Enhancing your compliance and integrity program with Predictive Corrosion Management

September 18-20, 2017
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BHGE inspections solution overview

**Inspection Devices**
- Permanent Monitoring
- Portables RVI, UT, EM

**Digital Inspections**

**Inspections Applications**

**Digital Inspections Cloud Platform**

**Industry-Differentiated Solutions and Services**

- Break down data silos and benefit from using a cloud-based, unified asset model
- Exploit asset integrity history and production quality information from other applications
- Ensure users always access the latest scalable, real-time cloud application functions and insightful UI
- Leverage broad suite of inspections products containing BHGE’s deep equipment and process knowledge
- Benefit from fast, evergreen analytics and self-learning models to gain insight often lost in data silos
- Leverage your current investments—open platform works with existing systems and equipment

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<table>
<thead>
<tr>
<th>Asset Integrity</th>
<th>Asset Productivity</th>
<th>Unplanned Downtime</th>
<th>Cost of Compliance</th>
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September 27, 2017

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BHGE Digital Product Portfolio Architecture

**Asset Performance Management (APM)**
- Reliability Management
- Compliance and Integrity Management
- Asset Strategy Optimization

**Machine and Equipment Health**

**Digital Twin Framework**
- Azure
- AWS
- GE Private Cloud

**BHGE Oil and Gas Digital Products**
- IntelliStream™
- Predictive Corrosion Management (PCM)
- BHGE Digital Other Products*

**SaaS Applications**
- Case Mgmt, Knowledge Mgmt, Alarm, Asset Mgmt, Condition Monitoring, SmartSignal, Visualization, and More

**PaaS**
- APM Shared Components

**IaaS**
- OT Sys
- PLM Sys
- ERP Sys

* New products under development by BHGE Digital

↓ Cost  ↑ Output  ↓ Response Time
**Risk-based inspection**
- Definition of corrosion loops/linking RBI piping components
- Assignment of potential thinning damage mechanism
- Defining the integrity operating windows (IOWs) for each thinning PDMs
- Calculate Semi Qualitative/Quantitative risk analysis for each thinning PDM

**Corrosion monitoring**
- Analytical calculations of thickness measurements of all thickness measurement locations to trend corrosion, determine remaining life, and adjust inspection intervals accordingly

**Inspection management**
- Define the overall inspection strategy for all piping components, including the extent, scope, and effectiveness of inspection

**Execute inspections**
- Mobile inspection capabilities enable inspectors to download templates to their device, once they are back in range the inspection data will automatically be loaded into the system
- Collection of thickness measurements using data loggers/Excel devices and storing against thickness measurement locations in APM

**Current compliance and integrity management program**

- **Strategy**
  - **Risk**
    - **Analytics and action**
      - **Operations & maintenance**
        - **Drive Work/Repair**
          - **Change Strategy**
<table>
<thead>
<tr>
<th>Pain points with current program</th>
</tr>
</thead>
<tbody>
<tr>
<td>No visibility to dynamic corrosion or erosion rates on high critical piping due to process fluctuations or changes related to corrosion inhibitor programs</td>
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<tr>
<td>Want to optimize my corrosion monitoring program and invest in advanced UT methods only on the right locations</td>
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<tr>
<td>Not able to take a risk-based mitigation strategy if there is a spike in corrosion rate on my process lines</td>
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<tr>
<td>Not able to feed UT sensor data to my RBI program</td>
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<tr>
<td>Don’t have high confidence UT data to lower my POF for thinning</td>
</tr>
<tr>
<td>Collecting UT sensor data where scaffolding is required and in areas that compromise safety</td>
</tr>
</tbody>
</table>
Enhancing your C&IM program with PCM

**Risk-based inspection**
- Help determine high risk assets which need PCM monitoring
- With established PCM, we can get better data confidence and get credit during the calculation of POF
- PCM installation can be one of the proposed strategies based on RBI

**Correlating PCM data with IOW excursions**
- Ability to correlate the impact of excursion of integrity operating windows for thinning damage mechanisms on the corrosion rates based on PCM data points and vice versa

**Dynamic monitoring health in APM**
- Trigger dynamic damage factor calculations for thinning damage mechanism based on the high corrosion rate calculated in thickness monitoring based on the measurements from PCM

**Predictive corrosion management**
- PCM technologies deployed on pipes to measure continuous wall thickness - helps validate and increase confidence of actual corrosion measurements over a period of time

**Installing the Righttrax sensor on the piping component**
- TMLs monitored using PCM can be tagged separately for additional focus and monitoring in APM dashboards
BHGE's Predictive Corrosion Management: how it works

Continuous data collection, real-time trending, powerful analytics

Predictive Corrosion Management from Baker Hughes, a GE company, is an APM extension that combines a ground-breaking package of Predix cloud-based software with RighthraxPM installed sensors and advisory services to continuously monitor corrosion-related risk, proactively make disposition decisions, and minimize total cost of operations.

- Righthrax PM installed sensors
- Predix, cloud-based software
- Expert advisory support

Collecting data: small profile installed sensors

- Proprietary SolGel – eliminates need for couplant, adhesives, or welding
- 1”x1” footprint – Fits under insulation
- Resolution - 0.02mm wall thickness
- UT frequency - 5 MHz
- ATEX certified

Wireless ultrasonic monitoring: Mote - 64 sensors

- Fully self-contained
- Battery powered – 5 year lifespan

Remote 64 sensors
Probe configurations

Sensors can be attached using a variety of methods and configurations on straight pipes, elbows, headers, large diameters, and flat surfaces.
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**Remote 64 sensors**
Successful applications

Wall loss due to general corrosion:
• Refineries: crude lines and Naphthenic acid
• Chemical plants: Hydrofluoric acid
• Utilities: Micro-Biological corrosion (MIC)

Wall loss due to erosion:
• Utilities: Flow Accelerated Corrosion (FAC) and high velocity steam
• Refineries: Sand in crude

Example Description
Component: Pipe
Material: Carbon steel
Fluid media: Crude oil or steam
Diameter: 2 to 22 in. (51 to 550 mm)
Thickness: 0.12 to 1.18 in (3 to 30 mm)
Onshore and above ground
Max operating temp: 200°C (392°F)
No severe corrosion on exterior
PCM demo
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Decrease inspection costs:
- 25% savings potential or $250K/year for average refinery inspection budget = $1M/year
  - Offset points with high cost-of-collection
  - Optimize with better decisions from continuous data
  - Identify critical points that are unmonitored today

Improve asset performance:
- 15% asset life extension potential
  - Optimize maintenance
  - Extend asset life 6-18 months

Optimize process/operations:
- 15% improvement in process efficiency
  - Extend run-times
  - Optimize corrosion inhibition
  - Make better decisions through predictive analytics