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Forthcoming Changes in the CSA Z276 LNG Standard

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The LNG standard published by the Canadian Standards Association, CSA Z276, *Liquefied natural gas (LNG) — Production, storage, and handling* was last published in 2015. This standard is primarily adopted by Canadian provinces for application to existing and proposed LNG facilities in Canada, but is also referenced in other areas of the world. The standard is similar to National Fire Protection Association (NFPA) standard 59A that is prevalent in the U.S. Z276 covers the location and siting, equipment selection, construction techniques, and fire protection requirements, as well as operations, maintenance, and personnel training guidelines for LNG facilities.

Recent developments implemented in the current revision cycle for the standard will expand or significantly modify Z276. These changes, scheduled for implementation in the 2018 edition of the standard, will revise the siting methodologies and scope of LNG facilities covered by the standard. The changes address the need to provide a modernized regulatory basis for a quickly-changing LNG industry that requires siting considerations from a more modern process safety perspective. This paper will describe the changes that have recently been implemented in the standard and how those changes seek to adapt to the types of LNG facilities being proposed and built.

INTRODUCTION

The LNG industry has for several decades been subject to codes and standards that define and/or regulate the siting, design, construction, and operation of the various facilities. While this can be seen as restrictive when compared to other hydrocarbon processing or handling facilities, the modern safety record of the LNG industry points to a conclusion that the codes and standards have served to prevent hazardous fluids releases. In Canada, the standard that is generally applied to

LNG facilities is the Canadian Standards Association (CSA) Z276 standard, *Liquefied natural gas (LNG) — Production, storage, and handling.* The standard was last published in 2015 and has undergone some significant recent developments.

The developer and publisher of the standard, CSA Group, is a not-for-profit membership-based association serving business, industry, government and consumers in Canada, and the global marketplace. CSA develops standards designed to enhance public safety and health, advance the quality of life, help to preserve the environment, and facilitate trade. Standards are developed through a consensus-based process accredited by the Standards Council of Canada that brings together volunteers representing varied viewpoints and interests. CSA standards are voluntary documents; only when a standard has been referenced by an authority having jurisdiction, is compliance with the standard mandatory.

In the early 1970's, a technical committee of liquefied natural gas (LNG) experts was formed in response to the newly constructed peak-shaving plants in Canada. The first edition of CSA Z276 was published in 1972 and there have been 9 subsequent editions. The standard establishes essential requirements and minimum standards for the design, installation, and safe operation of LNG facilities. The content currently covers site provisions, process equipment, storage systems, vaporization facilities, piping systems, instrumentation and electrical services, as well as, the transfer of LNG and refrigerants, fire protection, safety, and security and operation, maintenance, and personnel training. The standard has not evolved significantly to match the changing landscape of the LNG industry. In recent years, the bulk of the LNG facilities in Canada have shifted from peak-shaving facilities to smaller scale facilities, and one existing import facility. Proposed LNG plants have included large export plants and numerous small-scale developments.

The technical committee (TC) for Z276 meets twice yearly, and includes several sub-committees and task forces that are given assignment to work on specific issues, throughout the year. The TC is composed of Canadian regulators and representatives from across North America from the LNG industry including large and small operators, equipment manufacturers and suppliers, and consultants. This broad range of experience helps to make the Z276 standard balanced and technically sound.

RELATED CODES AND STANDARDS

CSA's Z276 is, of course, not alone in the establishment of standards for the LNG industry. The modern LNG industry is nearly 60 years old. During the industry's initial expansion in North America, it became obvious that consistent regulation was needed. In the U.S., the National Fire Protection Association (NFPA) first developed it's 59A standard in 1966, and has revised the edition 13 times since then. The United States Department of Transportation (US DOT) began its regulation in the 1970s, first with the 1971 edition of NFPA 59A being incorporated by reference, and permanent regulations promulgated in 1980 as Part 193 to Title 49 of the Federal Code of Regulations (49 CFR 193). In 2000, Part 193's subparts on siting, design, construction, equipment, and fire protection were largely removed and instead referenced chapters 1 through 9 of NFPA 59A, 1996 edition, with later incorporation of the 2001 edition. In 2009, PHMSA reviewed NFPA 59A's 2006 edition, but noted that the recent revisions to NFPA 59A lacked sufficient justification and did not address several of PHMSA's concerns, such that only specific sections were

referenced. Very few changes have been made to 49 CFR 193 following that effort.

The development of Z276 involved a major effort in the late 1990s to harmonize its approach and language with NFPA 59A. The two committees met together, and modified their respective standards, as of their 2001 editions, to make them largely identical. Since that time, Z276 has diverged from 59A, partly due to the unique needs in Canada, and partly due to a technical committee that has seen it necessary to modify the standard in ways that are different than the 59A committee has done.

Despite these differences, the codes or standards for LNG plants in the U.S. and Canada are in many ways the same. And in many ways, they have been nearly stagnant in the past few decades. However, there are changes taking place in both CSA Z276 and NFPA 59A (and by extension 49 CFR 193), some of which are influenced by other standards, and some are influenced by a rapidly evolving industry. These changes seek to adapt to this ever-changing industry and its need for consistent codes and standards.

CSA Z276 CHANGES

The multiple changes in the standard between the 2015 edition and the forthcoming 2018 version are ones that seek to adapt the standard to the current LNG industry. The changes are driven by both the smaller-scale LNG facilities, and proposed larger ones, as well as changing technologies in LNG plants. The following sections describe the significant changes that have been implemented.

Clauses 4 and 5 revisions

A revision and partial rewrite of Clause 5 (Plant Site Provisions), as well as modifications to Clause 4 (General Requirements) has been implemented to improve the arrangement of the siting requirements and to help clarify other items. The siting requirements are often a contentious part of the standard, and this revision sought to add some clarity to the process.

The primary re-arrangement sought to arrange the various siting topics more clearly into sub-clauses, which are proposed to be structured as follows:

5.1 General siting provisions
5.2 Spill/leak control, including impoundments
5.3 Siting and separation, including fixed spacing distances
5.4 Siting distance calculations – the definition of exclusion zones

This structure, with the re-arrangement of several parts, provides a clearer set of requirements for siting. It also makes references to Clause 5 from other clauses more straightforward.

Other rearrangement included moving certain topics, primarily from Clause 5 into Clause 4. These topics were not specifically pertinent to the plant site selection, layout, and spacing from the public, and so were deemed to be more appropriate for the general issues clause. The topics include buildings and structures, designer and fabricator competence, soil protection for cryogenic

equipment, falling ice and snow, concrete materials, and other miscellaneous issues that apply to the facility as a whole.

The portions of Clause 5 that were rewritten deal largely with the siting distance calculations. These changes sought to take the first step towards refining the calculations associated with exclusion zones. Traditionally, the hazard calculations have been "impoundment-centric," meaning that they are based on the assumption that LNG (and not another fluid) is spilled, all of it reaches the ground and flows to the pre-defined impoundment, and that is where the hazard originates in the form of a flammable heavy gas cloud or a pool fire. Because a modern understanding of the accidental release of hydrocarbons at an LNG plant is different than this approach, new considerations that incorporate the proper thermodynamics, physics, and release behavior of hazardous materials should be used. The expanded requirements in Clause 5 include consideration of:

- Momentum-based *and* evaporating pool vapor dispersion
- Jet fires *and* pool fires

The Z276 technical committee discussed adding consideration of flammable hazards from non-LNG fluids (such as flammable refrigerants), toxic hazards, and vapor cloud explosion hazards, but those additions were deferred to a future edition of the standard.

These changes seek to better describe the hazards present at an LNG plant, and to bring the hazards calculations closer to those used in the larger process safety community.

Clause 14

One of the more significant changes in the standard with the 2018 edition is the inclusion of a new Clause 14. This clause adds risk assessment considerations, as well as risk-based siting, to Z276.

The general risk assessment requirements are imposed on all LNG facilities under the jurisdiction of Z276. They outline a basic risk-informed approach to design, siting, construction, and operation. The requirements begin with the requirement for a risk management system, directed in Clause 4, which establishes a risk-based approach to the decision making throughout the life of the plant, and requires the implementation of risk reduction measures to control risks to an ALARP level. Further details and guidance on the risk management system are provided in Clause 14.

The information presented in Clause 14 begins with general concepts on risk management and assessment. A framework for the plant's risk assessment process is provided, such that at each stage of development, hazards are identified, consequences and likelihoods are determined, the risk is measured and assessed, and risk mitigation measures are implemented. Examples of risk assessment measures are provided for the design and operational stages of an LNG plant's life.

Risk-based siting as an alternative to Clause 5.4 (exclusion zone determination) is provided in the remainder of Clause 14. This presents a basic terms of reference (TOR) for conducting a quantitative risk analysis (QRA) that serves to replace the traditional fire radiation and vapor dispersion calculations that are used for plant siting. However, the TOR goes beyond fire radiation

and vapor dispersion calculations, requiring a full consequence and frequency analysis with emphasis on risk to the public as well as plant personnel.

Some of the requirements in the TOR include:

- A systematic hazards identification process;
- Broad-based selection of accidental release (loss of containment) events, including a range of release hole sizes from all portions of the plant;
- Consideration of a full range of hazards, including jet and pool fires, flashing jet and vaporizing pool vapor dispersion, vapor cloud explosions, and toxic vapor dispersion;
- Determination of fluid release behaviors (including thermodynamics and heat transfer);
- Evaluation of hazards over a range of environmental conditions;
- Full accounting for piping and equipment failure rates, probabilities of weather conditions, and probabilities of variables such as ignition timing and release orientation;
- Generation of measures of risk, including location-specific individual risk (LSIR) and societal risk in the form of F-N curves; and
- Assessment of the risk by comparison to given risk criteria.

The QRA-based siting option was developed due to the need for a more sophisticated siting process for large, primarily export, plants being proposed in Canada. Because CSA Z276 was originally developed for peak-shaving plants and smaller, regional facilities, it lacked a proper treatment of the risks at the world-scale plants.

A QRA TOR had already been put in place for British Columbia due to efforts by regulators at the Oil and Gas Commission (BGOGC) in that province. With BC regulator participation on the Z276 committee, as well as a task force of risk analysis professionals, the TOR for Z276 was put in place as part of Clause 14 so that this approach would be available to a broader audience. While the use of QRA for plant siting was intended for use on large export plants, the TOR and its application were developed with the flexibility to be applied to any LNG plant.

Annex B

Perhaps the most important change to the Z276 standard is the significant expansion of Annex B, which directly addresses small-scale LNG facilities. The growth of the LNG industry, especially in Canada, has been toward the smaller scale of facilities, often for the purpose of vehicular fueling or small power system needs. The annex specifically excludes vehicular fueling (that is covered by Z276's Annex D), rail or marine fueling, marine shipping and receiving, and floating LNG facilities.

The new Annex B, written exclusively for small-scale LNG facilities, was designed so that it could be a stand-alone portion of Z276. In this way, it provides an independent set of requirements for facilities that meet the definition of "small." Z276 defines small facilities as ones that:

- Use LNG storage containers that are insulated, shop-fabricated ASME vessels of 1,000 m^3 (264,000 gallon) capacity or less, with a maximum aggregate storage capacity of 4,000 m^3; and

- Have a liquefaction capacity not to exceed 2,000 m^3/day (528,000 gallons/day).

These requirements do not address vaporization capacity, product receipt or sendout rate, or any type of product transfer frequencies. The storage capacity is seen as a sufficient metric for limiting these rates and categorizing a facility as a small plant.

In many ways, Annex B is very similar to the main body of Z276, and many of the requirements are identical. The small-scale plants do receive different treatment in certain areas. Some of these are clearly related to the nature of small-scale, such as the requirement that the facility use only ASME LNG storage tanks. Others provide operational flexibility, such as a graduated scale (depending on size and throughput) for how often the facility is attended by operators, as compared to constant attendance for larger facilities.

The most notable difference between Annex B and the main body of Z276 is the siting provisions. The first difference is that Clause 5 defines design spills to be based on (effectively) a 2-inch diameter hole in process, vaporization, or transfer systems. Annex B defines the design spill as a breach equal to 10% of the pipe's cross-sectional area. While Annex B allows for deterministic siting (i.e., fire and flammable vapor cloud calculations) from these design spills, there is more emphasis on the use of spacing tables for siting the facility with respect to the property lines.

Annex B's spacing table is first based on LNG storage tank volume. This table is further classified by the largest pipe diameter serving that storage tank, which can push the siting distance to a category with larger distances if a storage tank uses larger diameter piping. Finally, there is a correction factor for the pressure in the system, such that systems with higher operating pressures will need to use longer spacing distances. These spacing guidelines also provide several equations for calculating design spill release flow rates, as well as a simplified calculation for an impoundment volume based on the design spill.

The overall approach to Annex B was to make design, construction, operation, and most importantly, siting, a more straightforward process for small LNG facilities. The annex achieves this, while maintaining a high level of safety for those facilities.

Miscellaneous

The other modifications to Z276 include minor wording changes for clarity; revision of existing, and addition of new, definitions; and updated references to external standards (primarily to reference a newer version of those standards). Also, the requirements for portable or temporary LNG facilities have been moved to Annex B. These requirements were previously located in Clause 5. Most of these changes can be thought of as the normal progress of a code or standard where the TC is actively involved in continuous improvement for the standard.

CONCLUDING REMARKS

The pending changes to CSA's Z276 standard are a significant step forward, towards a quickly-changing LNG industry. The changes have been implemented by a technical committee that recognizes the need for changes to the regulatory basis for LNG in Canada and elsewhere in the

world. The changes described in this paper will serve to clarify the requirements for all LNG plants, provide a more sophisticated siting option (primarily large plants) and establish a dedicated set of requirements for the quickly-growing small-scale portion of the industry. The 2018 edition of the standard is scheduled for publication in early December 2017, and the TC will certainly begin work on the next generation of changes soon afterward.