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Pipeline Construction:
Quality Issues and Solutions Action Plans

Best Practices in Applying API 1104 Appendix A

The INGAA Foundation, Inc.

Best Practices in Applying API Standard Practice 1104 Appendix A

Introduction

Welding continues to be one of the most commonly cited issues during U.S. Department of Transportation, Pipelines and Hazardous Materials Safety Administration (PHMSA) inspections of new pipeline construction projects. As use of mechanized welding has increased, PHMSA has reported that inspectors have observed instances where field construction practices failed to meet the requirements of API 1104, Appendix A. It is well recognized that the application of Appendix A can be complex, demanding thorough engineering analysis and disciplined implementation. If misapplied, the use of Appendix A may lead to added risk to pipeline serviceability and may also lead to a general lack of confidence in the industry's overall ability to apply the Appendix A methodology. The purpose of this document is to identify, explain, and provide guidance on how to mitigate the potential pitfalls associated with the application of API 1104, Appendix A.

API 1104, Appendix A Implementation Process

To understand the potential pitfalls associated with the application of Appendix A, it is first important to understand the process employed for implementing Appendix A. Figure 1 provides a high level process overview for implementing Appendix A.

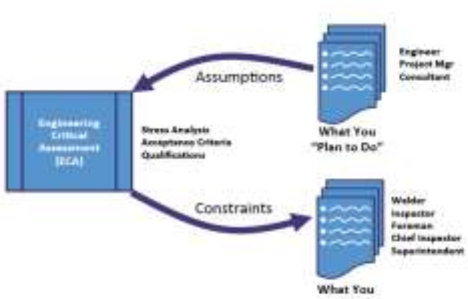

Figure 1. High-level process overview for implementing API 1104, Appendix A

The process for implementing Appendix A requires the development of an engineering basis to perform an engineering critical assessment (ECA). An example of the contents of an ECA is shown in Table 1.

Table 1 - Example of Contents of An Engineering Critical Analysis Report

1. Introduction
2. ECA Procedures
3. ECA Input Data
    a. Crack Tip Open Displacement (CTOD) Test Results
    b. Tensile Properties
    c. Applied Loadings/Stress
    d. NDE Sizing Errors
4. Results of ECA
5. Summary

The engineering basis provides inputs to a stress analysis. The stress analysis provides stress levels for use in the ECA that result in the establishment of defect acceptance criteria and qualification requirements for welding and non-destructive testing procedures. An example of the contents of a stress analysis is shown in Table 2.

Table 2 - Example Contents of Stress Analysis Report

1. Introduction
2. Approach
3. Identification and Classes of Stresses
    a. Construction
    b. Commissioning
    c. Operating
4. Analysis
    a. Curvature and Span Load
    b. Pipe Lowering Stress
    c. Horizontal Directional Drilling Stress
    d. Overburden and Vehicle Stress
    e. Operating Stress
    f. Thermal Stress
    g. Combined Stresses
    h. Code Requirements – ASME B31.8
5. Conclusions

It is critical that the engineering basis and ECA results are reflected as constraints used by construction personnel. Failure to ensure that the engineering bases used for the ECA are reflected as constraints during construction is often the root cause for problems that occur during the implementation of Appendix A.

Potential Pitfalls in Applying Appendix A

Potential pitfalls that are most commonly associated with the application of Appendix A have been identified and are provided below:

Stress Analysis

- Failure to control lifting and lowering practices within the limits used as input to the stress analysis used for the ECA
- Failure to account for other or abnormal stresses to be encountered during construction

Weld Procedure Qualification

- Failure to adequately consider base metal properties through proper qualification for each grade, manufacturing process or chemical composition
- Failure of actual materials and welding practices to match qualified procedures

Welder Qualification

- Failure to implement controls to prevent non-traditional welds to be made without sufficient qualification

Acceptance Criteria

- Failure to properly account for automated ultrasonic testing (AUT) inaccuracy during establishment of defect acceptance criteria

Inspection

- Failure to fully consider joint design and alignment variations during AUT qualification
- Failure to perform an adequate number of defect welds during AUT qualification

Mitigating Potential Pitfalls

Provide general overview of the keys to mitigating pitfalls (job aids, training, construction specifications)

Stress Analysis

Provide a brief overview of how to avoid pitfalls and provide tools to support:

1. Stress analysis table showing key stresses and assumptions
2. Lowering and lifting schematic, with maximum lift and lowering amounts that can be used to train and communicate requirements to equipment operators

Weld Procedure Qualification

Provide a brief overview of how to avoid pitfalls and provide tools to support:

- Provide sample qualification matrix showing various pipe material combinations

Welder Qualification

Provide a brief overview of how to avoid pitfalls, with specific examples of when qualified procedures may not cover abnormal situations – back welding, misalignment, repair welds, etc.

Acceptance Criteria

Provide a brief overview of how to avoid pitfalls and provide tools to support:

- Provide template for documenting ECA results, AUT error, and final defect criteria

Inspection

Provide a brief overview of how to avoid pitfalls and provide tools to support:

- Provide guideline document of joint designs and AUT qualification requirements (essential variables for AUT)
- Provide a standard for number of defect welds based on joint design variations

References

1. "Guidelines for Interpretation and Application of API 1104", PRCI Contract API 1-2, Pipeline Research Council International, Inc., Arlington, Virginia.

2. Wang, Y.Y., M. Liu, D. Horsley and G. Bauman, "A Tiered Approach to Girth Weld Defect Acceptance Criteria for Stress-Based Design of Pipelines, 6th International Pipeline Conference, Paper No. IPC2006-10491, September 25-29, 2006, Calgary, Alberta, Canada.

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