In-Line Inspection Data Interpretation

2012 Appalachian Underground Corrosion Short Course (AUCSC)

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For Consideration…

Discussion Question – Does strict compliance with code ensure that a pipeline or pipeline(s) are safe?

Will code maintain the integrity of the pipeline(s)?

The Pipeline Maintenance Toolbox In-Line Inspection (ILI) or Smart Pig

2004 (2011) (153.2 miles):
- 41.1 miles of 36" Mainline "C" - Station 140 to Station 145 (SC to NC)
- 60.6 miles of 30" Mainline "C" – MLV 180-15 to Station 190 (VA to MD)
- 45.8 miles of 30" Mainline "A" - Station 190 to Station 195 (MD to PA)
- 45.8 miles of 30" Mainline "B" - Station 190 to Station 195 (MD to PA)

2005 (2012) (45.3 miles):
- 20.5 miles of 30" Mainline "A" - Station 185 to Potomac River (VA)
- 24.8 miles of 30" Mainline "A" - Potomac River to Station 190 (MD)

2006 (2013) (229.0 miles):
- 44.3 miles of 30" Mainline "B" – Station 150 to MLV 155-2 (NC)
- 54.9 miles of 36" Mainline "B" – MLV 155-2 to MLV 160-10 (NC)
- 46.0 miles of 30" Mainline "A" – MLV 170-21 (James River) to Station 180 (VA)
- 43.0 miles of 30" Mainline "A" – Station 180 to Station 185 (VA)
- 45.8 miles of 36" Mainline "C" - Station 190 to Station 195 (MD to PA)

The Pipeline Maintenance Toolbox In-Line Inspection (ILI) or Smart Pig

2007 (2014) (325.5 miles):
- 40.0 miles of 30" Mainline "A" – Station 145 to Station 150 (NC)
- 40.2 miles of 30" Mainline "B" – Station 145 to Station 150 (NC)
- 46.1 miles of 36" Mainline "A" – Station 145 to Station 150 (NC)
- 68.1 miles of 36" Mainline "C" – Station 150 to MLV 155-20 (NC)
- 20.4 miles of 42" Mainline "D" - MLV 150-10 to Station 155 (NC)
- 39.5 miles of 42" Mainline "C" – MLV 155-20 to MLV 160-15 (NC to VA)
- 71.2 miles of 30" Mainline "B" - MLV 180-10 to Station 190 (VA to MD)

2008 (2015) (259.9 miles):
- 24.6 miles of 42" Mainline "D" - MLV 140-10 to Station 145 (SC to NC)
- 23.2 miles of 42" Mainline "D" – MLV 145-20 to Station 150 (NC)
- 82.4 miles of 30" Mainline "A" – Station 150 to Station 160 (NC)
- 64.9 miles of 30" Mainline "B" – Station 170 to MLV 175-20 (VA)
- 64.8 miles of 36" Mainline "C" – Station 170 to MLV 175-20 (VA)

The Pipeline Maintenance Toolbox
In-Line Inspection (ILI) or Smart Pig

2009 (2016) (480.8 miles):

- 41.2 miles of 30" Mainline "A" Station 140 to Station 145 (SC to NC)
- 41.3 miles of 30" Mainline "B" Station 140 to Station 145 (SC to NC)
- 124.9 miles of 30" Mainline "A" Station 160 to MLV 170-20 (NC to VA)
- 70.7 miles of 30" Mainline "B" MLV 160-10 to Station 170 (NC to VA)
- 62.6 miles of 36" Mainline "C" MLV 160-15 to Station 170 (VA)
- 36.0 miles of 36" Mainline "B" MLV 175-20 to MLV 180-10 (VA)
- 46.3 miles of 36" Mainline "C" MLV 175-20 to MLV 180-15 (VA)
- 17.7 miles of 42" Mainline "D" Cove Point Tap to Potomac River (VA)
- 26.2 miles of 42" Mainline "D" Potomac River to Station 190 (MD)
- 13.9 miles of 42" Mainline "D" MLV 190-20 to Station 195 (MD to PA)

2010 (2017) (186.9 miles):

- 6.74 miles of 42" Mainline "D" Station 150 to MLV 150-5 (NC)
- 17.8 miles of 10" Maiden Lateral "A" MLV 145-21 to EOL (NC)
- 17.8 miles of 16" Maiden Lateral "B" MLV 145-21 to EOL (NC)
- 69.1 miles of 20" South Virginia Lateral Station 165 to Station 165 (VA)
- 75.5 miles of 20" South Virginia Lateral Station 167 to EOL (VA to NC)

The Pipeline Maintenance Toolbox
In-Line Inspection (ILI) or Smart Pig

2011 (2018) (258.2 miles):

- 41.1 miles of 36" Mainline "C" - Station 140 to Station 145 (SC to NC)
- 60.6 miles of 30" Mainline "C" – MLV 180-15 to Station 190 (VA to MD)
- 45.8 miles of 30" Mainline "A" - Station 190 to Station 195 (MD to PA)
- 45.8 miles of 30" Mainline "B" - Station 190 to Station 195 (MD to PA)
- 105.0 miles of 24" Cardinal Lateral "A" Station 160 to EOL (NC)

2012 (2019) (45.3 miles):

- 20.5 miles of 30" Mainline "A" - Station 185 to Potomac River (VA)
- 24.8 miles of 30" Mainline "A" - Potomac River to Station 190 (MD)

The Pipeline Maintenance Toolbox In-Line Inspection (ILI) or Smart Pig

Summary of Baseline (First 10 years in Integrity Management Plan 2002-2012):

- 2004: 153.2 miles (153.2 miles cumulative) - Baseline
- 2005: 45.3 miles (198.5 miles cumulative) - Baseline
- 2006: 229.0 miles (427.5 miles cumulative) - Baseline
- 2007: 325.5 miles (752.0 miles cumulative) - Baseline
- 2008: 259.9 miles (1,011.9 miles cumulative) - Baseline
- 2009: 480.8 miles (1,492.7 miles cumulative) - Baseline
- 2010: 186.9 miles (1,679.6 miles cumulative) - Baseline
- 2011: 105.0 miles (1,784.6 miles cumulative) - Baseline
- 2012: 45.3 miles (1,829.9 miles cumulative) - Baseline

The Pipeline Maintenance Toolbox In-Line Inspection (ILI) or Smart Pig

Summary of Second Pass (Next 7 years in IMP 2011-2017):

- 2011: 258.2 miles (2,283.8 miles cumulative) – Second Pass*
- 2012: 178.4 miles (2,462.2 miles cumulative) – Second Pass*
- 2013: 229.0 miles (2,691.2 miles cumulative) – Second Pass
- 2014: 325.0 miles (3,016.2 miles cumulative) – Second Pass
- 2015: 240.1 miles (3,256.3 miles cumulative) – Second Pass
- 2016: 608.0 miles (3,864.3 miles cumulative) – Second Pass
- 2017: 186.9 miles (4,051.2 miles cumulative) – Second Pass

* 2011 & 2012 cumulative total includes the Baseline distance.

Class Outline

- The Challenge
- THE Goal: Safety
- Applicable Code
- Considerations for Successful In-Line Inspection
- In-Line Cleaning
- In-Line Geometry (Caliper)
- In-Line Smart Pig (MFL/TFI/CD)
- Data Interpretation
- Lessons Learned
- The End Result

The Challenge

Maintain the integrity of the pipeline and comply with regulations while at the same time maximizing shareholder return on investment and maintaining the competitive advantage by being the lowest cost provider.

The Challenge

In other words…

"Don't let the Pipeline Integrity Rule interfere with maintaining the Integrity of the Pipeline."

Randy W. Eckert

THE Goal: Safety

Target:

- Compliance with code in all the area, 100% of the time.
- No corrosion growth vs. critical corrosion growth rate.
- No leaks or ruptures.

It needs to be understood that no leaks or ruptures should be the target or goal, but maintaining compliance 100% of the time and achieving no corrosion growth are very costly and difficult to achieve in a large diameter multi-pipeline corridor with thousands of miles of 40+ year old asphalt coatings…which is the reason we need the Pipeline Integrity Rule.

Applicable Code

ASME/ANSI B31.8S

- Section 2.2 – Integrity Threat Classification
  - (Categories & Threats)
- Section 6.2 – Pipeline In-Line Inspection
  - (Tool Types & Threats Covered)
- Section 7.2 – Responses to Pipeline In-Line Inspections
  - Immediate: Indication shows that defect is at failure point.
  - Scheduled: indication shows defect is significant but not at failure point.
  - Monitored: indication shows defect will not fail before next inspection.

Applicable Code

49th CFR Part 192

- Subpart O - § 192.917 – How does an operator identify potential threats to pipeline integrity and use the threat identification in its integrity program?
- Subpart O - § 192.921 – How is the baseline assessment to be conducted?
- Subpart O - § 192.933 – What actions must be taken to address integrity issues?
- Subpart O - § 192.937 – What is a continual process of evaluation and assessment to maintain a pipeline's integrity?
- Subpart O - § 192.939 – What are the required reassessment intervals?
- Subpart O - § 192.943 – When can an operator deviate from these reassessment intervals?

Considerations for a Successful In-Line Inspection

For each segment of pipeline, determine and understand each of the following…each piece needs to be understood…what it is made of, how it was been built, and how it was maintained…KNOW YOUR SYSTEM:

- Location (under roads, creeks, orientation in ROW with multiple lines, etc.)
- Pipe Specifications (Diameter, Wall Thickness, Yield, Weld Type, etc.)
- Manufacturing Practices (at the mill and on site)
- Construction Methods (Pipe handling, adequate ditch, geology, etc.)
- Materials Used (Fittings, Valves, Taps, etc.)
- Coatings Used (effective, not effective, prone to shielding, etc.)
- Operating History (pressure & temperature fluctuations, liquids, etc.)
- Past Projects (smart pig runs, recoat, anomaly digs, CP effectiveness, etc.)
- Past Problems (corrosion, leaks, damage, deficiencies, etc.)

This information will be invaluable in deciding what steps are, or are not, taken…not just for the types of tools that are run but in dealing with the problems that are found.

Considerations for a Successful In-Line Inspection

- Choose the appropriate tools to clean the pipeline for a successful inspection.
- Choose the appropriate tools that will effectively evaluate each threat that can be evaluated with an in-line inspection tool…this includes evaluating the vendor.
- Determine the best method and speed for running the tools and in the case of cleaning tools how many times they will need to be run…involve everyone.
- Be prepared to deal with lines that cannot be cleaned well enough to run subsequent tools.
- Be prepared to deal with situations that prevent the running of other in-line inspection tools based on the results of geometry (caliper) tools.

In-Line Cleaning

Determine the cleanliness of the segment of pipeline…start with In-Line cleaning pigs…

KNOW OR DETERMINE YOUR SITUATION BEFORE SMART TOOLS ARE RUN.

Cleanliness is critical to accuracy and quality of both geometry (caliper) and ILI (smart pig) data.

In-Line Cleaning

Common Cleaning Mistakes:

- Assumption that pipeline segment is clean after one cleaning pass.
- Assumption that pipeline segment has to be squeaky clean to obtain acceptable data.
- Assumption that chemical cleaning is always required.

In-Line Cleaning

Factors to consider for success:

- Determine the best type and make up or configuration of cleaning pig to run for the segment of pipeline:
  - Number of and hardness of discs.
  - Are wiper arms needed and do they need brushes.
  - Magnet belt very helpful in picking up ferrous debris.
- Physical pressure and flow conditions required to propel cleaning pigs and remove debris and fluid.
- Volume and physical make up of fluid & debris received.
- Determine how many runs are necessary based on:
  - Debris and volume of liquids that come out.
  - Length of run and wear of the tool
- Potential for required chemical cleaning.

In-Line Geometry (Caliper)

Capabilities – Features that are located:

- Accurate linear position of anomalies.
- Welds and Joint Lengths.
- Dents and their size, length, and depth.
- Ovalities and their size.
- Wall thickness changes.
- Radius, degree, and direction of bends.
- Clock position of all anomalies.
- Bore restrictions such as those in valves and fittings.

The latest technology utilizes multiple channel digital tools.

In-Line Geometry (Caliper)

Critical Data Elements:

- Geometry (Caliper) tool inspection gives good indication of line cleanliness and physical condition of pipe.
- Weld mismatches or offsets that might impede and/or stop MFL Tools, potentially damaging them.
- Bore restrictions in excess of minimum MFL Tool specifications…generally cannot exceed 6 inches.
- Short radius bends.
- IMP dents.

In-Line Geometry (Caliper)

IMP Dents (ASME/ANSI B31.8S – Section 7.2.3):

- Dents located on the top 2/3 of the pipe.
- Dents that are plain and > 6% OD.
- Dents with metal loss (in particular gouges or scratches).
- Dents on a long seam or circumferential weld that are > 2% OD.
- Dents with cracking.

In-Line Geometry (Caliper)

Common Mistakes:

- Improper bore or restriction sizing.
- Improper dent sizing.
- Improper call on bend radius.

Proper tool speed is critical to accurate data collection. Faster speeds exaggerate features.

Technology advances have greatly reduced the incidence of these mistakes.

In-Line Smart Pig (MFL/TFI/CD)

Capabilities – Data Elements Collected by the Tool:

- Accurate linear position of anomalies (Absolute Distance, Mile Post, and Survey Station).
- Welds (Long Seam and Girth) plus Joint Lengths.
- External and Internal metal loss anomalies with depth expressed as a percentage loss of pipe wall thickness.
- Length, Width, and Burst Pressure of metal loss anomalies.
- Wall thickness changes.
- Mechanical damage (dents).
- Orientation or clock position of anomalies.
- Fittings, Valves, Taps, and other Features.
- Pipe material type (i.e. Seamless, ERW, or DSAW).
- GPS coordinates of features if Inertial Mapping Unit is used.

In-Line Smart Pig (MFL/TFI/CD)

Capabilities – Data Elements Collected by the Tool:

- Accurate linear position of anomalies (Absolute Distance, Mile Post, and Survey Station).
- Welds (Long Seam and Girth) plus Joint Lengths.
- External and Internal metal loss anomalies with depth expressed as a percentage loss of pipe wall thickness.
- Length of metal loss anomalies.
- Wall thickness changes.
- Mechanical damage (dents).
- Orientation or clock position of anomalies.
- Fittings, Valves, Taps, and other Features.
- Pipe material type (i.e. Seamless, ERW, or DSAW).

In-Line Smart Pig (MFL/TFI/CD)

Data Collection Sequence:

- Inspection tool is run.
- Data is downloaded from tool.
- Data translation into viewable format.
- View velocity plot and distance of data collected.
- Inspection accepted or rejected.
- Preliminary field report based on contracted terms.
- Analyst reviews data after automated data conversion.
- Pipe hoop stress remaining strength calculations.
- Notification of Immediate anomalies.
- Final graded report based on contracted terms.

In-Line Smart Pig (MFL/TFI/CD)

Factors to consider when accepting a run:

- Physical condition of tool upon receipt…are there missing or broken parts, cut cables, damage, etc.
- Cleanliness of tool upon receipt…how much debris and liquids came in and could they impeded data collection.
- Velocity plot…was tool surging, stopping and starting, or were there excessive speed excursions.
- Inspection accepted or rejected.
- Average velocity at which the tool collected data…smart pigs are speed sensitive.

Did any of these factors affect data collection?
Should a re-run be required?

2012 AUCSC - 5/15/2012

In-Line Smart Pig (MFL/TFI/CD)

Common Questions:

- Date of Run?
- Date of Receipt of Preliminary Report?
- Date of Receipt of Final Report?
- Discovery Date?
- How many Immediate digs?
- How many Scheduled digs?
- Where are the digs located?
- What will be the re-run date?

2012 AUCSC - 5/15/2012

In-Line Smart Pig (MFL/TFI/CD)

Projected Smart Pig Tool Accuracies:

- Grade corrosion down to X% wall loss on sentence listing.
- Tolerances apply to all measurements made by the tool…example: Depth is +/- 10% in 80% of the instances.
- Interaction Rules…VERY important decision that needs to be made (where will they be set: 1.5t x 1.5t, 3t x 3t, 6t x 6t, 12t x 6t, etc.).

Class Outline

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- In-Line Magnetic Flux Leakage (MFL)
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Data Interpretation

Grading order of anomalies:

- Deep metal loss pits (> 80%).
- Burst Pressure / MAOP ratios that require pressure reduction per ASME B31G or RSTRENG.
- Long seam or girth welds with corrosion or dents.
- Mechanical damage associated with corrosion.
- Mechanical damage anomalies with potential metal working (gouges).
- Lesser wall loss corrosion anomalies that do no qualify in above categories.

Data Interpretation

Grading order of anomalies:

1.) Conduct calibration dig(s) to confirm findings.
2.) All 80% depth metal loss anomalies are to be removed per code.
3.) Pressure reducing anomalies are excavated, measured, and removed or repaired.
4.) Excavate welds and dents with associated corrosion then analyze and repair if necessary.
5.) Excavate anomalies with potential metal working then analyze and repair if necessary.
6.) Excavate lesser wall loss anomalies within budget and repair.

Data Interpretation

Integrity Management Plan (IMP) Remediation Standards (ASME/ANSI B31G Section 7.2):

- Immediate
- Scheduled
- Monitored

Data Interpretation

Immediate Remediation

- Metal loss indication with a Burst Pressure that is $\leq$ 1.1 times MAOP.
- A dent having any indication of metal loss, cracking, or a stress riser.
- Metal loss indications affecting a detected longitudinal weld seam if that seam was formed by direct current or low frequency electric resistance welding or by electric flash welding.
- All indications of stress corrosion cracks.
- Indications that might be expected to cause immediate or near term leaks or ruptures based on their known or perceived effects on the strength of the pipeline.
- Any indication or anomaly that is judged by the person designated by operator to evaluate assessment results as requiring immediate action.

Data Interpretation

Scheduled Remediation

- ASME/ANSI B31.8S Figure 4 for repair of anomalies with metal loss before next scheduled assessment.
- A smooth dent at the upper 2/3 of the pipe with a depth > 6% of the pipeline diameter.
- A dent with a depth > 2% of the pipeline diameter that affects pipe curvature at a girth weld or at a longitudinal seam weld.

Data Interpretation

Monitored Remediation

- Everything Else.

Lessons Learned

- If possible, treat the segment as a bottle such that product is only being put in at one point and taken out at one point. I would recommend closing all taps during the running of Cleaning and ILI tools.
- Think long and hard about clustering rules and make sure the ILI vendor has the ability to assist with problems and supply data in the format required. In addition, make sure the vendor has a proven track record doing run comparison.
- Don't rush the vendor to get the data to you, they need to make sure that they sufficiently review the data before it is given to you.
- Definitely spend the money to get GPS positional data on all features that are recorded, it will save time and money.
- Be aware that on subsequent runs there will be anomalies that might not have been picked up on the previous runs, so dents that didn't have metal loss the first time might have them the second time.

The End Result?

Is it compliance? Yes and No…

It is, but it is a small part…there is more to it…

Bottom line, it is no ruptures or leaks, few anomalies found on smart pig runs.

Practical Advice

Several things that will help you achieve the goal that I have found to be crucial to success:

- If you don't know something ask.
- Take opportunities to educate and be educated.
- Have a support network of people you can go to in order to discuss problems and ask advice.
- Realize the need to stay open and teachable to any and all that offer advice, but be ready to determine if the source is reliable and filter out advice when the source is not reliable.
- Beware of conclusions that are drawn and then presented when they are based on only a partial set of facts.
- Keep a good journal…what happens, who you talk to and what is said, why you made certain decisions, etc.

For Consideration…AGAIN…

Discussion Question – Does strict compliance with code ensure that a pipeline or pipeline(s) are safe?

Will code maintain the integrity of the pipeline(s)?

Because we have run smart tools in a pipeline segment, does this mean that every anomaly was found and/or accurately reported?