Title

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Abstract

Displacement-controlled loading on pipelines can impose longitudinal strains much greater than yield strain. For onshore pipelines this type of loading comes from ground movements such as seismic activity, slope instability, frost heave, and mine subsidence, etc. One example of displacement-controlled loading for offshore pipelines is pipe laying by reeling. Pipeline construction and maintenance standards worldwide do not typically address this type of loading. Pipelines are designed and operated by assuming the materials response is within the elastic range.

Generally speaking, displacement-controlled loading imposes a much more severe demand on pipeline materials and their welds than load-controlled loading. The structural integrity of pipelines is much more profoundly influenced by the material specifications under displacement-controlled loading than under load-controlled loading. Certain aspects of material specifications that are beneficial for load-controlled loading may be detrimental for displacement-controlled loading.

Pipeline designs with specific objectives of sustaining displacement-controlled loading with longitudinal strains greater than material's yield strain (typically defined as strains greater than 0.5%) are often referred to as strain-based design. Such designs are inevitably affected by pipeline girth welds and the related weld defect acceptance criteria, as girth welds are generally considered the weakest link in the structural integrity of pipelines under high longitudinal strains. A framework relating girth weld defects, material properties, and strain capacity is first presented in this paper. The basis of this framework is akin to engineering critical assessment (ECA) and the philosophy of fitness-for-service (FFS). The framework establishes the baseline solution for determining tensile strain limits of pipelines. Specific issues related to high strength steels and their welds, such as HAZ softening and uniform strain, are discussed in the second part of the paper. The paper concludes with general remarks about strain-based design of pipelines and future research directions.

Keywords
Pipeline, Strain-based design, Tensile strain capacity, Linepipe specification, Welding procedure qualification