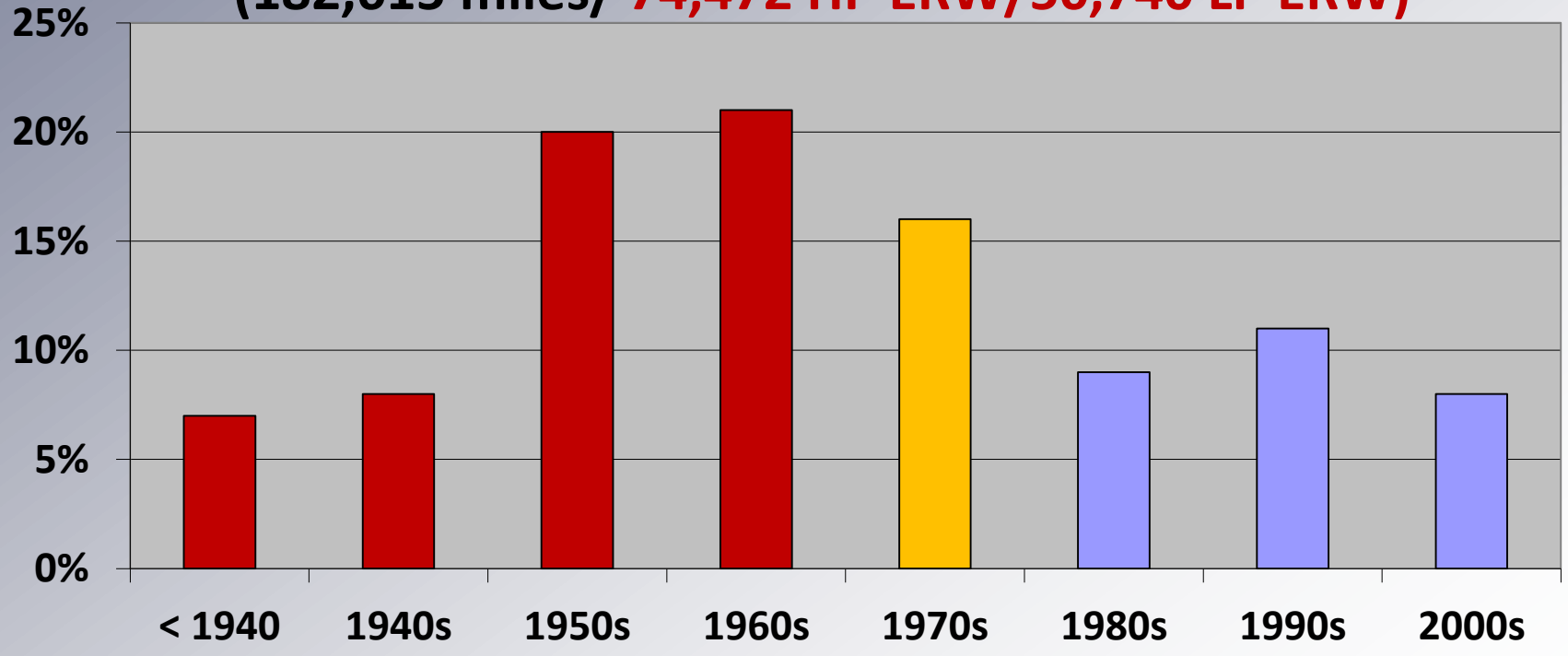
Decade	Hazardous Liquid		Gas Transmission		Gas Distribution Main		Gas Distribution Service	
Unknown & <1920	2%		---					
1920s	2%		2%		---		---	
1930s	3%	54%	4%	58%	6%		3%	
1940s	8%		7%		2%	47%	2%	
1950s	20%		22%		10%		8%	40%
1960s	21%		23%		17%		13%	
1970s	16%		11%		12%		14%	
1980s	9%	44%	10%	42%	14%		17%	
1990s	11%		11%		21%	53%	22%	60%
2000s	8%		10%		18%		21%	

Aging Infrastructure (% by Decade in USA)

Hazardous Liquid Pipeline Vintage

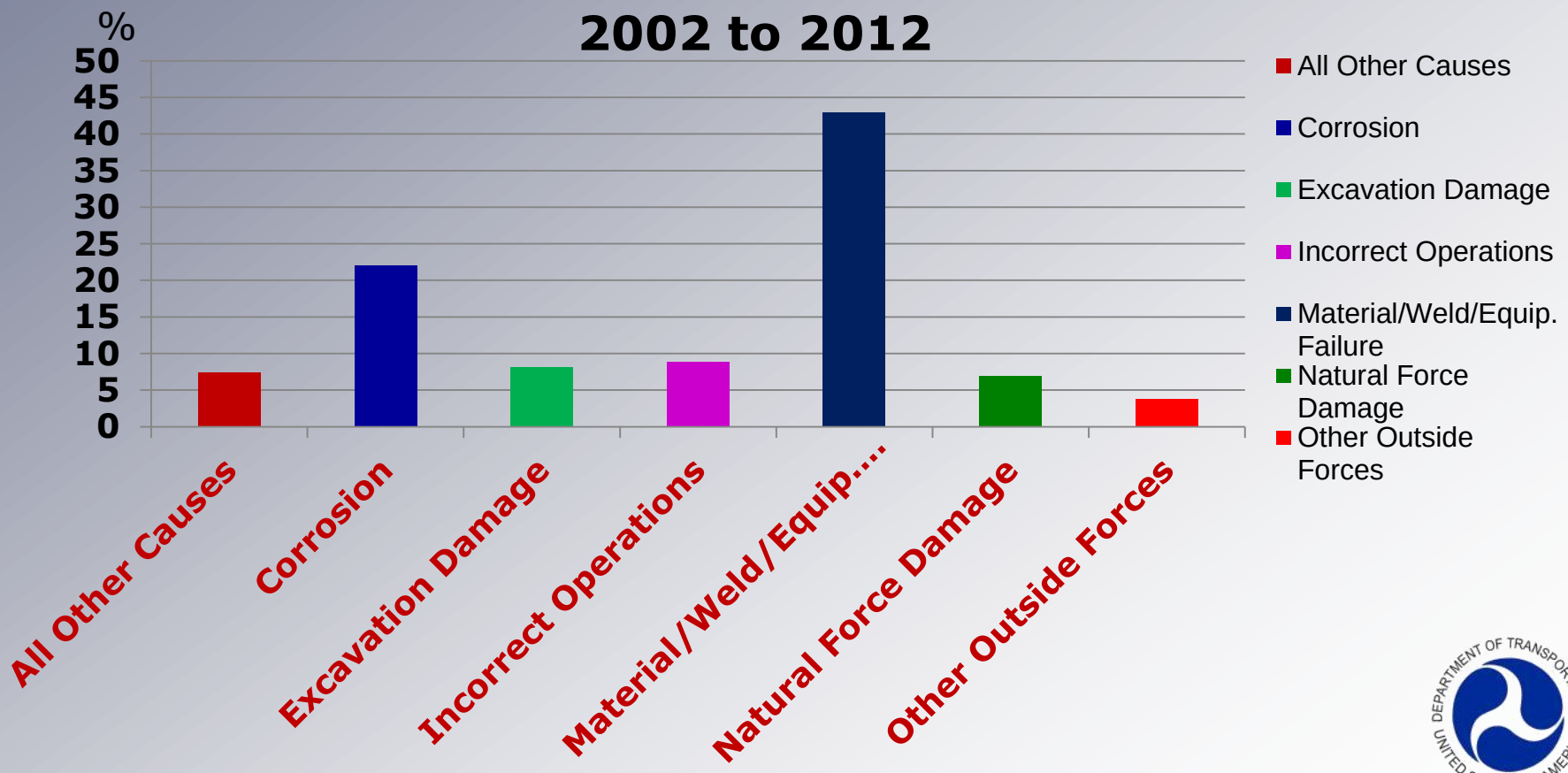
55% installed prior to 1970

(182,615 miles/ 74,472 HF-ERW/50,740 LF-ERW)



All Incidents – USA

Gas Transmission and Liquid Pipelines

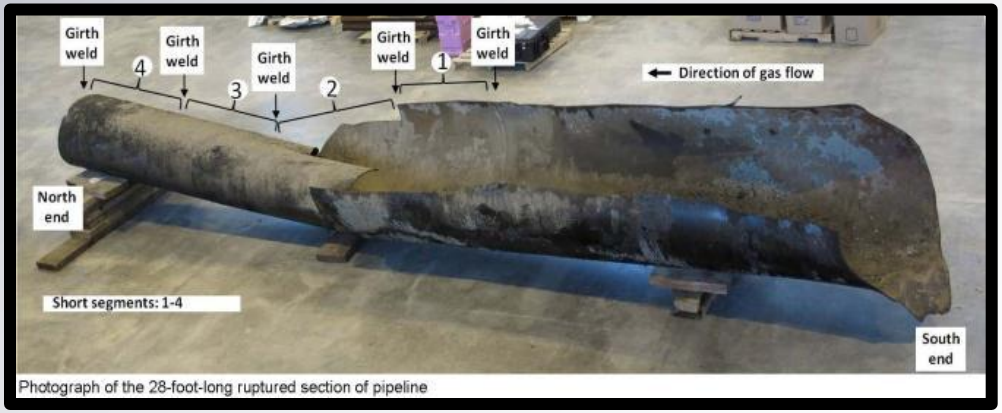


Major Incidents

- **Pipe Seam Issues**

Incident #1 - Carmichael, MS

Incident #2 - San Bruno, CA



Photograph of the 28-foot-long ruptured section of pipeline

NTSB Recommendations

- **NTSB P-09-01 – Comprehensive Study**
  - Identify measures to eliminate catastrophic longitudinal seam failures
  - Assess effectiveness/effects of ILI tools, hydrostatic pressure tests, and spike tests
  - Pipe material strength and failure mechanisms
  - Operational factors
  - Data collection and predictive analysis
- **NTSB P-09-02 – Implementation**
  - Implement actions needed from study findings

NTSB Recommendations From Failure Investigation

- **NTSB Recommendation P-11-14**
  - Eliminate Grandfather clause and require hydrotest with a spike test for all pre-1970 pipe
- **NTSB Recommendation P-11-15**
  - Manufacturing & Construction Defects Considered Stable Only for Pipe with Test Pressure ≥ 1.25 MAOP
- **NTSB Recommendation P-11-17**
  - Configure all lines to accommodate smart pigs, with priority given to older lines

Pipeline Safety Act of 2011, Section 23

- Verify records of Gas Transmission pipelines
- Confirm records for Class Locations 3 & 4 and HCAs
- Reconfirm MAOPs and determine what actions are appropriate to maintain safety until MAOP is confirmed
- Conduct tests to confirm the material strength of untested pipelines in HCAs and operating above 30% SMYS

PHMSA Long Seam R&D Project

Comprehensive Study to Understand Longitudinal ERW Seam Failures

- **Research Contractor:**
  - **Battelle**
- **Subcontractor:**
  - **Det Norske Veritas (DNV) & Kiefner and Associates (KAI)**
- **Principle Investigators:**
  - **Bruce Young – Battelle**
  - **Brian Leis & Bruce Nestleroth, in conjunction with**
  - **John Kiefner (KAI) & John Beavers (DNV)**

DOT PHMSA Agreement No.: DTPH56-11-T-000003

Phase 1 and 2 – Status Update

Completed reports for Phase 1 available at:
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=390

Phase 1

- **Final Report to close NTSB P-09-1 – January 2014**

Phase 2

- **Completion in late Fall 2014**

Phase 1 - Summary

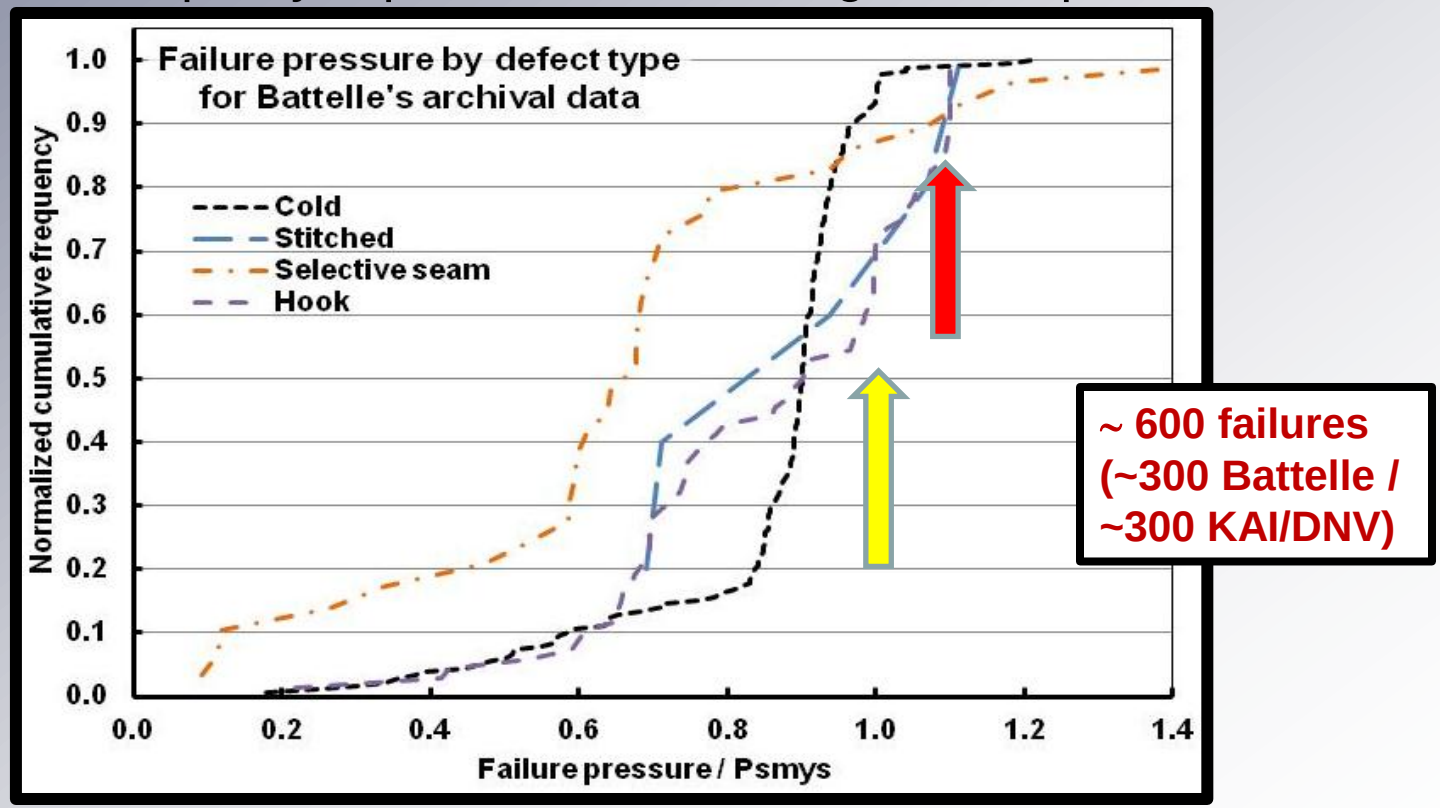
Database Analysis

- Assessed incident history
- Effectiveness of pressure testing to expose near-critical defects
- Models to predict failure & re-inspection intervals
- Detection & sizing via ILI & in-ditch tools
- Results of analysis posted on PHMSA R&D website

Phase 1 – Findings

Key Findings: Hydrotesting

- **High pressures needed to be effective**
  - Consider operating history, incident/test experience, implications of seam quality & potential for defect growth & pressure reversals



Task 1.4 - Battelle's Experience with ERW and Flash Weld Seam Failures: Causes and Implications, Pg. 48

Phase 1 - Findings

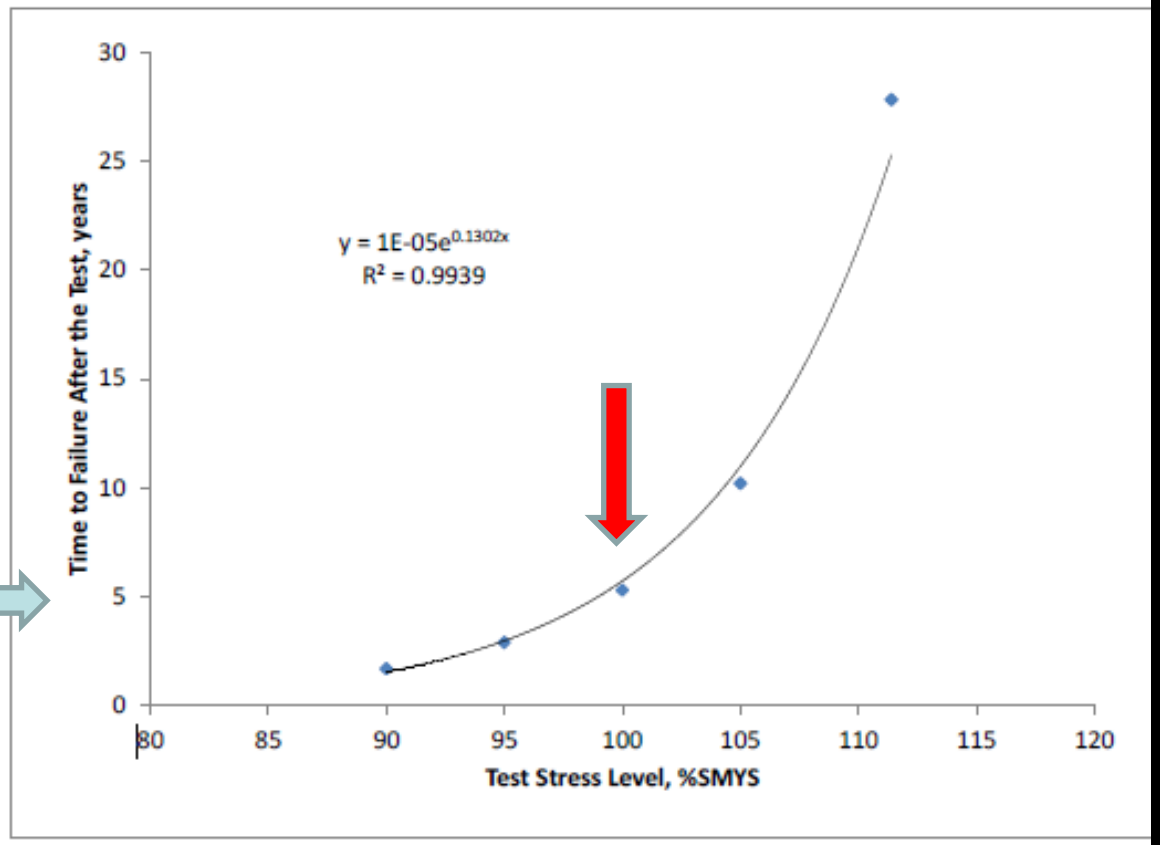


Figure 5. Relationship between Time to Failure and Test Pressure

- Time to failure increases at an exponential rate to increased test pressure.
- Highest test pressure assures a longer interval before a retest.
- Should not test so high that you get plastic expansion
- Test failures will increase with higher pressure

Task 2.5 - Predicting Times to Failure for ERW Seam Defects that Grow by Pressure-Cycle-Induced Fatigue, Pg. 20

Phase 1 – Findings

Table 11. Times to Failure for Various Test Scenarios

Stress Level that Defect Barely Survives, %SMYS	Test-Pressure-to-Operating – Pressure Ratio	Depth of Defect, inch	Years for Defect to Grow to Failure
90	1.25	0.1166	1.6
95	1.32	0.1018	2.9
100	1.39	0.0854	5.3
105	1.46	0.0667	10.2
111.4	1.55	0.0400	27.8

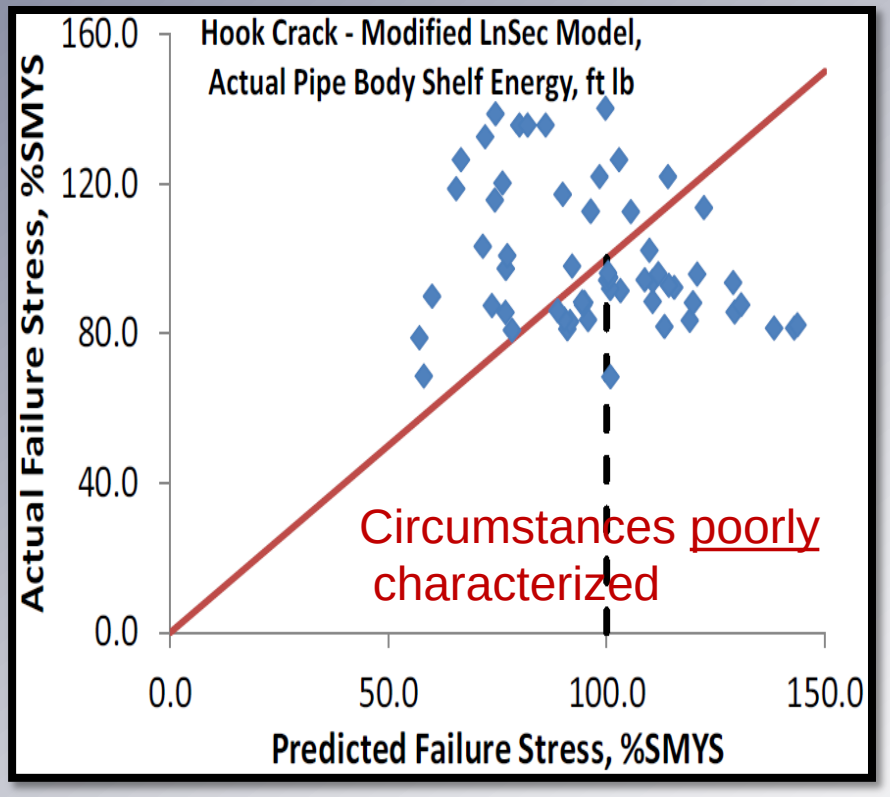
- Fatigue crack growth estimated using "Paris-law" approach
- Requires relevant data including: pipe geometry, strength level, operating pressure cycle, and test history,
- Need to use conservative values for material toughness and flow stress

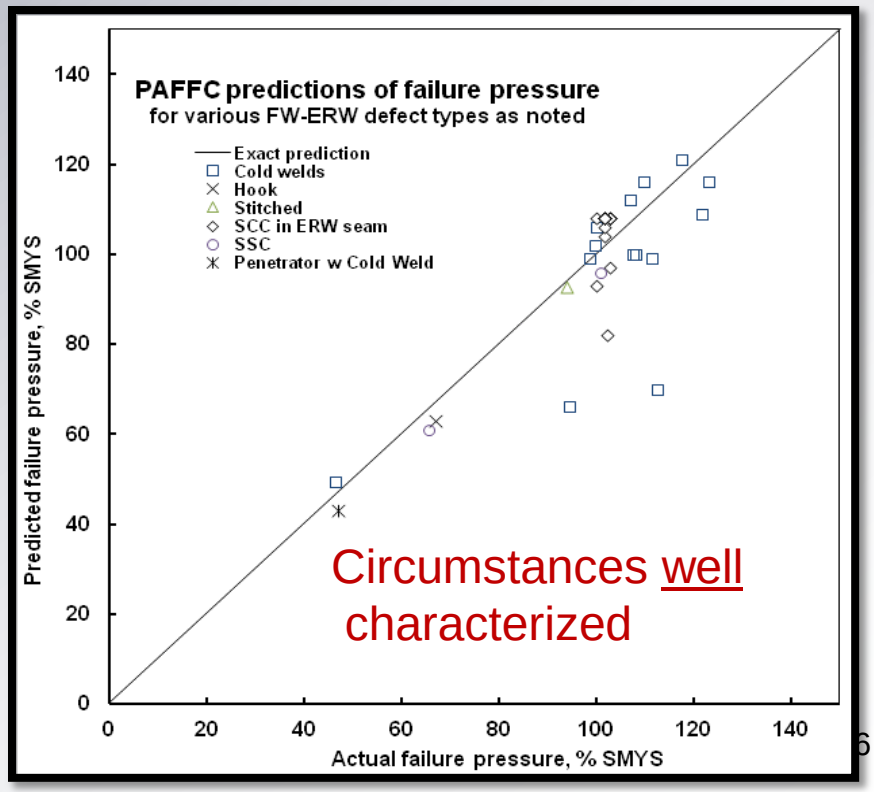
Task 2.5 - Predicting Times to Failure for ERW Seam Defects that Grow by Pressure-Cycle-Induced Fatigue, Pg. 20

Phase 1 - Findings

Key Findings: Modeling

- **Modeling and Prediction – success when defect shape is well sized & properties reasonably characterized**





Phase 1 - Findings

Key Findings: ILI

- **ILI Detection & Sizing:**
  - ILI results show inconsistencies with digs & hydrotest results
  - ILI tools are useful for finding & eliminating some seam defects
  - Finding tight cracks

Key Findings: In-the-Ditch Assessment Methods

- No consistent standard practice
- Can be inspector dependent

Phase 1 – Findings

- **In-the-Ditch Detection and Sizing Tools to provide ILI-validation Benchmarks – Improvements required for:**
  - More specific identification of anomaly type
  - Reduction of false calls
  - Improved sizing of defect depth and length for effective assessment and evaluation results
  - ILI tools need to be able to detect tight cracks

Phase 1 – Findings

- **Failure Pressure Models – Charpy Impact Toughness**
  - Should use a more representative position relative to the bond line
  - Toughness values when unknown, need to be conservative
- **Predictive Model for Assessing Failure Stress Levels**
  - Must be based upon whether the failure is brittle or ductile, if unknown evaluate for both
  - Must use lower-bound failure stress levels based upon defect type (cold weld, hook cracks, SSC, etc.)

Phase 1 – Findings

- **Hydrostatic test pressures**
  - Need to be higher to be effective based upon a review of over 600 seam failures
  - Time to failure increases at an exponential rate to increased test pressure
  - Higher test pressures should mean longer interval before a retest

Phase 2 – Overview

Phase 2 – Long Seam R&D (completion Late Fall 2014)

1. **Improve hydrotesting protocols for ERW/FW Seams**
   - Improve hydrotesting protocols and validate their practical utility
2. **Enhance Defect Detection and Sizing via Inspection**
   - Improve sensors, interpretive algorithms and tool platforms involved in ILI and In-the-Ditch methods
   - ILI Vendor pull tests, defect characterization & burst tests
3. **Defect characterization: Types, Sizes, & Shapes**
   - Bridge gaps in defect characterization and protocols for defect/size/report
   - Define basis to quantify key inputs for predictions of defect severity
   - Define timeline for response and re-inspection

Phase 2 – Overview

Phase 2 – Long Seam R&D (continued)

4. **Develop and Refine Predictive Models and Quantify Growth Mechanisms**
   - Identify gaps in existing models, where gaps exist, refine or develop models
   - Assess and quantify defect severity for cold welds, hook cracks and SSC (conduct full scale tests to validate models)
5. **Develop Management Tools**
   - Manual, software, protocols and training
6. **Public Meeting/Forum**

Thank you

Steve Nanney

US DOT / PHMSA

steve.nanney@dot.gov