DEFECT DETECTION AND CHARACTERIZATION IN PIPELINES

Current Programs at SwRI

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Government/Industry Pipeline R&D Forum
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TARGET AREAS

- Inspection of unpiggable pipelines
- Monitoring of cased pipelines
- Characterization of mechanical damage defects

APPLICATION OF RFEC TESTING TO INSPECTION OF UNPIGGABLE PIPELINES

U.S. DOT-PHMSA Contract No. DTRS56-02-T-0001

Participation by
Northeast Gas Assn.
Carnegie Mellon
U.S. DOE-NETL

PROBLEM
Some pipelines are "unpiggable" and cannot be inspected

Branch Connections
Non-Circular Valves
90-degree Elbows
Multiple Diameters
No Launch Traps

Low Flow Rates
Low Pressures

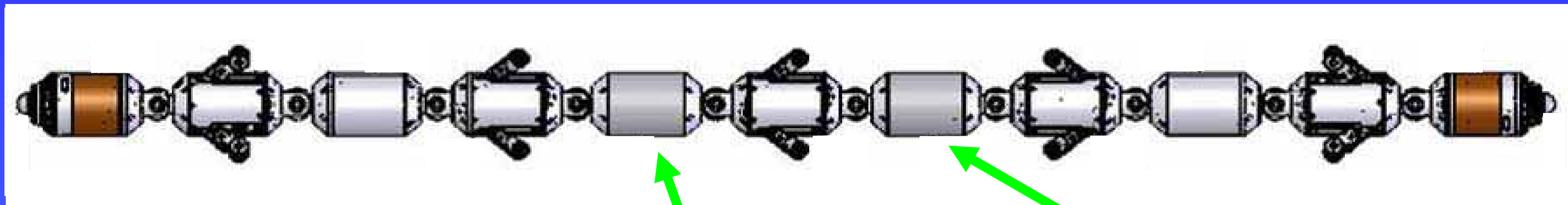
Project Objectives

- Develop remote field eddy current (RFEC) inspection system for natural gas pipelines that are currently unpiggable
- Accommodate obstacles such as elbows and Tees
- Integrate RFEC system with Carnegie Mellon robot
- Demonstrate in operating pipeline

APPROACH

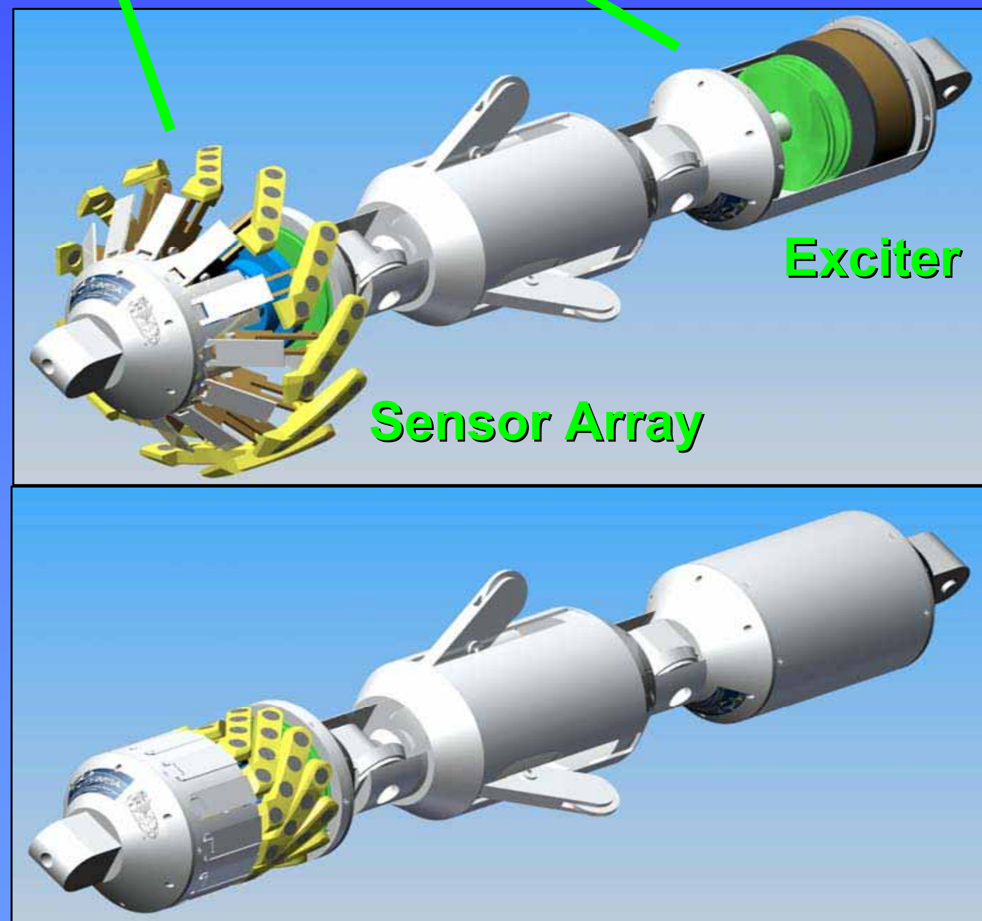
- Use remote-field eddy current (RFEC) method
  - RFEC system can adjust to variable pipe size and retract to pass through obstacles
  - Detects ID and OD corrosion defects
  - Can characterize defect depth, length, width
- Integrate RFEC with Carnegie Mellon Explorer II robotic transport system
  - Adjusts to variable pipe size and retracts to pass through obstacles
  - Self-powered
  - Nontethered—wireless remote control
  - Launched while pipe in service

RFEC DESIGN FOR EXPLORER II



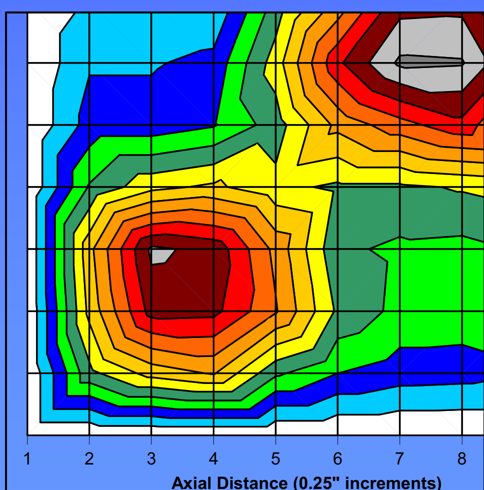
CMU Explorer II Robot

SwRI RFEC Inspection Modules

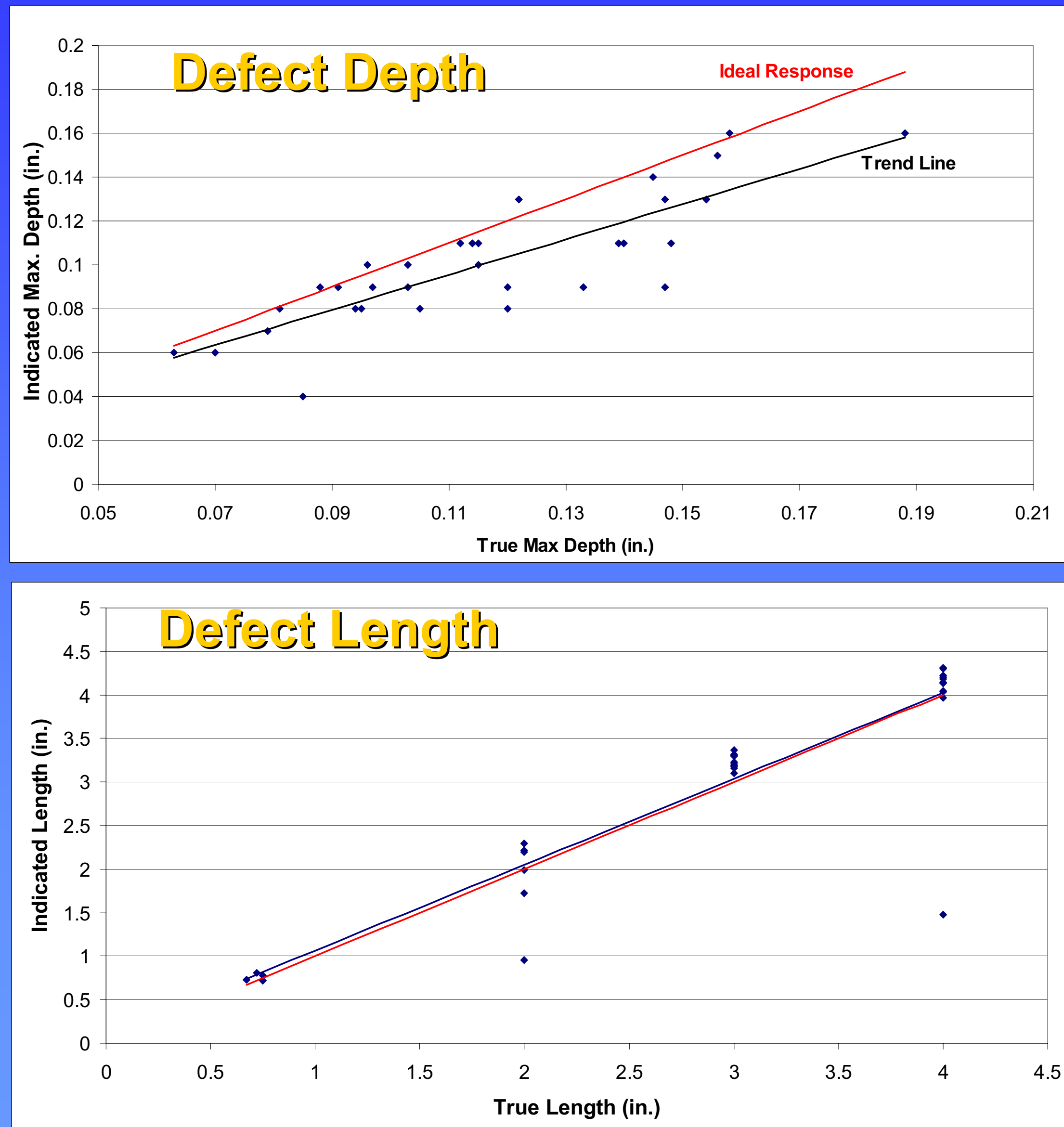


BLIND TEST DEFECT CHARACTERIZATION

(Breadboard System)



Typical Defects



CURRENT STATUS/PLANS

- RFEC modules undergoing fabrication and testing
- Integration with Explorer II robot in Spring 2007
- Demonstration on live pipeline in Summer 2007

Expected Outcome

- Inspection system for 6-8 inch pipelines that can negotiate 90 deg. elbows and Tee joints
- Analysis capability to characterize depth, length, & width of wall-loss defects
- Demonstration in live pipeline
- Transfer of technology

LONG-TERM MONITORING OF CASED PIPELINES USING LONG-RANGE GUIDED-WAVE TECHNIQUE

SwRI Project 14.12266
for
NYSEARCH/NGA and DOT/PHMSA

PROBLEM
INSPECTION of CASED LINES AT ROAD CROSSINGS

- High-consequence area
- Require direct assessment (DA)
- Access is difficult, need remote inspection technique

PROJECT OBJECTIVE

- Apply Magnetostrictive Sensor (MsS) long-range guided-wave testing to "cased crossings"
- Develop defect characterization capability
- Develop long-term monitoring capability using permanently installed sensors
- Perform field validation

MsS (MAGNETOSTRICTIVE SENSOR)

- MsS is a guided-wave probe that uses magnetostrictive effects for wave generation and detection
- Thin, ferromagnetic strips are bonded around pipe with encircling coils over the strips
- Sensors are inexpensive and suitable for long-term monitoring

MsS TEST SETUP ON A CASED-LINE MOCKUP

PROJECT STATUS/PLANS

- Defect signal modeling refined and validated
- Defect characterization algorithm development & software improvement underway–complete in March 2007
- Field evaluation to begin in April 2007
  - In NGA's test bed in Binghamton, New York

EXPECTED OUTCOME

- Defect signal simulation software
- Data analysis software for inspection and monitoring
  - Including some capability of defect sizing
- Procedures for sensor installation for long-term monitoring
- Determine capabilities and limitations of long-range guided wave technique for cased pipeline

NONLINEAR HARMONIC (NLH) MONITORING OF GOUGED DENTS IN PIPELINE SPECIMENS UNDER CYCLIC LOADING

U.S. DOT-PHMSA Contract No. DTRS 56-04-T-001
and PRCI Contract GRI 8715

PROBLEM

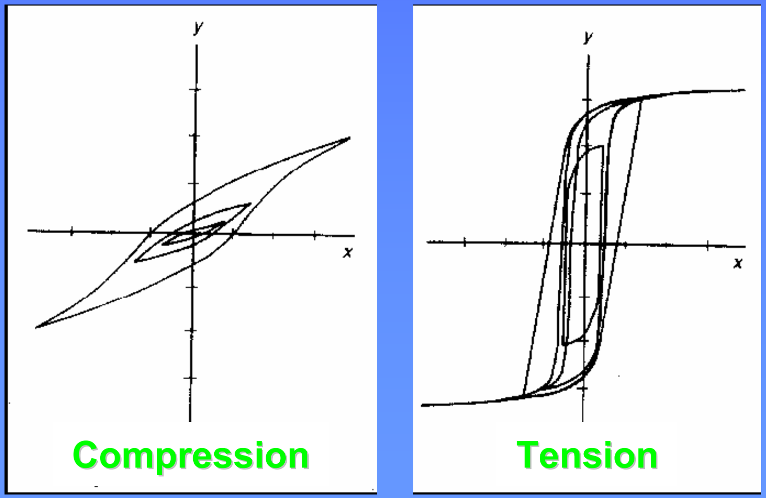
- Delayed failures from mechanical damage are related to time-dependent accumulation of damage (e.g. fatigue cracking)
- Current ILI systems cannot determine mechanical damage severity

PROJECT OBJECTIVES

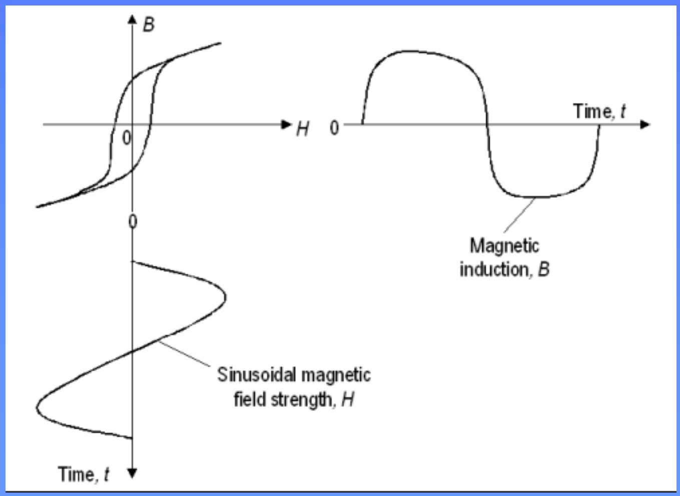
- Measure Nonlinear Harmonic (NLH) signals as a function of pressure cycles on full-scale pipe segments containing realistic gouged dents
- Derive NLH-based defect severity criteria related to fatigue life (delayed failure)
- Transfer NLH technology to ILI company (Tuboscope)

NONLINEAR HARMONICS (NLH)

- Uses AC magnetic field to locally infer magnetic properties of steel
- Strain anomalies produced by gouging change magnetic properties of steel and sensed by NLH



Magnetization Curves



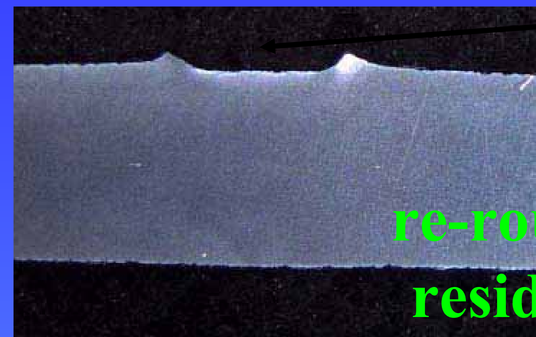
NLH Signal Generation

NLH RESPONSE TO GOUGING-INDUCED STRAINS

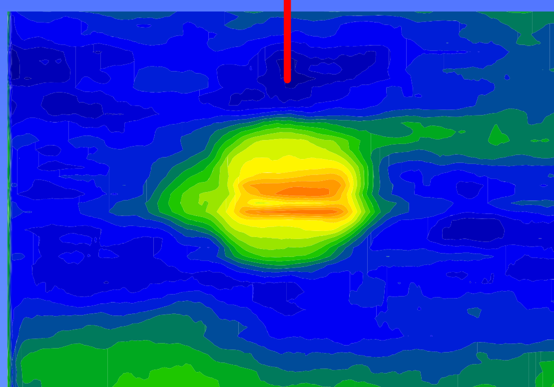
gouge

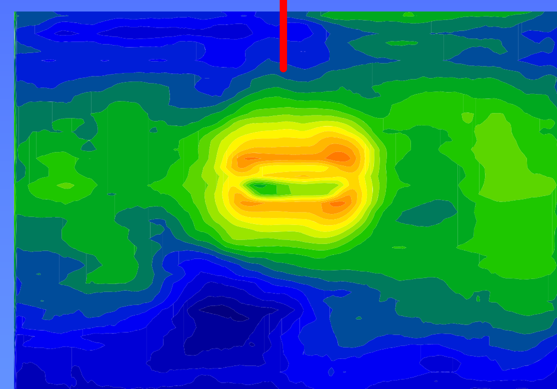
partial re-rounding: residual deformation

gouge



re-rounding: no residual inside deformation

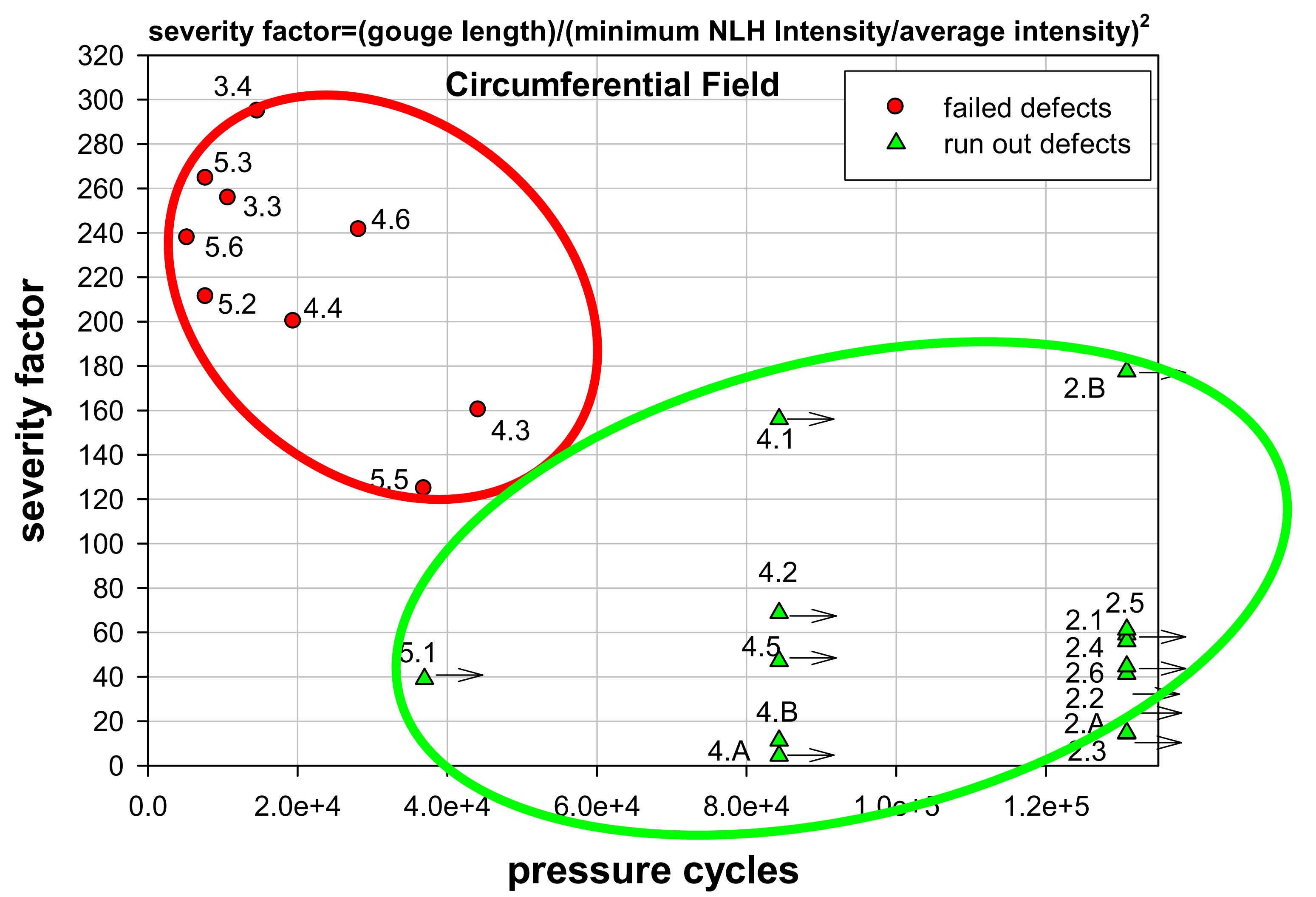




NLH signal measurements

Calipers and other ILI methods may miss re-rounded defects.

NLH DEFECT SEVERITY FACTOR RELATED TO FATIGUE LIFE



PROJECT OUTCOME

- NLH detects strain due to gouge-like defects even after re-rounding
- NLH severity index ranks the severity of gouge-like defects against fatigue (delayed) failure
- NLH severity index specification provided to ILI vendor and demonstrated in analysis software