NOVA SCOTIA
DEPARTMENT OF ENERGY

CODE
OF
PRACTICE

LIQUIFIED NATURAL GAS FACILITIES

July 2005

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Table of Contents

Table of Contents

Table of Contents

List of Tables

1 Overview

1.1 Introduction

This Code of Practice is adopted pursuant to the Nova Scotia *Energy Resources Conservation Act*, s. 29 (NS ERCA), the *Pipeline Act* s.44 (NS PA), and the *Gas Plant Facility Regulations.* Pursuant to Section 12 of the NS ECRA and Section 40 of the NS PA, the Governor's Council approves the delegation by the Energy Board to the Utility and Review Board (Board) of the powers, duties or authorities conferred or imposed upon the Energy Board under the Acts to administer and enforce the *Gas Plant Facility Regulations.*

The *Gas Plant Facility Regulations* incorporate by reference CSA Z276-01, which is the current version (2001) of the CSA Liquefied Natural Gas standard. This Code of Practice provides requirements and guidance for the design, construction, operation and abandonment of land-based liquefied natural gas (LNG) plants and the associated jetty and marine terminal as defined under section 1.5. It is intended to supplement both the requirements in the *Gas Plant Facility Regulations* and CSA Z276-01. A central purpose in the application of the Code of Practice is the protection of the public through the appropriate design, construction, operation, and abandonment of LNG facilities. Whenever the Code of Practice mentions safety, it is addressing public safety, for which the Board has a specific role to look after that public interest. Some of the information required by this Code of Practice may also be required to meet other regulatory requirements, such as an Environmental Screening under the *Canadian Environmental Assessment Act* (CEAA).

1.2 Applicability and Scope

The Gas Plant Facility Regulations cover all gas plant facilities; however the scope of this Code of Practice is limited to LNG facilities.

CSA Z276-01 encompasses all parts of a land-based LNG facility including the storage containers, systems that condition, liquefy or vaporize natural gas, and structures integral to the transfer of fluids between storage containers and points of receipt or shipment by pipeline, tank car, tank vehicle or marine vessel. This includes the transfer piping beginning with the connection of the marine unloading arms to the LNG tanker piping. Support facilities covered by CSA Z276-01 are also encompassed including emergency systems. The Code of Practice is intended to be applied with reference to other relevant standards and practices referenced herein. Any reference in the regulation or this Code of Practice to a code or standard is and is deemed to be a reference to the latest version of the code or standard unless the version is specifically referenced.

The applicability and scope of the specifications within this Code of Practice correspond generally to that of the CSA Z276-01. However, direction and guidance are also provided by this Code of Practice outside of that standard, where it is relevant to good practice related to liquefied natural gas plants and risk management.

This Code of Practice applies to all components of land-based liquefied natural gas plants and the associated jetties and marine terminals. The scope includes peak-shaving units and transfer piping to and from marine terminals.

This Code of Practice covers LNG as well as any hydrocarbons contained in, extracted from, and used in processing of LNG at the facility, which may include natural gas, methane, natural gas liquids (ethane, propane, and butane), flammable refrigerants and any other flammable or toxic materials.

The Code of Practice does not apply to:

a. Offshore liquefied natural gas facilities;
b. Liquefied natural gas marine transport vessels;
c. Liquefied natural gas dispensing facilities for motor vehicles or other uses.

Where any requirements of this Code of Practice are at variance with the requirements of other standards or codes incorporated by reference into this Code of Practice, the requirements of this Code of Practice take precedence, including requirements in CSA Z276-01.

As this Code of Practice has a primary focus on the safety of LNG plants, the critical components for safety are provided as separate sections addressing safety and safety equipment specifically. Other sections prescribe or define good industry practices that also contribute to the safety of LNG facilities.

This Code of Practice applies to liquefied natural gas facility permitting and licencing. A permit to begin construction is required to build an LNG facility. A license to operate is also required before liquefied natural gas can be produced or transferred at the facility. An operator must apply to the Board for the approvals to construct and operate the facility. Also, an operator must apply to the Board for approval to suspend or discontinue an LNG facility operation or to dismantle an LNG facility.

The Code of Practice identifies minimum standards for design, construction, operation and abandonment of LNG facilities. It also defines the information that must be submitted with any application to the Board for approvals to construct, operate or abandon LNG facilities. Direction and non-prescriptive guidance are provided for an operator in the safe development and operation of its facilities.

As acknowledged in Section 3.1 of CSA Z276-01, new concepts in the production, storage, and use of LNG are still evolving, and advancements in engineering and improvements in equipment may result in LNG facility design, equipment fabrication methods, and operating practices that differ from this Code of Practice. However, such changes or improvements may provide desirable safety and operational aspects that meet the intent of this Code of Practice. Therefore, notwithstanding requirements of this Code of Practice and CSA Z276-01, operators may apply to the Board for a variance from the requirements listed herein, if the application is supported by an assessment that demonstrates equal or greater safety. The application must include a rationale and reasoning for the variance prepared by a qualified person. Such deviations may be accepted after the Board has made a thorough investigation of all factors and comes to the conclusion, based on sound experience and engineering judgment, that the proposed deviation meets the intent of this Code of Practice.

1.3 Organization of Code of Practice

Section 3 of this Code of Practice provides the requirements for management and oversight of an LNG facility project, centered on requirements for obtaining a permit to construct and a licence to operate. It requires the implementation of a process safety management (PSM) system to manage activities throughout all phases of the project. The elements and specific requirements of a process safety management system are summarized in Appendix A. Section 3 defines which elements and requirements of the PSM system are required during design, construction, operation and abandonment. These requirements are presented first to emphasize the importance of early planning and thorough evaluation to meet the Code of Practice requirements as well as those for environmental assessment. Early incorporation of all requirements in planning can assist in the approval process.

The organization of the Code of Practice is similar to that of CSA Z276-01, particularly Section 4.0 Facilities and Equipment. However, the structure has been expanded and modified to follow the sequence of an LNG project through the phases of a project. The information is organized into subsections for major components or process and support system areas.

1.4 Relationship of the Code of Practice to Other Acts and Regulations

Other acts and related regulations also apply to the design, construction, operation and abandonment of LNG facilities. Some requirements or guidelines provided in this Code of Practice may also serve to meet requirements of other legislation. Legislation most relevant to land-based liquefied natural gas facilities is listed below under the Department with authority to enforce the legislation.

Nova Scotia Department of Environment and Labour

Environment Act, 1994-95, c.1, s.1.
Environmental Assessment Regulations
Activities Designation Regulations
Approvals Procedure Regulations
Emergency Spill Regulations

This Act provides for environmental assessment of a storage facility as a Class I undertaking. Approvals are also required for various activities related to storage facilities, which may include water supply wells, solid waste management, on-site sewage disposal systems and watercourse crossings.

The *Emergency Spill Regulations* would apply to leaks or spills of hydrocarbons. The regulations provide reporting requirements, address training for emergency responders, and provide for emergency orders and powers in the event of a spill.

Occupational Health and Safety Act, 1996, c.7, s. 1.
Occupational Safety General Regulations

The Department of Environment and Labour is responsible for worker safety inside LNG plants. The regulation provides requirements for the health and safety of persons at the workplace, including LNG Facilities. The Act is founded on the Internal Responsibility System for which all those associated with the workplace share responsibility for health and safety. This Act does not include requirements for public safety. For these issues the user is referred to CSA Z276-01 and this Code of Practice.

Nova Scotia Department of Energy

Pipeline Act, 1989, R.S.,c. 345, s. 1.
Pipeline Regulations

This Act regulates the transmission of oil and gas. It is relevant to the approvals for the design and operation of pipelines connecting to an LNG facility outside the defined physical scope.

Transport Canada

Marine Transport Security Act, SOR/2004-144
Part 3: Marine Facilities

This Act regulates various aspects of security at marine facilities including a requirement to perform security assessments and develop a security plan for the entire LNG terminal.

Note that this is not intended as a complete list of acts and regulations that may apply to various aspects of approval or operation of a storage facility or related components. For instance, there are other Transport Canada requirements for marine facilities. It is the responsibility of the operator to meet all regulatory requirements.

1.5 Definitions

Definitions provided in the Gas Plant Facility Regulations (GPFR), as well as the definitions in CSA Z276-01 apply to this Code of Practice. Where there is a conflict in the definitions between the Code of Practice and CSA Z276-01, those of the Code of Practice shall apply.

a. **Abandon** means permanently remove a gas plant facility from service pursuant to Section 23 of the GPFR or to declare it abandoned by the owner, operator, person responsible, inspector or the Board.

b. **Acts** means the *Energy Resources Conservation Act* and the *Pipeline Act* and includes regulations made pursuant to the Acts.

c. **Administrator** means a person designated by the Minister pursuant to Section 4 of the GPFR and includes an acting administrator.

d. **Application** means an application made to the Board pursuant to the GPFR and includes an application:

   i. for a permit or licence,
   ii. to change, modify or expand the activity that is the subject of a permit or licence,
   iii. to amend a term or condition of, add a term or condition to or delete a term or condition from a permit or licence,
   iv. to renew a permit or licence.

e. **Audit** means a systematic review that verifies conformance with established guidelines and standards and employs a well defined review process to ensure consistency and to allow the auditor to reach defensible conclusions.

f. **Board** means the Nova Scotia Utility and Review Board.

g. **Block valve** means a valve placed on a pipeline system so as to isolate sections of pipeline during maintenance or in the event of leaks or failures.

h. **Cathodic protection** means an electrochemical, anticorrosion technique for the protection of metal structures such as pipelines, tanks and buildings, whereby electric currents are induced to offset the current associated with metal corrosion.

i. **CSA Z276-01** means Canadian Standards Association standard Z276 *Liquefied Natural Gas (LNG) – Production, Storage and Handling*, as amended.

j. **Code of Practice** means a guideline prepared or adopted by the Minister or Administrator and, with respect to a LNG plant, means the Nova Scotia Code of Practice for LNG Plants, as amended.

k. **Construct** or **Construction** means building or field fabricating and generally starts with the laying of equipment and building foundations including driving of piles or other work necessary to lay the foundations.

l. **Deflagration** means a combustion mechanism caused by the reaction of a mixture of a reducing material such as a combustible gas and an oxidizer such as air or oxygen that transmits energy in the form of heat to the unreacted medium, this results in the expansion of reaction products and subsequent compression waves that propagate at speeds usually less than the speed of sound and up to 300 m/s in gaseous materials.

m. **ESD** means emergency shutdown, which may be achieved by remote or manual operation of valves.

n. **FEED** means the front-end engineering design, which is the process design of a facility.

o. **Fees** include(s) amounts payable to the Board

i. upon application for a permit or licence,
ii. for renewal, amendment, suspension, expansion, consolidation, transfer, assignment, cancellation, reinstatement or abandonment of a permit or licence, and
iii. for the purpose of recovering all or part of such direct and indirect expenses as the Board determines to be attributable to its responsibilities under the Acts or the GPFR.

p. **Fluid** includes natural gas, natural gas liquids or liquefied natural gas.

q. **Fractionation plant** means a plant that separates fluid into its constituted elements.

r. **Gas** means raw gas, including coal gas or any constituent of raw gas or marketable gas, including, but not limited to, condensate, propane, butane and ethane.

s. **Gas plant facility** means a plant used for processing, extracting or converting a fluid, including all structures located within the boundaries of the plant, such as compressors and other structures integral to the transfer of a fluid, and includes all of the following:

i. a battery processing plant,
ii. a gas processing plant,
iii. a fractionation plant,
iv. a liquefied natural gas plant,
v. a straddle plant.

t. **Hydrocarbon** means an organic compound containing carbon and hydrogen and includes oil and natural gas.

u. **Incident** means an unusual or unexpected occurrence that results in, or has the potential to result in,

i. serious injury to a person,
ii. significant damage to property,
iii. adverse environmental impact, or
iv. a major interruption of process operations.

A more detailed discussion of an incident is provided in Appendix A, section 8.

v. **Individual occupancy** is defined as the percentage of an individual's normal working day spent in a building.

w. **Inspection** means the process of physically examining a gas plant facility.

x. **Licence** means a licence issued pursuant to the Acts or the GPFR to operate a gas plant facility.

y. **Liquefied natural gas** means a fluid in a liquid state that is composed predominantly of methane and can contain minor quantities of ethane, propane, nitrogen or other components found in natural gas.

z. **Liquefied natural gas plant** or **LNG plant** means a plant the components of which are used to store liquefied natural gas and may also include a plant that conditions, liquefies, transfers or vaporizes liquefied natural gas.

aa. **Marketable gas** means a mixture mainly of methane originating from raw gas, if necessary through the processing of the raw gas for the removal or partial removal of some constituents, that meets specifications for use as a domestic, commercial or industrial fuel or as an industrial raw material.

bb. **Minister** means the Minister of Energy.

cc. **LNG** means liquefied natural gas which is predominately liquefied methane containing lesser amounts of other hydrocarbon and non-flammable components and that are liquid at storage pressures and temperatures.

dd. **LNG project** means all phases of the location, selection, design, construction, operation/maintenance, closure and abandonment of a liquefied natural gas facility.

ee. **LPG** means liquefied petroleum gas, which is predominately a mixture of hydrocarbon molecules comprised of 3 and 4 carbon atoms that are liquid at storage pressures and temperatures.

ff. **Maximum allowable working pressure (MAWP)** means the maximum gauge pressure permitted at the top of completed equipment, a container, or a vessel in its operating condition at a design temperature.

gg. **NGL** means natural gas liquids which may be a mixture of various hydrocarbon components that are liquid at storage pressures and temperatures.

hh. **Natural gas** means gaseous forms of hydrocarbons, principally methane, with minor amounts of ethane, butanes, pentanes, and hexanes along with non-hydrocarbon impurities such as nitrogen, carbon dioxide and hydrogen sulfide.

ii. **Normally occupied building** means a building that personnel occupy while doing a major part of their work, such as a control room or laboratory. A building can be considered unoccupied when the individual occupancy value is less than 25%.

jj. **Operate** includes repair, maintain, deactivate and reactivate.

kk. **Operator** means the holder of a license, approved for any phase of a liquefied natural gas facility.

ll. **Permit** means a permit issued pursuant to the Acts or the GPFR to construct a gas plant facility.

mm. **Process safety management program** means a program described in Section 17B of the GPFR.

nn. **Qualified person** means a professional engineer registered and licensed to practice in Nova Scotia.

oo. **Raw gas** means a mixture containing methane, other paraffinic hydrocarbons, nitrogen, carbon dioxide, hydrogen sulfide, helium and minor impurities, or some of them, that is recovered or is recoverable at a well from an underground reservoir and that is gaseous at the conditions under which its volume is measured or estimated.

pp. **Straddle plant** means a gas plant facility that is located on a pipeline transporting marketable gas that is used for the purpose of reprocessing the marketable gas.

qq. **Transfer area** means that portion of an LNG plant containing a piping system where LNG, flammable liquids, or flammable refrigerants are introduced into or removed from the facility, such as truck loading, or ship unloading areas, or where piping connections are connected or disconnected routinely.

rr. **Transfer of fluid** includes transfer between storage containers and points of receipt or shipment by pipeline, tank car, tank vehicle or marine vessel.

1.6 Glossary of Acronyms

ACI	American Concrete Institute
AGA	American Gas Association
AIChE	American Institute of Chemical Engineers
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASME-BPV	American Society of Mechanical Engineers - Boiler and Pressure Vessel Code
ASTM	American Society for Testing and Materials
BPCS	Basic Process Control System
CCPS®	Center for Chemical Process Safety of the AIChE
CEAA	Canadian Environmental Assessment Act
CGA	Canadian Gas Association
CGSB	Canadian General Standards Board
CSA	Canadian Standards Association
CTA	Canadian Transport Agency
DBI	Design Basis Incident
DCS	Distributed Control System
DP	Design Pressure
DT	Design Temperature
EA	Environmental Assessment
EN	European National (standards)
EPC	Engineering, procurement and construction
ERCA	Nova Scotia Energy Resources Conservation Act
ESD	Emergency Shutdown
FEED	Front-end Engineering Design
GPFR	Gas Plant Facility Regulations
GRI (GTI)	Gas Research Institute (currently called Gas Technology Institute)
HAZOP	Hazard and Operability (analysis)
IA	Instrument air
ICBO	International Conference of Building Officials
IEC	International Electrotechnical Commission
ISA	Instrument Society of America
ISO	International Organization for Standardization
JGA	Japan Gas Association
LFL	Lower Flammability Limit
LNG	Liquefied Natural Gas
LOPA	Layer of Protection Analysis
LPG	Liquefied Petroleum Gas
MAOP	Maximum Allowable Operating Pressure
MAWP	Maximum Allowable Working Pressure

MAWT	Maximum Allowable Working Temperature
MOC	Management of Change
MTSA	Marine Transportation Security Act
NACE	National Association of Corrosion Engineers
NDE	Non-destructive Examination
NFPA	National Fire Protection Association
NG	Natural Gas
NGL	Natural Gas Liquids
NIST	National Institute of Standards and Technology
NPRA	National Petrochemical and Refiners Association
NRCC	National Research Council Canada
NS	Nova Scotia
OBE	Operating Basis Earthquake
PA	Nova Scotia Pipeline Act
PERC	Powered Emergency Release Coupling
PES	Programmable Electronic System
PFD	Process Flow Diagram
PHA	Process Hazard Analysis
PID	Piping & Instrumentation Drawing
PMI	Positive Material Identification
PLC	Programmable Logic Controller
PSM	Process Safety Management
PSR	Pre-safety Startup Review
PSV	Pressure Safety Valve
QA	Quality Assurance
QC	Quality Control
RPT	Rapid Phase Transition
RV	Relief Valve
SIGTTO	Society of International Gas Tanker and Terminal Operators
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SSE	Safe Shutdown Earthquake
SVA	Security Vulnerability Assessment
TC	Transport Canada
T&I	Testing and Inspection
TEMA	Tubular Exchanger Manufacturers Association
ULC	Underwriter's Laboratory Canada
UPS	Uninterruptible Power Supply
VCE	Vapor Cloud Explosion

2 Authority and Responsibility

2.1 Energy Department

The Nova Scotia Department of Energy is responsible for the development of policy and the enactment of legislation and regulations. The Nova Scotia Utilities and Review Board (Board) is responsible under the *Pipeline Act* and *The Energy Resources Conservation Act* to issue permits to construct and licences to operate, and to monitor and enforce the same.

2.2 Board Authority

The Board has primary responsibility for granting a permit to construct and a licence to operate a gas plant facility, including an LNG facility, as defined in the *Gas Plant Facility Regulations*. Under its authority, the Board shall determine what information is necessary or required to carry out its powers and duties under the Acts and the regulation. The *Gas Plant Facility Regulations* requires the designers of LNG facilities to comply with CSA Z276-01 Liquefied Natural Gas (LNG) – Production, Storage, and Handling. The requirements of this standard are further defined and augmented by this Code of Practice.

3 Management and Oversight

This section of the Code provides the requirements for obtaining a Permit to Construct and a Licence to Operate from the Nova Scotia Utility and Review Board as specified in the *Gas Plant Facility Regulations*. It also provides requirements that must be followed during operation and ultimately for closure and abandonment.

All phases of an LNG project must have a Process Safety Management (PSM) system in place as described in Appendix A. Some elements of the PSM system will need to be in place during design; others will need to be implemented during construction and others during operation. Also, the requirements for some individual elements will change during difference phases of the project. These requirements are specified in the sections below.

3.1 Application for Permit and Licence

The *Gas Plant Facility Regulations* specify the form of the applications, timing, fees and costs, review procedures, and the terms and conditions of the permit or licence. This Code provides specific activities that need to be completed before submitting the application and documentation requirements that must accompany the application.

3.1.1 Application for the Permit to Construct

Prior to filing for a Permit to Construct, the project must obtain all required federal and provincial environmental approvals including a federal/provincial environmental assessment (EA). The project must complete at least the front end engineering design (FEED) and all of the associated studies listed in this section and summarized below. The individuals who are involved in the design, fabrication and construction of LNG facility equipment must meet the requirements of CSA Z276-01 Clause 4.4.

3.1.1.1 Process Safety Management During the Front End Engineering Design

Process Safety Management elements (see Appendix A) must be in place at the start of design and some of these elements must start to be implemented prior to submitting the application for the Permit to Construct. Other elements must be in place during the detailed design and construction phase that occurs between the time the Permit to Construct is issued and the Licence to Operate is issued.

In order to complete the requirements for obtaining a Permit to Construct, the following elements of PSM must be in place:

a. Process Safety Information (to support the process hazard analysis)
b. Process Hazard Analysis (preliminary hazard and operability study)

3.1.1.2 Front End Engineering Design Information

The front end engineering design is an early stage of design where process flow diagrams are available as well as preliminary piping and instrument diagrams. Equipment and instrumentation design has been developed in sufficient detail in order to conduct siting and layout analyses. Since there is no standard definition for what is included in a FEED, the specific information requirements for what needs to be submitted with the application for the Permit to Construct are summarized below. The requirements for some information are provided in Appendix B as noted below.

a. Chemical Hazard Information (see Appendix B)

b. Process Chemistry and Systems (see Appendix B)

c. Plot Plans for Siting and Layout (see Appendix B)

d. Plot Plan for Layout of Fire Protection System

   The application shall include a layout of the fire protection system showing the location of fire water pumps, piping, hydrants, hose reels, dry chemical systems, high expansion foam systems, and auxiliary or appurtenant service facilities.

e. Plot Plan for Layout of Detection, Control and Interlock Systems (see Appendix B)

f. Plot Plan of Spill Containment and Drainage System Layout (see Appendix B)

g. Plot Plan of Area Electrical Classification (see Appendix B)

h. Block Flow Diagram of Isolation and Shutdown Systems (see Appendix B)

i. Process Flow Diagrams (see Appendix B)

j. Piping and Instrument Diagrams (PIDs)

   The application shall include preliminary piping and instrument diagrams showing all major process and utility equipment and interconnecting piping, valves and instrumentation. Instrumentation shall include at least the detection, control and interlock systems required for item 3.1.1.2.e. Equipment and piping shall include capacity, dimensions, materials of construction, MAWP and MAWT, and heat duties. A legend showing all equipment, piping and instrument symbols, nomenclature and label identification shall be included.

k. Equipment, Piping and Building Specifications

The application shall contain an equipment list, piping specifications and a building list. Specifications for the LNG tanks, LNG pumps and marine unloading arms shall also be provided.

l. Applicable Codes and Standards (see Appendix B)

m. Relief System Design and Sizing Basis

The application shall contain a description of the methodology for determining the sizing basis for relief systems and shall include the sizing basis for relief devices on the LNG storage tanks, LNG pumps, LNG vaporizers and LNG liquefaction system. The sizing basis for any vent headers or flare systems shall be provided.

n. Ventilation System Design and Sizing Basis

The application shall contain the methodology and the sizing basis for all building ventilation systems.

o. Basic Process Control System

The application shall include a description of the process control philosophy, architecture, data communications, type of instrumentation (pneumatic, electronic), use of computer technology, and control room display and operation (operator interface). Describe the basic process controls on each piece of equipment. All process related interlocks and shutdowns, such as pressure, level, temperature, excess flow, shall be identified. A description of the alarm system, including any hardwired systems, and any alarm prioritization system shall be provided.

p. Safety Instrumented Systems (SISs)

The application shall contain a preliminary list of SISs and their required safety integrity levels (SILs) based on the preliminary HAZOP study.

q. Interlock Cause and Effect Chart

The application shall contain a cause and effect chart for all process shutdowns.

r. Design and Safety Studies (see Appendix B)

s. Electrical Power Systems

The application shall provide a description of the electrical power supply system and backup or emergency systems including any uninterruptible power supplies (UPSs) and the equipment that will be supplied with a UPS.

t. Compliance with Regulations (see Appendix B)

3.1.1.3 Climatology and Site Study

A climatology and site study shall be conducted. These studies shall investigate the items listed below and those in CSA Z276-01 Clause 4.1.

a. Site study:
    i. A soil survey that includes a geotechnical survey to define the geomechanical, geological and tectonic characteristics of the subsoil,
    ii. A study of terrain to assess the dispersion of liquid and gas clouds,
    iii. A study of vegetation to identify, in particular, vegetation fire risks,
    iv. Groundwater tables,
    v. Sea water quality and temperature (if sea water is used for cooling or fire water then the seal water quality will need to be determined in order to select the proper materials of construction, filtration equipment and means for control of micro-organisms and mollusks),
    vi. Tidal conditions,
    vii. Shock waves and flooding (such as tsunami or failure of dams),
    viii. A survey of the surrounding infrastructure (e.g., industrial sites, built up areas, communications).

b. Climatology study:
    i. Prevailing wind direction,
    ii. Maximum wind velocity and gust duration, and hurricane and tornado frequencies,
    iii. Lightning frequency,
    iv. Maximum and minimum temperature data and max and min design temperatures to be used for equipment and buildings,
    v. Atmospheric stability ,
    vi. Relative humidity,
    vii. Corrosive nature of the air (e.g., salt),
    viii. Rainfall (max, yearly and seasonal averages),
    ix. Snow loads and potential for freezing rain or ice buildup on equipment,
    x. Frost line depth,
    xi. Site elevation and standard atmospheric pressure, as well as the rate of change of barometric pressure.

3.1.1.4 Seismic Review

Provide a seismic study for the LNG tanks, impoundments and other critical structures or systems that meets the requirements of CSA Z276-01 Clause 6.1.3 and Clause 8.1.2 for piping.

The buildings shall be designed to keep their integrity in case of a safe shutdown earthquake (SSE).

3.1.1.5 Preliminary Hazard and Operability (HAZOP) Study

A preliminary HAZOP shall be conducted based on the process safety information developed during the FEED as summarized in section 3.1.1.2 a-q and focus on identification of major hazards, siting/layout and inherent safety issues. See also section 3.2.1.2 for the PSM requirements for conducting a HAZOP to meet the requirements of this Code. The HAZOP shall follow the methodology provided in the CCPS Guidelines for Hazard Evaluation Procedures (5). An independent third party shall lead the study.

While conducting the HAZOP, the applicant shall assess opportunities to make the process inherently safer as described in the CCPS book *Inherently Safer Chemical Processes*[6]. Also during the HAZOP, the safety instrumented systems (SISs) shall be identified following the requirements of ISA 84.01 *Application of Safety Instrumented Systems for the Process Industry*. A preliminary list of SISs shall be developed during the preliminary HAZOP and finalized in the HAZOP of the detailed engineering design. The required SILs may alternately be determined through the use of a Layer of Protection Analysis (LOPA)[7].

The study shall review any known historical incidents and ensure the design is adequately protected against such an incident at this facility. The study shall consider human factors issues, such as design or procedural deficiencies that could lead to an undesirable event caused by human error during operation of the facility.

Each scenario of the HAZOP that has potential undesirable consequences shall be risk ranked. Intolerable risks must have recommendations to mitigate risk to a tolerable level and an action plan for resolving each recommendation. Any unresolved recommendations from the preliminary HAZOP must be reviewed and resolved at the HAZOP of the detailed engineering design (see section 3.1.2.1). The risk ranking matrix in Table 3-1 shall be used. For the HAZOP study the "event" frequency range scale shall be used.

3.1.1.6 Facility Siting and Layout Analysis

The location of plant buildings shall be evaluated using a facility siting analysis as per API Recommended Practice 752[3]. The analysis shall consider releases of LNG liquid and vapor as well as releases of other flammable or toxic materials handled or stored onsite. The following building occupancy criteria shall be used to determine which occupied buildings need to be included in the analysis:

a. Occupancy load (total integrated time for all occupants in the building) over 400 hours per week;
b. Peak occupancy of 25 individuals for one hour;
c. Individual occupancy of at least one individual for more than 50% of their total time onsite.

Initiating events for the risk assessment shall be determined from the preliminary HAZOP study and shall include both internal and externally induced scenarios leading to fires, explosions or toxic releases. Risks may be determined qualitatively using the risk ranking matrix in Table 3-1. For the facility siting analysis the impact frequency ranges shall be used. Risks may also be determined quantitatively by conducting consequence modeling of scenarios and determining risk through event tree and fault tree analysis.

Layout of equipment and buildings shall consider prevailing wind direction and avoid locating buildings, critical equipment and ignitions sources downwind of potential flammable material inventories. Layout shall also consider safe access for construction, operation, maintenance and fire fighting.

Spacing of equipment and buildings, including impoundments and drainage systems, shall take into account potential thermal radiation levels, flammable vapor concentrations, blast effects and noise levels. See CSA Z276-01 Clause 4.2.4-4.2.7 for determination of exclusion zones for impoundment areas and minimum required spacing distances for containers, vaporizers, process equipment and loading/unloading equipment.

Layout and spacing of all other equipment and buildings shall be in accordance with the CCPS Guidelines for Facility Siting and Layout.[1]

3.1.1.7 Preliminary Facility Security Assessment

A marine facility security assessment and plan is required under the Marine Transportation Security Regulations (SOR/2004-144) of the Marine Transportation Security Act (MTSA) which is regulated by Transport Canada. This security assessment is limited to the jetty and marine terminal. A facility security assessment shall be performed for the land-based facilities using a methodology similar to that required under the MTSA. The application shall contain the following preliminary security information:

a. The physical aspects of the marine facility that are the most important to protect,
b. Possible threats to the marine facility, and
c. The potential vulnerabilities.

3.1.2 Conditions of the Permit to Construct

The following requirements shall be completed before the applicant submits the application for the Licence to Operate. These requirements shall be conditions under which the Permit to Construct is issued.

3.1.2.1 Process Safety Management During Detailed Design and Construction

The following elements of PSM shall be in place during the detailed design and construction phase and the applicant shall describe how each will be implemented:

a. Management of Change (following completion of the HAZOP on the detailed engineering design)
b. Mechanical Integrity (quality assurance during fabrication and installation)
c. Contractor Management (during construction)
d. Operating Procedures, including cool-down and initial startup, see CSA Z276-01 Clause 12 (prior to startup)

e. Training based on operating procedures, see also CSA Z276-01 Clause 3.4 and 12 (prior to startup)
f. Emergency Planning and Response (prior to startup)
g. Security Management (prior to startup)
h. Pre-startup Safety Review

Table 3-1: Risk Ranking Matrix

Consequence Range	Safety Consequence Criteria	
Level 4	One or more onsite or offsite fatalities	
Level 3	Disabling injury	
Level 2	Lost workday injury	
Level 1	Recordable injury	
Likelihood Range	**Event Frequency**	**Impact Frequency**
Level 5	>10-1/yr	>10-2/yr
Level 4	10-1 to 10-2/yr	10-2 to 10-3/yr
Level 3	10-2 to 10-3/yr	10-3 to 10-4/yr
Level 2	10-3 to 10-4/yr	10-4 to 10-5/yr
Level 1	<10-4/yr	<10-5/yr

Likelihood	Consequence			
	1	**2**	**3**	**4**
5	**C**	**B**	**A**	**A**
4	**D**	**C**	**B**	**A**
3	**D**	**D**	**C**	**B**
2	**D**	**D**	**D**	**C**
1	**D**	**D**	**D**	**D**

Risk Level	Action
A	Risk mitigation required to risk level D
B	Risk mitigation required to risk level D
C	Risk mitigation required to risk level D
D	No further risk mitigation required

3.1.2.2 HAZOP Study Based on Detailed Engineering Design

The preliminary HAZOP study shall be updated based on the final detailed engineering design. Any unresolved recommendations from the preliminary HAZOP shall be reviewed in the HAZOP and incorporated into the results. A final list of Safety Instrumented Systems and the required Safety Integrity Level shall be prepared. The Facility Siting Analysis shall be reviewed and any new recommendations shall be incorporated into HAZOP study.

An action plan shall be prepared for each recommendation and the resolution of each recommendation shall be documented. The HAZOP and action plan shall be submitted to the Board upon completion. Status of action items shall be summarized in Construction reports.

3.1.2.3 Management of Field Changes

Upon completion of the final HAZOP study, any modifications that require a change in the process safety information that was the basis for the HAZOP shall be reviewed according to the Management of Change procedure requirements in Appendix A.

3.1.2.4 Quality Assurance (QA) During Fabrication and Installation

Part of the Mechanical Integrity requirements under PSM is quality assurance during fabrication and installation of equipment (see Appendix A). These requirements include the training of individuals conducting mechanical integrity, procedures for quality assurance of the fabrication and installation of equipment and facilities and procedures for commissioning.

CSA Z276-01 also has specific requirements for quality assurance including:

a. Clauses 4.4 for designer, fabricator and constructor competence requirements,
b. 6.3.4 and 6.5 for LNG container construction, inspection and testing requirements,
c. 6.7 for qualifications of quality assurance personnel,
d. 8.3.4 for welder qualifications, and
e. 8.6 for inspection and testing of piping.

Prior to releasing equipment for fabrication, the owner shall pre-qualify potential suppliers to ensure that they have a satisfactory quality assurance program. Prior to start of construction, the requirements for welding, fabrication, and non-destructive examination (NDE), including tests and inspections, their frequency and acceptable limits shall be defined and appropriate procedures developed. In addition the required approvals, qualification of employees, hold and witness points, and audits shall be confirmed. Some typical quality assurance activities that shall be conducted during fabrication include:

a. Non-destructive testing of welds;

b. Witnessing of mill tests of materials of construction or examination of certified mill tests;
c. Stress relieving;
d. Impact (Charpy V) tests;
e. Hydro testing or pneumatic strength tests;
f. Non-destructive examination;
g. Verification of dimensions and tolerances.

Prior to installation of equipment, the existence of the required fabrication records shall be verified for accuracy and completeness.

The checks and inspections that shall be considered during installation include:

a. Soil compaction,
b. Soil load-bearing and swell characteristics,
c. Protection against frost heaves,
d. Strength of concrete,
e. Structural steel integrity,
f. Proper bolting techniques,
g. Positive material identification ,
h. Damage to coatings, linings and refractory.

3.1.2.5 Commissioning

Once construction is nearing completion, commissioning of the facilities shall be conducted. Typical activities that shall be conducted during commissioning include:

a. Cleaning and drying equipment;
b. Leak checking;
c. Function testing of instrumentation, controls and interlocks;
d. Verification of software functionality.

3.1.2.6 Pre-startup Safety Review

Prior to the introduction of LNG into the facility, a pre-startup safety review (PSR) shall be conducted. The PSR shall be conducted by a team with representatives from engineering, instrumentation and control, construction, maintenance and operations. The review shall include an audit of documentation and physical inspection of the facilities. Any deficiencies identified shall be documented and an action plan to resolve these deficiencies shall be developed. Prior to startup all action items required to be addressed prior to startup shall be verified to be complete and documented.

3.1.2.7 Initial Startup

Initial startup of the facility shall include the purging of equipment and initial cool-down following the requirements of CSA Z276-01 Clauses 12.3.6 and 12.3.7. Initial startup shall include any activities necessary to demonstrate the design capacity and reliability of the facility.

3.1.2.8 Reporting During Detailed Design and Construction

The following table outlines the contents of a monthly report that shall be submitted to the Board commencing one month after the Permit to Construct is issued and ending on the date the Licence to Operate is issued.

Table 3-2: Owner Construction Report Outline

a. Status of compliance with all Conditions in the Board Order Issuing the Permit to Construct
b. Status of project permits
c. Project Status (activities completed since the last report)
   i. Construction
   ii. Summary of fabrication and installation tests and inspections conducted to comply with the requirements of CSA Z276-01 and this Code
   iii. Summary of operational, maintenance, safety, emergency or security procedures and training to comply with the requirements of CSA Z276-01 and this Code that were completed
   iv. Project schedule, highlighting activities ahead or behind schedule
   v. Other activities, including any reviews, audits or inspections by the Board or its Certifying Authority, other regulatory agencies, the operating company, their contractors or insurance companies
   vi. Status of all recommendations made during reviews, inspections or audits by the Board or its Certifying Authority, other regulatory agencies, the operating company, their contractors or insurance companies
d. Incidents and Problems Encountered
   i. Incidents resulting in death or hospitalization, fire or explosion
   ii. Problems encountered including any tests and inspections where the results were outside specified limits or significant defects identified by quality control/quality assurance activities
   iii. Actions taken to investigate incidents and correct problems
   iv. Status of open action items from previous reports
e. Change Management
   i. Summary of significant design changes made prior to the HAZOP
   ii. Summary of all field changes made after the HAZOP and a review of the impact of each change on the HAZOP and regulatory requirements, including any additional recommendations
f. HAZOP
   i. Status of all recommendations from the HAZOP and any other recommendations necessary due to field changes

Application for the Licence to Operate

The application for a Licence to Operate a LNG facility shall include the following documentation (see Appendix B for details on requirements):

a. Chemical Hazard Information

b. Process Chemistry

c. Plot Plans for Siting and Layout

d. Fire Protection System

e. Plot Plan for Layout of Detection, Control and Interlock Systems

f. Plot Plan of Spill Containment System Layout

g. Plot Plan of Area Electrical Classification

h. Block Flow Diagram of Isolation and Shutdown Systems

i. Process Flow Diagrams

j. Equipment, Piping and Building Specifications

k. Applicable Codes and Standards

l. Piping and Instrument Diagrams

m. Relief System Design and Sizing Basis

n. Ventilation System Design and Sizing Basis

o. Basic Process Control System

p. Safety Instrumented Systems (SIS)

q. Interlock Cause and Effect Chart

r. Design and Safety Studies

s. Details of Electrical Power Systems

t. Compliance with Regulations

The following additional documentation will also be submitted:

u. HAZOP Report

A report of the HAZOP of the detailed engineering design which includes a list of all changes made after the completion of the HAZOP and a copy of the action plan showing the resolution of all action items (see section 3.1.2.2).

v. Emergency Response Plan

An emergency response plan that is developed in conjunction with the Facility Security Assessment and meets the requirements of CSA Z276-01 section 12.3.3 (see also Appendix A).

w. Facility Security Assessment and Plan

A facility security assessment and plan for the land-based facilities that follows the same methodology as required for the marine facility assessment under MTSA. In addition a copy of the MTSA marine facility security plan submitted to Transport Canada shall be provided.

x. Pre-startup Safety Review Report

A report summarizing the pre-startup safety review that was conducted, the action items identified and documentation of the resolution of all action items.

y. Preventive Maintenance Program

A summary of the testing and inspection frequencies, acceptable limits and their basis for all equipment, piping and instrumentation.

z. Process Safety Management System procedures (see Appendix A)

A complete set of PSM procedures to be followed during operation shall be developed; specifically the remaining procedures not already developed during design and construction shall be developed including:

i. Mechanical Integrity – requirements for maintenance, testing and inspection of all components
ii. Training – refresher training program
iii. Pre-startup safety review - conducted before startup of each change
iv. Process hazard analysis – revalidation of the HAZOP
v. Incident investigation
vi. Emergency planning and response
vii. Auditing

3.2 Requirements for Operation (Conditions of the Licence to Operate)

3.2.1 Process Safety Management During Operation

The following shall be the required frequency of conducting specific PSM activities. All other PSM activities shall be conducted routinely as required.

a. The HAZOP shall be revalidated for each facility change made to the process and at least every five years to confirm that the impact of all facility changes is reflected in the current HAZOP and that any changes in regulatory requirements or industry standards are incorporated in the study.
b. Refresher training shall be conducted at least every two years as specified in CSA Z276-01 clause 12.5.4. Refresher training content shall be developed in consultation with employees.
c. Internal PSM compliance audits shall be conducted every three years. Each element of PSM shall be audited.
d. Contractor safety performance shall be evaluated after each job or annually if the contract is evergreen.
e. Incidents shall be reported to the Board immediately and an investigation shall be initiated within 48 hours. An incident investigation report shall be submitted to the Board upon completion. (See Appendix A, section 8.)

3.2.2 Process Safety Management Report

Commencing one year after receipt of the Licence to Operate, the owner shall submit an annual Process Safety Management report to the Board containing the following information for the previous 12 months:

a. Summary of changes made to the facility and which changes required an update of the HAZOP;
b. Summary of incidents, outages and malfunctions;
c. A copy of any updates made to process safety information or reports submitted with the application for a Licence to Operate;
d. Status of all action items/recommendations from:

    i. Management of change and pre-startup safety reviews
    ii. HAZOP revalidation
    iii. Incident investigations
    iv. Any audits, reviews or inspections conducted by the company, its insurance company or contractor, other regulatory agencies, the Board or its Certifying Authority

e. Summary of testing and inspection activities, including components overdue for testing or inspection, significant defects found during testing and inspections and corrective action planned or taken;

f. A list of any components that have been taken out of service (for more than 30 days) or abandoned.

3.3 Closure and Abandonment

3.3.1 Notification

Notification to the Board shall be provided of any plan to abandon all or part of an LNG site as per the *Gas Plant Facility Regulations* section 23(1).

3.3.2 Abandonment Plan

Prior to abandonment of all or part of an LNG facility, an abandonment plan shall be submitted to the Board as per the *Gas Plant Facility Regulations* section 23(2). The plan shall include a Management of Change review.

Any component that will be abandoned shall first be physically disconnected or isolated (blinded) from the remaining in service equipment. Any abandoned equipment shall be cleaned of all process fluids or residues prior to disassembly. Cleaned equipment shall be labeled with appropriate markers and kept segregated from unclean equipment.

4 Facilities and Equipment

4.1 General Requirements

Section 3 provided the management and oversight requirements for LNG facilitates. This section provides specific requirements for design, installation, operation and maintenance of these facilities based on the requirements in CSA Z276-01. The intent is not to duplicate these requirements, but rather to clarify, expand, and in some cases supersede specific requirements. Any requirements in CSA Z276-01 that are superseded are noted and the new requirements are highlighted in bold typeface.

4.1.1 Other LNG Codes and Standards

At the time this Code of Practice was being developed, the next edition to CSA Z276 was still being drafted by the committee. Coincidental with this, the NFPA 59A Production, Storage, and Handling of Liquefied Natural Gas committee was close to issuing its 2005 edition. During the preparation of the 2001 edition of CSA Z276, there was an effort to harmonize the two standards as much as practicable. While it is possible that some harmonization may occur this time around as well, the CSA Z276 committee was not able to provide any guidance in this regard. Hence, some requirements in this Code of Practice incorporate concepts or changes that are based on the proposed changes to NFPA 59A in 2005.

Another major international LNG standard that was used as a primary source is European Standard EN 1473: 1997 *Installation and equipment for liquefied natural gas - Design of onshore installation.*(9)

4.2 Plant Site Provisions

4.2.1 General Site Selection

Clause 4.2 of CSA Z276-01 applies to the selection of storage facility locations during the design phase of a LNG project. Section 3.1.1 of this Code addresses the information requirements to be submitted with the application for a Permit to Construct which includes a facility siting and layout analysis in section 3.1.1.6.

4.2.2 Spill and Leak Control

CSA Z276-01 Clause 4.2.2 provides design requirements on spill and leak control to minimize the possibility that an accidental discharge of LNG will endanger adjoining property, waterways or important process equipment and structures. The following sections provide guidance on interpreting Z276 requirements for sizing of impoundments, and flammable vapor dispersion and thermal radiation exclusion zone calculations, and additional requirements under this Code of Practice.

4.2.2.1 Impoundment Area Capacity

Impounding areas serving an LNG container shall have a minimum volumetric holding capacity of 110% of the tank's maximum volumetric holding capacity for impoundments serving a single tank or 110% of maximum volumetric holding capacity of the largest container for impoundments serving more than one container.

This requirement supersedes the requirements for impounding volume to be equal to 100% of the volume of the container in CSA Z276-01 Clause 4.2.2.1.

The impoundment areas for vaporization, process or transfer areas shall be based on the largest total quantity of LNG or other flammable liquid that could be released from a single transfer line in ten minutes.

This requirement supersedes the option of choosing a spill duration of less than ten minutes in CSA Z276-01 Clause 4.2.2.2.

Also, permanent plant piping shall be considered in transfer areas.

This requirement supersedes the exclusion of permanent plant piping in the CSA Z276-01 definition of transfer areas in Clause 2.1.

For pipeline ruptures, the location of the rupture shall also be considered in determining the release rate. In lieu of determining release rates by conducting a fluid dynamics analysis based on the actual pump characteristics, the release rate shall be taken as 1.3 times the normal pumping rate. For facilities that have spare LNG transfer pumps, all pumps shall be included in determining the release rate of the spill unless the spare pumps are isolated from the LNG tank when not in service.

4.2.2.2 Drainage Systems

Drainage systems (troughs) within an LNG facility shall be as short and narrow as practical and/or be insulated to reduce vaporization rates and consequently dispersion distances.

4.2.2.3 Impoundment Area Siting

Design spills for impoundments serving only vaporization, process or LNG transfer areas shall include leaks from the largest transfer lines. The diameter of the hole used to determine the spill rate shall be 10% of the largest transfer line diameter.

This clarification provides specific guidance on how to calculate a design spill from "any single accidental leakage source" as required under Clause 4.2.3.4 (d) of CSA Z276-01.

Any impoundment areas shall be located so that the heat flux from a fire does not cause structural damage to an LNG vessel moored or berthed at the marine terminal. A limiting radiation of 15 kW/m^2 at the vessel shall be used to determine the safe separation distance.

4.2.2.4 Calculation of Source Term for Dispersion Analysis

For a continuous LNG release, the LNG vaporization rate shall be determined using either:

a. a detailed dynamic pool spreading and vaporization model.

b. an average vaporization rate of 0.05 kg/m2/s (0.61 lb/ft2/min) on land across a given pool cross-section. For a specified LNG release rate in (kg/s), it is possible to calculate the maximum pool area by assuming the mass inflow equals vaporization outflow when the pool reaches equilibrium. The area is obtained by dividing the flow rate (kg/s) by the average vaporization rate of 0.05 kg/m2/s.

If the pool is confined by a dike, and if the dike diameter is less than the pool diameter obtained from the above calculation methodology, then a pool spreading and vaporization model formulated for confined spills should be used or alternatively multiply the dike area in square meters by 0.05 kg/m2/s to obtain the vaporization rate.

4.2.2.5 Vapor Dispersion Modeling

For a design spill, the flammable vapor concentration shall be determined to a distance to ½ LFL of methane (2.5 mol %).

The following atmospheric conditions shall be used for calculating dispersion distances:

a. Pasquill-Gifford atmospheric stability, Category F
b. 4.5 mph wind speed
c. Relative humidity of 50%
d. Reference height of 10m
e. Receptor elevation of 0.5 m
f. Surface roughness of 0.03m

4.2.2.6 Calculation of Thermal Radiation Exclusion Zones

The modeling conditions for determination of thermal radiation exclusion zones shall be based on the wind speeds that produce the maximum exclusion distances, except for wind speeds that have occurred less than 5% of the time in the local area.

This requirement supersedes the zero wind speed specified in CSA Z276-01 Clause 4.2.3.2.2.

4.2.2.7 Equipment Spacing

LNG containers and other process equipment shall be spaced such the thermal radiation flux from a fire in an impoundment or drainage system does not exceed the following values or the separation distances specified in Table 2 of CSA Z276-01, whichever distance is greater:

a. 30 kW/m^2 at the concrete outer surface of an adjacent storage tank
b. 15 kW/m^2 at the metal outer surface of an adjacent storage tank or the outer surfaces of process equipment

If water spray or deluge systems are used to reduce thermal radiation flux, separation distances shall not be lower than those specified in Table 2 of CSA Z276-01.

4.2.3 Buildings and Structures

Standard CSA Z276-01, Clause 4.3 addresses building or structures in which LNG, flammable refrigerants, and flammable gases are handled. The following provisions address the hazards of these materials to normally occupied buildings.

4.2.3.1 Structural

The control room shall be designed to enable occupation for sufficient time to put into effect emergency procedures and to permit evacuation to a safe location.

Control rooms shall be designed to withstand at least the same seismic loads as the LNG storage containers (see section 4.4.1).

4.2.3.2 Location

The location of occupied buildings or structures at LNG facilities shall be based on a facility siting analysis that assesses the risk of explosion and fire impacts to occupants. (see section 3.1.1.6).

Where location alone cannot achieve a tolerable risk, means to prevent the hazard scenario or mitigate the effects shall be implemented such as safety instrumented systems, building pressurization, and structural reinforcement.

4.2.3.3 Ventilation

Air intakes shall be provided with gas detectors to shutdown air handling units and inhibit startup to avoid risk of introducing toxic or flammable gas into the building.

The control room HVAC system shall be designed to match the possible received thermal radiation flux in accordance with the specified maxima in Table 4-1.

No specific fire water protection is required if the radiation flux is equal to or less than the specified maxima below:

Table 4-1: Allowable thermal radiation flux in excess of solar radiation, kW/m^2

Structure	From LNG pool fire	From flare stack
Administration buildings	5	5
Control room, work shops, laboratory, warehouse	9	5

4.3 Process Equipment

General requirements for process equipment are addressed in CSA Z276-01 Clause 5.

4.3.1 Relief Devices

The sizing basis for relief devices shall be based on a documented contingency assessment with proper consideration being given to fire exposure, process upsets, thermal expansion, sudden change in barometric pressure, thermal expansion, control malfunction, improper valve position, mechanical failure (e.g., exchanger tube rupture) and loss of utilities. The controlling contingency for sizing shall be identified in the documentation. (See also section 4.6).

4.4 Stationary LNG Storage Containers

General requirements for stationary LNG storage containers are addressed in CSA Z276-01 Clause 6. Non-destructive examination techniques shall be as per the latest revision of API 620, but not limited to radiographic. The requirement for the percentage of welds to be inspected shall be as per CSA Z276-01 Clause 6.2.1.

4.4.1 Seismic Design

The safe shutdown earthquake (SSE) shall be representative of seismic ground motion that has a probability of exceeding not more than 0.04% per annum (2% in 50 years; mean return interval of 2475 years).

This section supersedes the requirements in CSA Z276-01 Clause 6.1.3.1(b).

4.4.2 Insulation

The outer tank wall shall be routinely inspected for cold spots using a portable infrared monitor or equivalent.

Thermal expansion of components shall be taken into account. Therefore, when insulation comprised of expanded Perlite is installed outside the primary container, it shall be protected from settling and compaction for example, by use of resilient glass wool blankets, which absorb variations in the diameter of the primary container.

4.4.3 Relief Device Sizing

The relief device sizing basis determined in accordance with CSA Z276-01 Clause 6.6.3 shall be documented as required under section 4.3.1 of this Code of Practice.

The boil off due to rollover shall be calculated using an appropriate validated rollover model, or where no model is used, the flow rate during rollover (V_B) shall be taken to be equal to:

$$V_B = 100 \times V_T$$

Where V_T is the maximum boil off rate from a tank due to heat input in normal operation, assuming ambient air at the maximum temperature observed during the summer.

4.4.4 Relief Device Installation

Relief devices installed in accordance with CSA Z276-01 Clause 6.6.2.1 shall:

a. be provided with means to detect leakage.
b. be provided with means to snuff an ignited discharge.

4.5 Boil off Recovery System

There are no requirements for boil off gas systems in CSA Z276-01.

A boil off recovery system shall be installed to in order to collect liquefied natural gas boil off due to heat in leak and flash present in the feed when filling tanks. The vapors shall be safely disposed of through re-liquefaction, used a fuel, returned to storage tanks (truck loading) or marine tankers (marine vessel unloading), recompression to a gas pipeline network, or as a last resort flared or released to atmosphere.

4.5.1 Boil off Gas Collection

The system shall be designed so that no direct emission of cold gas into the atmosphere can occur during normal operation. The system shall be designed to handle at least the following:

a. the boil off from the LNG tanks and all receivers containing LNG.
b. the degassing systems of piping and equipment containing LNG.

4.5.2 Systems for Return of Gas to the Marine Terminal

The system connects the boil-off collection system to the vapor return arm of the dock. It shall provide for the transfer of gas from the tank to ship(s) or reverse in order to compensate for the volume of liquid shifting during unloading or loading, and the collection of boil-off from the ship while it stays at the dock or during inerting of the tanks.

4.6 Flare and Venting System

There are no requirements for flare and venting systems in CSA Z276-01.

For installations where a vent or flare system is provided, the maximum flow rate is usually determined considering:

a. unloading of a liquefied natural gas carrier with gas return being unavailable;
b. any boil off recovery compressors are stopped;
c. operation of a submerged pump in full recycle; and
d. cool down of the LNG carrier (for export terminals only).

The flare/vent shall be sized for the maximum gas flow that can be expected, i.e., accidental flow rate as defined herein.

The following two flow rates are defined:

a. The nominal flow rate which is the sum of the boil off flow rates expected from the following:
   i. evaporation due to heat input;
   ii. displacement due to filling;
   iii. flash at filling;
   iv. variations in atmospheric pressure
   v. the recirculation from a submerged pump; and
   vi. the boil off due to heat input of all receivers (pipes, drain drums, etc.) containing LNG.

b. The accidental flow rate which is the greater of the following two combinations:
   i. Nominal flow rate and the flow rate at the outlet of the safety relief valve of one vaporizer as defined in CSA Z276-01 Clause 7.4.1, if it is connected to the same vent/flare system;
   ii. Nominal flow rate and the flow rate at the outlet of one tank safety relief valve as defined in CSA Z276-01 Clause 6.6.3, if it is connected to the same vent/flare system.

If the relief valves of the tanks and vaporizers are not connected to the vent/flare system, the accidental flow rate is then equal to the nominal flow rate.

The layout of the flare or vent shall be chosen according to prevailing wind/wind rose in order to minimize the risk of the flame being an ignition source for a potential release of flammable vapor.

4.7 Vaporization Facilities

General requirements for vaporization facilities are addressed in CSA Z276-01 Clause 7.

4.7.1 Materials of Construction

As vaporizers are in contact with a heating fluid, their materials of construction shall be compatible with the fluid, or they shall be protected from corrosion/erosion by the heating fluid.

4.7.2 Design Considerations

The following shall be considered for the design of a vaporizer:

a. vaporizer weight including connected equipment if applicable;
b. test pressure;
c. thermal and cool down transient stresses;
d. wind, snow and ice loads for units not located under cover;
e. operating basis earthquake (OBE), to be taken into account statically.

As a minimum, the vaporizer shall be designed for combinations of these factors that would be expected during conditions of normal operation, testing and cool down.

4.7.3 Relief Valves

The safety relief valves shall discharge directly to the atmosphere except in cases where this leads to an undesirable situation. In this case, the discharge of the safety relief valves shall be routed to a vent or flare.

4.8 Liquefaction Facilities

4.8.1 General

There are no requirements for liquefaction facilities in CSA Z276-01.

This section deals with the LNG export terminals and LNG peak-shaving plants, where natural gas is treated and liquefied for subsequent storage.

4.8.2 Gas Treatment

Before liquefaction, undesirable constituents, such as water, carbon dioxide, methanol, and sulfur compounds shall be removed to avoid equipment blockages due to solidification upon cooling. Mercury shall also be removed, as it can cause failure of components, such as heat exchangers, that are constructed from aluminum. Because mercury is extremely toxic, removal shall be carried out in an environmentally acceptable manner.

4.8.3 Cold Box Design

Cold boxes, which house many cold equipment items in one insulated enclosure, are conventionally used in LNG liquefaction plants. Where employed, seals shall be provided at the inlet and outlets of the cold box piping. Continuous purging of the cold box with nitrogen shall be performed to prevent ingress of moisture and to allow detection of hydrocarbon leaks into the cold box.

4.8.4 Refrigerant Storage

Hydrocarbon refrigerants are generally stored in pressure vessels at ambient temperature except for ethylene, which can be store at cryogenic temperatures. Design and installation of such storage shall conform to NFPA 30, *Flammable and Combustible Liquids Code of Practice*. (10)

4.9 Extraction of Natural Gas Liquids

There are no specific requirements for extraction of natural gas liquids in CSA Z276-01.

The extraction of natural gas liquids is typically preformed in two stages of cryogenic distillation beginning with a demethanizer column that separates the LNG feed into methane overhead and a raw NGL fraction (C_2^+ hydrocarbons) at the bottom. The NGL stream may also be fed to a deethanizer for separation of ethane from the liquefied petroleum gas (LPG) comprised primarily of a mixture of propane and butane. The NGL/LPG may be stored at the LNG terminal, depending on the means of transfer (i.e., pipeline, rail or highway tanker, marine vessel).

4.9.1 General

Installations for natural gas liquids (NGL) extraction shall comply with Clause 5 of CSA Z276-01, excepting that indoors installation per 5.1.1(b) shall not be allowed.

4.9.2 Storage

Storage facilities for NGL and LPG shall comply with the requirements of API Standards 2508, 2510 and 2510A. (11, 12, 13)

4.9.3 Piping

Piping systems shall comply with section 4.12 of this Code of Practice and Clause 8 Piping Systems and Components of CSA Z276-01 with the exception of those requirements that apply specifically to liquefied natural gas (LNG) service.

4.9.4 Transfer of NGL/LPG

Transfer systems for NGL/LPG shall comply with Clause 10 of CSA Z276-01 and API Standards 2508 and 2510. Where the requirements of CSA Z276-01 are in variance with the API standards, CSA Z276-01 shall take precedence.

4.10 LNG Pumps

General requirements for LNG pumps are addressed in CSA Z276-01 Clause 5.1.

This section covers the minimum requirements for centrifugal pumps used for LNG transfer and recirculation.

4.10.1 Application

The main applications of liquefied natural gas pumps include:

a. Boosting the LNG to desired send-out pressure prior to vaporization;
b. Feeding the above mentioned booster pumps;
c. Removing LNG from drain drums;
d. Transferring the LNG from the liquefaction plant to storage;
e. Circulating the LNG within tanks;
f. Tank to tank transfer;
g. LNG loading and unloading.

4.10.2 Design Considerations

Those parts of liquefied natural gas pumps that are normally in contact with LNG and all materials used in contact with LNG or cold LNG vapor shall conform to CSA Z276-01 Clause 6.1.2.2.

Thermal transient operating conditions shall be taken into account.

All piping that is part of an LNG pumping system shall be in accordance with Clause 8 of CSA Z276-01.

4.10.3 Inspection During Fabrication

A testing and inspection program shall be implemented during fabrication and shall include all of the following:

a. Radiographic inspection of all welds on the pump body;
b. Ultrasound inspection;
c. Crack detection using dry penetrant;
d. Visual inspection to check the compliance of the product with this Code of Practice and referenced standards;
e. Dimensional inspection to check the compliance of the product with supplier's reference documents;
f. Electrical inspections including verification of direction of rotation.

Inspection certificates for pump pressure containing parts shall be provided.

4.10.4 Specific Requirements

Each pump shall be individually valved in order to enable isolation, draining and purging for maintenance.

In cases of pumps running in parallel, a check valve shall be installed in each pump discharge line. Provisions shall be taken to avoid hydraulic hammer from this check valve.

For “in-pot” or “in-column” mounted pumps, provision shall be made to enable adequate venting of gas pockets.

The can of an in-pot pump shall be equipped with a drain and valve.

An arrow indicating the rotation direction shall be engraved or molded onto the outside wall of the pump body. Beneath the arrow, the marks of the connection terminals, if any, shall be shown in the order in which they are to be connected to the successive phases.

4.11 Utilities

There are no specific requirements for utility systems in CSA Z276-01.

4.11.1 Compressed Air

A backup instrument air system shall be provided for the time interval needed to put the plant in a safe condition upon failure of the main instrument air supply.

The instrument air system shall not be cross connected to the nitrogen system for use as a backup supply.

The plant or utility air distribution system shall be separate from the instrument air distribution system

4.11.2 Fuel Gas

LNG vapors from the LNG storage tanks and from the tanks of the LNG ship shall preferentially be used to supply the plant fuel gas system or alternatively be re-liquefied to LNG or be flared (if necessary).

Fuel gas used inside buildings shall have a reliable means of detection in case of a leak.

4.12 Piping Systems and Components

General requirements for LNG piping systems and components are addressed in CSA Z276-01 Clause 8.

4.12.1 Typical Piping Systems of LNG Plant

Piping systems of an LNG plant fall into the following four categories

a. Main process systems;
b. Auxiliary process systems;
c. Utility systems;
d. Fire protection systems.

4.12.2 Piping Design

When designing LNG piping, the maximum allowable line velocity shall be 8 m/sec (26.2 ft/sec).

4.12.3 Pipe Racks and Pipe Ways

Pipes should be arranged on a pipe rack or pipe way. Main and auxiliary process systems shall be routed in the open air as much as possible so as to avoid any confinement of accidental releases of flammable gases.

Pipe racks or pipe ways containing hazardous materials that cross active roadways shall have warning signs indicating the maximum height of vehicles that can safely pass underneath.

Pipe racks and pipe ways shall be designed so as the resist the OBE seismic events as defined in CSA Z276-01 Clause 6.1.3.1

Piping racks and sleepers shall be protected against exposure to fire, and/or a leak of LNG or cold gas as per CSA Z276-01 Clause 8.2.1.2

Ground level piping installed on sleepers shall be protected from vehicular impact when running close to or parallel to a road. The installation of sleepers shall be such as to avoid frost heaving.

4.12.4 Piping System Insulation

Hot and cold pipelines and accessories shall be insulated to:

a. Provide protection against condensation and/or frost;
b. Protect employees against accidental contact.

Insulation systems for LNG piping shall be designed using a coating or covering to prevent ingress of moisture into the insulation.

4.12.5 Differential Movement of Piping and Insulation

The insulation system shall be designed to remain moisture tight even after undergoing anticipated differential movement between the pipe and the insulating system.

Insulation joints shall be designed to resist differential movement cycles in relation to both internal and external temperature variations.

The thickness of each insulation layer shall, if necessary, be limited to reduce shear stresses due to temperature gradient between the warm and cold side, to a value less than the maximum acceptable shear stress, while taking into account a safety factor.

Insulation shall be resistant to normal expected vibration.

4.12.6 Insulation Thickness

To avoid outside surface condensation on insulation the difference between the ambient external temperature and the surface temperature shall be limited, to ensure that the outside temperature is higher than the dew point for about 75% of the time when it is not raining. This can be determined by the site metrological information.

4.12.7 Corrosion Under Insulation

Corrosion under insulation can be a major problem and can be the source of an initiating event. However because this corrosion is hidden it might not be detected until it is too late.

To reduce corrosion under insulation the following design practices shall be used:

a. Avoid primary reliance on mastic seals and caulking as a moisture barrier, as both of these materials dry with age and shrink.
b. Water-proof jacketing should be designed such that runoff of rain water will occur.
c. Nozzles, man ways, ladder and lifting lug clips, platform angle mounts, bleeder valves, fittings valves etc. should be designed for all connections to be outside the insulation.

4.12.8 Pipe Supports

Pipe supports shall permit the movement of pipe due to thermal expansion and contraction without exceeding the allowable stresses.

Branch lines shall be free to move during the cool down or heat up of the main line. This movement shall not be hindered by structural members and pipe supports.

4.12.9 Valves

Valves, control and block, shall be located in such a position as to minimize the potential for two phase flow, which can cause vibration and damage to the piping system.

4.12.9.1 Check Valves

When check valves are installed in a line they shall be installed downstream of the block valve in the direction of flow. In this manner any LNG trapped between the check valve and block valve will be relieved on expansion into the downstream piping

4.12.9.2 Emergency Shutdown Valves (ESD)

The closure time of ESD valves shall be adjusted to ensure their closing does not result in the generation of pressure surges that would cause the piping to fail or fall off its supports.

ESD valves shall meet the following criteria:

a. ESD valves that may be operated for process control reasons by the basic process control system shall only be operated for emergency reasons by the safety instrumented system (see section 4.14).
b. ESD vales shall fail in a safe position as identified in the HAZOP.
c. ESD valves are used also to isolate inventories of flammable materials shall be designed as fire safe.

4.12.10 Inspection and Testing

Water used for the hydraulic testing of stainless steel piping and equipment shall contain less than 100 ppm chloride ion.

Following a hydraulic test of equipment or piping all water shall be removed from the equipment or piping and the equipment dried to remove all visible water. Water shall not be allowed to remain in the low points of piping systems.

4.13 Instrumentation and Electrical Services

4.13.1 General

General requirements for instrumentation and electrical services are provided in Clause 9 of CSA Z276-01.

4.13.2 Emergency Power

An emergency power supply shall be designed to ensure, in case of failure of the main power supply, that all the vital safety functions are met for:

a. personnel
b. plant
c. environment

4.14 Control Systems

4.14.1 General

The LNG plant control systems shall enable the operator at a minimum to:

a. monitor and control gas processing.
b. monitor and control plant safety.
c. be informed of incoming or intruding people.

These main functions shall be performed by independent systems;

a. the basic process control system (BPCS),
b. the safety instrumented systems (SIS),
c. the access control system.

4.14.2 Basic Process Control System

The BPCS should deal with controlling the operation of the main functional areas of the plant. The control of the main functions can be automatic or semi-automatic. In general, the operator can initiate and co-ordinate the operation of equipment to ensure the proper working of a function.

The BPCS shall have a high reliability consistent with the safety level of the plant and shall be configured to fail safe. Remotely controlled equipment shall be capable of being stopped locally, in case of an emergency.

The BPCS shall be able to store and/or print all information returned by the process control devices necessary for safe and efficient operation of the plant, such as:

a. process conditions (pressure, temperature, etc.),
b. system faults,
c. vibrations,
d. voltages/currents/frequencies,
e. positions.

4.14.3 Safety Instrumented Systems

General requirements for emergency shutdown systems are provided in Clauses 11.2 and 11.3 of CSA Z276-01.

The SIS shall be designed to protect equipment and personnel from process upsets and emergency conditions. They shall be functionally independent systems from the BPCS.

SISs shall include systems for equipment, unit and process shutdowns

The SIS shall automatically detect unsafe conditions and shall activate automatically or manually the appropriate equipment, unit, process or emergency shutdown:

The main functions of the SIS shall include:

a. activate automatically the appropriate shutdown system;
b. activate automatically the appropriate protection equipment;
c. inform the operator of an incident;
d. inform the BPCS of SIS activation;
e. monitor and control the protection equipment (e.g., fixed fire protection systems);
f. monitor and control protection system auxiliaries (e.g., fire pumps, foam agent pumps, fire water system valves).

To assist with the design, a cause and effect matrix shall be established to ensure the correct SIS is configured as a function of the location and the nature of abnormal conditions detected (see Appendix B item 17).

4.15 Transfer Systems for LNG and Other Flammable Liquids

4.15.1 General

General requirements for transfer systems are provided in Clause 10 of CSA Z276-01. The applicable fluid transfers defined in Clause 10.1.1 of CSA Z276-01 shall include natural gas liquids (NGL) and liquefied petroleum gas (LPG).

4.16 Fire Protection

General requirements for fire protection systems are provided in Clause 11 of CSA Z276-01.

4.16.1 Flammable Gas and Fire Detection

The fire and flammable gas detection system shall be a Safety Instrumented System.

4.16.2 Fire water system

As a minimum, two fire water pumps shall be installed. Independent power sources shall be provided in such as way that full capacity can be delivered taking in to account the unavailability of one pump.

Fire water networks shall be provided around all sections of the facility containing flammable fluids.

The water supply system shall be designed with independent sections so that in case of maintenance of a section, the water supply to others sections in not interrupted.

4.16.3 Foam Generation

Fire fighting foams can be used to reduce the heat radiation and evaporation rate fires and spills of LNG. Foams shall be suitable for LNG fires.

Foam generators associated with an LNG impoundment systems shall be located taking into account the prevailing winds. Generators shall preferably be located so that the prevailing winds will tend to blow the foam towards and across the impoundment system.

4.16.4 Dry Power Extinguishment

Because immediate and complete application is required to be effective, enough dry powder shall be provided to permit a second shot in case of re-ignition.

The dry powder shall be suitable for extinguishing LNG gas fires and be compatible with any foam to be used.

4.17 Personnel Safety

General requirements for personnel protective equipment and confined space entry are provided in CSA Z276-01 Clause 11.8. Work practices for confined space entry are of particular interest, because LNG is not odorized.

LNG plants in Nova Scotia are subject to the Provincial Department of Environment and Labour as the agency responsible for worker safety, which requires the development of other safe work practices.

4.18 Security Facilities

General requirements for security are provided in CSA Z276-01 Clause 11.7.

4.18.1 Facility Security Plan

A security plan shall be prepared based on the requirements of the facility security assessment that is required under the Marine Transportation Security Regulations (SOR/2004-144) of the Marine Transportation Security Act (MTSA) which is regulated by Transport Canada.

4.18.2 Security Enclosures

The following facilities shall be surrounded by protective enclosures, unless located within the overall facility boundary, provided that protective enclosures are provided for the entire facility boundary, such as a perimeter fence:

a. LNG Storage containers,
b. Impoundment systems,
c. Onshore LNG transfer systems,
d. Flammable refrigerant storage tanks,
e. Flammable liquid storage tanks,
f. Natural gas metering stations,
g. Control rooms and stations,
h. Outdoor process equipment areas,
i. Fire control equipment,
j. Security communication systems,
k. Emergency power sources.

Enclosures may consist of fences, building walls or natural barriers.

Grading that does not impair the effectiveness of an enclosure shall be provided.

Control of vegetation and grading, inside and outside of an enclosure shall be provided, that does not compromise the effectiveness of an enclosure and the ability to monitor the enclosure.

Remote means of monitoring the enclosures to detect intrusion, such as closed circuit television (CCTV) and motions detectors, shall be provided, and shall at the location where security personnel are continually on duty and the central control room. In addition to these devices the enclosures shall be observed by security personnel while making patrols. Security monitoring devices shall be provided with a backup power supply.

4.19 Communications and Lighting

General requirements for communications and lighting are provided CSA Z276-01 Clause 10.8.

4.19.1 Communication Systems and Backup

Communications shall be provided for utilization in normal operations, emergency response and for security of the site. Communication methods may consist of radios, flashing lights, signal horns, telephone systems, audible horns, and pubic address systems or a combination of these items.

Radios used in the facility shall be suitable for use in hazardous locations.

Telephones shall conform to the electrical classification of the area in which they are located.

The LNG marine transfer area shall have a ship-to-shore communication system and a separate emergency system which shall be continuously monitored during unloading aboard ship and at the terminal.

Signal horns or other communication systems used to alert personnel to an emergency shall be audible in all buildings and areas of the plant.

Systems for communicating emergencies to local authorities or mutual aid groups shall be dedicated for this purpose.

Personnel with responsibility for security shall have a direct means of communication with the central control room.

A backup system shall be provided for all emergency and security communications systems.

4.19.2 Lighting Systems and Backup

Adequate lighting in the LNG facility is essential for safe operation and maintaining the security of the site.

The following minimum illumination levels shall be provided in the areas listed:

a. Inside a security enclosure: 2.2 lux (0.2 ft candles)

b. Outside work areas: 11 lux (1 foot candle)

Those lighting systems that are required to ensure facility security shall be connected to an on site standby power supply that will automatically start on the loss of power to the lighting circuits. The controls, switches and distribution panels for the security lighting shall be located in a security enclosure.

4.20 Operation, Maintenance and Training

General requirements for operating and maintenance procedures, recordkeeping, and training are provided in Clause 12 of CSA Z276-01. Additional management system requirements are specified in Appendix A of this Code of Practice.

4.20.1 SIS Testing

Functional testing of safety instrumented systems (SIS) shall comply with ISA 84.01.

4.21 Jetties and Marine Facilities

This section covers the siting, engineering design, pre-operational training and safety requirements of the jetty and marine facilities.

4.21.1 Siting

The siting of an LNG marine facility shall include an assessment of the potential accidental and intentional scenarios that could result in a loss of containment of LNG from the cargo tanks and the potential thermal radiation and flammable vapor dispersion effects of these spills. The Sandia study, *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*, may be used as guidance for developing scenarios and modeling potential consequences.[14]

The location of the jetty at an LNG marine terminal is critical for establishing the safety of the ship/shore transfer. A location that minimizes the potential for unexpected movement of the tanker during unloading is desired. The selection of the jetty/marine terminal location shall follow the guidance in the SIGTTO publication *Site Selection and Design of LNG Ports and Jetties.* [15]

4.21.2 Engineering Design

The design of the jetty structure shall consider the following factors:

a. Soil conditions
b. Loads imposed on the jetty due to natural phenomenon, such as winds, tides, waves, currents, temperature variation, ice, tsunamis and earthquakes
c. Loads imposed by operational activities, such as berthing, mooring, cargo handling, and vehicles used during construction, operation and maintenance.

The design of the mooring and fendering systems shall consider the full range of vessels and mooring requirements (port and/or starboard) that might be berthed at the terminal.

The location of potential spills shall be identified, especially those occurring from the unloading arms, and protection shall be provided for critical steel structures that may be contacted by LNG. Curbing and drainage systems shall be provided to contain and direct any spilled LNG to the spill impoundment required under CSA Z276-01 clause 4.2.2.2.

A control room on the jetty shall be constructed with communications capability to both the ship and main terminal control rooms. The jetty control room shall contain controls for the emergency shutdown and release equipment for the LNG transfer system and jetty remotely operated fire-fighting equipment. Instrumentation shall also be provided to monitor sea and weather conditions and the ship's position and tension on the mooring lines.

Detection systems shall be provided for LNG spills and fires. These detection systems shall be part of the SIS and initiate an ESD of the ship-shore transfer and alarm in the jetty, terminal control room and ship control room.

Marine unloading arms equipped with powered emergency release couplings (PERCs) shall be used for the transfer of LNG from ship to shore.

Quick release mooring hooks shall be provided, but shall be designed such that failure of a single component or operation of a single switch will not release all moorings simultaneously.

4.21.3 Safety

Rapid access to the jetty and marine terminal by emergency vehicles shall be provided. Also rapid egress from any location on the jetty or marine terminal to a point of safety shall be provided.

5 References

1. Center for Chemical Process Safety (CCPS), *Guidelines for Facility Siting and Layout*, 2003.
2. Center for Chemical Process Safety (CCPS), *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires,* 1996.
3. American Petroleum Institute(API), *Recommended Practice 752, Management of Hazards Associated with Location of Process Plant Buildings*, May 1995
4. Center for Chemical Process Safety (CCPS), *Inherently Safer Chemical Processes*, 1996.
5. Center for Chemical Process Safety (CCPS), *Guidelines for Hazard Evaluation Procedures,* Second Edition with Worked Examples, 1992
6. ISA 84.01, *Application of Safety Instrumented Systems for the Process Industry*.
7. Center for Chemical Process Safety (CCPS), *Layer of Protection Analysis*, 2001
8. EN 1473: *Installation and equipment for liquefied natural gas – Design of onshore installations*, 1997
9. NFPA 30: *Flammable and Combustible Liquids Code,* 2003.
10. API Standard 2508, *Design and Construction of Ethane and Ethylene Installations at Marine and Pipeline Terminals, Natural Gas Processing Plants, Refineries, Petrochemical Plants and Tank Farms*, 1985
11. API Standard 2510, *Design and Construction of Liquefied Petroleum Gas (LPG) Installations,* 2001
12. API Publication 2510A, *Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities,* 1996
13. Access Northeast Energy Inc., *Environmental Assessment for the Proposed Bear Head LNG Terminal, Bear Head, Nova Scotia,* May 2004.
14. Sandia National Laboratories, *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water*, December 2004.
15. SIGTTO, *Site Selection and Design of LNG Ports and Jetties,* 1997.

Appendix A: Process Safety Management

Starting with the initial design and continuing construction and the operational phase of the facility, a process safety management system will be implemented.

The Process Safety Management System shall consist of the following elements:

1. Process Safety Information
2. Process Hazard Analysis
3. Management of Change
4. Pre-startup safety review
5. Operating Procedures
6. Training
7. Mechanical Integrity
8. Incident Investigation
9. Emergency Planning and Response
10. Contractor Management
11. Security Management
12. Auditing

The implementation of each PSM element requires a documented management system that will consist of the following characteristics:

a. Scope and Objectives
b. Policies and Procedures
c. Training and Experience
d. Verification and Measurement
e. Feedback and Improvement

Some elements will need to be in place during design, others during construction and others during operation. Some elements may have different requirements at different stages of the project, but all elements are required during operation.

The requirements of each element are summarized below:

a. Process Safety Information

a. Chemical hazard information
    i. Physical properties
    ii. Toxicity
    iii. Flammability
    iv. Reactivity
    v. Stability
    vi. Chemical interaction matrix

b. Technology information for process, utility and support systems
   i. Process chemistry
   ii. Plot plans
   iii. Block flow diagrams
   iv. Process flow diagrams (including material and energy balances)
   v. Equipment, piping and building specifications
   vi. Applicable codes and standards

c. Process information for process, utility and support systems
   i. Piping and instrument diagrams (PIDs)
   ii. Relief system design and design basis
   iii. Ventilation system design and design basis
   iv. Basic process control system
   v. Safety Instrumented Systems
   vi. Interlock cause and effect chart

b. **Process Hazard Analysis**[5]

a. Use the hazard and operability (HAZOP) methodology.
b. Facilitated (i.e., led) by an independent third party.
c. Conducted by a team including representatives from engineering, operations, maintenance, instrumentation and control.
d. Review previous incidents onsite, including known historical incidents in similar facilities.
e. Consider human factors.
f. Document each scenario with a credible cause.
g. Risk rank each scenario.
h. Provide recommendations for each intolerable risk.
i. Prepare a report including recommendations.
j. Prepare an action plan for each recommendation.
k. Track and document the resolution of each recommendation.
l. Revalidate the HAZOP for each change made to the process and at least every five years.

c. Management of Change (MOC)

a. Shall apply to any modification of an LNG component or support system which requires an update to the process safety information, operating, mechanical integrity or PSM procedures, including any components that are abandoned (decommissioned).
b. Shall include a review of and if necessary an update of the HAZOP and any safety and health concerns.
c. Shall specify the duration of temporary changes, including any component that is taken out of service .

d. Shall require training of affected personnel prior to implementation of the change.
e. Shall require updates to process safety information and other affected documentation, including procedures, plans and practices.
f. Shall include special procedures for emergency changes.

d. Pre-startup Safety Review (PSR)

a. For new facilities a PSR shall be conducted prior to the introduction of LNG into the facility.
b. For existing facilities, a PSE shall be conducted on each change to an LNG component or support system.
c. The PSR shall include a review of documentation as well as a physical inspection of the new or modified facilities.
d. The PSR shall verify that:
   i. A Management of Change review has been completed;
   ii. Recommendations from the HAZOP have been addressed;
   iii. fabrication and installation of equipment is according to design;
   iv. Operating, maintenance, emergency and security procedures have been developed or updated.
e. Any recommendations from the PSR shall be reviewed to determine which are required to be addressed prior to startup.
f. The resolution of all recommendations shall be documented.
g. Authorization to startup shall be documented.

e. **Operating Procedures** (see CSA Z276-01 Clause 12)

a. Shall include all phases of operation, including initial startup, normal startup, normal operation, normal shutdown, emergency shutdown and subsequent startup, emergency conditions and any temporary operations.
b. Shall include the properties and hazards of all materials.
c. Shall include safety and health precautions and required personal protective equipment.
d. Shall include safe operating limits and associated indications, alarms and interlocks, the consequences of exceeding these limits, the actions by operations personnel to correct the deviation or the actions taken by interlock systems.
e. Shall include quality control procedures for LNG, flammable refrigerants, and any other toxic or flammable materials stored or handled onsite.
f. Shall include procedures to control the inventory of flammable materials so as not to exceed the capacity of impoundment areas and calculated exclusion zones.
g. Any changes to these procedures shall be reviewed under the Management of Change procedure.
h. Shall be accessible to all affected employees.

f. **Training** (see CSA Z276-01 Clauses 3.4 and 12.5)

a. Shall apply to all operating personnel and any contractors involved in operating the process, including loading and unloading operations.
b. Refresher training frequency shall be conducted at least every two years (see CSA Z276-01 clause 12.5.4).

g. **Mechanical Integrity** (see CSA Z276-01 Clauses 12.4 and 12.5)

a. Shall apply to every LNG component, utility and support system.
b. Shall have written procedures for each activity.
c. Shall include training of employees in the mechanical integrity procedures and the hazards of the operation.
d. Shall include quality assurance:
   i. during fabrication and installation;
   ii. of maintenance materials and spare parts.
e. Shall include testing and inspection of new and in service components including:
   i. Type of test or inspection;
   ii. The acceptable limits of the test or inspection;
   iii. Frequency of test or inspection and the basis;
   iv. Results of each test or inspection, including the individual performing the test, the date, and the component identifier or number;
   v. The documented resolution of any identified deficiencies.
f. Shall include routine and breakdown maintenance.

h. Incident Investigation

a. Each incident shall be reported and investigated (see section 3.2.1 (e)).
b. The investigation shall be conducted by a team of qualified persons and a contactor representative (if the incident involves a contractor activity). The team leader shall have experience and/or training in conducting incident investigations.
c. The investigation report shall include:
   i. A description of the incident and the date;
   ii. The root causes of the incident;
   iii. Recommendations to prevent recurrence.
d. The resolution of each recommendation shall be documented.
e. The results of the investigation shall be communicated to affected employees.
f. The HAZOP study shall be reviewed and updated as necessary to incorporate the findings of the investigation.
g. An incident is defined as any LNG related event that caused or could reasonably have caused:
   i. An injury requiring hospitalization or fatality;
   ii. Fire;

iii. Explosion;
iv. Any defect in equipment or instrumentation identified during the mechanical integrity testing and inspection program that is outside of the acceptable limits including:
    1. storage tank vibration and/or vibrations in associated cryogenic piping;
    2. storage tank settlement;
    3. relative movement of storage tank inner vessel;
v. Any event that causes a relief (pressure or vacuum) device to actuate on a component containing LNG or other flammable or toxic material;
vi. An event that requires activation of the emergency response plan;
vii. Inner tank leakage, ineffective insulation (cold spots), or frost heave of an LNG storage tank;
viii. Safety-related incidents to LNG trucks or LNG vessels occurring at or in route to or from the LNG facility;
ix. Storage tank stratification or rollover;
x. Geysering;
xi. Higher than design boil-off rates;
xii. A breach of security;
xiii. Any other significant event.

i. **Emergency Planning and Response** (see CSA Z276-01 Clause 12.3.3)

a. In addition, an annual table top exercise or drill shall be conducted to test the emergency response plan.

j. Contractor Management

b. Applies to all contractors performing work that could impact the integrity of the facility, such as maintenance, testing, inspection or calibration.
c. The employer must establish criteria for the contractor's safety performance and programs that must be met prior to hiring and must be reviewed annually as a condition of employment.
d. The employer must communicate to the contractor:
    i. Any known hazards in the process;
    ii. The applicable provisions of the facility emergency response and security plans.
e. The contractor must ensure that each employee is trained in the following areas and there is documentation of the training:
    i. In the safe work practices required to perform the required work;
    ii. In the known process hazards and the applicable provisions of the emergency response plan and security plan.
f. The contractor shall ensure that its employees follow the facility safety rules and safe work practices.
g. The contractor shall advise the employer of any unique hazards posed by the chemicals, tools, or equipment required to perform the work.

k. **Security Management** (see CSA Z276-01 Clause 11.7)

a. A security plan shall be prepared based on the requirements of the facility security assessment that is required under the Marine Transportation Security Regulations (SOR/2004-144) of the Marine Transportation Security Act (MTSA) which is regulated by Transport Canada.
b. The security plan shall be reviewed and updated as necessary for any change in equipment or procedures.

l. **Auditing** (see Gas Plant Facility Regulations Section 20)

a. An audit to verify compliance with the Gas Plant Facility Regulations, any terms or conditions of the Licence to Operate, CSA Z276-01 and this Code of Practice shall be conducted at least once every three years.
b. The resolution of each finding from the audit shall be documented and reported in the annual Process Safety Management Report.

Appendix B: Design Information Details

a. Chemical Hazard Information

Provide information on the physical properties and toxic, flammable, and reactive hazards posed by any chemical stored or handled onsite in quantities of 50 kg or more. Material safety data sheets may be used to supply some of this information. Provide a chemical interaction matrix showing potential unwanted reactions between chemicals or between chemicals and materials of construction.

b. Process Chemistry and Systems

Provide a description of the overall project including the marine terminal and marine vessels. Describe the initial and planned future capacity of the facility. Provide a detailed description of the LNG process, loading and unloading facilities, utilities, support facilities, equipment and buildings. Describe the physical and chemical processes used in the facilities. Provide the expected composition and physical properties of LNG or natural gas to be supplied to the facility, including pressures and temperatures. Describe the type of docking system and ship unloading system required on the marine terminal. Describe the size (length and draft), capacity and type of ships that the marine terminal must handle and the expected arrival frequency of ships. For LNG receiving terminals provide the pumping rates and pressures for the ship unloading systems and the type of unloading arms to be used.

c. Plot Plans for Siting and Layout

Provide a plot plan showing the location of all major components to be installed, including marine unloading and transfer, storage, natural gas liquids (NGL) extraction, storage of LNG, NGL, and any other flammable or hazardous chemicals, compression, pretreatment, liquefaction, transfer piping, vaporization, truck loading/unloading, vent stacks, pumps, and auxiliary service facilities. Include any equipment that is required for security purposes.

For import terminals, the plot plan should show the marine berth and trestle details, mooring arrangement and unloading platform. In addition to showing the major equipment, the plot plan should show the location of major utility systems, such as water and air. The plot plan should show the safe spacing of all the equipment as required by CSA Z276-01 and other industry codes and standards.(1) Additionally it should show all the pipe racks and major building on the site including those that will be occupied. These building would be control rooms (including the main terminal and jetty), offices, warehouses, maintenance shops, utility buildings, and manned security points. All facility entrances and security systems should be shown. Additionally all the roads, drainage ditches and dikes for containment should be shown as well as the planned site contours and elevations. The plot plan should show true north and plant north and should included a grid system used to fix the location of buildings and process equipment.

d. Fire Protection System (see also CSA Z276-01 Clauses 11.1-11.6)

Provide a copy of the evaluation conducted to meet the requirements for fire protection according to CSA Z276-01 section 11.1.2.

Provide a layout of the fire protection system showing the location of fire water pumps, piping, hydrants, hose reels, dry chemical systems, high expansion foam systems, and auxiliary or appurtenant service facilities.

The fire protection system utilizing fire water pumps, piping, hydrants, monitor nozzles, hose reels, and high expansion foam systems, can be shown as an overlay of the plot plan discussed above. The drawing should show the fire water supply, the sizing of the firewater mains, how they are arranged in either a loop or grid system through the site, and isolation (post indicating) valves to allow water flow in case a portion of the system is damaged. The area of coverage of fire water monitors should be shown. The plot plan should show the estimated maximum flows for all water supplies, the required pressure and the maximum total water flow for the design fire scenario. If reliance is to be made on municipal fire water sources documentation should be supplied to show the municipal source can in fact meet the demands of the system.

Dry chemical systems and high expansion foam systems (primarily for LNG vapor suppression) should also be shown on a drawing. For manually activated systems the actuation locations should be shown. In the initial submittal those area in which dry chemical extinguishers are to be provided can be shown.

e. Plot Plan for Layout of Detection, Control and Interlock Systems

Provide a layout of the hazard detection system showing the location of combustible-gas detectors, fire detectors, heat detectors, smoke or combustion product detectors, and low temperature detectors. Identify those detectors that activate automatic shutdowns and the equipment that would shut down. Include all safety provisions incorporated in the plant design, including automatic and manually activated emergency shutdown systems. Manual activation points for all interlocks and shutdowns should be shown on the layout drawing.

f. Plot Plan of Spill Containment System Layout

Provide a layout of the spill containment system showing the location of impoundments, sumps, sub dikes, channels, and water removal systems.

The layout should show the containment system to capture the initial spill before it enters any drainage channels or troughs. The routing of drainage channels or troughs should be shown and the spacing from major equipment, including the LNG storage tanks, should be supported by calculations of thermal radiation levels in case of fire (see section 4.2.2).

g. Plot Plan of Area Electrical Classification

Provide a plot plan showing the area electrical classification of equipment to comply with the Canadian Electrical Code as specified in CSA Z276-01 Clause 9.6.2.

h. Block Flow Diagram of Isolation and Shutdown Systems

Provide a block flow diagram of the emergency shutdown and isolation system and provide the manufacturer's specifications, drawings, and literature on all emergency shutdown valves (liquid and vapor) including those at the marine unloading terminal (if applicable), storage tanks, recondenser, vaporizers, liquefiers, NGL extraction facilities, and heat transfer systems. In addition the means and conditions to actuate (manual, fire, ESD, loss of power or air) these shut-off valves should be provided. If closure of these valves in less than ten minutes is to be used to reduce the spill duration for design spills, the basis for the valve closure time must be provided.

i. Process Flow Diagrams (PFDs)

Provide an overall schematic diagram of the entire process flow system and each utility system, including a material and energy balance.

A Process Flow Diagram (PFD) shall contain:

i. Major equipment and tag numbers;
ii. Design information for all equipment shown, including capacity, operating temperature and pressure, heat duty;
iii. Major isolation valves indicating which are normally closed;
iv. direction of flow will be shown with arrows;
v. Instruments essential to control the process are shown.

The lines shall be numbered to correspond to the stream number in the material balance. These streams in the material balance should show the phase, fluid mole fraction, normal and maximum mass and volumetric flowrates, heat flow, temperature, pressure, molecular weight, specific gravity and the component composition of each stream. Where the project may be built in phases, the flowrates for each phase should be provided. For any stream where there is significant heat loss or gain the heat duty should be listed.

j. Piping and Instrument Diagrams (PIDs)

Provide up-to-date piping and instrumentation diagrams for all process (LNG and NGL), utility and support systems (including potable, process and fire water, instrument and plant air, heat transfer, relief and flare, nitrogen or inert gas, heating value adjustment equipment, fuel gas, boil-off gas, steam, and liquid fuels).

Piping and Instrumentation Diagrams should have as a minimum the following information.

i. All items of process equipment (including package units) shown including spare items.
ii. All equipment will have identification numbers (tag number) that are shown on the drawings.
iii. Key data for each piece of equipment should be shown on the PID. Usually MAWP, MAWT, capacity, dimensions, heat duties, and material of construction.
iv. Equipment nozzles, sizes and approximate location will be shown.
v. All process lines and utility lines serving process equipment will be shown including hoses, arms, expansion joints and sight glasses.
vi. Arrows showing the direction of flow.
vii. All required valves and check valves are shown and identified by number and the type of valve by symbol. Automatic valves will show the fail safe position.
viii. Process and utility lines will be numbered to include line size, fluid class, line number, piping specification and type of insulation required. Piping specification breaks will be shown.
ix. All instrumentation for indication, control or recording operating conditions shall be on the PID, including the location of device (local or control room), alarm and interlock points and equipment interlocked. Each instrument should have a unique tag number.
x. Mechanical safety equipment, including pressure and vacuum relief devices, flame arrestors, their setpoints and venting location.
xi. A legend showing all equipment, piping and instrument symbols, nomenclature and label identification.

k. Equipment, Piping and Building Specifications

Provide an equipment list for major process components (i.e., tanks, vessels, pumps, compressors, heat exchangers, and piping which include (as applicable): function, capacity, type, manufacturer, drive system (horsepower, voltage), operating pressure, and temperature. Provide general design criteria including the overpressure design criteria for structures and process equipment and standard corrosion allowances.

i. Function
ii. Capacity
iii. Type

iv. Manufacturer
v. Drive System (horsepower and voltage)
vi. Dimensions of equipment
vii. Operating pressure and temperature
viii. Equipment Maximum Allowable Working Pressure (MAWP) and Temperature (MAWT)
ix. Equipment materials of construction and corrosion allowance
x. Applicable codes for design and fabrication of item
xi. Process fluids in equipment and piping
xii. Vessel internals, including linings
xiii. Major nozzles identified for equipment
xiv. Heat transfer area for heat exchangers
xv. Deadhead pressure for pumps and compressors

Provide manuals and construction drawings for the LNG storage tank(s).

Provide a list of all required buildings, their purpose, type of construction, overpressure rating, fire rating and occupancy level.

l. Applicable Codes and Standards

Identify all codes and standards under which the plant (and marine terminal, if applicable) will be designed and any special considerations or safety provisions that were applied to the design of plant components.

The applicant should list all the major design codes that they will follow in the design and construction. These should include at least:

i. ACI for construction of concrete
ii. AGA for purging procedures
iii. API for construction of low pressure storage tanks and associated relief devices, SVA
iv. ASME for design of piping and pressure vessels and associated relief devices
v. ASTM for specifications of steel and concrete
vi. CGA for cryogenic liquid standards
vii. CGSB for piping systems and qualification of personnel conducting non-destructive examination
viii. Canadian Geotechnical Society for foundation design
ix. CSA for LNG facilities and equipment
x. CTC (Canadian Transport Commission) for loading/unloading facilities
xi. GTI (formerly GRI) for information on modeling of LNG releases using LNGFIRE, DEGADIS and FEM3A.
xii. ISA for design of safety instrumented systems
xiii. NACE for corrosion protection of equipment
xiv. NFPA for fire protection systems
xv. NRCC for the Canadian National Building Code

xvi. TEMA for design of heat exchangers
xvii. ULC for methods of testing burning characteristics of building materials

m. Relief System Design and Sizing Basis (see also CSA Z276-01 Clause 6.6 for LNG containers,7.4 for LNG vaporizers and 8.8 for other relief requirements)

Documentation shall include the sizing basis for relief devices on LNG storage tanks and other major equipment. The sizing basis shall include at least the worst-case contingency for over or under pressure specified in CSA Z276-01, including flash vaporization as a result of mixing of products with different compositions (i.e., rollover). If rollover is not considered an applicable contingency, the basis for excluding this scenario shall be justified using layer of protection analysis (LOPA) or equivalent risk based methodology. The dispersion of flammable vapor from relief devices on storage tanks and vaporizers shall be modeled to determine if a hazardous condition could result. Describe vent headers and flare or effluent handling systems and provide the design case for sizing.

n. Ventilation System Design and Sizing Basis

Provide details of the requirements for ventilation in buildings to control hazardous levels of chemicals in the atmosphere, either due to handling of hazardous materials inside buildings or by introducing hazardous chemicals into buildings through ventilation systems. Provide a description of the detection systems, alarm and interlock points and required ventilation rates.

o. Basic Process Control System (BPCS)

Include a description of the process control philosophy, architecture, data communications, type of instrumentation (pneumatic, electronic), use of computer technology, and control room display and operation (operator interface). Include details of local panel controls, such as for metering. Describe the basic process controls on each piece of equipment. Provide the control limits for each instrument, including alarm and interlock points, the consequences of deviation from normal operating range and the actions (troubleshooting and emergency response) needed to correct any deviation. All process related interlocks and shutdowns, such as pressure, level, temperature, excess flow, should be identified. Describe the alarm system, including any hardwired systems, and any alarm prioritization system.

p. Safety Instrumented Systems

Critical instrumentation should follow the requirements of ISA 84.01 *Application of Safety Instrumented Systems for the Process Industry* (6). ISA 84 requires the implementation of Safety Instrumented Systems (SISs) that are independent of the Basic Control System and are designed to a specific Safety Integrity Level (SIL), which defines the required reliability of each instrument. Describe each safety system or emergency shutdown system that is independent of the BPCS, including hazard detection systems, such as fire, flammable vapor detection or LNG spill detection systems. Describe the shutdown order or hierarchy. Provide a list of each SIS and its required SIL.

q. Interlock Cause and Effect Chart

For each interlock and shutdown system, provide a cause and effect chart showing the instrument or actuation device that is a permissive to startup or continue operation or initiates an interlock and the corresponding equipment that is affected. Specify the effect on the interlocked equipment (i.e., open/close, startup/shutdown).

r. Design and Safety Studies

Provide copies of company, engineering firm, or consultant studies of a conceptual nature that show the engineering planning or design approach to the construction of new facilities or plants. Examples include:

i. Equipment design evaluations (i.e., LNG tanks, vaporizers, unloading arms)
ii. Equipment isolation study
iii. Process optimization study

These would be in addition to the studies specifically required under section 3.1.1.

s. Details of Electrical Power Systems

Provide engineering information on the plant's electrical power generation system, distribution system, emergency power system, uninterruptible power system, and battery backup system.

The following details should be provided regarding the electrical system as well as the past history of power failures in area.

i. Plant Electrical Power Generation System
ii. Electrical Power Distribution System
iii. Emergency Power System
iv. Uninterruptible Power Supply (UPS) System and Users:
    1. DCS process computer with associated displays and printers,
    2. Packaged process equipment computer systems,
    3. Plant shutdown DCS and PLC,
    4. Safety related instruments (gas analysis, chromatographs,
    5. Critical controls and interlocks,
    6. Fire detection and alarm systems,
    7. Large rotating equipment local control panels,
    8. Plant emergency alarm systems,
    9. Plant security systems, radios, and intrusion detectors.

t. Compliance with Regulations

Identify how each of the applicable requirements of this LNG Code of Practice and CSA Z276-01 are met in the application or will be met during detailed design, construction, startup and operation. For new facilities, the siting requirements must be given special attention.

The applicant should prepare a summary table that lists each of the numbered sections of this Code of Practice and CSA Z276-01 with a cross reference to the applicable section of the application. Sections that are not applicable should be so identified. Each section in the table shall have a written discussion of how the applicant will meet the requirements.

For the siting analysis (see CSA Z276-01 Clause 4.2.1-4.2.3), the applicant shall provide the basis and justification for determination of all spills used for sizing of impoundments, and determination of thermal radiation and flammable vapor exclusion zones. All calculations of spill rates and quantities used to calculate impoundment volumes, design spills and vapor generation rates for determination of flammable vapor exclusion zones should be provided, including all assumptions made to allow use of the models. The input data and results of all models used in the calculations must be provided. If any additional computer models other than those listed in CSA Z276-01 are used for calculation of release rates and vaporization rates, the application of those models to the spill scenario must be justified. The results of the analysis must be summarized.

Also, provide a summary of the status of complying with other applicable regulations including requirements for Environmental Assessments and preparation of the facility security plan for Transport Canada.