CSA GROUP RESEARCH

Development of a risk consistent safety class system and design safety factors for CSA Z662 – Phase 1

Executive Summary

January 2019

Author

C-FER Technologies, 3712 Roper Road, Edmonton, AB, T6B 3T9 Canada

Funders

This work has been funded by Enbridge, Husky Energy, Trans Mountain Corporation, TransCanada Pipelines, and CSA Group.

Executive Summary

The objective of this project is to develop a set of pipeline safety factors that achieve known, acceptable, and consistent public safety and environmental protection levels for all pipelines and service fluids addressed in CSA Z662, *Oil and gas pipeline systems.*

The project is divided into two phases, with Phase 1 focusing on demonstrating the methodology and its design implications, and developing a work plan for full implementation. Subject to acceptance of the approach and development plan, and availability of the required funding, the content for the standard will be developed in Phase 2. This document describes the results of Phase 1.

Background

The Technical Committee (TC) for CSA Z662 has formed a Class Location Task Force (CLTF) to review and propose improvements to the class location system and location factors used in Clause 4 of the 2015 Edition of the Standard. In addition to making proposals for short-term incremental changes to the location factors, the CLTF is also developing a long-term plan for a more fundamental change from the current class location system to a new risk-based safety class system and an associated set of design safety factors. The CLTF has targeted the 2023 Edition of the Standard for possible inclusion of this fundamental change to Clause 4.

The specific objective of Phase 1 was to develop sufficient information to permit the CLTF and, subsequently, the TC to make an informed evaluation of the value of the proposed approach and a decision on pursuing full implementation. The work utilized the reliability based design and assessment approach underpinning Annex O in the current CSA Z662-15. The scope of Phase 1 was limited to pipelines that have been addressed in this Annex, which include buried cross-country non-sour natural gas and high-flash-point low vapour pressure (LVP) liquid transmission pipelines.

Problem

CSA Z662-15 relies on a working stress pipeline design approach based on limiting the hoop stress in the new pipe to a fraction of the specified minimum yield strength of the pipe material. This approach has been shown to result in variable safety levels. This has been identified by the industry and regulators as an opportunity to efficiently direct resources toward the goal of maximizing overall pipeline safety.

Proposed solution

This project aims to develop new pipeline safety factors. The new safety factors were developed by creating a comprehensive database of pipelines within the scope of the CSA Z662-15 (i.e., different diameters, pressures, steel grades, location classes, and service fluids). Considering all applicable design conditions, the reliability based design approach was used to find the wall thickness required to meet the appropriate reliability target for each pipeline in the database. The wall thicknesses were then used to back-calculate equivalent single hoop stress safety factors (i.e., the hoop stress safety factor that would result in the wall thickness obtained from the reliability based design approach), and these safety factors were then synthesized and summarized in a format suitable for inclusion in the standard.

The key outcomes of the work include the following:

1. Safety class system

Six pipeline safety classes have been defined and an approach to assign a safety class to any individual pipeline has been developed. To ensure risk consistency, the safety class assignment is based on the line attributes that control failure consequences, including diameter, pressure and population density for gas pipelines, and diameter and site sensitivity for LVP liquid pipelines. The safety class system is proposed as a replacement to the current class location system in CSA Z662-15.

2. Safety factors

Risk-consistent safety factors were developed to replace the design and location factors in Clause 4 of CSA Z662-15. The safety factor is defined as a function of the safety class and the basic design parameters (pressure, diameter, and grade). The safety factor can be calculated using a simple formula or selected from a table.

3. Safety factor adjustments

Safety factor adjustments were developed to reduce the required wall thickness for pipelines with enhanced mechanical damage protection, and increase the required wall thickness for pipelines with low fracture toughness.

4. Full implementation work plan

The work plan developed for Phase 2 of the project covers extending the approach to include all pipelines within the scope of CSA Z662 and providing the content for the standard. The plan covers developing an approach to assign safety classes to service fluids not addressed in Phase 1, including low-flash-point LVP liquids, high vapour pressure (HVP) liquids, sour products, multiphase, oilfield water, and carbon dioxide), as well as developing safety factors for upstream lines, gas distribution lines, crossings, and station piping. It also covers drafting CSA Z662 to incorporate the new design approach and working with the appropriate committees to support the approval process.

Benefits

The proposed approach is fundamentally different from the wall thickness design provisions in CSA Z662-15. The new design approach uses risk and reliability principles to develop safety factors that achieve known, consistent, and defensible levels of public safety and environmental protection. It provides a comprehensive solution to the opportunities raised for industry to change the approach in CSA Z662. Specifically, the new design approach will ensure that CSA Z662 has a consistent safety class system that fully addresses the safety and environmental implications of a release, and a rational design approach that addresses the key failure mechanisms, including burst under pressure and failure of gouged-dents caused by external interference. The results of the work demonstrate that the approach enhances safety for small diameter pipelines in high consequence areas and reduces cost for large diameter pipelines in low consequence areas. This new pioneering design methodology will help distinguish CSA Z662 as having one of the most progressive onshore pipeline design approaches in the world.