Integrity Management Performance

Rafael G. Mora, MBA, P. Eng

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Edmonton, AB, Friday 21 Nov 2014

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Seminar Outline

1. Purpose
2. Terminology: KPI and IM, Indicator, Measure, Criteria and Symbols
3. Where to Start Looking for Indicators & Measures
4. Characteristics of Integrity Measures
5. Classification of Public Domain IM-KPIs
6. Strategies for IM-KPI Development
7. Strategies for IM-KPI Implementation
8. Components of Management Review

KPI: Key Performance Indicator  IM: Integrity Management
Purpose

Enable attendees to develop, implement and measure pipeline integrity performance using:

- The four (4) stages of the performance cycle
- Both Integrity Management System and/or Program approaches
- Benchmark against Publicly available Indicators

2 Class Exercises: Characteristics and Classification of KPIs

Video: Harvard Business “Five Ways to Measure Performance”

Permission granted by HBR for website view
KPIs and Integrity Management

Key Performance Indicators (KPI) purpose is to

**FUNCTION**
- Represent (Rear-View)
- Anticipate (Forecast)

**INTEGRITY FOCUS**
- Condition (e.g. pipe)
- Events (e.g. internal/external)
- Processes (e.g. technical, mgmt)

**AT A TIME**
- Output-driven (e.g. Call for Action)
- Periodic (e.g. weekly, monthly, quarterly, yearly)

**GOAL**
(e.g. cracking)

Support & Improve

Compare

**KPI**: Key Performance Indicator  **IM**: Integrity Management
Approach: IMP + MS [Generic Categories]
Indicator and Measure

Integrity Performance Indicator
Defines an integrity focus, objective or outcome to be measured and compared against stakeholders’ goals, targets or expectations.

- **Pipeline Integrity Condition** (e.g. Technical Or Program)
- **Integrity Program Effectiveness** (e.g. management)
- **Environmental consequences** (e.g. technical & mgmt)

Integrity Performance Measure
Quantifies *one* or *the* key factor of an integrity performance indicator within a given time period. Indicators may be comprised of one or more measures.

**Pipeline Integrity Condition – Quarterly Measures**

- Number of anomalies exceeding criticality criteria
- Estimated remaining life of the worst anomalies (i.e. depth or Safety Factor)
Criteria and Symbols

Integrity Performance Criteria
Provide the acceptability of the integrity performance measure based on a pre-defined expectation, benchmark or standard. Multiple level criteria can be used.

- Criticality Criteria for Anomaly Depth
  - Not Acceptable/Critical: > 70% wall thickness
  - Scheduled Mitigation: 50 to 70% wall thickness
  - Acceptable/Monitoring: < 50% wall thickness

Integrity Performance Symbols
Provide expression of the results vs. acceptability criteria

- 3-color code (e.g. green, yellow, red)
- Binary response (i.e. Yes/No)
- Percentage
- Qualitative measure (e.g. low, medium, high) or
Where to Start Looking? Own and Industry (1 of 4)

1. Pipeline Characteristics *(e.g. design, manufacturing, construction)*
2. Operating conditions *(e.g. MOP, pressure cycling & spikes, on-off flows)*
3. Historical Challenges for Threat Susceptibility *(e.g. Incidents, stats)*

*Source: USA PHMSA Incidents*
Where to Start Looking? Integrity Practices (2 of 4)

**Program (Examples)**

- **Threat**
  - Hazards influencing threats?
  - All Integrity threats considered?
  - Individual and Coincidental threats assessed?

- **Consequence and Risk**
  - Consequence timely evaluated?
  - Up-to-date estimated Risk?

- **Mitigation, Monitoring, Prevention**
  - All Repairs identified?
  - Growth being reduced?
  - New threats timely caught?

- **Measure**
  - Degradation improving/worsening?
  - Trends changed?

**Management System**

- **Completed**
  - Goal, Targets and Objectives defined?
  - Required procedures available?

- **Implemented**
  - Enough resources (e.g. Human, budgetary)?
  - Planned versus Actual?
  - Followed procedures?
  - Programs on track? Delays?

- **Effective**
  - Non-Conformances?
  - Non-Compliances?
  - Incidents?
  - Continuous Improvement?
### Where to Start Looking? Integrity Threats

**Threat @ a time:** Top Event (Failure) - Intermediate - Root Cause

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOP EVENT</td>
<td>Lack of Manufacturing Quality</td>
<td>Construction Issues</td>
<td>Inadequate Operations</td>
</tr>
<tr>
<td>INTERMEDIATE</td>
<td></td>
<td></td>
<td>Overpressure</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Critical Pressure Cycling</td>
</tr>
<tr>
<td>BASIC or ROOT CAUSE</td>
<td></td>
<td></td>
<td>Human Error</td>
</tr>
</tbody>
</table>

**Threat-in-Scenario:** Initiating Event – Barrier - P of Failure - Consequence

**Number of operational events exceeding pressure limits per year-km in a given pipeline (Initiating Event)**

**Measures**

- Automatic Overpressure Protection Responded?
- Controller timely Reacted?
- Release Detected and Isolated
- Smaller Release
- Larger Release
- Barrier, Protection or Safeguard
Where to Start Looking? Human Factors

- **Human**
  - Controller Training?
  - Fatigue or tired?
  - Insufficient sleep? Call on short notice?

- **Workplace**
  - Console Overloaded?
  - Equipment with inconsistent input?
  - Excessive phone activities?

- **Operational**
  - Too many steps?
  - Distraction to abnormal by other duties (e.g. reports)
  - Task too complex?
  - Very small margin of error/response?
  - Shift Hand-off adequate/effective?

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[1] References

  
Characteristics of Integrity Measures

<table>
<thead>
<tr>
<th>Core</th>
<th>Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Integrity Approach</td>
<td>3. Types of Measures</td>
</tr>
<tr>
<td>- Integrity Management Program</td>
<td>- Lagging</td>
</tr>
<tr>
<td>- Management System</td>
<td>- Leading</td>
</tr>
<tr>
<td>2. Integrity Performance Cycle Stages</td>
<td>- Qualitative</td>
</tr>
<tr>
<td>- Input ((Feed))</td>
<td>- Predictive (Signal)</td>
</tr>
<tr>
<td>- Process ((Progress/Fraction))</td>
<td>4. Measurement Units</td>
</tr>
<tr>
<td>- Output ((System Response))</td>
<td>- Magnitude</td>
</tr>
<tr>
<td>- Outcome ((End-Results -&gt; Goals))</td>
<td>- Frequency</td>
</tr>
<tr>
<td></td>
<td>- Percentage</td>
</tr>
<tr>
<td></td>
<td>- Cumulative</td>
</tr>
</tbody>
</table>
Performance Cycle Stages:

- **HUMAN PERFORMANCE**
  - Input
    - ...
    - ...
    - ...
  - Process
    - ...
    - ...
    - ...
  - Output
    - ...
    - ...
    - ...
  - Outcome (Goals)
    - Long healthy years
    - Happiness &
    - Inner Peace

Class Exercise
Integrity Performance Cycle Stages

Outcome
[End-Results]

Output
[Response]

Process
[Progress or Fraction]

Input
[Feed]

INTEGRITY END-RESULTS
[Toward Goals]
- Safety of People
- Environment Protection
- Reliable Service

INTEGRITY RESPONSE
Reduction or Increase
- Probability of Failure
- Consequence
- Risk

INTEGRITY PROGRESS
- Identify
- Assess
- Mitigate
- Prevent
- Monitor

INTEGRITY FEED
- Competence
- Technology
- Knowledge
- Industry and Regulatory Framework
- Financial Resource

Continuous Improvement
**1. Integrity Feed (Input)**

*Shows the Integrity feed provided to the IMP and MS processes for achieving integrity objectives*

- **Number of years of experience of a given job classification (as an input)**
  - pipeline controller, cathodic protection technician, integrity engineer, in-line inspection specialist, defect assessment professional

- **Number of kilometers inspected by a given technology (as an input)**
  - Electro-Magnetic Acoustic Emission – EMAT-, Phased Array – PA-, Circumferential Magnetic Flux Leakage – CMFL-

- **Number of equipment [or man] hours [or additions] in a given activity per site/km (as an input)**
  - Variable Speed Pump, Right-of-Way surveillance, landslide remediation, assessments
2. Progress/Fraction (Process)

Shows the progress (or lack of) or fraction of an integrity process completed

- **Percentage (%) of pipeline surveillance patrols completed versus planned** [Identify]
  - Progress of Geotechnical Monitoring Program: Actual versus Planned/year

- **Number of pipeline kilometers identified as susceptible to geohazards/corrosion** [Assess]
  - Fraction of pipeline system with geohazard susceptibility

- **Percentage (%) of inhibition program completed versus planned** [Mitigate]
  - Progress of Internal Corrosion Mitigation Program: Planned versus Executed in the year

- **Number of pressure spikes between 100 to 110% MOP** [Monitor]
  - Progress of Crack Management Program
3. System Response (Output)

Shows how the pipeline system has responded to the integrity feed and progress/fraction: improving, same or deteriorating the integrity health

- **Number of releases (i.e. leaks and ruptures) on the pipeline** [Direct Output]
  - End result or outcome of Integrity Management
- **Change in the growth (e.g. corrosion, cracking, movement) from previous years** [Probability]
  - Response to Anomaly Growth Mitigation
- **Volume Reduction from Valve Program from previous years** [Consequence]
  - Response to reducing valve spacing and drain-down volume
- **Risk Reduction on Cracking from previous years** [Risk]
  - Response to reducing valve spacing and drain-down volume
Integrity Performance Cycle Stages (4 of 4)

4. End-Results (Outcome)
Shows how much the integrity goals has been achieved by the corporation

- Number of employee (or public) injuries (or deaths) resulting from pipeline incidents
  - Safety of our people
- Volume of product released (area affected) from a pipeline incident
  - Environmental protection/degradation by our operation
- Number of hours of interrupted service to customers or shippers this year
  - Reliable service to our shippers or customers

INTEGRITY END-RESULTS
[Toward Goals]
- Safety of People
- Environment Protection
- Reliable Service
Attributes of Integrity Measures

Lagging
Reports the performance occurred in the past during a defined period (e.g. monthly, quarterly, annually)
- Number of defects reported exceeding the acceptable criteria (e.g. depth or Safety Factor) - [Output/Response]

Leading
Reports the performance occurred in the past during a period of time, but it is intrinsically connected to the future providing a better chance to anticipate (not predicting)
- Percentage (%) of completion of the cracking In-Line Inspection Program [Process/Progress]

Qualitative
Reports the performance during rapid changes, breakdown and emergency capturing events, issues and achievements (i.e. Typically, when quantitative is immediately not available)
- Extent of environmental consequence (e.g. land, water, fauna, flora) during a emergency response
Attributes of Integrity Measures

Predictive or Signal Indicators

Manifestation, symptom or event (e.g. ferrous deposits) signaling a potential condition (e.g. corrosion) at an early stage (e.g. initiation, growth, dormant)

- Ferrous deposits collected during pig cleaning
  - Corrosion Initiation
  - Corrosion growth
  - Corrosion dormant

Harvard Business Review Video,
Stacey Barr
Five Ways to Measure Performance
Permission granted by HBR for website view
Attributes of Integrity Measures

Pipeline Integrity Performance Indicators

Magnitude
- Numeric (e.g. number of leaks) or
- Qualitative (e.g. controller response: low, medium, high)

Frequency or Ratio
- E.g. kilometers per year

Percentage
- E.g. % change in the minimum, average and maximum growth

Cumulative
- E.g. leak rate change between a given year and the year before
Draft KPIs in Upcoming Standards

**Draft DNV RP-F116**

*Integrity Management of Submarine Pipeline Systems*
- Management System Approach
- Uses Barriers to create KPIs
  - Design (e.g. Wall thickness)
  - Protection Systems (e.g. CP)
  - Control Systems
  - Processes and Procedures (e.g. Inspect, Mitigate, assess, monitor)
- Management-driven implementation

**Draft API RP 1173**

*Pipeline Safety Management Systems Requirements*
- Management System Approach
- Adequacy (Completion)
- Effectiveness (Risk Reduction)
- Improve pipeline safety performance
- Use of Lagging and Leading KPIs
- Frequency to identify trends and corrective actions
- Management-driven implementation

Courtesy of ASME IPC 2014 Panelists - Authorized
# Public Domain Performance Measures

## Class Exercise

<table>
<thead>
<tr>
<th>ORGANIZATION PUBLIC DOMAIN INFORMATION</th>
<th>MEASURE APPROACH</th>
<th>PERFORMANCE CYCLE STAGES</th>
<th>MEASURE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Integrity Management Program (IMP)</td>
<td>Management System (MS)</td>
<td>Integrity Nurture (INPUT)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INDUSTRY ASSOCIATIONS [Public Domain]</th>
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<table>
<thead>
<tr>
<th>REGULATORY AGENCIES [Public Domain]</th>
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<table>
<thead>
<tr>
<th>CONSENSUS STANDARDS</th>
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23
2012 API-AOPL Association Performance Measures - Class Exercise

API-AOPL PIPELINE SAFETY EXCELLENCE™
2014 STRATEGIC PLAN

GOAL 1: IMPROVE INSPECTION TECHNOLOGIES

GOAL 2: ENHANCE THREAT IDENTIFICATION & RESPONSE

GOAL 3: EXPAND SAFETY CULTURE & MANAGEMENT PRACTICES

GOAL 4: BOOST RESPONSE CAPABILITIES

Number of Releases from Onshore Transmission Pipelines
Percent Decrease in Number of Liquid Pipeline Releases Over Last Ten Years
Barrels of Crude Oil or Petroleum Product Released from Onshore Transmission Liquid Pipelines in 2012
Percentage of Crude Oil or Petroleum Product Reaching Their Destination Safely by Transmission Liquid Pipeline in 2012
Percent Decrease in Barrels Released from Onshore Transmission Liquid Pipelines Over Last Ten Years
Number of Releases Caused by Corrosion in 2012
Percent Decrease in Corrosion as a Cause of Liquid Pipeline Release Over Last Ten Years
Number of Releases Caused by Third-Party Damage in 2012
Percent Decrease in Third-Party Damage to Liquid Transmission Pipeline Over Last Ten Years
Number of Releases Caused by Materials Defect, Seams or Weld Failures in 2012
Percent Decrease in Material Defects, Seam and Weld Failures as Cause of Liquid Pipeline Release Over Last Ten Years

# of Pipeline Releases

3 yr. avg. 1999-2001 to 2010-2012

-62%

Barrels of Crude Oil and Petroleum Products Delivered by Transmission Pipeline
Crude Oil Barrels Delivered by Transmission Pipeline
 Petroleum Product Delivered by Transmission Pipeline
Liquid Pipeline Miles Operated
Crude Oil Pipeline Miles Operated
Petroleum Product Pipeline Miles Operated
Natural Gas Liquid Pipeline Miles Operated

Amount Spent Evaluating, Inspecting & Maintaining Liquid Pipeline Infrastructure
Miles of Liquid Pipeline Inspected by “Smart Pig”
In-Line “Smart Pig” Inspections of Liquid Pipeline
Number of Digs for Pipeline Maintenance
Pipeline Public Awareness Spending

# API Standard 1160-2013 Performance Measures - Class Exercise

## Table 9 - Examples of Performance Measurement by Threat

<table>
<thead>
<tr>
<th>Threat</th>
<th>Measure Number</th>
<th>Process Measures</th>
<th>Operational Measures</th>
<th>Integrity Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Leading</td>
<td>Laggng</td>
<td>Leading</td>
</tr>
<tr>
<td><strong>External corrosion</strong></td>
<td>1</td>
<td>Planned to inspect 20 highest risk segments in Year 1</td>
<td>Actually inspected 19 highest risk segments</td>
<td>Potentials on the five highest risk segments brought into compliance with NACE criteria</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Planned to inspect the remaining segments by the end of Year 5</td>
<td>All segments inspected by the end of Year 5 to bring all segments into compliance</td>
<td>Potentials on 96% of mileage brought into compliance with NACE criteria</td>
</tr>
<tr>
<td><strong>Internal corrosion</strong></td>
<td>1</td>
<td>Planned to inspect one problematic segment</td>
<td>Inspected segment identified and repaired</td>
<td>Spot checks of 100% of locations after five years showed no further wall loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hydrostatically tested two segments every 10 years</td>
<td>Reclaimed 20 miles of pipe where coating was mostly disbonded</td>
<td>Spot checks after 10 years showed no areas of disbonding</td>
</tr>
<tr>
<td><strong>Stress corrosion cracking (SCC)</strong></td>
<td>1</td>
<td>Planned to hydrostatically test two segments every 10 years</td>
<td>Recycled 20 miles of pipe where coating was mostly disbonded</td>
<td>Spot checks after 10 years showed no areas of disbonding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contact every land occupant once in three years</td>
<td>Personal contact was made with 95% of land occupants</td>
<td>Land occupants informed of risks and obligations</td>
</tr>
<tr>
<td><strong>Mechanical damage (immediate failure)</strong></td>
<td>1</td>
<td>Hire additional personnel for ground patrolling</td>
<td>Four technicians added to ground patrol staff</td>
<td>Four technicians added to ground patrol staff</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide training and alarm drills for control room operators</td>
<td>All operators received training and attended all five drills</td>
<td>All operators received training and attended all five drills</td>
</tr>
<tr>
<td><strong>Incorrect operations</strong></td>
<td>1</td>
<td>Conduct hydrostatic testing of segments once every 10 years</td>
<td>Install variable speed pumps at stations in fatigue affected segments</td>
<td>Hydrostatic testing of segments completed within first two years</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Conduct hydrostatic testing of segments once every 10 years</td>
<td>Install variable speed pumps at stations in fatigue affected segments</td>
<td>Hydrostatic testing of segments completed within first two years</td>
</tr>
</tbody>
</table>

**Courtesy of American Petroleum Institute**
<table>
<thead>
<tr>
<th><strong>A. Operations and Maintenance Corrective and Preventative Actions</strong></th>
<th><strong>IV. Integrity Management - 6. Pipeline Integrity Shutdowns for Hazard Control</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. The total number corrected</td>
<td>a. The total number of shutdowns of a pipeline segment or facility to protect the public, property and the environment as a result of emergencies</td>
</tr>
<tr>
<td>b. The total number identified for the calendar year</td>
<td></td>
</tr>
</tbody>
</table>

**VI. Environmental Protection - 1. Environmental Protection Program Training**

| a. The total number of company employees with training on the company-wide Environmental Protection Program |

**VII. Damage Prevention - 3. Pipeline Awareness - Landowners**

| a. The total number of unauthorized activities by landowners |
| b. The total number of permissions granted to landowners |

**IV. Integrity Management - 1. Pipeline Condition**

| a. The total number of features identified by ILI for field investigation, according to IMP dig criteria, for metal loss |

**IV. Integrity Management - 5. Assessment of Pipeline Hazards**

| a. The kilometres of pipeline that have been assessed for metal loss hazard |

**V. Integrity Inspection Information - 2. Kilometres of Integrity In-Line Inspections**

| a. Kilometres inspected in calendar year using corrosion or metal loss in-line inspection tools |

**V. Integrity Inspection Information - 3. Integrity Action Taken Based on In-Line Inspections Features Excavated**

| Based on in-line inspection data, the total number of features excavated in a calendar year because they met the company Integrity Management Program criteria for excavation. |

*Courtesy of National Energy Board https://www.neb-one.gc.ca/sftnvrnmnt/sft/pplnprfrmncmsr/index-eng.html imized.pdf*
Strategies for KPI Development

What are stakeholders’ needs and expected benefits from pipeline integrity KPIs?

- Be Systematic – (mid-long term and holistic)
  - Consistent in time to see the trend
  - Measures (tactic or Operational) connected with Senior Mgmt. Goal (strategic):

- Identify the Purpose (Why)
  - Internal Conformance, Performance Improvement/benchmark, External Compliance/regulatory

- Identify the Approach (How)
  - Planning, Implementation or Verification (Mgmt System)
  - Integrity Threat, Consequence or Risk reduction (IMP)

- Recognize the Focus (Where)
  - Efficiency: Integrity Feed (Inputs) or Progress (Process)
    - Leading or Qualitative
  - Effectiveness: System Response (Outputs) or End-Results (Outcomes)
    - Lagging or Qualitative or Signal
KPI Testing using SMART

Specific: clear and focused avoiding misinterpretation

Measurable: quantifiable avoiding “Yes/No”

Attainable: achievable, reasonable, credible

Realistic: possible within organization (cost effective)

Timely: doable within the timeframe provided

Courtesy of University of California
Strategies for KPI Implementation

Once performance indicators and measures developed

- **Management approval**: verification of performance indicators aligned with goals and objectives
- **Release planning**: audience expectations and needs, opening a solution space
- **Implementation**: test run or pilot, feedback mechanism
- **Checking**: Completeness and Quality; and Correcting
Management Review

Required: understanding IMP process including Integrity Threat fundamentals in conjunction with risk management focused on continuous improvement. Societal, Professional and Corporate Responsibilities are important.

- Adequacy or Completeness
  - Processes, Procedures and Activities to be safe and efficient
  - Industry Standards = Minimum Consensus (not Best Practices)
  - What are we doing for...? (Threat, Consequence, Risk, Management System element)
  - Typical Adequacy Findings
    - processes or procedures not documented or incomplete;
    - multiple procedure versions of how to do things (e.g. headquarters versus field);
    - not all integrity threats and/or consequences being assessed and/or not periodically;
    - processes focused on probability of failure not accounting for changing consequence
Management Review

Implementation

*Focus: Walking the talk by doing what we planned*

- 3-Part Comparison: Plans (needed), Budgets (available) and Execution
- *Did we do what we planned....? Why not?*

Effectiveness

*Focus: Comparing the goals against what was achieved*

- *Not much work about what was done, but what is was achieved towards the Goals*
- *What goals were achieved? no releases? no environmental damage? no unplanned downtime in the service to shippers and customers?*

- *Corrective Action Plans (CAP) + Continuous Improvement (CI) plans*
Thank YOU!

Rafael G. Mora, MBA, P. Eng

Email: rafmora@yahoo.com

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