ILI Data Interpretation

Emerging Pipeline Technologies – Sept 29th, 2014

Jason Skow
Integrity Maintenance Planning

- Quantify risk profile along pipeline
- Evaluate factors influencing risk
- Optimize maintenance and inspection programs
- Report to regulators
Calculating the Failure Probability

Pipe Dimension Distribution

Defect Size or Force Distribution

Resistance Model

Resistance Distribution

Material Strength Distribution

Load Distribution

Resistance Distribution

Safety Margin = Resistance - Load

Probability of Failure

Load Distribution

Failure Probability

Mean Load

Mean Resistance

Load or Resistance

Load Distribution

Probability of Failure
ILI Performance Metrics

- Probability of Detection (POD)
- Probability of Identification (POI)
- Probability of False Call (POFC)
- Sizing
  - Depth
  - Length
  - Area
  - Burst pressure

- Testing a performance claim vs calculating a performance claim
### Probability of Detection

- **Possible outcomes of an inspection**

<table>
<thead>
<tr>
<th></th>
<th>Defect</th>
<th>No Defect</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-line Tool Result Positive (+)</td>
<td>$x$</td>
<td>$w$</td>
<td>$x + w$</td>
</tr>
<tr>
<td>In-line Tool Result Negative (-)</td>
<td>$y$</td>
<td>$z$</td>
<td>$y + z$</td>
</tr>
<tr>
<td>TOTAL</td>
<td>$n = x + y$</td>
<td>$w + z$</td>
<td>$x + y + w + z$</td>
</tr>
</tbody>
</table>

$$POD = p(+ | defect) = \frac{x}{n} = \frac{x}{x + y}$$
• Depends on length and depth – but not both equally
• Estimating what was missed – is it an integrity concern?
• POD depends on what is not in the dig sets
• Scenario 1:
  • a minimum length bell hole targeting defects
  • it is unlikely that undetected defects will be properly represented in the sample
• Scenario 2:
  • extend the length of the dig
  • more length provides more information about undetected defects
• Model the rate of undetected defects
Sizing

- Depth, Length, Area, Shape
- Unity Plot
- Errors in two dimensions

Sample size: 246
Testing the Vendor Claim

- Results in a ‘reject’ or ‘not reject’ evaluation
- Minimizes Type I errors
- Pros – simple
- Cons – does not use expensive data

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Reality</th>
<th>Probability Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>False</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>Reject</td>
<td>Correct Call</td>
<td>Type I Error</td>
</tr>
<tr>
<td>Not Reject</td>
<td>Type II Error</td>
<td>Correct Call</td>
</tr>
</tbody>
</table>
Calculating Performance

- **Pros:**
  - Use all available data
    - Specification
    - Excavation data
    - Pull tests
    - Lab tests
  - Estimates performance
  - Critical feature assessment
  - Integrity optimization

- **Cons:**
  - Complicated
  - Requires more data

![Histogram of POD](histogram.png)

- **Mean:** 0.922
- **95% CI:** 0.872 to 0.968

[Website: www.cfertech.com]
Defect Shape

- Burst pressure from ILI: 108.71% SMYS
- Burst pressure from profile: 108.8% SMYS
Optimizing Integrity Management

Graph showing the relationship between length of flaw (mm) and depth of flaw (mm) with data points indicating non-detected defects and lines representing 50% 7450KPa and 100% 9951KPa.
Thank you!