Refined Methodology for Assessment of Weld High-Low Misalignment

MATH-5-2

Contract Number: PR-350-174511

Center for Reliable Energy Systems
5858 Innovation Dr.
Dublin, OH 43016
614-376-0834

PRCI 2018 TC Meeting
October 23 - 26, 2018
San Diego, CA, USA
Background and Incentives

- Several incidents in the US around 2009 - 2010
  - Hydrostatic failures
  - In-service leaks soon after lines were put in service
- PHMSA issued ADB-10-03 (March 18, 2010)
  - Girth weld quality issues were identified.
  - Some of the contributing factors
    - Improper transitioning
    - Misalignment
    - Improper welding practice and/or not following qualified welding procedure
    - Hydrogen-assisted cracking and high stress
- Questions
  - Misalignment is not new in pipelines. Why do some welds fail while others are OK?
  - Is the current practice (including codes and standards) adequate?

Bruce, W., pipeline construction issues

https://primis.phmsa.dot.gov/construction/issuewelding.htm
Objectives and Deliverables

- Objectives
  - Develop recommendations for misalignment limits in formats consistent with API 1104 and CSA Z662
  - Communicate the recommendations to the target standard committees

- Deliverables
  - Recommendations on misalignment limits as workmanship criteria
  - Recommendations on applying existing ECA procedures to welds containing misalignments
  - Final report
Status of Deliverables

- Recommendations on misalignment limits as workmanship criteria
  - Completed
  - Uploaded to PRIME (Jan 2018 monthly update)
- Recommendations on applying existing ECA procedures to welds containing misalignments
  - Completed
  - Included in draft final report
- Final report
  - Draft report was uploaded on 09/20/2018
  - Voting period was closed on 10/16/2018
  - In process of addressing comments
Recommendations on workmanship criteria

- Two-level approach
  - For misalignments below a threshold level
    - Recommendations on the dimensions of the weld profile were provided to protect against the detrimental effects of misalignment
      - Applicable to most misalignment scenarios
      - Relatively easy to implement
  - For misalignments exceeding the threshold level
    - Additional recommendations on the weld profile were provided
    - No hard limit on misalignment
    - More demanding in implementation

- Developed based on experimental results from the preceding phases
- Validated by finite element analyses (FEA)
Recommendations on applying ECA procedures

- Evaluates the conservatism in the API 1104 Annex A procedures when applied to welds containing misalignments
Recommendations on Workmanship Criteria

Part 1 – Default requirement

- The weld profile dimensions are given in Figure 1.
- The high-low misalignment, as measured at the pipe OD surface, shall not exceed the maximum permissible misalignment in Table 1.
- The weld cap width shall meet the requirements in Table 1. If the weld bevel angle is not given in Table 1, the minimum required weld cap overbuild calculated for Part 2 over typical weld profiles weld cap width may be obtained by interpolating two values between two bevel angles in Table 1.
- The weld cap height shall meet the requirement in Figure 1.
- The weld cap should have a convex shape and generally smooth transitions at the ends.
<table>
<thead>
<tr>
<th>Wall Thickness</th>
<th>Maximum Permissible Misalignment</th>
<th>Minimum Required Weld Cap Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20° Bevel Angle</td>
</tr>
<tr>
<td>$t &lt; \frac{3}{16}$&quot;</td>
<td>1/8&quot;</td>
<td>9/16&quot;</td>
</tr>
<tr>
<td>3/16&quot; $≤ t &lt; \frac{1}{4}$&quot;</td>
<td>1/8&quot;</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>1/4&quot; $≤ t &lt; \frac{3}{8}$&quot;</td>
<td>1/8&quot;</td>
<td>11/16&quot;</td>
</tr>
<tr>
<td>3/8&quot; $≤ t &lt; \frac{1}{2}$&quot;</td>
<td>1/8&quot;</td>
<td>13/16&quot;</td>
</tr>
<tr>
<td>1/2&quot; $≤ t &lt; \frac{5}{8}$&quot;</td>
<td>1/8&quot;</td>
<td>7/8&quot;</td>
</tr>
<tr>
<td>5/8&quot; $≤ t &lt; \frac{3}{4}$&quot;</td>
<td>5/32&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>3/4&quot; $≤ t &lt; \frac{7}{8}$&quot;</td>
<td>3/16&quot;</td>
<td>1-1/16&quot;</td>
</tr>
<tr>
<td>7/8&quot; $≤ t &lt; 1$&quot;</td>
<td>7/32&quot;</td>
<td>1-1/8&quot;</td>
</tr>
<tr>
<td>1&quot; $≤ t$</td>
<td>1/4&quot;</td>
<td>1-1/4&quot;</td>
</tr>
</tbody>
</table>
Part 2 – Additional Requirements if Default Misalignment Allowance is Insufficient.

- Misalignment greater than that given in Part 1 is permitted, provided the following additional requirements are met.
  - The weld cap width shall meet the requirement in Figure 2.
  - The weld cap height shall meet the requirement in Figure 2.
  - When there is a conflict in the requirements between Part 1 and Part 2, the requirements leading to greater weld cap width and weld cap height shall prevail.
Weld Cap Height $\geq \frac{1}{16}''$

Misalignment, $h$

$t$

$\leq \frac{5}{16}''$

$t$
Recommendations on Applying ECA Procedures

- For high-low misalignments up to 40% of pipe wall thickness, the ECA procedures in API 1104 Annex A can be applied, without the need to correct for the misalignments, to obtain conservative alternative flaw acceptance criteria.
Thank You

- Q&A