

**Liquefied natural gas (LNG) —
Production, storage, and
handling**



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Z276-07

Liquefied natural gas (LNG) — Production, storage, and handling

0 Introduction

This Standard establishes essential requirements and minimum standards for the design, installation, and safe operation of liquefied natural gas (LNG) facilities. It is not a design handbook, and competent engineering judgment is necessary for its proper use.

1 Scope

1.1

This Standard applies to the

- (a) design;
- (b) location;
- (c) construction;
- (d) operation; and
- (e) maintenance

of facilities for the liquefaction of natural gas and facilities for the storage, vaporization, transfer, handling, and truck transport of LNG. It also contains requirements for the training of personnel.

1.2

For facilities that load or unload LNG from a marine vessel, this Standard contains requirements for the interconnecting piping between the loading/unloading arm flange and the storage tank(s), and other piping and appurtenances on the pier or jetty if applicable.

1.3

This Standard applies to all containers for the storage of LNG, including those with insulation systems applying a vacuum.

1.4

This Standard does not apply to frozen ground containers.

1.5

This Standard includes non-mandatory guidelines for small LNG facilities (see the definition of “small facility” in Clause 3 and see Annex B).

1.6

This Standard does not apply to the following:

- (a) the transportation of refrigerants by any means;
- (b) the transportation of LNG by railcar or marine vessel;
- (c) the transportation of regasified LNG by pipeline beyond the facility boundary; and
- (d) facilities designed to allow the use of LNG as a fuel for highway vehicles, railroad locomotives, or marine vessels.

1.7

All references to pressure throughout this document refer to gauge pressures unless otherwise specified.

1.8

All pipe sizes refer to nominal pipe sizes (NPS).

1.9

The values given in SI (metric) units are the standard. The values given in parentheses are for information only.

1.10

In CSA Standards, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; “may” is used to express an option or that which is permissible within the limits of the standard; and “can” is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, unless the user finds it more appropriate to use newer or amended editions of such publications.

CSA (Canadian Standards Association)

CAN/CSA-A23.1-04/CAN/CSA-A23.2-04

Concrete materials and methods of concrete construction/Methods of test and standard practices for concrete

A23.3-04

Design of concrete structures

A23.4-05

Precast concrete — Materials and construction

B51-03

Boiler, pressure vessel, and pressure piping code

B51S1-05

Supplement No. 1 to B51-03 Boiler, Pressure Vessel, and Pressure Piping Code

Δ CAN/CSA-B149.1-05
Natural gas and propane installation code

CAN/CSA-B149.2-05

Propane storage and handling code

C22.1-05

Canadian Electrical Code, Part I

CAN/CSA-G30.18-M92 (R2002)

Spillet-steel bars for concrete reinforcement

G279-M1982 (withdrawn)

Steel for prestressed concrete tendons

CGS (Canadian Geotechnical Society)*Canadian Foundation Engineering Manual, 2006***CGSB (Canadian General Standards Board)**

CAN/CGSB-24.3-92

Identification of Piping Systems

CAN/CGSB-48.9712-2006/ISO 9712:2005

*Non-destructive Testing — Qualification and Certification of Personnel***Government of Canada***Canada Labour Code, Part II, 1985***Government of the United States***29 Code of Federal Regulations, Subtitle B, Chapter XVII, Part 1910.146***GTI (Gas Technology Institute)**

GRI-89/0176 (1990)

LNGFIRE: A Thermal Radiation Model for LNG Fires

GRI-89/0242

LNG Vapor Dispersion Prediction with the DEGADIS Dense Gas Dispersion Model

GTI-04/0032 (2004)

*LNGFIRE3: A Thermal Radiation Model for LNG Fires***NACE International (National Association of Corrosion Engineers)**

RP 0169-2002

*Control of External Corrosion on Underground or Submerged Metallic Piping Systems***NFPA (National Fire Protection Association)**

10-2002

Standard for Portable Fire Extinguishers

11-2005

Standard for Low-, Medium-, and High-Expansion Foam

11A-1999

Standard for Medium- and High-Expansion Foam Systems

12-2005

Standard on Carbon Dioxide Extinguishing Systems

12A-2004

Standard on Halon 1201 Fire Extinguishing Systems

13-2002

Standard for the Installation of Sprinkler Systems

14-2003

Standard for the Installation of Standpipe and Hose Systems

15-2001

Standard for Water Spray Fixed Systems for Fire Protection

16-2003

Standard for the Installation of Foam-Water Sprinkler Systems and Foam-Water Spray Systems

June 2008

(Replaces p. 5, July 2007)

17-2002
Standard for Dry Chemical Extinguishing Systems

20-2003
Standard for the Installation of Stationary Fire Pumps for Fire Protection

22-2003
Standard for Water Tanks for Private Fire Protection

24-2002
Standard for the Installation of Private Fire Service Mains and Their Appurtenances

25-2002
Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

30-2003
Flammable and Combustible Liquids Code

37-2006
Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines

Δ 54-2006
National Fuel Gas Code

57-2002
Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code

58-2004
Liquefied Petroleum Gas Code

59-2004
Utility LP-Gas Plant Code

68-2002
Standard on Explosion Protection by Deflagration Venting

69-2002
Standard on Explosion Prevention Systems

70-2005
National Electrical Code®

72-2002
National Fire Alarm Code®

77-2000
Recommended Practice on Static Electricity

101-2006
Life Safety Code®

205-2006
Standard Method of Test of Surface Burning Characteristics of Building Materials

700-2005
Standard on Industrial Fire Brigades

750-2006
Standard on Water Mist Fire Protection Systems

8.3.4

The isolation of an idle manifolded vaporizer to prevent leakage of LNG into the vaporizer shall be accomplished with two inlet valves, or other double-block-and-bleed systems, and a safe means shall be provided to dispose of the LNG or gas that can accumulate between the valves. Ambient vaporizers having inlets of 60 mm (2 in) OD or less shall not be required to comply with this provision.

8.3.5

Each heated vaporizer shall be provided with a device to shut off the heat source. The device shall be capable of being operated both locally and remotely. The remote location shall be at least 15 m (50 ft) from the vaporizer.

8.3.6

A shut-off valve shall be installed on the LNG line to a heated vaporizer at least 15 m (50 ft) from the vaporizer. If the vaporizer is installed in a building, the shut-off valve shall be installed at least 15 m (50 ft) from the building. This may be the valve specified in Clause 9.3.3.2. The shut-off valve shall be operable either at its installed location or from a remote location, and the valve shall be protected so that it does not become inoperable due to external icing conditions. Where the vaporizer is closer than 15 m (50 ft) to the container from which it is supplied (see Clause 5.2.5.4), the provisions of Clause 8.3.7 shall apply.

8.3.7

Any ambient vaporizer or a heated vaporizer installed within 15 m (50 ft) of an LNG container shall be equipped with an automatic shut-off valve in the liquid line. This valve shall be located at least 3 m (10 ft) from the vaporizer and shall close when loss of line pressure (excess icing) occurs, when abnormal temperature is sensed in the immediate vicinity of the vaporizer (i.e., due to fire), or when low temperature in the vaporizer discharge line occurs. At attended facilities, this valve may be operated remotely from a point at least 15 m (50 ft) from the vaporizer.

8.3.8

If a flammable intermediate fluid is used with a remotely heated vaporizer, shut-off valves shall be provided on both the hot and cold lines of the intermediate fluid system. The controls for these valves shall be located at least 15 m (50 ft) from the vaporizer.

8.4 Relief devices on vaporizers

8.4.1 Relief-valve capacity

Each vaporizer shall be provided with a safety relief valve sized in accordance with one of the following:

- (a) the relief-valve capacity of heated or process vaporizers shall be such that the relief valve discharges 110% of the vaporizer's rated natural gas flow capacity without allowing the pressure to rise more than 10% above the vaporizer's maximum allowable working pressure; or
- (b) the relief-valve capacity for ambient vaporizers shall be such that the relief valve discharges at least 150% of the vaporizer's rated natural gas flow capacity (as specified for standard operating conditions) without allowing the pressure to rise more than 10% above the vaporizer's maximum allowable working pressure.

8.4.2 Relief-valve location

Relief valves on heated vaporizers shall be so located that they are not subjected to temperatures exceeding 60 °C (140 °F) during normal operation, unless designed to withstand higher temperatures.

8.5 Combustion air supply

Combustion air required for the operation of integral heated vaporizers or the primary heat source for remotely heated vaporizers shall be taken from outside a completely enclosed structure or building.

8.6 Products of combustion

Where integral heated vaporizers or the primary heat source for remotely heated vaporizers are installed in buildings, provisions shall be made to prevent the accumulation of hazardous products of combustion.

9 Piping systems and components

9.1 General

Δ 9.1.1

All piping systems shall be in accordance with ASME B31.3. The additional provisions of Clause 9 shall apply to piping systems and components for flammable liquids and flammable gases. Requirements for fuel gas systems are set out in NFPA 54 or CAN/CSA-B149.1.

9.1.2

The piping seismic design forces shall be determined in accordance with Paragraph 4.1.8.17 of the *National Building Code of Canada*. Sentence (2) of Paragraph 4.1.8.17 shall not apply, and seismic design shall always be performed. The allowable stress for the piping shall be in accordance with the requirements of ASME B31.3.

9.1.3

Container-associated piping up to and including the first container shut-off valve in LNG lines shall be designed to meet the provisions of Item (b) of Clause 7.1.3.3. Piping seismic accelerations shall be taken as the container or container roof acceleration determined from the container dynamic analysis at the location of the pipe.

9.1.4

Piping systems and components shall be designed to accommodate the effects of fatigue resulting from the thermal cycling to which the systems are subjected. Particular consideration shall be given where changes occur in the wall thickness between pipes, fittings, valves, and components.

9.1.5

Provision for expansion and contraction of piping and piping joints due to temperature changes shall be in accordance with ASME B31.3, Section 319.

9.1.6

The maximum allowable working pressure shall be specified for all components.

9.2 Construction materials

9.2.1 General

9.2.1.1

All piping materials, including gaskets and thread compounds, shall be suitable for use with the liquids and gases handled throughout the range of temperatures to which the materials are subjected. The temperature limitations for pipe materials shall be as specified in ASME B31.3.

9.2.1.2

Piping that can be exposed to the cold of an LNG or refrigerant spill or the heat of an ignited spill during an emergency, where such exposure can result in a failure of piping that can significantly increase the emergency, shall be

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Contents

Technical Committee on Liquefied Natural Gas *viii*

Preface *x*

0 Introduction 1

1 Scope 1

2 Reference publications 2

3 Definitions 7

4 General requirements 9

- 4.1 Future developments 9
- 4.2 Retroactivity 10
- 4.3 Adoptions 10
- 4.4 Control centre 10
- 4.5 Safety and loss management system 10
- 4.6 Records 11

5 Plant site provisions 11

- 5.1 General 11
- 5.2 Major site provisions for spill and leak control 12
 - 5.2.1 General 12
 - 5.2.2 Impounding area and drainage system design and capacity 12
 - 5.2.3 Impounding area siting 14
 - 5.2.4 Container spacing 16
 - 5.2.5 Vaporizer spacing 16
 - 5.2.6 Process equipment spacing 17
 - 5.2.7 Loading and unloading facility spacing 17
- 5.3 Buildings and structures 18
 - 5.3.1 Construction 18
 - 5.3.2 Ventilation 18
 - 5.3.3 Other buildings and enclosures 18
 - 5.3.4 Portable equipment 19
 - 5.3.5 Odorization 19
- 5.4 Designer and fabricator competence 20
- 5.5 Soil protection for cryogenic equipment 20
- 5.6 Falling ice and snow 20
- 5.7 Concrete materials 20
- 5.8 Underground LNG containers 21

6 Process equipment 22

- 6.1 General 22
- 6.2 Flammable refrigerant and flammable liquid storage 22
- 6.3 Process equipment 22
 - 6.3.1 Siting 22
 - 6.3.2 Boilers and pressure vessels 22
 - 6.3.3 Shell and tube heat exchangers 23
 - 6.3.4 Internal combustion engines and gas turbines 23
 - 6.3.5 Boil-off and flash gas handling 23

- 6.3.6 Internal vacuum 23
- 6.3.7 Equipment depressurizing 23
- 6.3.8 Cold boxes 23
- 6.3.9 Salt-bath heaters 23
- 6.3.10 Air injection 23
- 6.3.11 Relief devices 24
- 6.3.12 Process equipment supports 24

7 Stationary LNG storage containers 24

- 7.1 General 24
 - 7.1.1 Inspection 24
 - 7.1.2 Basic design considerations 24
 - 7.1.3 Seismic design 25
 - 7.1.4 Wind and snow loads, ice, and flooding 27
 - 7.1.5 Container insulation 27
 - 7.1.6 Filling volume 27
 - 7.1.7 Foundations 28
- 7.2 Metal containers 28
 - 7.2.1 Containers designed for operation at 103 kPa (15 psi) and less 28
 - 7.2.2 Containers designed for operation at greater than 103 kPa (15 psi) 29
- 7.3 Concrete containers 30
 - 7.3.1 Scope 30
 - 7.3.2 Container structure 30
 - 7.3.3 Materials subject to LNG temperature 31
 - 7.3.4 Construction, inspection, and tests 32
- 7.4 Marking of LNG containers 32
- 7.5 Testing of LNG containers 32
 - 7.5.1 Leak testing 32
 - 7.5.2 Reference standard 32
 - 7.5.3 Tests 32
 - 7.5.4 Vacuum leaks 33
 - 7.5.5 Retesting 33
- 7.6 Relief devices 33
 - 7.6.1 General 33
 - 7.6.2 Installation 33
 - 7.6.3 Relief device sizing 34
- 7.7 Quality assurance personnel qualifications 35

8 Vaporization facilities 35

- 8.1 Types of vaporizers 35
 - 8.1.1 Heated vaporizers 35
 - 8.1.2 Ambient vaporizers 36
 - 8.1.3 Process vaporizers 36
- 8.2 Design and materials of construction 36
- 8.3 Vaporizer piping, and intermediate fluid piping and storage 36
- 8.4 Relief devices on vaporizers 37
 - 8.4.1 Relief-valve capacity 37
 - 8.4.2 Relief-valve location 37
- 8.5 Combustion air supply 37
- 8.6 Products of combustion 38

9 Piping systems and components 38

- 9.1 General 38
- 9.2 Construction materials 38

9.2.1	General	38
9.2.2	Piping	39
9.2.3	Fittings	39
9.2.4	Valves	40
9.3	Installation	40
9.3.1	Bolted connections	40
9.3.2	Piping joints	40
9.3.3	Valves	40
9.3.4	Welding	41
9.3.5	Pipe marking	42
9.4	Pipe supports	42
9.5	Piping identification	42
9.6	Inspection and testing of piping	42
9.6.1	Pressure tests	42
9.6.2	Records of test conditions	42
9.6.3	Welded pipe tests	42
9.6.4	Welding examination	43
9.6.5	Test records	43
9.6.6	Records and certifications	43
9.7	Purging of piping systems	43
9.8	Safety and relief valves	43
9.8.1	Pressure-relieving safety devices	43
9.8.2	Thermal expansion relief valves	44
9.9	Corrosion control	44
9.9.1	Underground and submerged piping	44
9.9.2	Austenitic stainless steels and aluminum alloys	44
10 Instrumentation and electrical services		44
10.1	Liquid-level gauging	44
10.1.1	LNG containers	44
10.1.2	Tanks for refrigerants or flammable process fluids	45
10.2	Pressure gauge — LNG containers	45
10.3	Vacuum gauge	45
10.4	Temperature indicators	45
10.4.1	Field-erected containers	45
10.4.2	Vaporizers	45
10.4.3	Liquefaction systems	45
10.4.4	Heated foundations of cryogenic containers and equipment	45
10.5	Emergency shutdown	45
10.6	Electrical equipment	46
10.6.1	General	46
10.6.2	Classified areas	46
10.6.3	Seals	46
10.6.4	Monitoring	47
10.6.5	Venting	47
10.7	Electrical grounding and bonding	47
10.7.1	General	47
10.7.2	Bonding	47
10.7.3	Stray or impressed currents	47
10.7.4	Lightning protection	47
11 Transfer of LNG and refrigerants		47
11.1	General	47
11.2	Piping system	48

- 11.3 Pump and compressor control 48
- 11.4 Marine shipping and receiving 49
 - 11.4.1 General 49
 - 11.4.2 Dock structures 49
 - 11.4.3 Protection of loading and unloading piping and components 49
 - 11.4.4 Isolation valving and bleed connections 50
 - 11.4.5 Isolation valve on shore 50
 - 11.4.6 Check valve 50
 - 11.4.7 Vapour return line 50
 - 11.4.8 Emergency shutdown (ESD) system 50
- 11.5 Highway tank loading and unloading facilities 50
- 11.6 Connection to pipeline systems 51
- 11.7 Hoses and arms 51

12 Fire protection, safety, and security 52

- 12.1 General 52
 - 12.1.1 Application 52
 - 12.1.2 Evaluation 52
 - 12.1.3 Detailed provisions 53
 - 12.1.4 Sources of electrical power 53
- 12.2 Emergency shutdown systems 53
- 12.3 Fire and leak control 54
- 12.4 Fire-protection water systems 54
- 12.5 Fire-extinguishing and other fire-control equipment 55
- 12.6 Maintenance of fire-protection equipment 55
- 12.7 Security 55
- 12.8 Personnel safety 56
- 12.9 Other operations 56
- 12.10 Communications and lighting 57
 - 12.10.1 Communications 57
 - 12.10.2 Lighting 57

13 Operation, maintenance, and personnel training 58

- 13.1 General 58
- 13.2 Basic requirements 58
- 13.3 Documentation of operating procedures 58
 - 13.3.1 Manual of operating procedures 58
 - 13.3.2 Manual contents 58
 - 13.3.3 Emergency procedures 59
 - 13.3.4 Ignition source control 59
 - 13.3.5 Monitoring operation 60
 - 13.3.6 Cool-down procedure 60
 - 13.3.7 Purging 60
 - 13.3.8 Transportation of LNG 61
 - 13.3.9 Product transfer 61
 - 13.3.10 Marine shipping and receiving 62
 - 13.3.11 Tank vehicle and tank car loading and unloading facilities 65
- 13.4 Maintenance 66
 - 13.4.1 General 66
 - 13.4.2 Maintenance manual 67
 - 13.4.3 Site housekeeping 67
 - 13.4.4 Purging 68
 - 13.4.5 Repairs 68
 - 13.4.6 Control systems, inspection, and testing 68

- 13.4.7 Corrosion control 69
- 13.4.8 Records 70
- 13.5 Training 70
- 13.6 Operational security requirements 71

Annexes

- A** (informative) — Seismic design of LNG plants 81
- B** (informative) — Guidelines for small LNG facilities 83

Tables

- 1** — Thermal radiation flux limits to property lines and occupancies 72
- 2** — Design spills 73
- 3** — Distances from containers 74
- 4** — Distances from underground LNG containers 74
- 5** — Allowable stresses 75
- 6** — Environmental factors 75
- 7** — Classified areas 76

Figures

- 1** — Proximity to containers of dike or impounding wall 78
- 2** — Classified areas 78
- 3** — Classified areas with dike height less than distance from container to dike ($H < x$) 79
- 4** — Classified areas with dike height greater than distance from container to dike ($H > x$) 79
- 5** — Classified areas for containers with liquid level below grade or below the top of the dike 79
- 6** — Maximum filling volume for pressure containers 80

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Preface

This is the eighth edition of CSA Z276, *Liquefied natural gas (LNG) — Production, storage, and handling*. It supersedes the previous editions published in 2001, 1994, 1989, 1981, 1978, 1973, and 1972.

The following significant changes have been introduced in this edition:

- (a) **Clause 4** contains additional requirements for safety and loss management systems;
- (b) **Clause 5** contains additional definitions and requirements for double and full containment containers and updated requirements for vapour dispersion limits;
- (c) **Clause 7** contains updated seismic design requirements;
- (d) **Clause 11** specifies additional requirements related to the design and installation of on-shore facilities for marine shipping and receiving and additional requirements for LNG pipelines;
- (e) **Clause 12** contains additional security requirements; and
- (f) **Clause 13** specifies additional requirements related to the operation of on-shore facilities for marine shipping and receiving and additional operational security requirements.

This Standard contains basic reference data relating to design, supplemented by specific requirements, where necessary, to establish a uniform interpretation of the design requirements.

This Standard was prepared by the Technical Committee on Liquefied Natural Gas, under the jurisdiction of the Strategic Steering Committee on Petroleum and Natural Gas Industry Systems, and has been formally approved by the Technical Committee. It will be submitted to the Standards Council of Canada for approval as a National Standard of Canada.

July 2007

Notes:

- (1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*
- (2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*
- (3) *This publication was developed by consensus, which is defined by CSA Policy governing standardization — Code of good practice for standardization as “substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity”. It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*
- (4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*
- (5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*
 - Requests for interpretation should*
 - (a) *define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;*
 - (b) *provide an explanation of circumstances surrounding the actual field condition; and*
 - (c) *be phrased where possible to permit a specific “yes” or “no” answer.*

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization and are published in CSA’s periodical Info Update, which is available on the CSA Web site at www.csa.ca.

Z276-07

Liquefied natural gas (LNG) — Production, storage, and handling

0 Introduction

This Standard establishes essential requirements and minimum standards for the design, installation, and safe operation of liquefied natural gas (LNG) facilities. It is not a design handbook, and competent engineering judgment is necessary for its proper use.

1 Scope

1.1

This Standard applies to the

- (a) design;
- (b) location;
- (c) construction;
- (d) operation; and
- (e) maintenance

of facilities for the liquefaction of natural gas and facilities for the storage, vaporization, transfer, handling, and truck transport of LNG. It also contains requirements for the training of personnel.

1.2

For facilities that load or unload LNG from a marine vessel, this Standard contains requirements for the interconnecting piping between the loading/unloading arm flange and the storage tank(s), and other piping and appurtenances on the pier or jetty itself.

1.3

This Standard applies to all containers for the storage of LNG, including those with insulation systems applying a vacuum.

1.4

This Standard does not apply to frozen ground containers.

1.5

This Standard includes non-mandatory guidelines for small LNG facilities (see the definition of “small facility” in [Clause 3](#) and see [Annex B](#)).

1.6

This Standard does not apply to the following:

- (a) the transportation of refrigerants by any means;
- (b) the transportation of LNG by railcar or marine vessel;
- (c) the transportation of regasified LNG by pipeline beyond the facility boundary; and
- (d) facilities designed to allow the use of LNG as a fuel for highway vehicles, railroad locomotives, or marine vessels.

1.7

All references to pressure throughout this document refer to gauge pressures unless otherwise specified.

1.8

All pipe sizes refer to nominal pipe sizes (NPS).

1.9

The values given in SI (metric) units are the standard. The values given in parentheses are for information only.

1.10

In CSA Standards, “shall” is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; “should” is used to express a recommendation or that which is advised but not required; “may” is used to express an option or that which is permissible within the limits of the standard; and “can” is used to express possibility or capability. Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material. Notes to tables and figures are considered part of the table or figure and may be written as requirements. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, unless the user finds it more appropriate to use newer or amended editions of such publications.

CSA (Canadian Standards Association)

CAN/CSA-A23.1-04/CAN/CSA-A23.2-04

Concrete materials and methods of concrete construction/Methods of test and standard practices for concrete

A23.3-04

Design of concrete structures

A23.4-05

Precast concrete — Materials and construction

B51-03

Boiler, pressure vessel, and pressure piping code

B51S1-05

Supplement No. 1 to B51-03, Boiler, Pressure Vessel, and Pressure Piping Code

CAN/CSA-B149.2-05

Propane storage and handling code

C22.1-06

Canadian Electrical Code, Part I

CAN/CSA-G30.18-M92 (R2002)

Billet-steel bars for concrete reinforcement

G279-M1982 (withdrawn)

Steel for prestressed concrete tendons