Transactions, **SMiRT-26**
Berlin/Potsdam, Germany, July 10-15, 2022
Division VIII

Level 3 Fitness for Service Assessment of an NPS 3 Buried Pipe with Dents and Local Wall Thinning

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Introduction

The aim of this study is assessing the fitness for service (FFS) of a NPS 3 scheduled STD buried pipe until the next scheduled inspection. The investigated pipeline is buried in a dense soil (0.08 lb/in^3) at 6.5 ft below the ground level. The pipe is used to transfer machinery lubrication oil from the oil tanks to supply line. Using an inline automatic ultrasound inspection (AUT) tool, a dent of 0.07 in depth and 1.18 in width. While the minimum thickness measured was 0.205 mm with an estimated conservative corrosion rate of 0.63 Mil/year. Due to the pipe relatively small size and the soil load, a level 3 elastic-plastic FFS assessment using finite elements analysis (FEA) is performed as per the rules of parts 5 and 12 of API 579-1/ASME FFS-1, 2016.

Methodology

The pipe material was modeled using a multi-linear isotropic hardening model based on Annex-3D of ASME BPVC VIII, 2019. The indentation is performed on the FEA model using a spherical rigid indenter. To get the radius of the indenter, a curve fitting of the AUT inspection data was conducted and the smallest radius (2.35″) from the circumferential and axial direction was conservatively used, as shown in Figure 1. The measured thicknesses at the dent location are used to determine the corrosion rate of the pipe and estimate its thickness at the next planned inspection date.

Four different loads were considered in this level-3 FFS assessment, namely, internal design pressure (60 psi), dead weight, hydrostatic
pressure, and soil weight (external pressure). Factorized load combinations are used to check against the global plastic collapse and local failure criteria checks according to the rules of part 5 API 579-1/ASME FFS-1, 2016.

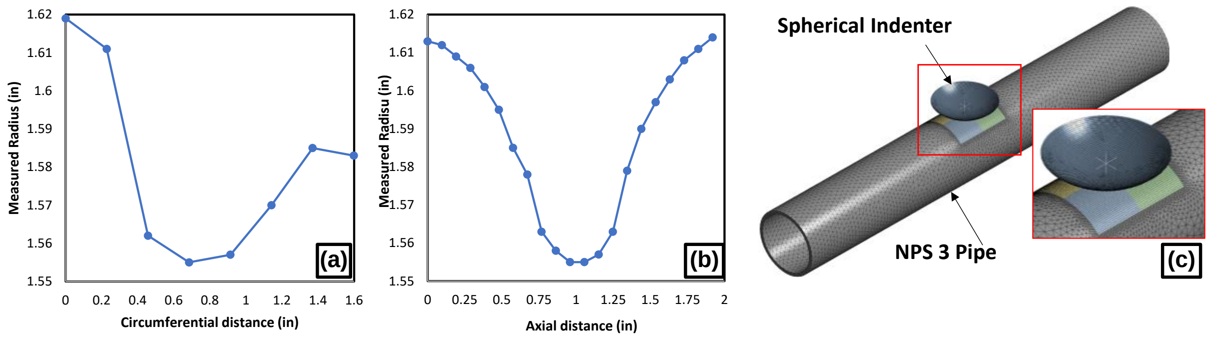

Figure 1. Variation of the inner radius of the inspected pipe at the indentation area: (a) circumferential, b) axial path, and c) meshed model of the pipe with the indenter.

Results

The indentation profile obtained from the FE model conservatively exceeds the measured AUT profile, as shown in Figure 2(a) and (b). The model has converged during the global plastic failure analysis, as shown in Figure 2(c). The strain ratio of the equivalent plastic strain to the limiting strain during the local failure analysis was 0.65.

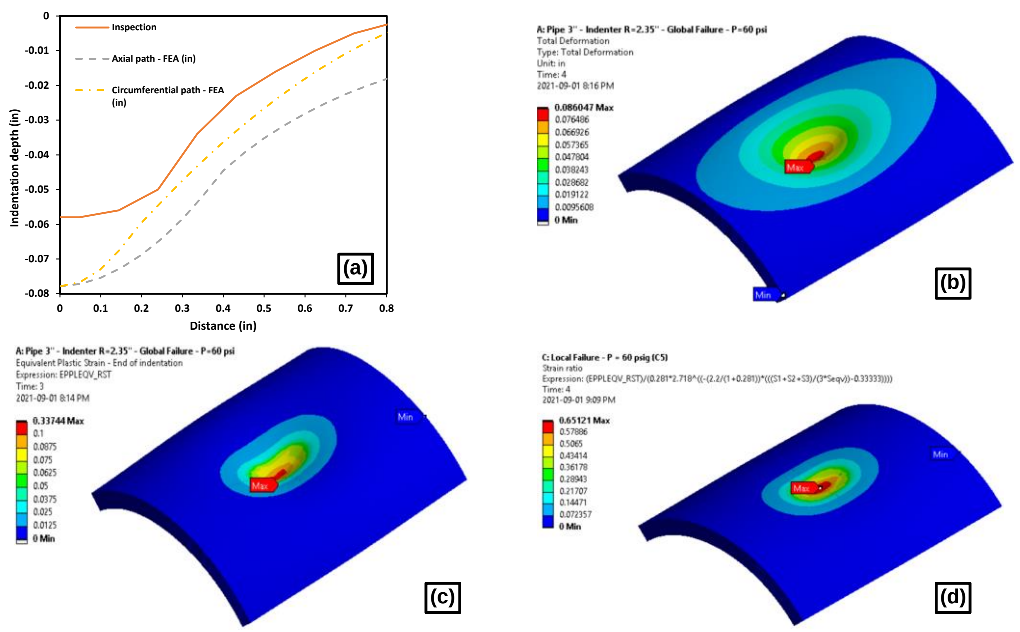

Figure 2. (a) Indentation profile comparison, b) total deformation, c) plastic strain, and (d) strain ratio.

Conclusions

Since convergence was achieved for the global collapse check; the defected pipe is stable under the applied design loads and the projected thickness. Since the maximum strain ratio is less than 1.0, the allowable plastic strain is greater than the maximum predicted plastic strain and the requirement for protection against local failure is satisfied.

References

American Petroleum Institution. (API) (2016). *Fitness-For-Service, API 579-1/ASME FFS-1*, Washington, DC, USA.

American Society of Mechanical Engineers (ASME), (2019). Boiler and Pressure Vessel Code, Section VIII - Rules for Construction of Pressure Vessels, Division 2 - Alternative Rules, New York, NY, USA.