Northeast GAS ASSOCIATION

NYSEARCH

Cased Pipe Risk Assessment and Inspection Technologies

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Background

- Differences between Cased Pipe & Line Pipe
  - Corrosion is a different time-dependent threat inside a casing
  - Time independent threats might be lower inside a casing
  - ECDA difficult to apply inside a casing
- Risk is a basis to compare cased and uncased pipe allowing resource optimization

Vision for Cased Pipe Integrity Assurance Model

- Operators are collecting data on cased pipe
- Need to separate casings into categories on basis of threat or risk
- Cased Pipe Integrity Assurance model designed to be
  - Thorough and defensible to regulators
  - Flexible to allow for available data
  - Conservative and able to accommodate input by SMEs
  - Robust

PHMSA 'Serious' Incident Data

- Avoidance of threats (gas transmission)
  - –Third party damage (34.4% of all incidents)
  - –Other external forces plus natural forces (4.6%)
  - –Material failure (10.6%)
    - some of these would be avoided since activation requires external force
- Cased pipe might be ~40% lower PoF than uncased

Specific Threats by Category

Category	Example
Time Dependent	External Corrosion, Internal Corrosion, SCC, Erosion, Fatigue
Static or Resident	Manufacturing, Welding/Fabrication, and Equipment Defects
Time Independent or Random	Mechanical Damage, Incorrect Operations, Weather and Outside Forces

Cased Pipe Integrity Assurance Model

- Objective
  - Develop an overall risk assessment algorithm to support risk and integrity management of encased pipe
- Benefits
  - Allow threats within casings to be evaluated differently than threats outside of casings; helps to balance opportunity to reduce risk and prioritize threats
  - Provide a means for assessing cased pipe that would otherwise not be possible or would be cost prohibitive
  - Provide a formal, technically defensible consensus-based process for assessing risk on cased pipe

Applicability of Model

1. Low Risk
   - Risk insignificant
2. Susceptible
   - Work to put casing in 'Low Risk' category
     - Collect additional data to determine if categorization is from uncertainty (i.e., conservative assessment was assumed)
     - Perform action to stop atmospheric or external corrosion
     - Mitigate or eliminate corrosive environment
       - e.g., remove short, dry annulus and repair end seals, use dielectric wax
3. At risk
   - Examine or inspect pipe
   - Possible repair
   - Possible P & M measures
   - Mitigate or eliminate corrosive environment

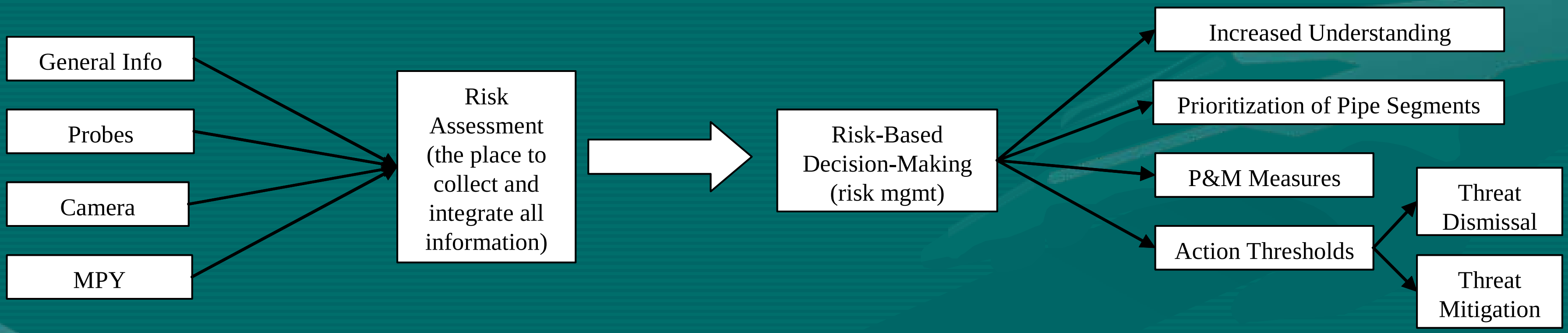
Corrosion Mechanisms in Casings

- Oxygen corrosion in liquid water
- Oxygen corrosion in condensed water
- MIC in liquid water

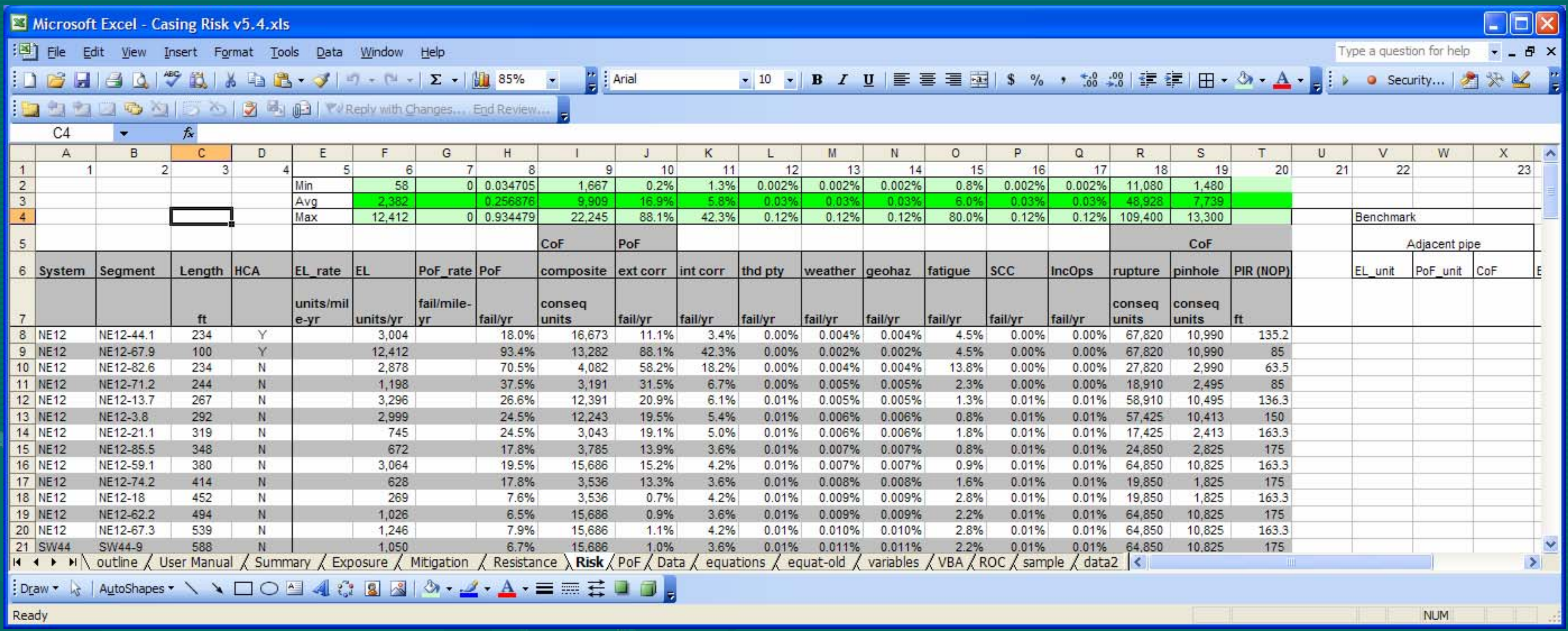
Estimate Risk Using Prob of Failure & Consequence of Failure

- Utilize three concepts for PoF
  1. Exposure (corrosivity) = *likelihood of an active pipe failure reaching the pipe when no mitigation applied*
  2. Mitigation (CP and Coatings) = *reduces likelihood or intensity of the exposure reaching the pipe; keeps mechanism off the pipe*
  3. Resistance (Pipe Wall Thickness and/or SMYS) = *ability to resist failure given presence of exposure/threat*
- Probability of Damage (PoD) determined by #1 and #2
- Probability of Failure (PoF) determined by PoD and #3
- Risk = PoF x CoF

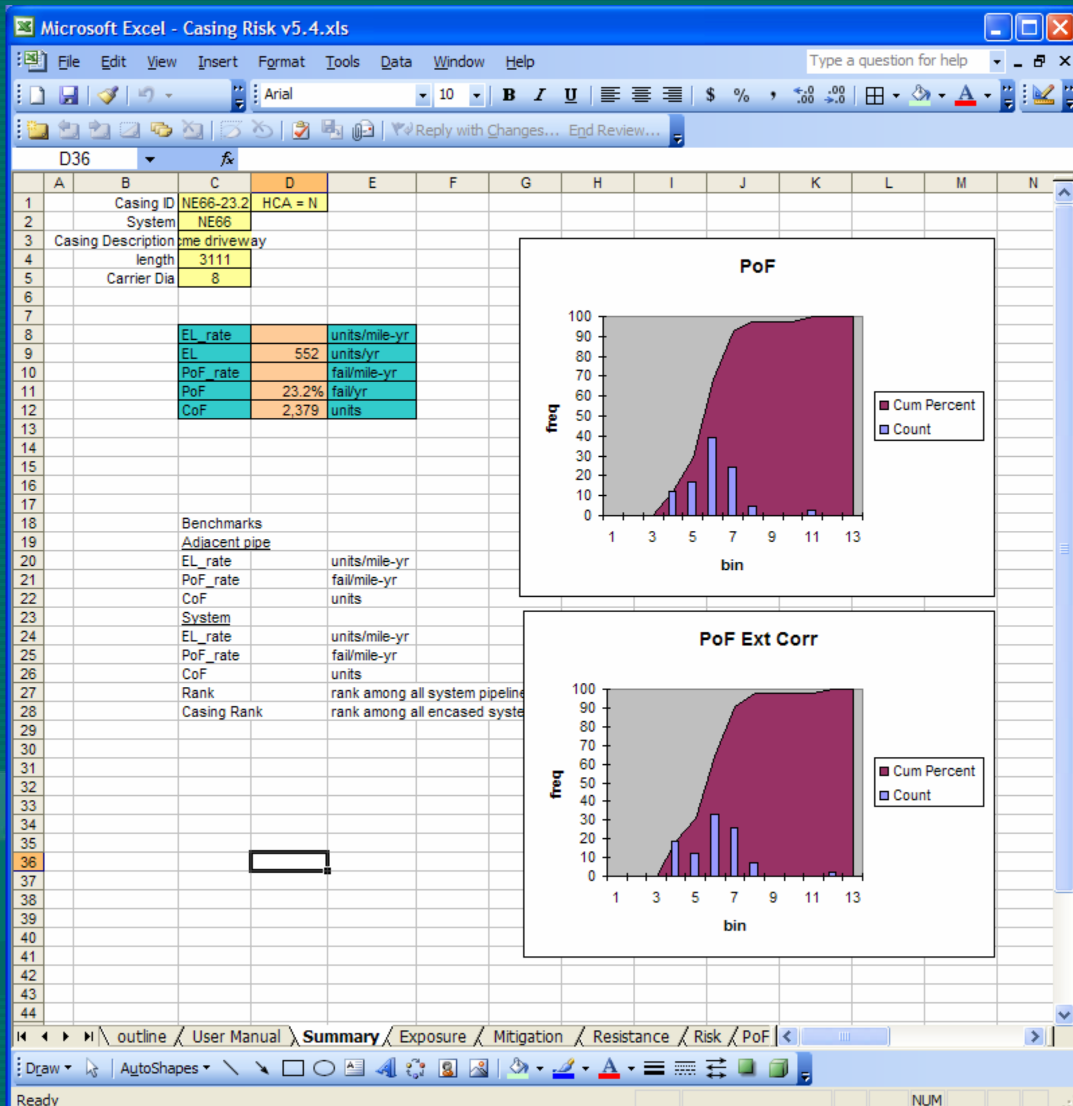
The Cased Pipe Integrity Assurance Process



The Result: Calculate Risk from PoF and CoF for Each Casing



Explore Relative Risk of Single Casing Compared to Others

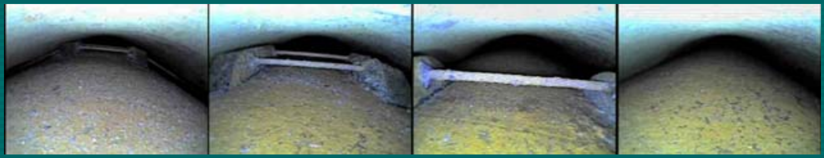


Status of Cased Pipe Integrity Assurance Model

- WKM/Muhlbauer and CCT/DNV completed model in 2009
- Spreadsheet deliverable and user manual provided to funders
- User-friendly graphical version of model available through licensed commercializer; New Century Software (rich.arata@newcenturysoftware.com)
- NYSEARCH funders working on independent validation (by WKM) of model based on casing job data

Annular Space Direct Inspection Robot

- Purpose: To develop a platform for inspection of the carrier pipe in the annular space
- Ph I: development, testing & implementation of visual inspection camera
- Video Inspection can provide data
  - Integrity of Coating
  - Physical placement & condn of insulators
  - Presence of Electrical contacts
  - Environmental Conditions
  - Risk Assessment

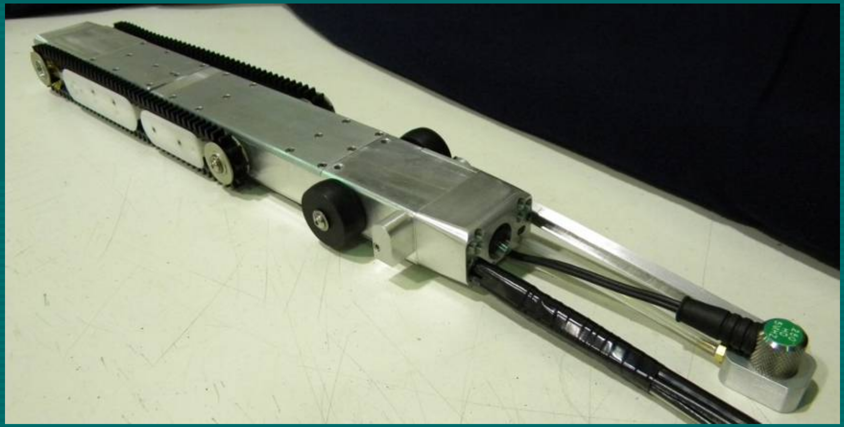


Casing Camera passing over casing spacer

Annular Space Direct Inspection Robot

- Phase II Objectives
  - Enhance System Reliability and Availability
  - Develop functionality to assess carrier pipe integrity

- Phase II system enhancements include:
  - Spot pipe wall thickness measurement sensor
  - Humidity sensor for direct readings of humidity level inside the casing
  - Inclinometer for on screen display of radial positioning
  - Video measuring tool for precision measurement of features and defects



Development Status of Annular Space
Direct Inspection Robot

- Field test inspections continue with first generation robot
- Additional prototypes available to accommodate more jobs and spares
- Ultrasonic metal loss sensor, moisture sensor and inclinometer developed and tested in lab; field testing pending
- Commercial service offering is likely to be available in 2010;
  currently assessing market interest

Overall Data Collection Efforts related to Projects & Casings

- ILI data, casing inspection data, casing history and construction information being collected where possible
- Direct information from Annular Space Inspection Robot can also provide condition of coating, location/position of spacers, presence of moisture and location of anomalies
- Direct information from robot can be used to complement other information

Overall Data Collection Efforts related to Projects & Casings (cont.)

- Through scientific methods established by CCT/DNV, we are quantifying the boundaries of corrosion rates in annular space (Corrosion Rate Estimation Project)
  - Benchscale testing
  - Full laboratory testing
  - NYSEARCH/NGA test bed controlled tests
  - Member field tests
- All this information can further substantiate calculations made through cased pipe integrity assurance model

Summary

- The external corrosion threat on pipelines differs when the pipe is within a casing
- The principles of corrosion and risk are the same both inside and outside of the casing
- Methods are being developed that apply existing tools to cased pipelines
- Inspection tools are being developed that can navigate in the annular space