Materials Verification (MatV) Program
Steel pipelines
Practical considerations for ramping up
to meet the new (SGTGL) rule

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Pipeline Integrity
2017

Concepts presented here generally work well – You must confirm them for yourself.
No warranty, express or implied, is given by this presentation
Part 1
Understand why we need to field verify materials

Why verify materials? – Need for

- Regulatory compliance (Safety of Gas Transmission & Gathering Lines)
- Basic pipeline design - e.g. modernization / modifications / etc)
- Integrity Management e.g. hoop stress by FET (class, seam, temperature)
- Operations (MAOP) and maintenance – install taps & connections
- Emergent issues
- Engineering Critical Analysis / Fracture mechanics (hopefully rare)
Regulations – What you must do where you do & don’t have TVC data

- **1970 – 49CFR192.105 to 113**
  - Barlow’s (hoop stress) modified by FET
  - UKP

  - Verified work order extents (pipelines built using work order packages) – Backbone of GIS data
  - Acceptable or un-acceptable documents (data)
  - Gaps in documents & therefor data
  - Exactly what data is missing in each gap
  - Strongly recommend you
    - develop document scanning & data mining process - enter into GIS
    - Use Tier levels – 1 = Single, quality record / 2 = Complementary

  - If T-MAOPV above has been completed, you only need to test where you do not have Traceable, Verifiable & Complete records
Part 2
Understand steel properties & variability to know what to test

➢ Properties – see following slides

➢ Variability in properties

   ▶ Due to pipelines being built by different work orders over time

   ▶ Manufacturing & construction (ties in with IM M&C defects)

     ✓ Variability of steels & irons
     ✓ Variability of construction documents
     ✓ Assume all mill certifications are single, quality record – must be traceable to work order segment

   ▶ Materials verification

     ✓ Variability in Non destructive test (NDT) methods
     ✓ Variability in destructive test (DT labs) methods (e.g. +/- 4.5% accuracy ASME tensile test study)
Processing → Microstructure → Properties

Begins with molten metal → Post process – Remove excess C, S & P

Specific risks by process (contaminants / defects)

- API 5L mill PT 40 -56%
- 1941 API 5L mill PT 60 -90%
- 1963 API 5L mill seam NDE
- 1967 API 5L mill seam PWHT

Figure 3. The growth of railway network in Germany

Figure 5. Total number of publications related to fatigue failures in the 19th century
# Probability of pipe by process - Nationwide

<table>
<thead>
<tr>
<th>Year</th>
<th>Raw steel (mil. tons)</th>
<th>Raw steel %</th>
<th>Open Hearth</th>
<th>Open Hearth %</th>
<th>Basic Oxygen</th>
<th>Basic Oxygen %</th>
<th>Electric Arc</th>
<th>Electric Arc %</th>
<th>Total %</th>
<th>Total ton</th>
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<td>3%</td>
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### 1940 to 1970 by decade

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### 1970 to 1990 by decade

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<th>Basic Oxygen</th>
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### 1990 to 2010 by decade

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<td>54.9%</td>
<td>42.7%</td>
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**WWII Refurbished & relocated pipe – May be a lot older than relocation work package dates**
Steel – Stress Strain diagrams

Toughness (absorb energy) approximation (low strain rate)

42,000 psi x \(\frac{1}{4}\)" x \(\frac{1}{4}\)" x 0.250" x 1 ft / 12" = 55 ft lb

80,000 psi x \(\frac{1}{4}\)" x \(\frac{1}{4}\)" x 0.150" x 1 ft / 12" = 62 ft lb
Part 3
Understand where to plan verification work

- For transmission, the MAOP Verification (T-MAOPV) program / updated GIS data tells you where data needs to be verified
  - Pipeline Safety Act of 2011 Section 23 – Transmission) - Verify MAOP documentation in Class 3 & 4 & HCAs
  - The SGTGL NPRM (192.607) proposes material verification in Class 3 & 4 & HCAs
  - If the T-MAOPV program has been completed, the only testing needed will be for segments with non TVC (missing or unacceptable) documents
  - If the Transmission MAOP Verification program has not been completed – It should be done asap or the NPRM could require testing for all segments – This would ignore all legacy documentation

- Plan groups of tests within work order extents
Where - What dig site spacing to test in work order segments

SGTGL NPRM 192.607(d)

(v) The minimum number of test locations at each excavation or above-ground location is based on the number of joints of line pipe exposed, as follows:

   (A) 10 joints or less: one set of tests for each joint.

   (B) 11 to 100 joints: one set of tests for each five joints, but not less than 10 sets of tests.

   (C) Over 100 joints: one set of tests for each 10 joints, but not less than 20 sets of tests.

(vi) For non-destructive tests, at each test location, a set of material properties tests must be conducted at a minimum of five places in each circumferential quadrant of the pipe for a minimum total of 20 test readings at each pipe cylinder location.

(vii) For destructive tests, at each test location, a set of materials properties tests must be conducted on each circumferential quadrant of a test pipe cylinder removed from each location, for a minimum total of four tests at each location.

(viii) … if the test results identify line pipe with properties that are not consistent with existing expectations based on all available information for each population, then the operator must perform tests at additional excavations
Part 4
Understand how to do testing

- **Pipe**
  - Direct exam
  - Destructive testing
  - NDT option to destructive testing

- **Valves**
  - Markings
  - Markings not legible or missing

- Use standardized planning & testing process – Plan, do tests & document DT & NDT tests the same way on every dig in every work order
Testing Pipe – At each Bell Hole dig

➢ Step 1 – Always perform Direct Exam with OES chemistry

   ▶ Provides

   ✓ integrity exam while bell hole is open – Fill out your normal IM Direct Exam forms

   ✓ Collect all “free” info

   ✓ “Fingerprint of pipe at each dig site – Compare fingerprints of digs within work orders

   ▶ Should be done at every bell hole no matter which of the following options are chosen
Testing Pipe – At each Bell Hole dig

- **Step 2 – Get sample with accurate location info**
  - Preference – If line can be shutdown, cutout ~ 30 inch pipe & replace with new (fully documented pup) – Use paint pencil to mark info on pipe (dig #, lat / long, etc)
  - If line can’t be shutdown, locate seam weld & install hot tap fitting (pipe dia. X 6 inch branch) and remove coupon (curved coupon is ~ 5 ¼ inches in dia.) for lab destructive testing – Do not reinstall coupon in pipe
  - Be sure field crew fills out Chain of Custody tracking forms with accurate location info (most challenging step is to make sure crews document accurate locations) – if not:
    - No document – Test can’t be used
    - Wrong location – Test can’t be used

- **Step 3 – Send cutout / hot taps to IM for review of COC & pipe / hot tap inspection**

- **Step 4 – Send to machine shop & lab for testing – Be sure they use COC process**
Testing - Pipe - Destructive testing at lab

- Always ship pipe samples to location where they can be examined by IM - Allows
  - Chain of custody paperwork is correct
  - Samples properly marked
  - Check location info
    - lat / long
    - street address
    - sketch

Possible 4 toughness samples

4 tensile test samples

Chemistry samples
NDT options to destructive Pipe tests

SGTGL NPRM 192.607(d)(iv) – May use NDT if approved by SME in Metallurgy & Fracture Mechanics

Hardness vs. YS

ASME ____ study

SSM

Fig. 3 — Decarburization of 5160 modified spring steel defined by surface hardness and incremental tunings analyzed chemically for carbon content as a function of whether or not the surface was descaled or was covered by mill scale, and austenitizing at 1600°F for 60 minutes.

Indentation curve

Tensile curve
Pipe testing - NDT – SSM

- Positive Material Identification process
  
  - NDT industry calls only chemistry identification (e.g. OES or XRD) PMI
    - Identifies the type of steel (e.g. low C steel, 304SS, 347SS)
    - XRD has “recipes” for many alloys for immediate ID of the most common ones
  
- TDW uses the term PMI for a combination of SSM & OES
  
  - Need to be aware of limitations of SSM
Non mainline pipe - SGTGL

(4) For mainline pipeline components other than line pipe, the operator must develop and implement procedures for establishing and documenting the ANSI rating and material grade (to assure compatibility with pipe ends).

(i) Materials in compressor stations, meter stations, regulator stations, separators, river crossing headers, mainline valve assemblies, operator piping, or cross-connections with isolation valves from the mainline pipeline are not required to be tested for chemical and mechanical properties.

(ii) Verification of mainline material properties is required for non-line pipe components, including but not limited to, valves, flanges, fittings, fabricated assemblies, and other pressure retaining components appurtenances that are:

(A) 2-inch nominal diameter and larger, or

(B) Material grades greater than 42,000 psi (X-42), or

(C) Appurtenances of any size that are directly installed on the pipeline and cannot be isolated from mainline pipeline pressures.

(iii) Procedures for establishing material properties for non-line pipe components where records are inadequate must be based upon documented manufacturing specifications. Where specifications are not known, usage of manufacturer’s stamped or tagged material pressure ratings and material type may be used to establish pressure rating. The operator must document the basis of the material properties established using such procedures.
Valves

- Plan field verification on each valve separately
  - Photo valve setting & nameplate data
  - Nameplate can be enough to verify the valve data

- If flanged valve nameplate is missing or unreadable – Can verify flange rating on next page, but – if flanges were welded on weld end valve, flanges may not be same rating as valve
  - Note – Check ASTM standards – Get API 6D standard

- If valve is old & undocumented, consider replacing
Read markings if legible

Wrought butt weld fittings
WP = certified to ASME B16.9
ASTM A 234 / B = Grade B

Specialty fittings (TDW)

For marked components
Don’t need OES
Rating considers material
Flanged components – No markings or not legible

Scrap off paint & scale & measure
Do OES – Rating varies by material

Recoat

Stations - Use station survey process

➢ Survey all data in station

<table>
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<tr>
<th>Use calipers</th>
<th>Yellow = can’t use</th>
<th>Use set of nuts</th>
<th>Bolt holes covered</th>
<th>Use calipers</th>
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<td>13 1/2</td>
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<td>3/4</td>
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<td>18 1/2</td>
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If dimensions don’t match ASTM, flange may be special – Contact manufacturer if known
Welded valves

- Can we use valve dimensions per GTI presentation?
Welds - Metallography

Figure 11
Specimen ID: Sample K
Magnification: 7X
Etchant: 2% Nital

Figure 12
Specimen ID: Sample L
Magnification: 7X
Etchant: 2% Nital

Bond Plane Microstructure

- "As welded" microstructure showing weld bond plane and HAZ (Heat Affected Zone) with "hour glass" very evident.
- A seam annealed microstructure.
- U.S. Steel full body normalized and hot reduced microstructure, no visible HAZ. Weld bond plane virtually invisible.
More info

Questions