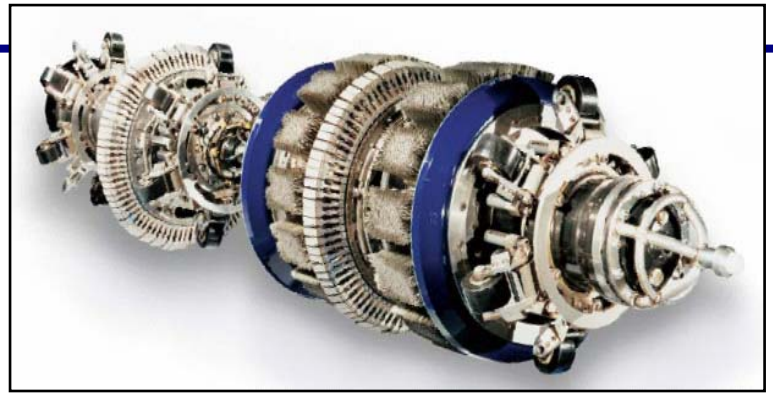
ExxonMobil Production

An Approach to Pipeline Integrity Management



NACE Int'l Houston Section Meeting

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Overview

- Pipeline assets
- 11-Element Operations Integrity Management System (OIMS)
  - Pipeline design and construction
  - Pipeline operations & integrity management
- Developing a pipeline integrity program
- Identifying integrity threats to an operating pipeline
- Adopting a ‘Failures are Preventable” mindset
- Objectives of the Facilities Integrity Management System (FIMS)
- FIMS implementation
- FIMS specific requirements for pipelines
- Pipeline Internal Corrosion
- Corrosion management 10 best practices
- Inspection tools
- Conclusions

Upstream Production Pipeline Assets

- Onshore construction costs typically $1-2M/mile
- Transportation of hazardous fluids – requires protection of Health, Safety and the Environment
- Transportation of valuable sales products – must minimize downtime

Pipelines transport:

- Produced oil
- Produced gas (with H_2S/CO_2/water)
- Produced gas liquids
- Helium
- CO_2

11-Element Operations Integrity Management System

Rigorous integrity management system provides framework for

1. **Management leadership, commitment and accountability**
2. **Risk assessment and management**
3. **Facilities design & construction – specs, codes, standards**
4. **Information / documentation**

6. **Operations & maintenance**
7. **Management of change**
8. **Third-party services**
9. **Incident investigation & analysis**
10. **Community awareness & emergency preparedness**
11. **Operations integrity assessment and improvement**

Developing a Pipeline Integrity Program

Operation Integrity Management System (OIMS)

1. Management leadership, commitment and accountability
2. Risk assessment and management
3. Facilities design & construction – specs, codes, standards
4. Information / documentation
5. Personnel & training

6.Operations & maintenance

7. Management of change
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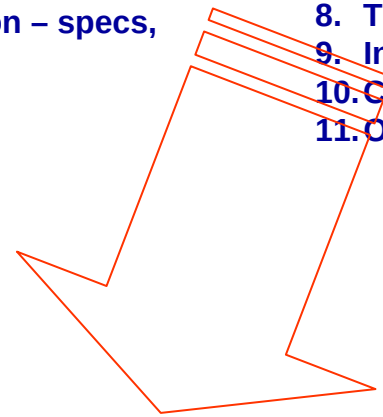


Facilities Integrity Management System (FIMS)

- **Identify integrity threats**
- **Design and execute a pipeline integrity program**
- **Steward and report program results**
- **Continuously improve the program**

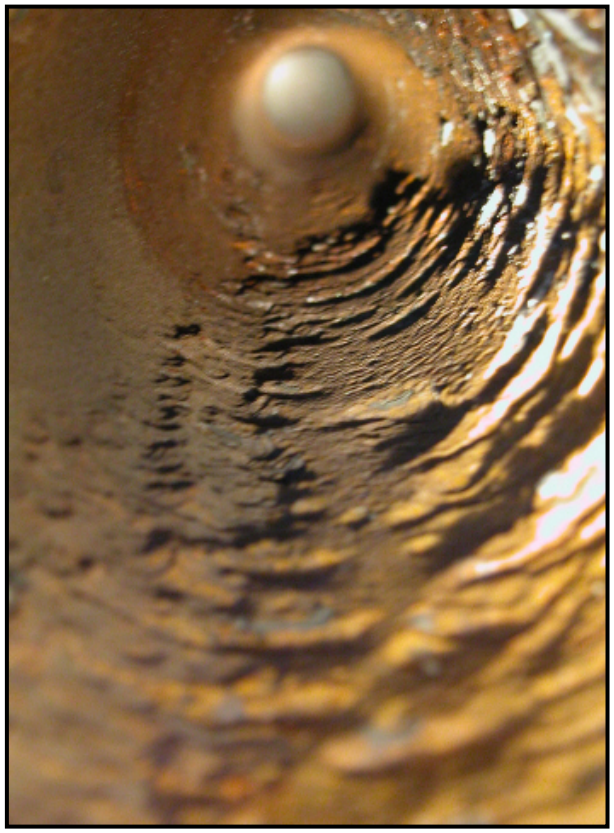
Threats to Operating Pipeline Integrity

3rd Party Damage

Pipeline fire caused by backhoe

External Corrosion

Internal Corrosion



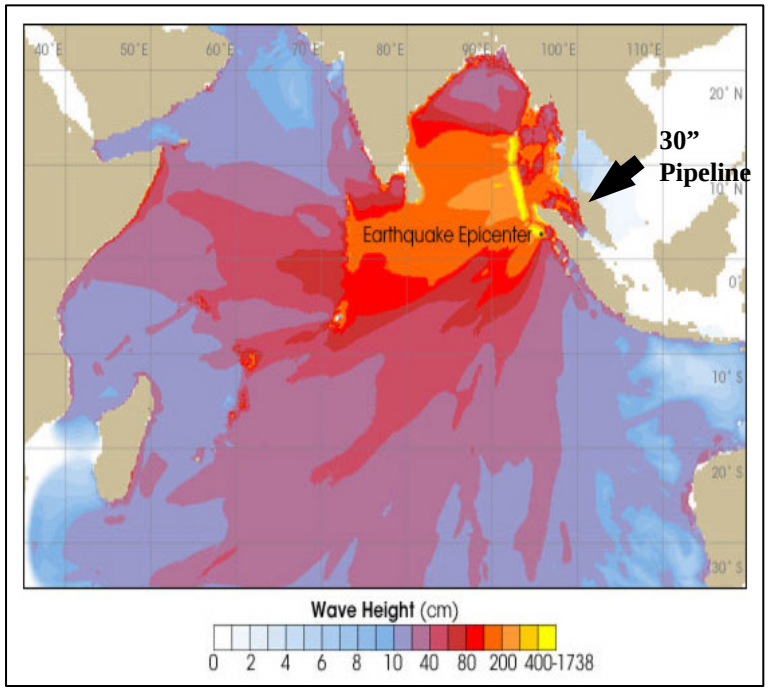
Threats to Operating Pipeline Integrity – cont'd

External Stress Corrosion Cracking

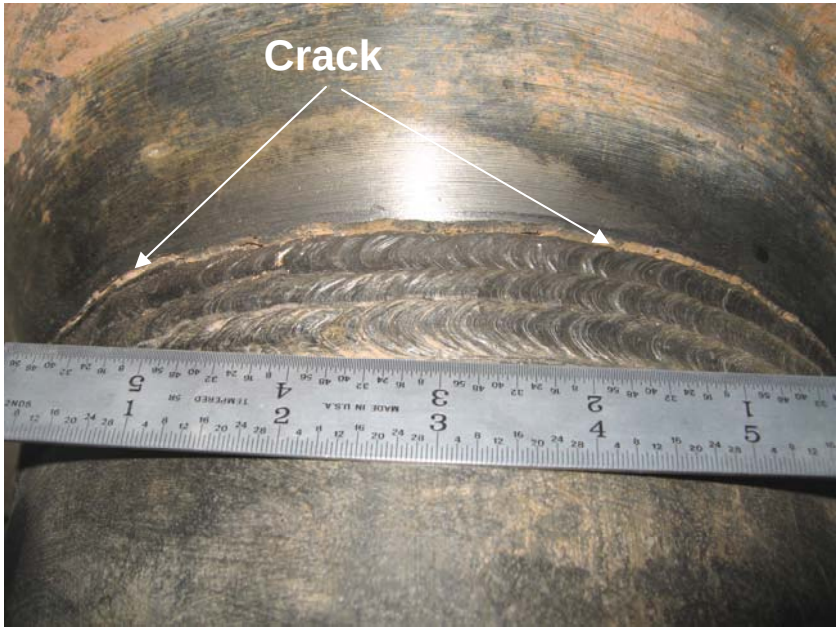
External Corrosion at ERW Seam

Threats to Pipeline Integrity in Operation – cont'd

Upheaval Buckling (Seismic)

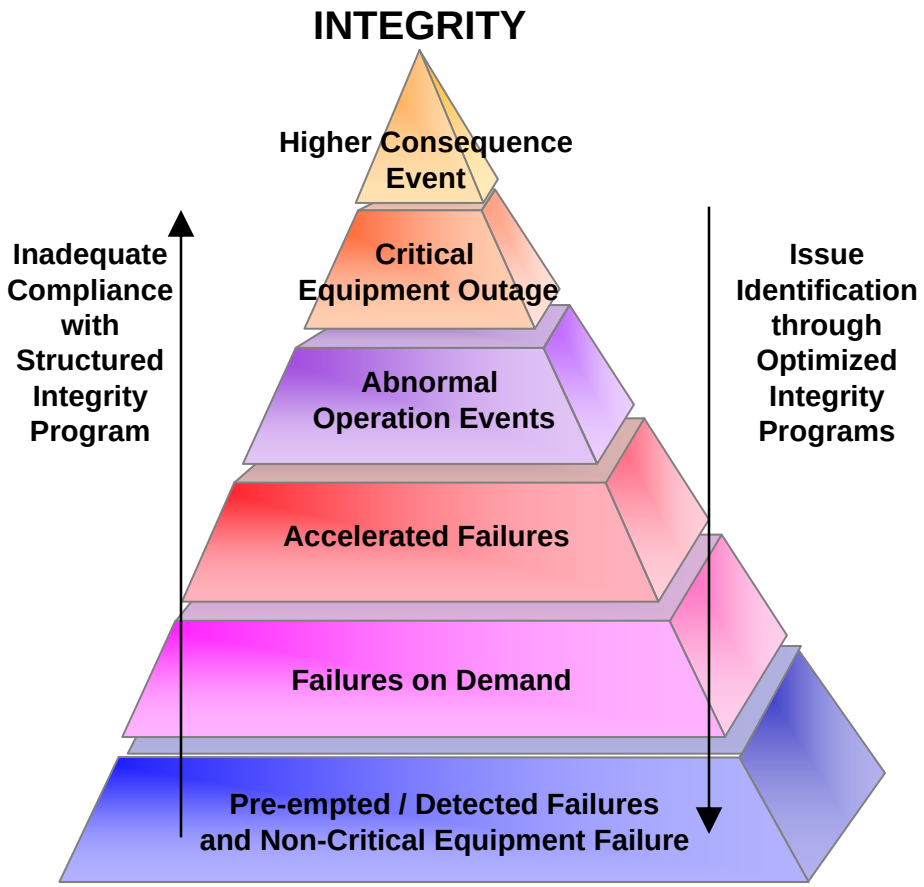


Thermal Stresses



Adopting a "Failures are Preventable" Mindset

Injuries are Preventable



Failures are Preventable

FIMS Objectives & Benefits

What are we trying to accomplish with the Facilities Integrity Management System (FIMS)?

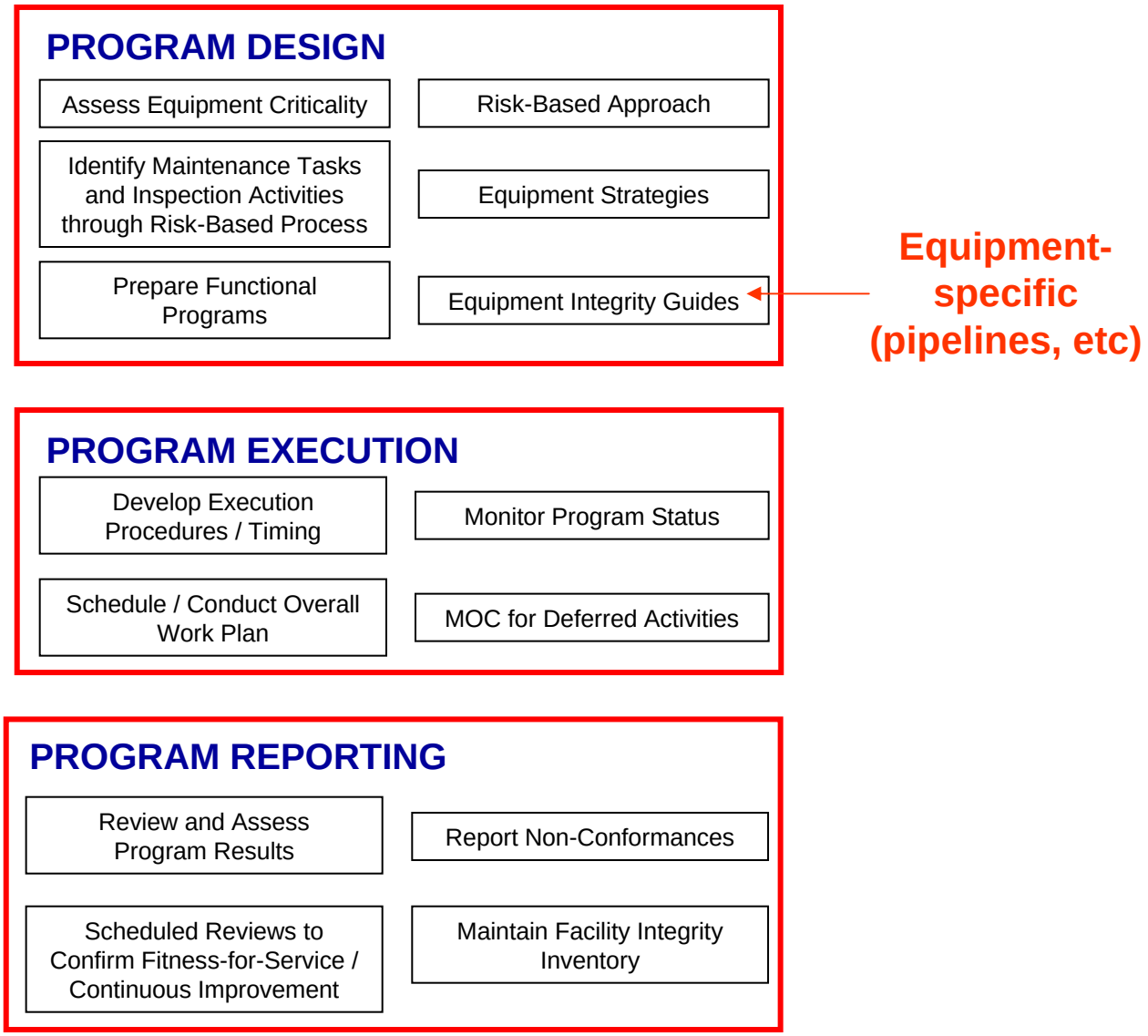
Objectives

- Eliminate higher consequence facility incidents and improve overall facility reliability
- Incorporate Best Practices into integrity management and ensure continuous improvement

Business Benefits

- Established a common global integrity management approach
- Aligned organization to identify and address integrity issues
- Elevated awareness & understanding of global risk profile
- Improved management stewardship program
- Global “fleet management” approach
- Maintain positive reputation with public

FIMS Implementation



Pipeline Integrity Requirements

FIMS Pipeline Integrity Requirements - Corrosion

- Pigging for solids control (weekly to monthly)
- Caliper pig for mechanical damage (5 year default)
- Process monitoring & MOC (Annually)
  - Temperature, pressure, fluid rates/volumes
- Fluids monitoring (Annually)
  - Full water analysis yearly
  - Includes chlorides, inhibitor residual, organic acids
- Chemical treatment (Annually)
- Corrosion inspection (MFL or UT) (Min 5 yr default)
- Corrosion monitoring program (Annually)
  - Options include coupons, electric resistance probes, test spools, fluid sampling
- CP P/S potentials and interference checks (Annually)


Brush BiDi


Cantilever Brush


Pit Boss

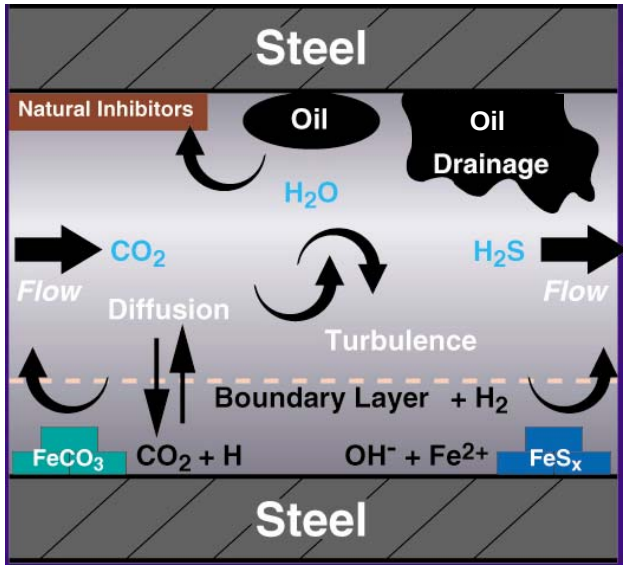
FIMS Pipeline Integrity Requirements - Other

- Right of way patrols
- Crossings over navigable water ways
- Walking inspections; monitoring of exposed segments
- First responder communication with local authorities

Frequencies shown here are typical, and must be individually developed for specific pipelines by assessing risk and analyzing operating and monitoring data

Internal Corrosion in Produced Oil & Gas Pipelines

Corrosion Basics: Steel + Water = Corrosion



Oilfield Factors Add Complexity

- *Accelerating factors* - salts, CO_2, H_2S, oxygen, organic and inorganic acids
- *Inhibiting factors* - liquid hydrocarbon, corrosion inhibitors
- *Fluid flow regime effects* – location of water, solids
- *Formation of protective scales* – carbonate, sulfide

Need to Account for These Factors in Predictions

- Accurate predictions require knowledge of fluid chemistry and flow conditions throughout field life
- Predictions are based primarily on laboratory testing and field experience

Problems Can Occur When

- Expected mitigating factors are not present; e.g. inadequate corrosion inhibition or cleaning
- Flow stream compositions and flow regimes are outside range from the design qualification
- Monitoring insufficient to detect changes in corrosion

Corrosion Management 10 Best Practices

1. **Operator has a Corrosion Monitoring Program**
   - **Risk-based, considers tools, intervals, all degradation mechanisms**
2. **Operator has a Corrosion Control Program**
   - **Inhibition, CP, coatings surveillance types and intervals**
3. **Operator has a Corrosion Inspection Program**
   - **Risk-based, describes tools, intervals**
4. **Programs have written objectives, performance measurements, and stewardship**
5. **Programs have a performance assurance process - ext. audits**

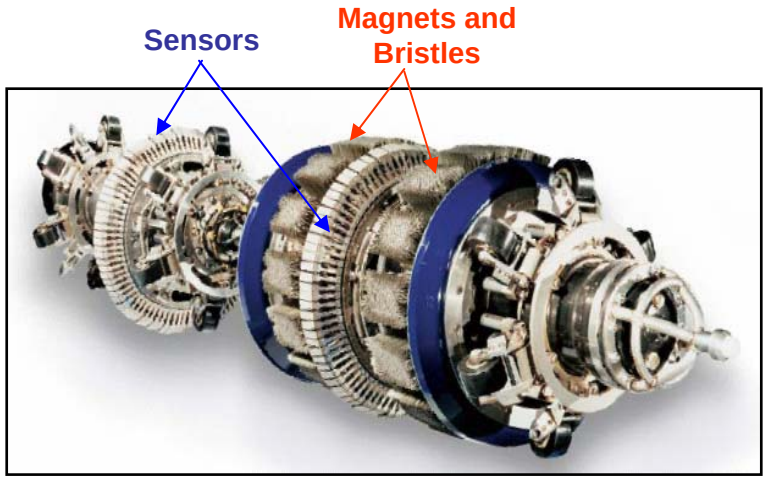
Corrosion Management 10 Best Practices

6. **Resources and Organization**
   - Responsibilities and accountabilities, definition of resources required
7. **Corrosion Management Operational Requirements**
   - Planning & scheduling tools
   - Record keeping
   - Planning & budgeting
8. **Corrosion Management of Change Process**
   - Review, approval, documentation
9. **Personnel Roles and Competencies**
   - Competency Assurance System
   - Training
   - Documentation
10. **Self-Assessment and Improvement**
    - Operator assesses and reviews the effectiveness of his system regularly

Pipeline Corrosion In-line Inspection (ILI) Tools

Inspection Options

- Magnetic Flux Leakage (MFL) is primary tool
  - Accuracy +/- 10% of wall thickness
  - Indirect method, requiring calibration and sizing models
  - Need supplemental ultrasonic (UT) prove-up for validation digs
  - Accuracy an issue for measuring low wall loss and narrow axial corrosion
- Ultrasonic pigs can be used in liquid filled lines
  - Better accuracy than MFL for low wall loss
  - Subject to UT signal degradation with rough pipe surfaces
- Direct wall thickness measurements sometimes used
  - Requires good understanding of fluids, topography and corrosion mechanisms to systematically select NDT locations

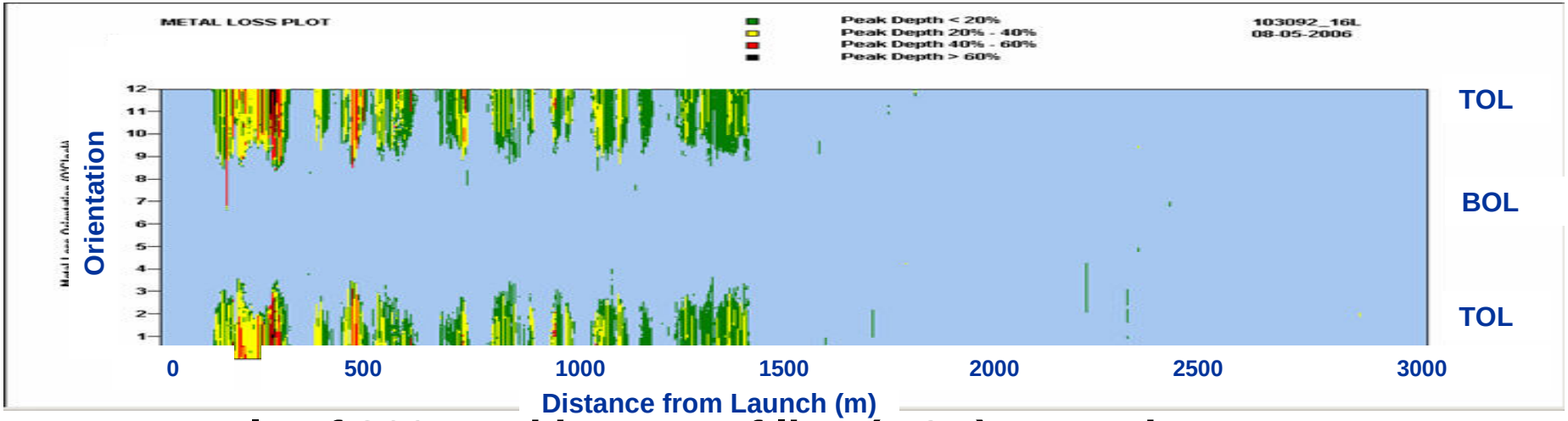


In-line Magnetic Flux Leakage (MFL) Pig

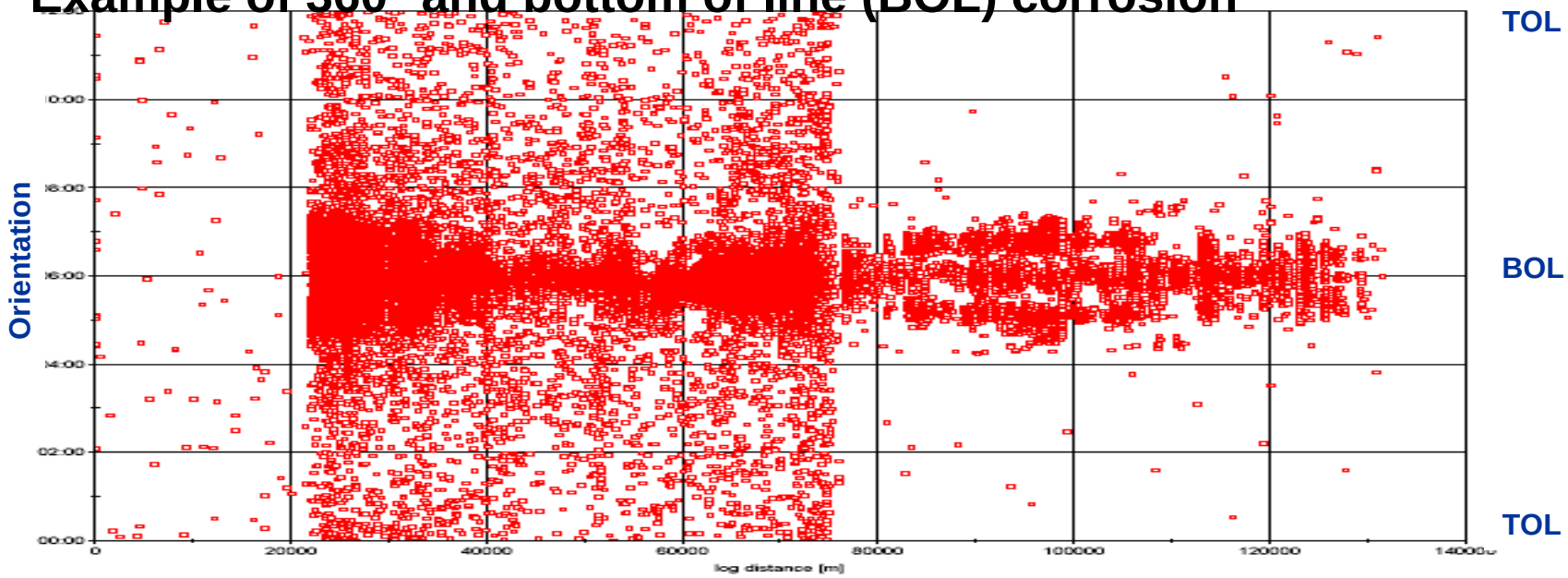
Confirming and mitigating external corrosion detected by ILI

Examples of Internal Corrosion Detected by ILI

Example of top-of-line (TOL) corrosion



Example of 360° and bottom of line (BOL) corrosion



Conclusions

Pipelines are an integral asset to upstream operations

Pipeline integrity must consider all aspects of the design, construction, and operating phases

Pipeline integrity requires adopting a:

- **"Failures are Preventable" mindset**
- **Systematic program that accounts for integrity threats**

A formalized Operations Integrity Management System describes management expectations of pipeline integrity

A formalized Facilities Integrity Management System describes how to meet management expectations by documenting and stewarding integrity programs written by subject matter experts

Adoption of corrosion management best practices can improve overall performance of pipeline operation