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Anomaly Detection and Characterization – Issues and R&D Priorities

Government/Industry Pipeline R&D Forum

Working Group No. 3 – Anomaly Detection/Characterization

Mark Stephens

m.stephens@cfertech.com

C-FER Technologies

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The Integrity Management Process

The Approach for Existing Damage

- Find existing damage before it becomes failure critical
- Manage integrity through periodic inspection & selective repair

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The Integrity Management Process

Key Process Elements and Associated Considerations

- Detect existing defects
  - Detection capability of inspection method
- Size existing defects
  - Sizing accuracy of inspection method
- Assess existing defects at time of detection
  - Accuracy of remaining strength prediction model
  - Uncertainties associated with capacity model inputs
- Assess time to remediation or re-inspection
  - Applicability of adopted growth rate model
  - Uncertainties associated with growth model inputs

The Integrity Management Process

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Comments on Available Assessment Methods

- Deterministic (e.g. B31G modified)
  - Uncertainties addressed through conservative input selection
  - Desired safety level achieved through safety factor (design factor)
- Semi-probabilistic (e.g. Probability of Exceedance, POE)
  - Some uncertainties explicitly considered in analysis (e.g. feature sizing error)
  - Other uncertainties addressed through conservative inputs
  - Desired safety level achieved through prescribed limit on maximum allowable POE and conservative exceedance criteria (i.e. burst and leak condition)
- Full probabilistic (e.g. Probability of Failure, POF or RBDA)
  - All significant uncertainties explicitly considered in analysis
  - Desired safety level achieved through prescribed limit on maximum allowable POF

All meant to do the same thing → provide a basis for demonstrating fitness for service. Differences lie in the treatment of uncertainties (implicit vs. explicit), the safety margins achieved and the consistency in the achieved safety levels.

Considerations for Future R&D

Detection

- Desired end point
  - Technologies with high probability of detecting significant features
- Current status
  - High detection probability not always assured and varies with feature type, size, shape and location
  - Technology gaps (i.e. feature types for which detection/identification is potentially problematic)
    - Crack and crack-like features, in proximity to welds in particular (ILI) – the issue is detection
    - SCC features (ILI) – is the issue detection or correct identification?
    - Gouges/cracks/metal loss within dents (ILI) – is the issue detection or correct identification?
- Requirements given current status
  - Detection capability of chosen technology should be understood
    - Standardized procedures to verify/update detection claims (how to correctly interpret dig data)
    - Third party pull test facility for in-line tool performance validation
  - Detection uncertainty should be acknowledged in the integrity assessment
    - Explicit guidance on how best to address within a deterministic or probabilistic analysis

Considerations for Future R&D

Sizing

- Desired end point
  - Technologies with minimal sizing uncertainty
- Current status
  - Sizing uncertainty is not insignificant and varies with feature type, size and shape
  - Technology gaps (i.e. feature types for which sizing is potentially problematic)
    - Crack and crack-like features, including SCC and long seam features (both ILI and in-ditch)
    - Gouges or cracks or metal loss within dents (ILI)
- Requirements given current status
  - Sizing accuracy of chosen technology should be understood
    - Standardized procedures to verify/update sizing claims (how to correctly interpret dig data)
    - Third party pull test facility for in-line tool performance validation
    - Better in-ditch tools/procedures for sizing cracks and crack-like features
    - Better information on accuracy of in-ditch sizing methods (req'd for API 1163 procedure)
  - Sizing uncertainty should be reflected in the integrity assessment
    - Explicit guidance on how to appropriately and consistently address sizing uncertainty within a deterministic or probabilistic analysis

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Considerations for Future R&D

Remaining Strength Prediction

- Desired end point
  - Accurate strength prediction models with minimal uncertainty
- Current status
  - Accuracy of capacity prediction models varies with feature type
  - Technology gaps (i.e. feature types for which capacity prediction is potentially problematic)
    - Metal loss in high strength pipe / very deep metal loss
    - Real (as opposed to idealized) planar defects (i.e. cracks)
    - Dents with cracks/gouges, dents with metal loss, dents with welds
    - Other combined damage features
- Requirements given current status
  - Accuracy of chosen capacity model should be understood
    - Additional burst test data for feature types identified above
  - Capacity prediction uncertainty should be reflected in the integrity assessment
    - Explicit guidance on how to appropriately and consistently address model uncertainty within a deterministic or probabilistic analysis

Considerations for Future R&D

Remaining Life Prediction

- Desired end point
  - Remaining life prediction methods with appropriate treatment of inherent uncertainties
- Current status
  - Remaining life prediction highly dependent on growth rate assumptions
  - Technology gaps (i.e. feature types for which growth prediction is potentially problematic)
    - Planar features growing by fatigue (e.g. ERW and other long seam defects)
    - Planar features growing by environmental processes (e.g. SCC)
- Requirements given current status
  - Appropriate methods/models for estimating feature growth should be employed
    - Additional lab/field growth data for feature types identified above
  - Growth rate uncertainty should be reflected in integrity assessment
    - Explicit guidance on how to appropriately and consistently address growth uncertainty within a deterministic or probabilistic analysis