

Boiler, pressure vessel, and pressure piping code



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Update No. 1

B51-09

March 2009

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The following revisions have been formally approved and are marked by the symbol delta (Δ) in the margin on the attached replacement pages:

Revised	Clause 3
New	None
Deleted	None

CSA B51-09 originally consisted of **152 pages** (xx preliminary and 132 text), each dated **January 2009**. It now consists of the following pages:

January 2009	iii–xx, 1–6, and 9–132
March 2009	7 and 8

- Update your copy by inserting these revised pages.
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Authorized inspector — an inspector authorized by a regulatory authority to perform inspections required under the Act.

Boiler — a vessel as defined in the Act.

Brazing — a group of metal-joining processes that produce a coalescence of materials by heating them to a suitable temperature and by using a filler metal having a liquidus above 450 °C (840°F) and below the solidus of the base materials. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

Canadian Central Registration Number (CCRN) — a registration number, allotted by a nationally recognized organization such as CSA in accordance with procedures accepted by more than one province, that allows a fitting to be used in such provinces.

Canadian Registration Number (CRN) — a registration number, allotted by a provincial regulatory authority, that allows a boiler, pressure vessel, or fitting to be used in the province.

Certificate — a certificate of inspection issued under the Act.

Compressed natural gas (CNG) container — a pressure vessel for storing CNG or for use as a motor vehicle fuel tank, designed in accordance with the requirements of this Standard.

Cushion tank — a pressure vessel installed in a closed hot water heating system or cooling system to provide a pneumatic cushion for the expansion of the water.

Design — calculations, drawings, specifications, specimens, models, etc.

Δ **Design pressure** — *Deleted*

Diameter — the inside diameter, unless otherwise specified in Part 1 of this Standard.

Fired-heater pressure coil — the total fluid-retaining piping system within the internally insulated enclosure and header boxes of a petroleum or chemical plant fired heater, including tubes, return bends, crossover piping, inlet and outlet headers, and manifolds.

Fitting — an appurtenance attached to a boiler, pressure vessel, or piping, including such items as valves, gauges, and controlling devices. It can include other pressure-retaining components installed in a piping system within the scope of the Act.

Heat exchanger — a pressure vessel such as a condenser, evaporator, heater, cooler, or similar apparatus, not specifically identified in Part 1 of this Standard, where the tube side or shell side, or both, meet the definition of a pressure vessel.

Note: "Heat exchanger" does not include a condenser regularly used in connection with a turbogenerator or other power plant prime mover.

Hot tapping — an alteration involving cutting into a pressurized line or vessel without interruption of service in order to attach a connection such as for a branch line.

Hot water tank — a pressure vessel that is used to store hot water and is not equipped with a heating unit.

Hydropneumatic tank — a pressure vessel containing both water and air, the compression of which serves only as a cushion.

Inspector — an inspector of boilers, pressure vessels, and piping appointed under the Act.

Internally insulated enclosure of a petroleum or chemical plant fired heater — that part of the structure that encloses the radiant, shield, and convection sections of a heater.

Lethal substances — poisonous gases or liquids of such a nature that a very small amount of the gas or of the liquid's vapour mixed or unmixed with air is dangerous to life when inhaled. For the purposes of Part 1 of this Standard, this definition includes substances of this nature that are stored under pressure or can generate pressure if stored in a closed vessel.

Liquefied petroleum gas tank — a pressure vessel containing liquefied petroleum gas, designed and fabricated in accordance with the requirements of this Standard.

Manufacturer — the company or person that manufactures, completely or in part, a boiler, pressure vessel, fitting, fired-heater pressure coil, or piping. The manufacturer completes the product and is responsible for the end product.

Manufacturer's data report — a document in an accepted form by which a manufacturer certifies that a boiler, pressure vessel, or fired-heater pressure coil has been manufactured in accordance with a particular section of the ASME Code or this Standard. The document supplies a technical description of the vessel, is signed by a representative of the manufacturer, and, when required by this Standard, provides for a countersignature by an inspector or authorized inspector.

Maximum allowable working pressure (MAWP) — the pressure indicated on the design registration.

Note: Where applicable, MAWP is as defined in the referenced construction code.

Miniature pressure vessel — a pressure vessel meeting the criteria for UM stamping in Section VIII, Division 1, of the ASME Code.

National Board — the National Board of Boiler and Pressure Vessel Inspectors.

Piping — pipes or piping as defined in the Act.

Pressure-relief devices — safety valves, relief valves, safety-relief valves, and non-reclosing devices, including rupture discs and fusible plugs.

Pressure vessel — a closed vessel for containing, storing, distributing, transferring, distilling, processing, or otherwise handling a gas, vapour, or liquid.

Province — a province or territory of Canada.

Regulatory authority — a body responsible for administering and enforcing the Act governing the design, fabrication, installation, repair, and alteration of boilers, pressure vessels, fittings, and piping.

Repair — work necessary to restore a boiler or pressure vessel to a safe and satisfactory operating condition, provided that there is no deviation from the original design.

Soldering — a joining process that produces a coalescence of materials by heating them to a soldering temperature and by using a filler metal (solder) having a liquidus not exceeding 450 °C (840°F) and below the solidus of the base metals.

Thermal fluids — fluids, other than water, that transfer heat with or without vaporization.

Water heater — a pressure vessel in which potable water is heated by combustion of fuel, by electricity, or by any other heat source, and from which the water is withdrawn for external use.

4 General requirements

4.1 Registration of designs

4.1.1

The calculations, drawings, and specifications pertaining to the designs of boilers, pressure vessels, fittings

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Preface

This is the seventeenth edition of CSA B51, *Boiler, pressure vessel, and pressure piping code*. It supersedes the previous editions published in 2003, 1997, 1995, 1991, 1986, 1981, 1975, 1972, 1969, 1965, 1960, 1957, 1955, 1951, 1945, and 1939.

In keeping with CSA's goal of harmonizing its standards with those of other countries to the greatest extent possible, CSA's Technical Committee on Boilers and Pressure Vessels and its Subcommittees have, in the course of developing this Standard, worked closely with the National Board of Boiler and Pressure Vessel Inspectors in the USA and with The American Society of Mechanical Engineers (ASME) committees responsible for producing the *National Board Inspection Code* and ASME's *Boiler and Pressure Vessel Code*.

There are three parts to this Standard.

Part 1 contains requirements for boilers, pressure vessels, pressure piping, and fittings. It is intended mainly to fulfill two objectives: first, to promote safe design, construction, installation, operation, inspection, testing, and repair practices, and second, to facilitate adoption of uniform requirements by Canadian jurisdictions.

Part 2 contains requirements for high-pressure cylinders for the on-board storage of natural gas, blends of natural gas and hydrogen (hydrogen blends), and hydrogen as fuels for automotive vehicles. It has been harmonized with International Organization for Standardization (ISO) Standard 11439:2000, *Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles*. In addition, the CSA Subcommittee responsible for developing Part 2 has consulted with the American National Standards Institute (ANSI) committee responsible for developing ANSI Standard NGV2-2000, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*, and the draft *American National Standard/CSA Standard for Compressed Hydrogen Gas Vehicle (HGV) Fuel Containers*. The members of these two committees are dedicated to harmonizing their Standards as far as circumstances allow.

Part 3 contains requirements for compressed natural gas and hydrogen refuelling station pressure piping systems and ground storage vessels. These requirements have been allotted a separate part of the Standard to emphasize the differences between them and the requirements in Part 1, thereby facilitating their application.

This Standard has undergone technical and editorial revisions since the previous edition. The current edition contains all of the revisions published in Update No. 1 to CSA B51-03 and in CSA B51S1-05, *Supplement No. 1 to B51-03*, Boiler, pressure vessel, and pressure piping code. Some of the more noteworthy changes to Part 1 are found in the following clauses:

- (a) [Clause 4.2.4](#) (acceptability of fittings manufactured outside Canada);
- (b) [Clause 4.2.6](#) (documentation supporting registration or reregistration);
- (c) [Clause 4.7.3](#) (new requirement for hot tapping);
- (d) [Clause 4.8.2\(g\)](#) (small pressure vessels registered as Category H fittings are exempt from shop inspection);
- (e) [Clause 4.11](#) (audit requirements for manufacturers outside of Canada);
- (f) [Clause 6.3.1.3](#) (two means for determining the water level for high-pressure steam boilers);
- (g) [Clause 6.8](#) (new requirements for welded staybolts); and
- (h) [Clause 8.2](#) (fittings used in piping systems need to be registered).

In addition, a new definition of "design pressure" has been added to Parts 1 and 2. There have been no significant changes to Part 3.

The users of this Standard should note that it is a recommendatory document only and does not have the force of law except where it has been officially adopted by a Canadian jurisdiction. Users should also note that adoption does not necessarily mean that the Standard has been adopted unchanged. For example, a jurisdiction may decide to make an informative annex normative.

In addition, owners and users of cylinders designed to the requirements of Part 2 should note that the safe operation of such cylinders requires, first, compliance with the service conditions specified by the manufacturer, and second, use of the cylinders only during the service life specified by the manufacturer. Each cylinder is marked with an expiry date, and owners and users are responsible for ensuring that a cylinder is not used after that date.

The Technical Committee intends to meet periodically to review this Standard and, if necessary, to revise it to meet changing conditions and maintain uniformity of practice throughout Canada.

This Standard was prepared by the Technical Committee on Boilers and Pressure Vessels, under the jurisdiction of the Strategic Steering Committee on Mechanical Industrial Equipment Safety, and has been formally approved by the Technical Committee.

January 2009

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.*

CSA Standard

B51-09, Part 1

***General requirements for boilers,
pressure vessels, and pressure piping***



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B51-09, Part 1

General requirements for boilers, pressure vessels, and pressure piping

1 Scope

1.1

Except as indicated in [Clause 1.2](#), Part 1 of this Standard applies to all boilers, pressure vessels, pressure piping, and fittings, as provided for by the Act (as defined in [Clause 3](#)) and identified in Part 1 of this Standard.

Notes:

- (1) *It is possible that the size limitations specified in provincial or territorial statutes or regulations will differ from those specified in Part 1 of this Standard. The applicable regulatory authority should be consulted.*
- (2) *The pressures specified in Part 1 of this Standard are gauge pressures above atmospheric pressure.*
- (3) *This Standard applies to all boilers, pressure vessels, pressure piping, and fittings installed subsequent to its adoption.*

1.2

Requirements for compressed natural gas cylinders and refuelling station pressure piping systems and containers are covered in Parts 2 and 3 of this Standard.

1.3

This Standard does not apply to

- (a) pressure-retaining components in hydraulic elevators;
- (b) pressure-containment devices for gas-filled switchgear and controlgear; and
- (c) pressure vessels for the transportation of dangerous goods regulated by Transport Canada.

1.4

Where a clause in Part 1 of this Standard is at variance with a Code or Standard referenced in Part 1 of this Standard, the requirements of Part 1 of this Standard govern.

1.5

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.

1.6

The values given in SI (metric) units are the standard. The values given in parentheses are for information only. Nominal pipe sizes are expressed in non-dimensional terms.

2 Reference publications

Part 1 of this Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

B52-05

Mechanical refrigeration code

CAN/CSA-B149.1-05

Natural gas and propane installation code

CAN/CSA-B149.2-05

Propane storage and handling code

CAN/CSA-B149.5-05

Installation code for propane fuel systems and tanks on highway vehicles

CAN/CSA-ISO 9001-00 (R2005)

Quality management systems — Requirements

CAN/CSA-Z180.1-00 (R2005)

Compressed breathing air and systems

Z299 series of Standards

CAN3-Z299.1-85 (R2006)

Quality assurance program — Category 1

CAN3-Z299.2-85 (R2006)

Quality assurance program — Category 2

CAN3-Z299.3-85 (R2006)

Quality assurance program — Category 3

CAN3-Z299.4-85 (R2006)

Quality assurance program — Category 4

CAN/CSA-Z305.3-M87 (withdrawn)

Pressure Regulators, Gauges, and Flow-Metering Devices for Medical Gases

CAN3-Z305.4-M85 (withdrawn)

Qualification Requirements for Agencies Testing Nonflammable Medical Gas Piping Systems

Z662-07

Oil and gas pipeline systems

CAN/CSA-Z7396.1-06

Medical gas pipeline systems — Part 1: Pipelines for medical gases and vacuum

ANSI (American National Standards Institute)

K61.1-1999

Safety Requirements for the Storage and Handling of Anhydrous Ammonia

ANSI/ASQ (American National Standards Institute/American Society for Quality)

Z1.4-2003

Sampling Procedures and Tables for Inspection by Attributes

API (American Petroleum Institute)

STD 530 (1996)

Calculation of Heater Tube Thickness in Petroleum Refineries

ASME (The American Society of Mechanical Engineers)

Boiler and Pressure Vessel Code (2007)

Section I — Power Boilers

Section II — Materials — Part A — Ferrous Material Specifications

Section II — Materials — Part B — Nonferrous Material Specifications

Section II — Materials — Part C — Specifications for Welding Rods, Electrodes, and Filler Metals

Section II — Materials — Part D — Properties

Section IV — Heating Boilers

Section V — Nondestructive Examination

Section VIII — Rules for Construction of Pressure Vessels — Division 1

Section VIII — Rules for Construction of Pressure Vessels — Division 2 — Alternative Rules

Section VIII — Rules for Construction of Pressure Vessels — Division 3 — Alternative Rules of High Pressure Vessels

Section IX — Welding and Brazing Qualifications

Section X — Fiber-Reinforced Plastic Pressure Vessels

B31.1-2007

Power Piping

B31.3-2006

Process Piping

B31.4-2006

Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids

B31.5-2006

Refrigeration Piping and Heat Transfer Components

B31.9-2004

Building Services Piping

CSD-1-2006

Controls and Safety Devices for Automatically Fired Boilers

PVHO-1-2007

Safety Standard for Pressure Vessels for Human Occupancy

CDA (Copper Development Association)

A4015 (2006)

Copper Tube Handbook

CGSB/ISO (Canadian General Standards Board/International Organization for Standardization)

CAN/CGSB 48.9712-2006/ISO 9712:2005

Nondestructive Testing; Qualification and Certification of Personnel

ISO (International Organization for Standardization)

9001:2000

*Quality management systems — Requirements***MSS (Manufacturers Standardization Society of the Valves and Fittings Industry)**

SP-25-1998

*Standard Marking System for Valves, Fittings, Flanges and Unions***National Board of Boiler and Pressure Vessel Inspectors**

NB-18 (2008)

National Board Pressure Relief Device Certifications

NB-23 (2007)

*National Board Inspection Code***NFPA (National Fire Protection Association)**

58 (2008)

*Liquefied Petroleum Gas Code***PACE (Petroleum Association for the Conservation of the Canadian Environment)**

Report No. 87-1

*Guideline Specification for the Impressed Current Method of Cathodic Protection of Underground Petroleum Storage Tanks***Note:** Although PACE no longer exists, a copy of this report can be obtained by contacting the Canadian Petroleum Products Institute.**RMA (Rubber Manufacturers Association)**

IP-2

*The 2003 Hose Handbook***ULC (Underwriters' Laboratories of Canada)**

CAN/ULC-S603.1-03

External Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids

3 Definitions

The following definitions apply in Part 1 of this Standard:

Accepted — registered and accepted by the regulatory authority.

Act — the Acts, regulations, or ordinances governing the design, fabrication, installation, repair, and alteration of boilers, pressure vessels, fittings, and piping.

Alteration — a change in an item described in an original manufacturer's data report that requires a change of design calculations or otherwise affects the pressure-containing capability of a boiler or pressure vessel. Non-physical changes such as an increase in the MAWP (internal and external) or design temperature of a boiler or pressure vessel are also considered alterations, as are reductions, e.g., in minimum temperature, such that additional mechanical tests are required.

Anhydrous ammonia tank — a container for storing anhydrous ammonia, designed and fabricated in accordance with the requirements of this Standard.

ASME Code — the American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code*.

Authorized inspection agency — an inspection agency authorized by a regulatory authority to perform inspections required under the Act.

Authorized inspector — an inspector authorized by a regulatory authority to perform inspections required under the Act.

Boiler — a vessel as defined in the Act.

Brazing — a group of metal-joining processes that produce a coalescence of materials by heating them to a suitable temperature and by using a filler metal having a liquidus above 450 °C (840°F) and below the solidus of the base materials. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

Canadian Central Registration Number (CCRN) — a registration number, allotted by a nationally recognized organization such as CSA in accordance with procedures accepted by more than one province, that allows a fitting to be used in such provinces.

Canadian Registration Number (CRN) — a registration number, allotted by a provincial regulatory authority, that allows a boiler, pressure vessel, or fitting to be used in the province.

Certificate — a certificate of inspection issued under the Act.

Compressed natural gas (CNG) container — a pressure vessel for storing CNG or for use as a motor vehicle fuel tank, designed in accordance with the requirements of this Standard.

Cushion tank — a pressure vessel installed in a closed hot water heating system or cooling system to provide a pneumatic cushion for the expansion of the water.

Design — calculations, drawings, specifications, specimens, models, etc.

Design pressure — 1.25 times the working pressure.

Note: *The maximum pressure is usually achieved during the fast filling of the cylinder.*

Diameter — the inside diameter, unless otherwise specified in Part 1 of this Standard.

Fired-heater pressure coil — the total fluid-retaining piping system within the internally insulated enclosure and header boxes of a petroleum or chemical plant fired heater, including tubes, return bends, crossover piping, inlet and outlet headers, and manifolds.

Fitting — an appurtenance attached to a boiler, pressure vessel, or piping, including such items as valves, gauges, and controlling devices. It can include other pressure-retaining components installed in a piping system within the scope of the Act.

Heat exchanger — a pressure vessel such as a condenser, evaporator, heater, cooler, or similar apparatus, not specifically identified in Part 1 of this Standard, where the tube side or shell side, or both, meet the definition of a pressure vessel.

Note: *“Heat exchanger” does not include a condenser regularly used in connection with a turbogenerator or other power plant prime mover.*

Hot tapping — an alteration involving cutting into a pressurized line or vessel without interruption of service in order to attach a connection such as for a branch line.

Hot water tank — a pressure vessel that is used to store hot water and is not equipped with a heating unit.

Hydropneumatic tank — a pressure vessel containing both water and air, the compression of which serves only as a cushion.

Inspector — an inspector of boilers, pressure vessels, and piping appointed under the Act.

Internally insulated enclosure of a petroleum or chemical plant fired heater — that part of the structure that encloses the radiant, shield, and convection sections of a heater.

Lethal substances — poisonous gases or liquids of such a nature that a very small amount of the gas or of the liquid's vapour mixed or unmixed with air is dangerous to life when inhaled. For the purposes of Part 1 of this Standard, this definition includes substances of this nature that are stored under pressure or can generate pressure if stored in a closed vessel.

Liquefied petroleum gas tank — a pressure vessel containing liquefied petroleum gas, designed and fabricated in accordance with the requirements of this Standard.

Manufacturer — the company or person that manufactures, completely or in part, a boiler, pressure vessel, fitting, fired-heater pressure coil, or piping. The manufacturer completes the product and is responsible for the end product.

Manufacturer's data report — a document in an accepted form by which a manufacturer certifies that a boiler, pressure vessel, or fired-heater pressure coil has been manufactured in accordance with a particular section of the ASME Code or this Standard. The document supplies a technical description of the vessel, is signed by a representative of the manufacturer, and, when required by this Standard, provides for a countersignature by an inspector or authorized inspector.

Maximum allowable working pressure (MAWP) — the pressure indicated on the design registration.

Note: Where applicable, MAWP is as defined in the referenced construction code.

Miniature pressure vessel — a pressure vessel meeting the criteria for UM stamping in Section VIII, Division 1, of the ASME Code.

National Board — the National Board of Boiler and Pressure Vessel Inspectors.

Piping — pipes or piping as defined in the Act.

Pressure-relief devices — safety valves, relief valves, safety-relief valves, and non-reclosing devices, including rupture discs and fusible plugs.

Pressure vessel — a closed vessel for containing, storing, distributing, transferring, distilling, processing, or otherwise handling a gas, vapour, or liquid.

Province — a province or territory of Canada.

Regulatory authority — a body responsible for administering and enforcing the Act governing the design, fabrication, installation, repair, and alteration of boilers, pressure vessels, fittings, and piping.

Repair — work necessary to restore a boiler or pressure vessel to a safe and satisfactory operating condition, provided that there is no deviation from the original design.

Soldering — a joining process that produces a coalescence of materials by heating them to a soldering temperature and by using a filler metal (solder) having a liquidus not exceeding 450 °C (840°F) and below the solidus of the base metals.

Thermal fluids — fluids, other than water, that transfer heat with or without vaporization.

Water heater — a pressure vessel in which potable water is heated by combustion of fuel, by electricity, or by any other heat source, and from which the water is withdrawn for external use.

4 General requirements

4.1 Registration of designs

4.1.1

The calculations, drawings, and specifications pertaining to the designs of boilers, pressure vessels, fittings

as specified in [Clause 4.2](#), fired-heater pressure coils, and piping shall be submitted to the regulatory authority in the province where the item is intended to be used. The submission shall identify the substance for which the item is intended. It shall be the responsibility of the users or an agent they designate to determine whether the substance is lethal. [Figures 1\(a\)](#), [\(b\)](#), and [\(c\)](#) shall be used to determine whether items are to be registered as pressure vessels or Category H fittings (see [Table 1](#)). The name of the authorized inspection agency to be employed when a boiler or pressure vessel is to be manufactured outside Canada shall also be submitted when required by the regulatory authority. Acceptance and registration shall be obtained before construction begins.

4.1.2

Any number of boilers, pressure vessels, fittings, fired-heater pressure coils, and piping systems may be constructed from a registered design until a change in the applicable Act, Codes, or Standards invalidates the design, in which case the design shall be obsolete and no further construction to the design shall be made after the effective date of the change as established by the Act. When the Act does not specify an effective date of change, the effective date shall be the date specified in the changed document or six months from the published date of the change, whichever comes first.

4.1.3

If a registered design is subsequently found to be defective in any detail, it shall be revised.

4.1.4

Alterations or revisions to designs of pressure-retaining components already registered shall be submitted for reregistration.

4.1.5

When a design is submitted and not registered, the reasons for its rejection shall be supplied to the submitter. The rejected drawings and specifications may be destroyed or, if requested by the submitter, returned.

4.1.6

The registration of a design shall not relieve the manufacturer of the responsibility for the design or construction of a boiler, pressure vessel, fitting, fired-heater pressure coil, or piping in accordance with the applicable Act, Codes, and Standards.

4.1.7

Boilers, pressure vessels, fittings, fired-heater pressure coils, and piping that have been used or are of a design that differs from the requirements of this Standard shall not be installed in a province without written permission from the regulatory authority. The regulatory authority shall be supplied with complete design drawings and specifications, the manufacturer's data report, and the last inspection report, as applicable.

4.1.8

The design specifications and calculations for fired-heater pressure coils shall be submitted for registration. Such coils may be considered separately or in conjunction with other pressure piping for registration purposes.

4.2 Registration of fittings

4.2.1

Fittings shall be registered in accordance with [Clauses 4.2.2](#) to [4.2.9](#) unless they form a part of a boiler or pressure vessel that is subject to inspection by an authorized inspection agency. Registrations of fittings shall be resubmitted for validation not more than ten years after the date of acceptance by the regulatory authority in the original registering province or by a nationally recognized organization as specified in [Clause 4.2.3](#).

4.2.2

Each category of fitting manufactured (see [Table 1](#)) shall be separately registered by the manufacturer with the regulatory authority in the province of manufacture or, for installation-specific specialized fitting designs, with the regulatory authority in the province of installation. In the latter instance, evidence that the manufacturer has in place a valid quality control program for the manufacturing of the fitting, and that this program is accepted by the regulatory authority in the province of manufacture, shall be provided. Fittings manufactured outside Canada shall be registered initially in the province where they are intended to be used first.

Initial registration with one regulatory authority may be accepted by the regulatory authority in another province if the latter is provided with an accepted copy of the statutory declaration form (see [Figure D.6](#)) and the supporting documentation specified in [Clause 4.2.6](#).

4.2.3

As an alternative to [Clause 4.2.2](#), and when accepted by the province of installation, a fitting design may be registered through a central registration process administered by a nationally recognized organization such as CSA.

4.2.4

When fittings are manufactured outside Canada, the statutory declaration form specified in [Clause 4.2.2](#) shall be accompanied by proof that the manufacturer's quality control program for the manufacturing of the fittings for which registration is sought has been accepted by an independent third-party agency acceptable to the regulatory authority in the province where registration is sought. For a manufacturer with more than one plant or facility, proof of a quality control program shall be submitted for each plant or facility where production occurs.

4.2.5

It shall not be necessary to register separately each fitting design in a category.

Note: *The manufacturer may collectively register the fittings in any category listed in [Table 1](#) by submitting to the regulatory authority a statutory declaration form with supporting documentation.*

4.2.6

At a minimum, the following documentation in support of an application for a new design registration or a reregistration shall be required:

- (a) for new applications for fittings that are built to a nationally recognized Standard (e.g., as listed in paragraph UG44, Section VIII, Division I, of the ASME Code or Table 326.1 of ASME B31.3) that specifies the dimensions, construction materials, pressure/temperature ratings, and identification markings of the fittings:
 - (i) a properly completed statutory declaration form for the registration of fittings clearly identifying the applicable nationally recognized Standard;
 - (ii) the manufacturer's scope within the Standard; and
 - (iii) the manufacturer's identification marking(s);
- (b) for new applications for fittings not covered by Item (a):
 - (i) a properly completed statutory declaration form for the registration of fittings;
 - (ii) the designation of the Code or Standard;
 - (iii) material specifications;
 - (iv) identification markings;
 - (v) maximum allowable working pressure (MAWP);
 - (vi) maximum working temperature;
 - (vii) dimensions; and
 - (viii) detailed calculations and/or copies of proof test results witnessed by an inspector or an authorized inspector and acceptable to the regulatory authority (except for Category G fittings, for which capacity certification data sheets may be submitted in lieu of the calculations or proof test); or

- (c) for the resubmission for validation required by [Clause 4.2.1](#) (provided that the documentation specified in Item (a) or (b) was provided to and evaluated by the regulatory authority and is still applicable, and that [Clauses 4.1.2](#) and [4.1.4](#) do not apply):
- (i) a properly completed statutory declaration form for the registration of fittings;
 - (ii) a copy of the manufacturer's valid quality control program certificate; and
 - (iii) the manufacturer's scope within the original registration.

4.2.7

Safety valves, relief valves, safety-relief valves, and rupture discs shall be registered in accordance with [Clause 4.2.2](#). Rating sheets certified by the National Board or other agencies approved by the regulatory authority shall be submitted for each type, size, and classification of the safety valves, relief valves, safety-relief valves, and rupture discs to be registered.

4.2.8

When required by the regulatory authority, sample fittings and any related data shall be submitted and returned or otherwise disposed of at the expense of the registering party.

4.2.9

The regulatory authority may select and test, at the manufacturer's expense, any registered fittings. If a representative selection proves to be faulty, or if a fitting does not fully comply with the requirements of the applicable Code or Standard, the registration may be cancelled immediately.

4.3 Canadian Registration Numbers (CRNs)

4.3.1

Designs and specifications that are accepted and registered by the regulatory authority shall be assigned a Canadian Registration Number. The province in which a design is registered shall be indicated by a digit or letter following a decimal point (see [Clause 4.3.2](#)).

4.3.2

When a design that is registered in a province is subsequently registered in other provinces, additional digits or letters identifying those provinces shall be added after the digit or letter representing the original registering province. The following identifications shall be used:

1	British Columbia	6	Québec	T	Northwest Territories
2	Alberta	7	New Brunswick	Y	Yukon
3	Saskatchewan	8	Nova Scotia	N	Nunavut
4	Manitoba	9	Prince Edward Island		
5	Ontario	0	Newfoundland and Labrador		

Notes:

- (1) For example, a design registered in Ontario and allotted the registration number K4567 will be registered as CRN K4567.5. If this design is subsequently registered in Alberta, the CRN will be K4567.52; and if afterwards registered in Manitoba, the CRN will be K4567.524.
- (2) If a design is registered in all provinces and territories, the CRN stamped on the nameplate and marked on the data report may be shortened to include the designation of first registration plus the letter "C", e.g., K4567.5C.
- (3) If a design is registered in all provinces and territories that require registration but not in provinces and territories that do not require registration, the CRN may be shortened to include the designation of first registration plus the letters "CL", e.g., K4567.5CL. (The "L" means limited.)

4.3.3

When submitting designs that have already been registered in one province for registration in another province, manufacturers shall provide the name of the province in which the designs have already been

registered, the CRN, and evidence of registration by the original registering province. Once a design has been registered in one province, it may be submitted simultaneously to all other provinces for registration.

4.3.4

The number allotted to a registered design of a fitting shall be a number preceded by a zero and the category letter and followed by a decimal point, to the right of which shall be added the digit or letter indicating the first province in which the design is registered.

Note: For example, a flange design registered in Manitoba will be allotted a number such as 0B675.4.

A number allotted to a centrally registered fitting design shall be a number preceded by the initialism or acronym that represents the nationally recognized organization, followed by a zero and a letter representing the category of fitting.

Note: For example, CSA0B123.

4.4 Registration of welding and brazing procedures

4.4.1

Welding and brazing procedures shall be registered with the regulatory authority of the province where the welding or brazing is to be performed.

4.4.2

Welding or brazing procedures for equipment fabricated outside Canada shall be registered with the regulatory authority at the place of installation or, at the discretion of the regulatory authority, with an authorized inspection agency.

4.5 Welding and brazing qualifications

4.5.1

Welding and brazing procedures, procedure qualifications, and performance tests shall be as specified in, or the equivalent of, the procedures, qualifications, and tests specified in

- (a) Section IX of the ASME Code; and
- (b) the Code to which the pressure-retaining component is either manufactured or installed.

4.5.2

Welding or brazing tests for equipment fabricated in Canada shall be acceptable for the purposes of [Clause 4.5](#) only if approved by the regulatory authority of the province where the welding or brazing is to be performed.

4.5.3

Welding or brazing tests for equipment fabricated outside Canada shall be acceptable for the purposes of [Clause 4.5](#) only if approved by an inspector or authorized inspection agency approved by the regulatory authority in the province of installation.

4.6 Submission of manufacturer's data report

4.6.1

On completion of construction of a boiler, pressure vessel, fired-heater pressure coil, or pressure piping covered by this Standard, a manufacturer's data report signed by a representative of the manufacturer and, except as specified in [Clause 4.8.3](#), countersigned by the inspector or authorized inspector, shall be sent by the manufacturer to the regulatory authority of the province of installation.

4.6.2

When welded pressure parts that require inspection under the rules of the applicable ASME construction Code are constructed by an organization other than the final manufacturer, that organization shall forward

a duly certified partial data report to the organization responsible for completing construction. The partial data report shall be attached to the manufacturer's data report and shall not require an original signature.

The original of the partial data report shall be retained by the parts manufacturer for the period specified by the applicable ASME construction Code.

4.6.3

When a boiler or pressure vessel is manufactured for stock, the name and address of the ultimate owner and the location of installation, when not available to the manufacturer at the time the boiler or pressure vessel leaves the plant, shall be provided by the sales agent.

4.6.4

Multiple identical pressure vessels manufactured and receiving final inspection in a period not exceeding five consecutive working days, and in lots of 100 or less, may be recorded on one master data report form, which shall be sent to the regulatory authority of the province of manufacture. A copy of this form shall be sent to the regulatory authority of the province of installation for each vessel.

4.6.5

For cast iron sectional boilers, the installer shall, in lieu of a manufacturer's data report, complete a form for each cast iron sectional boiler installed (see [Figure D.7](#)), and the completed forms shall be sent by the installer to the regulatory authority of the province of installation.

4.7 In-service repairs and alterations

4.7.1

The owner of a boiler, a pressure vessel, a fired-heater pressure coil, or piping shall be responsible for maintaining and operating it in a safe working condition.

4.7.2

Repairs and alterations shall not be made to a pressure-retaining component of a boiler, pressure vessel, fired-heater pressure coil, or piping without the prior agreement of the regulatory authority in whose jurisdiction the component is installed.

Notes:

- (1) *Subject to the approval of the regulatory authority, Parts RC and RD of the National Board Inspection Code may be used as a guide in developing repair or alteration procedures.*
- (2) *Where jurisdictional regulations permit, prior agreement for repair or alteration work may be established by the development of a quality control program that uses the guidelines in [Annex B](#) and is satisfactory to the regulatory authority. See also [Clause 4.9.3](#) regarding quality control systems.*

4.7.3

Hot tapping should be considered only when no alternative method is feasible or practical. Regulatory authority acceptance of the proposed procedure, including joint design, welding method, and base material identification, shall be obtained when required. Appropriate safety precautions shall be taken. The hot tapping experience and competency of the company and personnel performing this activity may be considered by the regulatory authority.

4.8 Fabrication inspection

4.8.1

Shop inspection of boilers, pressure vessels, fired-heater pressure coils, or piping covered by this Standard shall be conducted as follows:

- (a) in Canada, by an inspector employed by the regulatory authority in the province of fabrication. The inspection may be carried out in ASME Code shops by an inspector holding a valid National Board

- commission and employed by an authorized inspection agency as defined in the ASME Code, in which case the boiler or pressure vessel shall be registered with the National Board; and
- (b) outside Canada, by an authorized inspection agency.

4.8.2

Vessels shall be subject to individual shop inspection except as follows:

- (a) low-pressure steel boilers with 4.5 m^2 (50 ft^2) or less of wetted heating surface;
- (b) cast iron sectional boilers;
- (c) miniature pressure vessels, as defined in Section VIII, Division 1, of the ASME Code, when the manufacturer has registered its quality control manual with the regulatory authority where the manufacturing shop is located and has completed a manufacturer's data report for miniature pressure vessels (see [Figure D.1\(a\)](#));
- (d) hot water tanks, hydropneumatic tanks, and cushion tanks not exceeding 762 mm (30 in) in diameter (with no limit on capacity);
- (e) propane storage tanks for recreational vehicles not exceeding 0.09 m^3 (3.2 ft^3) in volume and 2153 kPa (312 psi) in design pressure;
- (f) electric boilers of a capacity up to 60 kW; and
- (g) small pressure vessels registered as Category H fittings and inspected in accordance with [Figures 1\(a\)](#), (b), and (c).

4.8.3

The manufacturer of boilers and pressure vessels specified in [Clause 4.8.2](#), except those specified in [Clause 4.8.2\(e\)](#), shall certify compliance with the requirements of this Standard by submitting a manufacturer's data report to the regulatory authority in the province where the item is intended to be used.

Notes:

- (1) *The report is not countersigned by the inspector or authorized inspector.*
- (2) *It is possible that the regulatory authority will not require a data report for [Clause 4.8.2\(g\)](#).*

4.9 Quality control program

4.9.1

4.9.1.1

The manufacturer of a boiler, pressure vessel, fitting, fired-heater pressure coil, or piping shall demonstrate to the regulatory authority that a satisfactory quality control system is in operation.

Note: *Recommended guidelines for quality control program requirements for manufacturers of fittings are provided in [Annex F](#), the CSA Z299 series of Standards, ISO 9001, and CAN/CSA-ISO 9001.*

4.9.1.2

Quality control programs maintained by manufacturers of fittings shall be resubmitted for validation at least every five years.

4.9.2

An organization wishing to set, service, or repair Category G fittings (see [Table 1](#)), except fittings of the non-reclosing type, shall first demonstrate to the regulatory authority that it has proper repair facilities and a satisfactory quality control system, including a written manual for the work to be carried out.

Note: *Guidelines for safety valve, relief valve, and safety-relief valve repair organizations are provided in [Annex C](#). A holder of a National Board VR stamp (see the National Board Inspection Code) is deemed to meet the guidelines.*

4.9.3

An organization wishing to repair or modify a boiler, pressure vessel, fitting, fired-heater pressure coil, or piping shall demonstrate to the regulatory authority that it has a satisfactory quality control system, including a written manual for the work to be carried out. An organization holding a valid R certificate of authorization issued by the National Board shall be deemed to have a satisfactory quality control system in operation.

Note: See also Parts RC and RD of the National Board Inspection Code for guidelines on in-service repair and alteration procedures.

4.9.4

An organization that supplies materials, including piping and fittings for use in pressure piping systems, shall satisfy the regulatory authority that a quality control system is in operation.

4.10 Program implementation for manufacturers in Canada

4.10.1 Holders of ASME Certificate of Authorization

Manufacturers of boilers, pressure vessels, fittings, or piping holding a current Certificate of Authorization issued by ASME for the range of products being manufactured shall be deemed to have a satisfactory quality control system in operation.

4.10.2 Non-holders of ASME Certificate of Authorization

Manufacturers not holding an ASME Certificate of Authorization may be eligible for acceptance of their boilers, pressure vessels, fittings, or piping by the regulatory authority under the following conditions:

- (a) The manufacturer shall demonstrate by means of a written manual and by a review of the manufacturing facilities and procedures that the quality control system in operation meets the requirements of the applicable section of the ASME Code (e.g., Appendix 10, Section VIII, Division 1) or conforms to the quality control program described in [Annex F](#).
- (b) The manufacturer shall be deemed acceptable if the regulatory authority concludes, as a result of the review, that the manufacturer meets the requirements of the applicable section of the ASME Code, and confirms its conclusion in writing.
- (c) The manufacturer shall continue to be acceptable if subsequent reviews demonstrate that its manufacturing facilities and procedures meet the requirements of the applicable section of the ASME Code. If it is found that the manufacturer is not adhering to or implementing the procedures outlined in the quality control system, the approval of the regulatory authority may be withdrawn.

4.11 Program implementation for manufacturers in other countries

Manufacturers in countries other than Canada that manufacture and export boilers and pressure vessels to Canada shall hold an ASME Certificate of Authorization and ensure that all boilers and pressure vessels are stamped with the appropriate ASME Code symbol stamp and registered with the National Board.

Manufacturers not holding an ASME Certificate of Authorization shall be eligible for acceptance of their boilers and pressure vessels if they demonstrate to the regulatory authority (by means of a written manual) that the quality control system in operation meets the applicable section of the ASME Code (e.g., Appendix 10, Section VIII, Division 1). An audit of the manufacturing facility and the quality management procedures by the regulatory authority or a third-party agency acceptable to the regulatory authority shall also be required for acceptance.

4.12 Non-destructive examination

Non-destructive testing personnel associated with the quality control system shall be certified in accordance with CAN/CGSB 48.9712/ISO 9712 or other Standards acceptable to the regulatory authority.

4.13 Water tanks

Tanks that contain water at a temperature not exceeding 65 °C (150°F) and are not equipped with heating units shall not be subject to registration.

4.14 Requalification of vessels in liquefied petroleum gas service

4.14.1

The requirements of CAN/CSA-B149.2 and CAN/CSA-B149.5 shall apply to the reinspection, retesting, and requalification of highway vehicle fuel tanks.

4.14.2

Ground storage tanks shall be inspected and tested periodically, as required by the Act.

4.15 High-pressure cylinders for compressed natural gas and hydrogen and compressed natural gas and hydrogen refuelling station pressure piping systems and containers

High-pressure cylinders for compressed natural gas and hydrogen and compressed natural gas and hydrogen pressure piping systems and containers shall meet the requirements of Parts 2 and 3 of this Standard.

4.16 Piping

4.16.1

The method by which any pressure piping system is to be tested, and the test pressure to be used, shall be submitted for approval to the regulatory authority in the province of installation.

4.16.2

When required by the regulatory authority in the province of installation, the piping fabricator or installer shall furnish an acceptable piping data report to the regulatory authority.

Note: See [Figure D.5](#) for a sample report form.

5 Identification

5.1 Nameplates

5.1.1

The nameplate of every boiler, pressure vessel, and Category G fitting (see [Table 1](#)), excluding fusible plugs, shall be stamped in accordance with the requirements of the appropriate section of the ASME Code. The stamping shall include the Canadian Registration Number (CRN) or Canadian Central Registration Number (CCRN). The stamping for other categories of fittings shall include, at a minimum, identification traceable to the manufacturer and to the CRN or CCRN. This identification shall be submitted to the regulatory authority or a central registration agency with the fitting registration.

5.1.2

When a pressure vessel requiring a nameplate will be exposed to corrosive matter, the nameplate shall be attached in a manner that prevents accumulation of foreign material between the nameplate and the shell, head, or any other part of the pressure vessel subject to internal pressure.

5.1.3

The designer of a fired-heater pressure coil shall provide a nameplate for the complete heater. The organization responsible for the field assembly shall be shown on this nameplate.

5.1.4

Only whole numbers shall be used for specifying pressure and temperature ratings on nameplates.

5.2 Additional nameplates

When an alteration to a boiler or pressure vessel is made, or when such an item is rerated (i.e., when the MAWP, the allowable temperature, or the minimum design metal temperature is changed), an additional nameplate shall be affixed next to the original nameplate of the boiler or pressure vessel. This additional nameplate shall specify

- (a) whether it relates to an alteration or a rerating;
- (b) the name of the company responsible for the change;
- (c) the maximum allowable working pressure and temperature;
- (d) the minimum design metal temperature (where applicable);
- (e) the date of alteration; and
- (f) the CRN.

Letter sizing and other nameplate requirements shall be in accordance with the applicable section of the ASME Code.

5.3 Stamping

5.3.1

Boilers, pressure vessels, safety valves, relief valves, safety-relief valves, and rupture discs shall be stamped with an ASME Code symbol stamp or other stamp acceptable to the regulatory authority.

5.3.2

Individual modules and welded pressure parts of a fired-heater pressure coil shall be identified by stamping, stencilling, welded tag plates, or other appropriate means to provide traceability to the accompanying documentation.

5.3.3

At a minimum, individual pressure coils shall have a means of identification that includes the manufacturer's name, year of manufacture, maximum allowable working pressure and design metal temperature, a serial number, and the CRN.

5.3.4

Welded parts for a boiler or pressure vessel for which a manufacturer's partial data report is required shall be marked as required by the appropriate section of the ASME Code, except that the ASME Code symbol stamp shall be required only if the completed boiler or pressure vessel is to be ASME stamped.

5.4 Fittings

Fittings shall be permanently marked as required by MSS SP-25.

6 Boilers and related components

6.1 General

Except as otherwise specified in this Standard, the standards governing the design, construction, installation, inspection, testing, and repair of boilers shall be those specified in

- (a) the following portions of the ASME Code:
 - (i) Section I;
 - (ii) Section II, Part A;
 - (iii) Section II, Part B;
 - (iv) Section II, Part C;
 - (v) Section II, Part D;
 - (vi) Section IV;
 - (vii) Section V;

- (viii) Section VIII, Division 1;
 - (ix) Section VIII, Division 2;
 - (x) Section VIII, Division 3; and
 - (xi) Section IX; and
- (b) ASME CSD-1.

6.2 Lap-seam riveted boilers

The recommended age limit for high-pressure lap-seam riveted boilers shall be 20 years, after which the factor of safety shall be increased by at least 0.1 each year. If relocated, a lap-seam riveted boiler shall not be operated at a pressure higher than 103 kPa (15 psi).

6.3 Supplementary construction and installation requirements

6.3.1 Water gauges

6.3.1.1

When the top connection of a water gauge is more than 2 m (7 ft) and less than 6 m (20 ft) from the floor or working platform of a boiler room, it shall be fitted with rods or chains so that it can be operated from the floor or working platform. When the top connection of a water gauge is 6 m (20 ft) or more from the operating floor level, it shall be of the inclined type or other accepted type.

6.3.1.2

Safe and effective means, including adequate lighting, shall be provided to permit the level in the gauge glass to be distinctly seen at all times.

6.3.1.3

High-pressure steam boilers that have a maximum allowable working pressure of 2758 kPa (400 psi) or less and only a manually controlled water feed shall be fitted with two means for determining the water level.

6.3.2 Low-water cut-off

6.3.2.1

Steam boilers not continuously attended by a certified operator shall be equipped with at least two low-water fuel cut-off devices, each of which shall be independent of the other or others. These devices shall be installed so that they cannot be rendered inoperative. The installation shall be such that the devices can be tested under operational conditions.

Note: The term "tested under operational conditions" refers to a procedure that involves closure of the fuel supply valve or, in the case of an electric boiler not of the probe type, an interruption of the energy source.

6.3.2.2

Automatically fired hot water boilers not continuously attended by a certified operator shall be equipped with a low-water fuel cut-off device, except as specified in [Clause 6.3.2.3](#). This device shall be installed so that it cannot be rendered inoperative. The installation shall be such that it can be tested under operational conditions.

6.3.2.3

In lieu of a low-water fuel cut-off device, automatically fired hot water boilers requiring forced circulation to prevent overheating (e.g., coil or fin-tube type boilers) shall be equipped with a flow-sensing device to automatically cut off the fuel supply to the burner if the flow rate is reduced to a point where it is inadequate to protect the boiler against overheating. The device shall be installed on the boiler outlet

piping, be of a type certified safe and suitable by a nationally recognized testing agency, and installed so that it cannot be rendered inoperative. The installation shall be such that it can be tested under operational conditions.

6.3.3 Fusible plug

When a solid fuel firetube boiler operating at a pressure over 103 kPa (15 psi) is provided with a fusible plug, the plug shall be as specified in the ASME Code.

6.3.4 Boiler installation

6.3.4.1

Boilers shall be installed in a manner that provides adequate access for operation, inspection, and maintenance.

6.3.4.2

Except as specified elsewhere in [Clause 6.3.4](#), a passageway at least 0.6 m (2 ft) wide and clear of obstructions shall be provided on both sides and at the rear of each boiler. When necessary, this clearance shall be increased to facilitate removal or opening of closures, casings, or covers.

6.3.4.3

Boilers with a bottom opening or handhole shall have a minimum clearance of 300 mm (12 in) above the floor or similar structure. Adequate clearance shall be provided between the floor and the lowest insulated surface of a boiler to facilitate inspection or repair.

6.3.4.4

Adequate clearance shall be provided for cleaning and replacing boiler tubes, fuel-burning equipment, and all other boiler-related equipment.

6.3.4.5

Platforms, walkways, ladders, and stairways shall be installed to provide access to important parts of boilers. They shall be of fire-resistant construction and equipped with handrails and toe-plates.

6.3.4.6

Each boiler in a battery of boilers shall have its blowoff line connected in such a manner that the boiler can be isolated from the other boilers under pressure. For the purpose of blowoff, boilers should be numbered both back and front when set in batteries.

6.3.5 Boiler inspection openings

When manholes are specified or required for a boiler, they shall be at least 406 mm (16 in) in inside diameter or oval with inside dimensions of 305 × 406 mm (12 × 16 in).

6.4 Boiler outlet dampers

Outlet dampers on automatically fired boilers shall be interlocked to the burner control system so that the boilers cannot be fired unless the dampers are sufficiently open.

6.5 Blowoff vessels, systems, and devices

6.5.1

When the blowoff from a boiler having a working pressure exceeding 103 kPa (15 psi) is discharged into a sewer system, a registered blowoff vessel or other suitable registered device shall be placed between the boiler and sewer to reduce the temperature of the water entering the sewer system to 65 °C (150°F) or lower. Blowoff vessels shall be designed in accordance with [Clause 7.5](#).

Notes:

- (1) Temperature-limit control devices may be attached to the vessel or water discharge line to control the temperature at or below 65 °C (150°F).
- (2) Austenitic stainless steel used in water-wetted service is susceptible to stress-corrosion cracking and should not be used.

6.5.2

Blowoff systems of a proprietary design that do not meet the requirements of [Clause 7.5.1.2](#) or [7.5.1.3](#) shall be designed to meet the requirements of [Clause 7.1](#). The design shall be submitted to the regulatory authority for registration before installation of the system.

6.6 Thermal fluid heaters and piping

Except for coils covered by [Clauses 10.1](#) and [10.2](#), thermal fluid heaters shall be designed in accordance with the requirements of Section I or Section VIII, Division 1, of the ASME Code.

When thermal fluid heaters are designed to Section VIII, Division 1, of the ASME Code, controls shall meet the requirements of Parts PG and PVG, Section I, of the ASME Code.

Piping used with thermal fluid heaters shall be designed to ASME B31.3.

6.7 Cast iron steam and hot water boilers

Each design covering a cast iron steam or hot water boiler shall be accompanied by a proof test certificate indicating the destruction test pressure for each type or series submitted for approval.

6.8 Welded staybolts

Welded solid staybolts that are 8 in long or shorter shall have telltale holes in accordance with the dimensional requirements of paragraph PG-47.1, Section I, of the ASME Code.

7 Pressure vessels**7.1 General****7.1.1**

Except as otherwise specified in [Clause 7](#), the standards governing the design, construction, installation, inspection, testing, and repair of pressure vessels shall be those specified in

- (a) the following portions of the ASME Code:

- (i) Section II, Part A;
- (ii) Section II, Part B;
- (iii) Section II, Part C;
- (iv) Section II, Part D;
- (v) Section V;
- (vi) Section VIII, Division 1;
- (vii) Section VIII, Division 2;
- (viii) Section VIII, Division 3;
- (ix) Section IX; and
- (x) Section X; and

- (b) ASME PVHO-1.

7.1.2

In addition to the impact testing requirements specified in the ASME publications listed in [Clause 7.1.1](#), carbon and low alloy steel used for the construction of pressure vessels at a minimum design metal temperature below -46 °C (-50°F) shall be impact tested at the minimum design metal temperature or a lower temperature, and the test results shall meet the requirements of paragraph UG 84, Section VIII, Division 1, of the ASME Code.

7.2 Pressure vessel installation

7.2.1 General

7.2.1.1

Pressure vessels shall be installed in a manner that provides adequate access for operation, inspection, and maintenance.

7.2.1.2

Except as specified elsewhere in [Clause 7.2](#), a passageway at least 0.6 m (2 ft) wide and clear of obstructions shall be provided on both sides and at the rear of each pressure vessel. When necessary, this clearance shall be increased to facilitate removal or opening of closures, casings, or covers.

7.2.1.3

Adequate clearance shall be provided between the floor and the lowest insulated surface of a pressure vessel to facilitate inspection or repair.

Note: There should be a minimum clearance of 300 mm (12 in).

7.2.1.4

Adequate clearance shall be provided for cleaning and replacing internal components, e.g., heat exchanger tubes.

7.2.1.5

Platforms, walkways, ladders, and stairways shall be installed to provide access to important parts of pressure vessels. They shall be of fire-resistant construction and equipped with handrails and toe-plates.

7.2.2 Propane tanks

Buried propane tank installations shall be designed to meet the requirements of CAN/CSA-B149.2.

7.2.3 Other buried pressure vessels

7.2.3.1

Buried pressure vessel installations shall be designed to meet the requirements of [Clauses 7.2.3.2 to 7.2.3.6](#). Design documentation shall be submitted to the regulatory authority before installation.

7.2.3.2

The pressure vessel shall be designed for underground service and provided with a means for placing it in position without damage to the vessel or its protective coatings.

7.2.3.3

The pressure vessel shall be externally protected in accordance with CAN/ULC-S603.1 unless an impressed-current system is employed.

7.2.3.4

The pressure vessel shall be cathodically protected by

- (a) a sacrificial-type system designed in accordance with CAN/ULC-S603.1;
- (b) an impressed-current system, using PACE Report No. 87-1 for design criteria; or
- (c) a system designed by a registered professional engineer accredited by NACE International.

7.2.3.5

The pressure vessel shall be installed in accordance with CAN/ULC-S603.1.

7.2.3.6

Corrosion-control monitoring shall be undertaken at least annually to ensure compliance with the design criteria. A permanently connected on-site voltmeter shall be installed to continuously indicate the cathodic protection potential (see CAN/ULC-S603.1).

7.3 Pressure vessel inspection openings

When manholes are specified or required for a pressure vessel, they shall be at least 406 mm (16 in) in inside diameter or oval with inside dimensions of 305 × 406 mm (12 × 16 in).

7.4 Water heaters and hot water, hydropneumatic, and cushion tanks

7.4.1 Water heaters

7.4.1.1

A water heater with a maximum diameter of 610 mm (24 in) or a maximum heat input of 30 kW electrical or 400 000 Btu/h shall not be subject to the requirements of this Standard.

7.4.1.2

Water heaters shall be designed to meet the requirements of Section I; Part HLW, Section IV; or Section VIII, Division 1, of the ASME Code, but the heat input, temperature, and volume exemptions in the ASME Code shall not apply.

7.4.1.3

Relief valves for water heaters shall be of adequate capacity, with a minimum inlet size of NPS 3/4 (NPS 1 for water heaters heated indirectly by steam in a coil or pipe), and shall be provided with a suitably designed lifting device.

7.4.2 Hot water tanks

7.4.2.1

A hot water tank with a maximum diameter of 610 mm (24 in) shall not be subject to the requirements of this Standard.

7.4.2.2

Hot water tanks shall be designed to meet the requirements of Section VIII, Division 1, of the ASME Code. Corrosion-resistant potable hot water tanks may be designed to Part HLW, Section IV, of the ASME Code.

7.4.2.3

Hot water tanks shall be designed for a minimum pressure of 690 kPa (100 psi) and a minimum design temperature of 95 °C (200°F).

7.4.2.4

Relief valves for hot water tanks shall be of adequate capacity, with a minimum inlet size of NPS 3/4, and shall be provided with a suitably designed lifting device.

7.4.3 Hydropneumatic tanks

Hydropneumatic tanks shall have a minimum design pressure of 690 kPa (100 psi) and meet the requirements of Section VIII, Division 1, of the ASME Code. A hydropneumatic tank with a maximum diameter of 610 mm (24 in), a total volume of 450 L (16 ft³) or less, and a temperature of 65 °C (150°F) or less shall not be subject to the requirements of this Standard.

7.4.4 Cushion tanks

Cushion tanks having a working pressure exceeding 207 kPa (30 psi) or a diameter exceeding 610 mm (24 in) shall meet the requirements of Section VIII, Division 1, of the ASME Code. Cushion tanks with a maximum diameter of 610 mm (24 in) and a pressure of 207 kPa (30 psi) or less shall not be subject to the requirements of this Standard.

7.5 Blowoff vessels

7.5.1 Design requirements

7.5.1.1

The design pressure for blowoff vessels shall be as specified in [Table 2](#). A corrosion allowance of at least 3 mm (1/8 in) shall be added to the vessel thickness necessary to meet the requirements of [Table 2](#). The plate thickness shall be at least 9.5 mm (3/8 in).

7.5.1.2

The minimum diameter and volume of blowoff vessels (other than for coil-tube boilers) shall be as specified in [Table 3](#). When more than one boiler is connected to the same blowoff vessel, the vessel shall be designed to suit the largest boiler, except as specified in [Clause 7.5.1.3](#).

7.5.1.3

The minimum diameter and volume of blowoff vessels for coil-tube boilers having a capacity of less than 1200 L (250 Imp gal) may be as specified in [Table 4](#), but shall be not less than the fully flooded volume of the boiler.

7.5.2 Cleaning and inspection facilities

7.5.2.1

To facilitate internal inspection and permit cleaning, a manhole that complies with the requirements of [Clause 7.3](#) shall be provided, except in the case of a vessel that is less than 610 mm (24 in) in diameter, where an oval hand hole with inside dimensions of 100 × 150 mm (4 × 6 in) may be used.

7.5.2.2

A drain connection of not less than NPS 1-1/2 shall be provided for cleaning and drainage and installed in the bottom of the vessel.

7.5.3 Inlets and outlets

7.5.3.1

Blowoff vessels shall be provided with an atmospheric vent pipe

- (a) not less than 76 mm (3 in) in inside diameter;
- (b) sized to ensure that the liquid drain seal cannot be blown out;
- (c) without consideration for the area of the water discharge pipe; and
- (d) having no isolating valves.

7.5.3.2

A water discharge pipe, of a size sufficient to discharge the maximum quantity of water that can enter the vessel without an appreciable rise in the water level in the vessel, shall be provided. The water discharge outlet shall be at least 51 mm (2 in) in inside diameter. The water discharge seal shall be designed for 125% of the maximum expected water flow into the vessel.

7.5.3.3

An anti-siphon device shall be fitted on the water seal.

7.5.3.4

A cold water connection shall be provided and enter separately from the blowoff inlet connection. The cold water supply line shall be a minimum of NPS 3/4.

7.5.3.5

A connection with a minimum of NPS 1/2 shall be provided on the vessel shell above the liquid level for a pressure gauge connection.

7.5.3.6

When tangential inlet connections are used, an impingement wear plate shall be provided to take the erosive wear of the entering blowoff.

7.6 Anhydrous ammonia service

7.6.1

Except as required by [Clauses 7.1](#), [7.6.2](#), and [7.6.3](#), the design, construction, and installation of pressure vessels and piping to be used for storage and handling of anhydrous ammonia shall comply with ANSI K61.1.

7.6.2

Anhydrous ammonia storage tanks with a water capacity of 13 660 L (3000 Imp gal) or more shall be constructed with a manhole.

7.6.3

Except for vessels used in refrigeration systems, pressure vessels intended for use in anhydrous ammonia service shall

- (a) be subjected to post-weld heat treatment before the hydrostatic test; and
- (b) have head and shell materials produced in accordance with fine-grain practice.

7.7 Liquefied petroleum gas and natural gas liquids services

7.7.1 Liquefied petroleum gas service

7.7.1.1

Pressure vessels and piping for liquefied petroleum gases shall meet the requirements of the following:

- (a) for fuel tanks on highway vehicles:
 - (i) Section VIII, Division 1, of the ASME Code;
 - (ii) CAN/CSA-B149.2 and CAN/CSA-B149.5; and
 - (iii) [Annex G](#); or
- (b) for ground storage tanks:
 - (i) Section VIII, Division 1, of the ASME Code; and
 - (ii) CAN/CSA-B149.2.

7.7.1.2

Liquefied petroleum gas vessels with a water capacity of 13 660 L (3000 Imp gal) or more shall be constructed with a manhole.

7.7.2 Natural gas liquids service

When flexible hoses are used with natural gas liquid storage tanks for loading and unloading product, an excess flow valve that is adequately sized for each tank opening used for product flow shall be installed.

8 Piping and fittings

8.1

Except as otherwise specified in this Standard, the design, materials, construction, installation, inspection, testing, and repair of pressure piping shall meet the requirements of the following, as applicable:

- (a) ASME:
 - (i) B31.1;
 - (ii) B31.3;
 - (iii) B31.4;
 - (iv) B31.5; and
 - (v) B31.9 (except for the requirements allowing use of soldered joints for air piping);
- (b) CSA:
 - (i) CAN/CSA-B149.1;
 - (ii) CAN/CSA-B149.2;
 - (iii) CAN/CSA-Z180.1;
 - (iv) Z662; and
 - (v) CAN/CSA-Z7396.1;
- (c) RMA IP-2; and
- (d) CDA A4015 (for soldering).

8.2

Fittings used in piping systems shall be registered in accordance with [Clause 4.2](#).

Note: For flexible hose assemblies, refer to RMA IP-2.

8.3

Welded joints in a pressure piping system shall not be painted or covered until inspection by an authorized inspection agency has been completed.

8.4

Soldered joints shall not be permitted in services subject to shock or vibration.

8.5 Bending of non-metallic joints

Bonding of non-metallic joints shall be performed in accordance with the applicable code of construction. Bonding procedure specifications, and procedure and performance qualification testing, shall be subject to the acceptance of the regulatory authority.

Note: For an example of requirements for bonding, refer to Chapter VII of ASME B31.3.

9 Refrigeration equipment

The design, construction, installation, inspection, testing, and repair of refrigeration equipment shall meet the requirements of CSA B52.

10 Fired-heater pressure coils in petroleum and chemical plant service

10.1

Subject to [Clauses 10.2 to 10.5](#), and except for components designed and fabricated to Section I of the ASME Code or ASME B31.1, the design, construction, installation, inspection, and testing of fired-heater pressure coils shall meet the requirements of ASME B31.3 and API STD 530.

10.2

The thickness of tubes, return bends, headers, and manifolds inside the internally insulated enclosure may be designed in accordance with API STD 530 and fabricated and inspected in accordance with this Standard and ASME B31.3.

10.3

The owner or a person designated by the owner shall determine design and service conditions for pressure coils. These conditions shall be identified to the regulatory authority at the time of registration or before repairs to or alterations of such coils.

10.4

The minimum inspection requirements for welds in fired-heater pressure coils designed, constructed, installed, inspected, tested, and repaired in accordance with this Standard shall be as specified in ASME B31.3.

Welds exposed to direct radiant heat shall meet the requirements of [Annex E](#).

10.5

Piping, headers, manifolds, crossovers, and other equipment external to the enclosure are not part of the fired-heater pressure coil and shall be designed, fabricated, and inspected in accordance with this Standard. After final assembly, the completed pressure coil shall be tested in the presence of the authorized inspector. A description of the method and test pressure shall be submitted to the regulatory authority before testing.

11 Repairs and alterations

11.1

The Codes and Standards referenced in [Clauses 6 to 8](#) and [10](#) are intended for new construction and are not necessarily entirely applicable to repairs or alterations. For all repairs or alterations, the methods employed shall maintain the factor of safety determined in accordance with the ASME Code section referenced when the unit was first manufactured.

Note: See [Clause 4.7](#) for additional requirements pertaining to repairs and alterations and [Figure D.8](#) for a recommended repair/alteration report form for boilers and pressure vessels.

11.2

Repairs to Category G fittings (see [Table 1](#)) shall be performed in such a manner that the original manufacturer's specifications for the device are restored or maintained.

Note: Recommended guidelines for safety valve, relief valve, and safety-relief valve repair organizations are provided in [Annex C](#). A holder of a National Board VR stamp is deemed to meet the guidelines.

11.3

All repairs to and alterations of vessels specified in [Clause 7.6](#) shall be made in accordance with ANSI K61.1.

11.4

If hot tapping is to be performed, the fitting rating, joint configuration, and reinforcement shall meet the requirements of the code of construction for the piping system or vessel.

Table 1
Categories of fittings

(See [Clauses 4.1.1, 4.2.2, 4.2.5, 4.9.2, 5.1.1, and 11.2](#) and [Figures 1\(a\), \(b\), and \(c\).](#))

Category	Type of fitting
A	Pipe fittings, including couplings, tees, elbows, wyes, plugs, unions, nipples, pipe caps, and reducers
B	All flanges
C	All line valves
D	All types of expansion joints, flexible connections, and hose assemblies
E	Strainers, filters, separators, and steam traps
F	Measuring devices, including pressure gauges, level gauges, sight glasses, levels, and pressure transmitters
G	Certified capacity-rated pressure-relief devices acceptable as primary overpressure protection on boilers, pressure vessels and pressure piping, and fusible plugs
H	Pressure-retaining components that do not fall into Categories A to G

Notes:

- (1)** *These categories do not take into account size, materials, end connections, ratings, schedules, and methods of fabrication.*
- (2)** *Category H can include*
- (a) small pressure vessels registered and inspected as specified in [Figure 1\(a\), \(b\), or \(c\)](#); or*
 - (b) a series of components (including piping components) joined together to form a single fitting, provided that the diameter of any component does not exceed 152 mm (6 in) and the total volume of the fitting does not exceed 42.5 L (1.5 ft³).*

Table 2
Design pressures for blowoff vessels

(See [Clause 7.5.1.1.](#))

Maximum boiler pressure	Vessel design pressure
103–2060 kPa (15–300 psi)	30% of the maximum boiler pressure, but shall be at least 103 kPa (15 psi)
Over 2060 kPa (300 psi)	690 kPa (100 psi)

Table 3
Minimum dimensions of blowoff vessels
(other than for coil-tube boilers)
 (See [Clause 7.5.1.2.](#))

Boiler steam evaporative capacity, kg/h (lb/h)*	Minimum diameter, mm (in)	Minimum volume, m ³ (ft ³)
Up to 340 (750)	457 (18)	0.10 (3.5)
680 (1 500)	610 (24)	0.25 (8.0)
1 360 (3 000)	760 (30)	0.42 (15.0)
3 175 (7 000)	915 (36)	0.51 (20.0)
5 900 (13 000)	915 (36)	0.71 (25.0)
11 300 (25 000)	1 066 (42)	1.13 (40.0)
45 400 (100 000)	1 220 (48)	1.70 (60.0)
136 000 (300 000)	1 220 (48)	2.27 (80.0)
227 000 (500 000)	1 220 (48)	2.83 (100.0)
454 000 (1 000 000)	1 220 (48)	3.68 (130.0)
680 000 (1 500 000)	1 220 (48)	4.53 (160.0)
907 000 (2 000 000)	1 220 (48)	5.66 (200.0)

*At 100 °C (212°F).

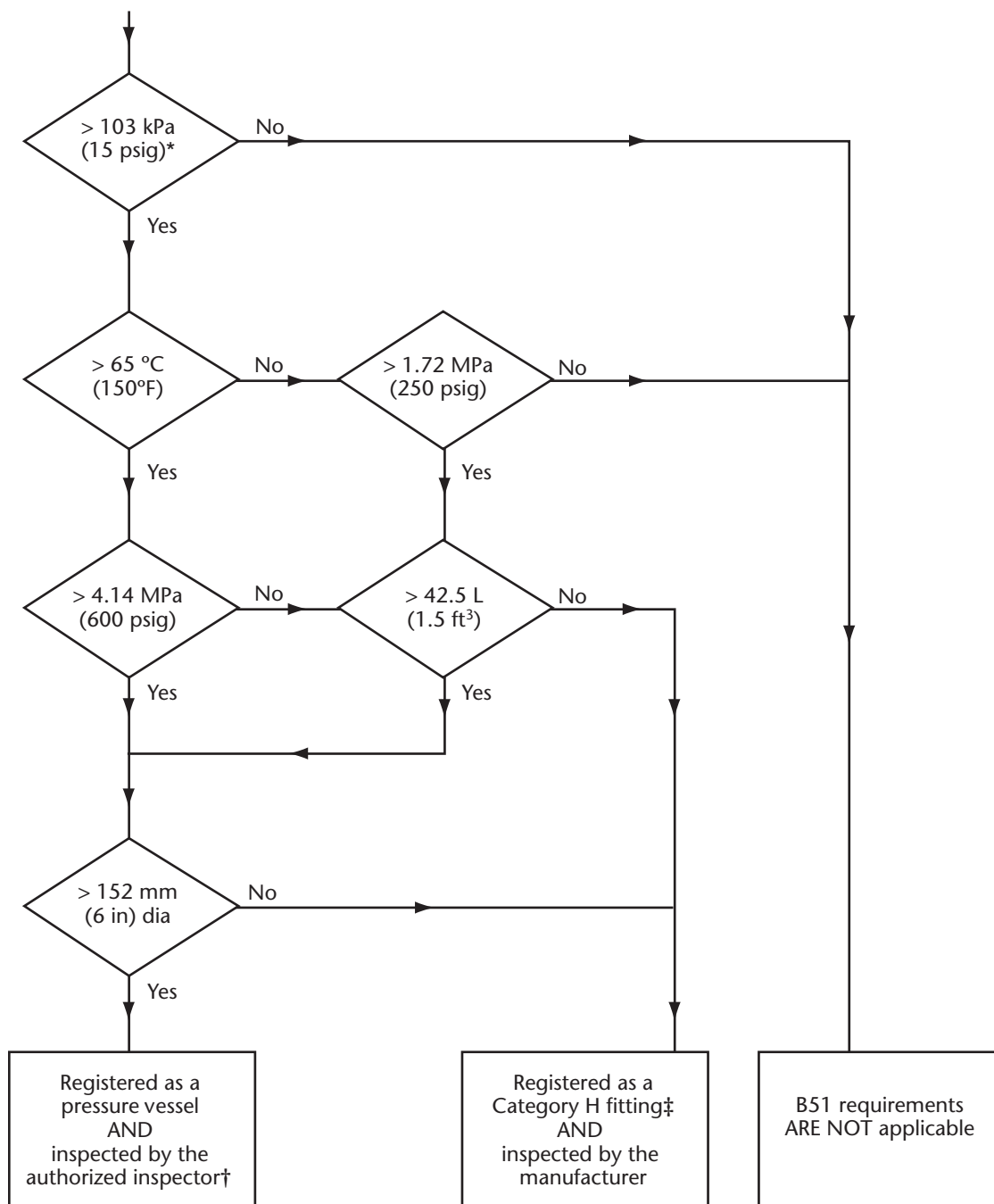
Notes:

- (1) Interpolation may be used for evaporative capacities less than 907 000 kg/h (2 000 000 lb/h). Extrapolation shall be used for evaporative capacities greater than 907 000 kg/h (2 000 000 lb/h).
- (2) The design of a blowoff vessel less than 457 mm (18 in) in diameter for evaporative capacities less than 340 kg/h (750 lb/h) may be accepted by the regulatory authority when supported by design analysis.

Table 4
Minimum dimensions of blowoff vessels for coil-tube boilers
 (See [Clause 7.5.1.3.](#))

Boiler steam evaporative capacity, kg/h (lb/h)*	Minimum diameter, mm (in)	Minimum volume, m ³ (ft ³)
Up to 1585 (3500)	457 (18)	0.09 (3.2)
3945 (8700)	610 (24)	0.20 (7.0)
Over 3945 (8700)	760 (30)	0.37 (13.1)

*At 100 °C (212°F).

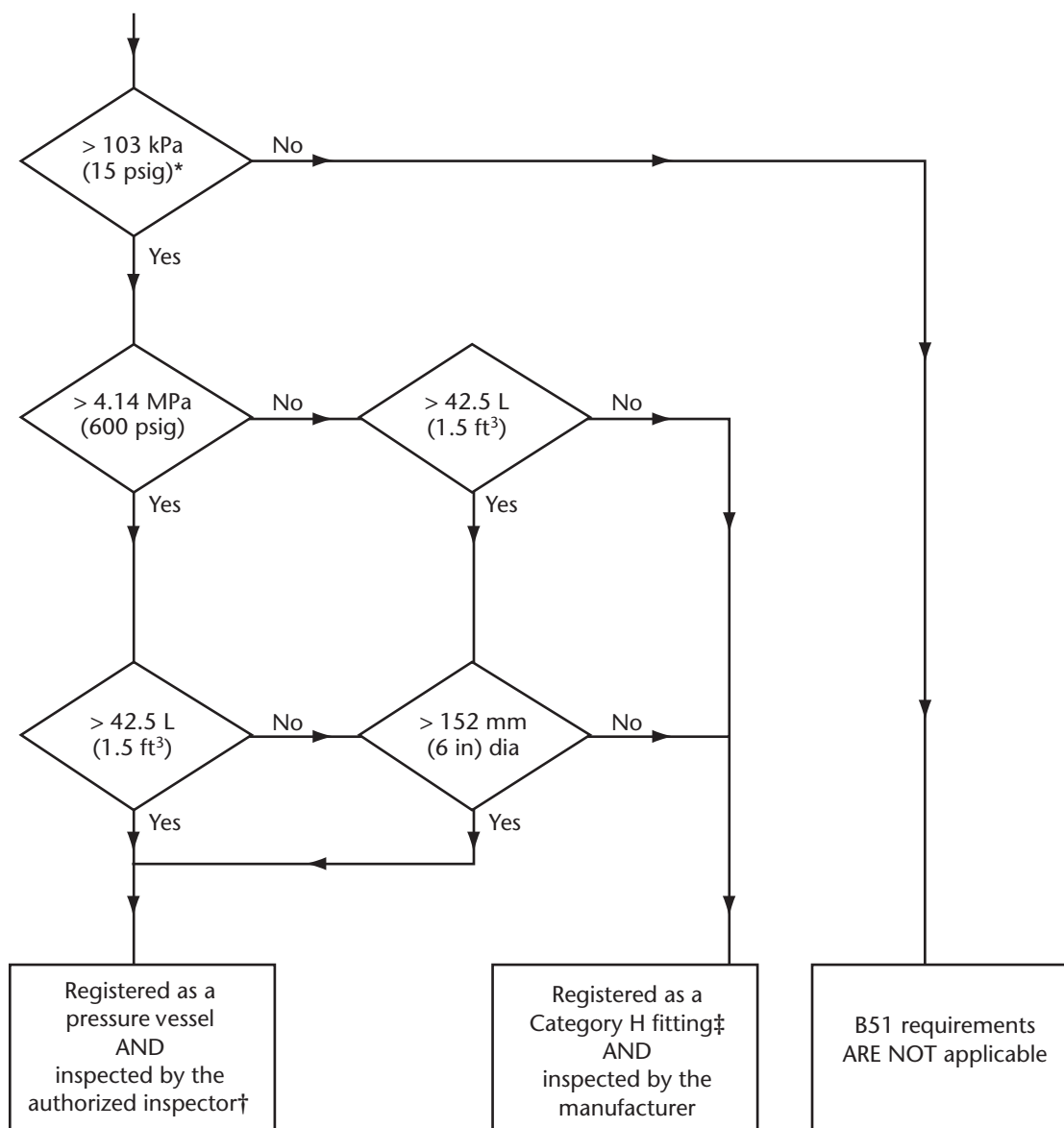


*Maximum allowable working pressure (MAWP).

†See Clause 4.8.2 for exceptions to inspection requirements.

‡See Table 1.

Figure 1(a)
Registration and inspection requirements for pressure vessels
(and pressure vessels registered as Category H fittings) for liquid service
with liquids not more hazardous than water
 (See Clauses 4.1.1 and 4.8.2, Table 1, and Figure 1(b).)

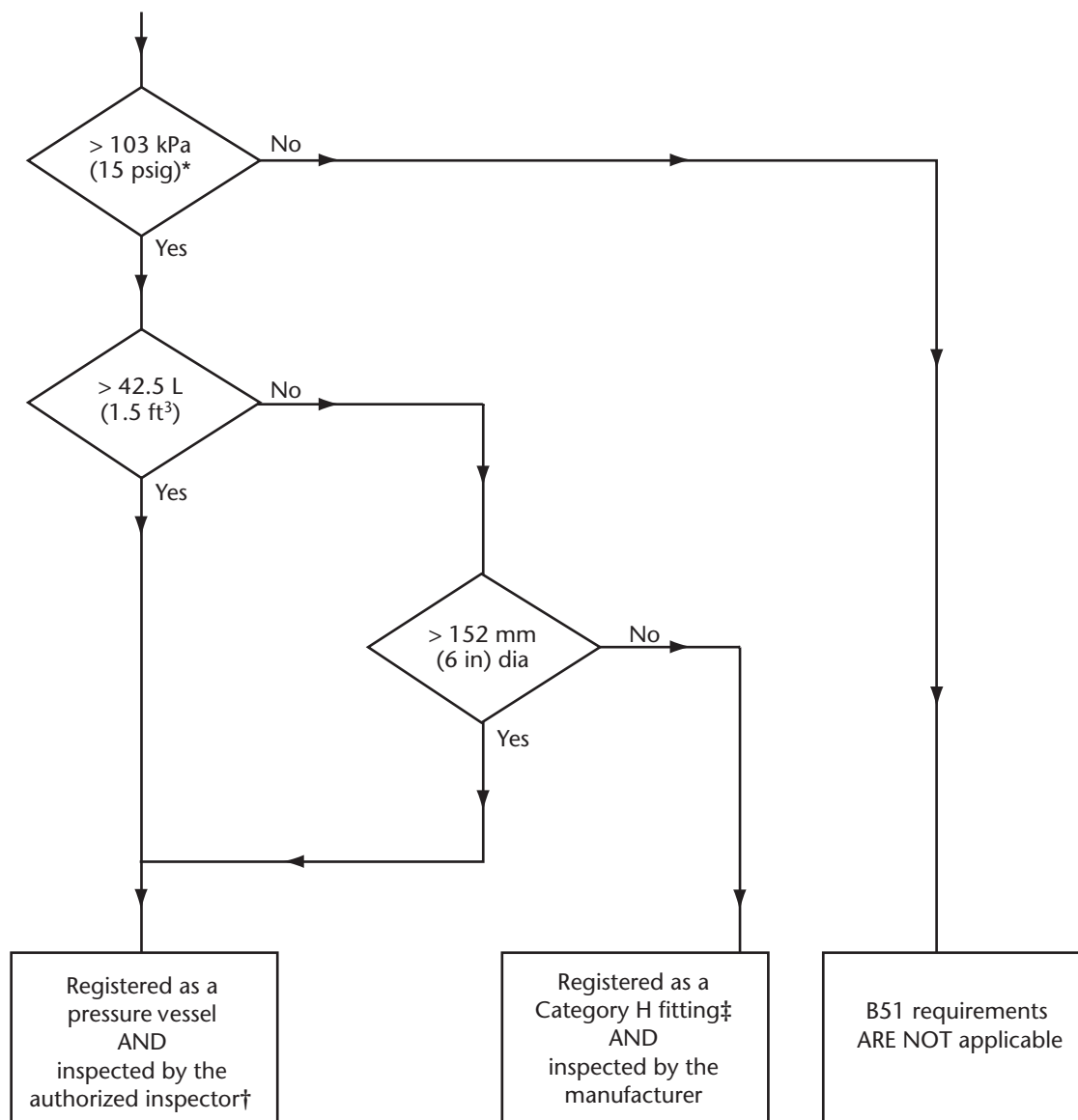


*Maximum allowable working pressure (MAWP).

†See Clause 4.8.2 for exceptions to inspection requirements.

‡See Table 1.

Figure 1(b)
Registration and inspection requirements for pressure vessels
(and pressure vessels registered as Category H fittings)
containing a non-lethal gas or vapour or a non-lethal
liquid not covered by Figure 1(a)
 (See [Clauses 4.1.1](#) and [4.8.2](#) and [Table 1](#).)



*Maximum allowable working pressure (MAWP).

†See Clause 4.8.2 for exceptions to inspection requirements.

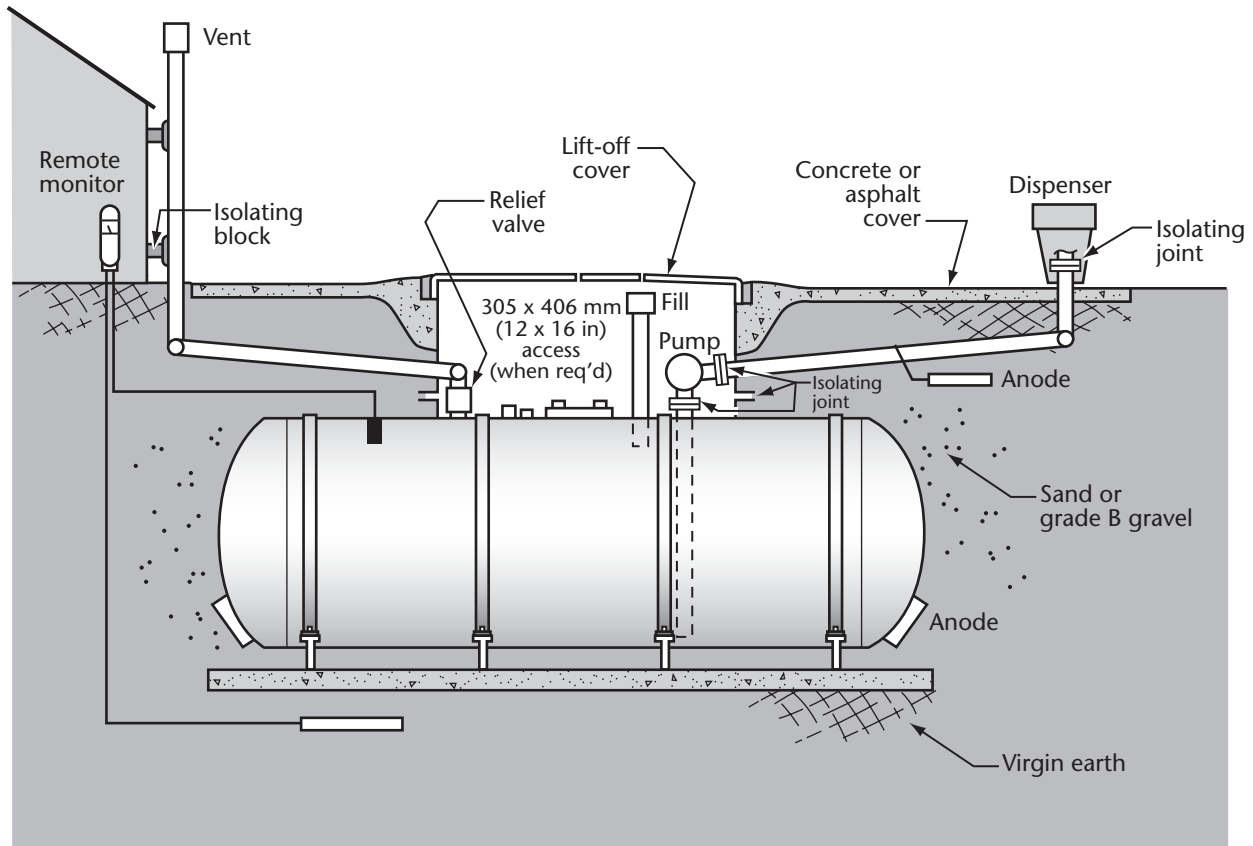
‡See Table 1.

Figure 1(c)
Registration and inspection requirements for pressure vessels
(and pressure vessels registered as Category H fittings)
containing lethal substances
 (See [Clauses 4.1.1](#) and [4.8.2](#) and [Table 1](#).)

Annex A (informative)

Burial of pressure vessels

Note: This Annex is not a mandatory part of this Standard.



Note: Vessel and piping are coated with corrosion-resistant compound complete with attached sacrificial anodes.

Figure A.1
Typical installation of an underground pressure vessel

Annex B (informative)

Quality control program for defect prevention and in-service reliability

Note: *This Annex is not a mandatory part of this Standard.*

B.1 Scope

This Annex describes a program that allows owners of boilers, pressure vessels, fired-heater pressure coils, or piping to enhance the safety and reliability of pressure-retaining components.

B.2 Development of the program

B.2.1

The company should establish a program of safety control, defect prevention, and in-service reliability. The person responsible for the program should be independent of the production line responsibility and have well-defined authority for making decisions relating to equipment safety and reliability.

B.2.2

The company should provide professional competence and technical experience in the application of appropriate codes and standards. The quality control group should anticipate and prevent deviations in the use of pressure plant components by coordinating efforts to control quality through planning at all stages of design, repair, maintenance, periodic testing, and operation.

B.2.3

The company should institute methods and procedures for the activities necessary to prevent and eliminate defects and control safety. For effective quality control and defect prevention, department heads should coordinate their plans for work on pressure-retaining components with the quality control group and with the plans of other departments, to ensure that the agreed-on plans are being followed.

B.2.4

The following principles should apply:

- (a) Emphasis should be placed on preventing defects at all stages of design, use, examination, maintenance, repair, and operation.
- (b) Procedures for quality control and defect prevention should be specified in a manual and kept up-to-date (see [Clause B.2.9](#)).
- (c) Communication between the quality control group, suppliers of materials, and activity supervisors should be maintained to prevent misunderstandings about the requirements.
- (d) Design and method changes should be carefully controlled and records kept of the timing of significant changes.
- (e) A calibration program should be established to cover all inspection and testing equipment.

B.2.5

The company should determine the scope of repairs and alterations and develop repair methods and procedures.

B.2.6

The company should provide the facilities and equipment required for examination, testing, maintenance, supply of materials, and records as they relate to pressure plant components.

B.2.7

Tests of the pressure-retaining components should be conducted at critical points and at established intervals, and records kept to provide evidence of control.

B.2.8

Regular reviews of procedures and practices should be conducted by the quality control group to ensure that efforts to prevent defects are suitable, that approved procedures are followed, and that defect prevention is being attained.

B.2.9

The quality control group should ensure that the manual describing the activities, procedures, and methods to be used and maintained (see [Clause B.2.4\(b\)](#)) is adhered to in the plant. The manual should include procedures for in-plant inspection to ensure that basic materials are in compliance with specifications. It should also include in-plant defect-prevention forms and describe how they are to be processed.

B.2.10

The person responsible for the program should evaluate, at regular intervals, the degree of control achieved, the causes of deviations, and actions taken to prevent deviations from recurring, and report the results of the evaluation to senior management.

Annex C (informative)

Guidelines for safety valve, relief valve, and safety-relief valve repair organizations

Note: This informative Annex has been written in normative language to facilitate its adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

C.1 Administrative requirements

C.1.1 Scope

These guidelines are provided for organizations that wish to obtain a certificate of authorization for the repair of safety valves, relief valves, and safety-relief valves. This certificate of authorization may be for shop repair, field repair, or both.

C.1.2 General

The general rules of this Annex apply only to the repair of registered safety valves, relief valves, and safety-relief valves that have a rating sheet certified by the National Board of Boiler and Pressure Vessel Inspectors or other agencies approved by the regulatory authority. These devices may be ASME Code V-stamped (Section I), HV-stamped (Section IV), or UV-stamped (Section VIII) pressure-relief valves. Manufacturers, assemblers, and organizations holding VR stamps are deemed to meet the requirements of this Annex.

C.1.3 Certificate of authorization

Repair organizations, manufacturers, assemblers, or users that repair pressure-relief valves for boilers and pressure vessels may apply to the regulatory authority for acceptance of their quality control program. A provincial certificate of authorization expiring on the third anniversary of the review shall be issued.

The certificate of authorization shall be renewable every three years, subject to review and acceptance of the quality control program by a designated representative of the regulatory authority.

C.1.4 Documentation

The applicant shall keep copies of the following publications and make them available to any interested party on request:

- (a) the latest edition of and addenda to NB-23, the *National Board Inspection Code*;
- (b) NB-18, the *National Board Pressure Relief Device Certifications*;
- (c) the applicable safety valve information from the ASME Code; and
- (d) the manufacturer's repair information (manuals, drawings, specification sheets, etc.).

C.1.5 Performance testing

The applicant shall repair and submit for verification testing one valve for each ASME Code section and test fluid (steam, air/gas, liquid) that will appear on the certificate of authorization. A minimum of two valves shall be required regardless of the ASME Code sections or test fluid. Before the certificate of authorization is issued or renewed, the demonstration valves shall successfully complete verification tests at the applicant's facility or at a field site in the presence of the regulatory authority representative during the quality control program review.

Valves not meeting the operational requirements to which they are manufactured shall be considered to have failed. Replacement valves shall be repaired and selected for testing as specified above, at a rate of two valves for each one that failed.

If either of the two replacement valves fails to meet the above criteria, the applicant shall document the cause of the noted deficiencies and the actions taken to prevent future occurrences. On acceptance of this

information by the regulatory authority representative, the applicant shall be required to repair and resubmit one additional valve for each replacement valve that failed.

Valves marked for steam service, or having special internal parts for steam service, shall be tested with steam. Valves marked for air, gas, or vapour service shall be tested with air or gas. Valves marked for liquid service shall be tested with water or another suitable liquid. ASME Code Section IV hot water valves shall be tested with water, steam, or air. Each valve shall be tested to demonstrate set pressure (as defined by the valve manufacturer and as listed in NB-18), response to blowdown (if required), and seat tightness in accordance with the requirements of the applicable sections of the ASME Code.

When the applicant is unable to test a steam valve with steam because of boiler size or availability limitations, the quality control program shall provide a procedure acceptable to the regulatory authority to test valves and demonstrate the final pressure setting and sealing with steam at the customer's facilities.

C.1.6 Nameplate

C.1.6.1

When a pressure-relief valve is repaired, a metal repair nameplate stamped with the information required by [Clause C.1.6.2](#) shall be permanently attached to the valve above, to one side of, or below the original stamping. If there is insufficient space on the valve for the repair nameplate to be permanently attached, a metal tag showing the repair nameplate information may be securely attached to the repaired valve.

C.1.6.2

C.1.6.2.1

At a minimum, the information on the valve repair nameplate shall include

- (a) the name of the repair organization;
- (b) a unique identifier (e.g., repair serial number, shop order number);
- (c) the date of repair;
- (d) the Canadian Registration Number;
- (e) the set pressure;
- (f) the capacity (only if changed); and
- (g) the type/model number (only if changed).

C.1.6.2.2

If the set pressure is changed, the previous set pressure, capacity, and blowdown, if applicable, on the original nameplate or stamping shall be crossed out but left legible. The new capacity shall be based on that for which the valve was originally certified.

When the original valve nameplate is missing, and the valve is not traceable, the repair organization shall not be authorized to perform repairs on the valve. Pressure valves not clearly identified or traceable shall be scrapped.

C.1.7 Performance testing equipment

Performance testing equipment shall meet the following requirements:

- (a) It shall include a pressure vessel with volume and pressure source capacity adequate to ensure compliance with [Clause C.1.5](#).
- (b) Before use, it shall be qualified by the certificate holder to ensure that the equipment and testing procedures will provide accurate results when used within the ranges established for the equipment. This qualification shall be documented, and provision shall be made to retain such documentation for at least five years after the equipment is no longer in use. The documentation shall include, but not be limited to,
 - (i) a schematic of the equipment;
 - (ii) the size and pressure ranges of the valves to be tested;
 - (iii) the dimensions of the test vessels;
 - (iv) the accuracy of the pressure-measuring equipment; and
 - (v) the size and design type of the valves used to control flow.

C.2 Quality control program requirements

C.2.1 General

The repair organization shall have an operating quality control program that is documented in a manual and reviewed and accepted by the regulatory authority.

C.2.2 Outline of requirements for a quality control program

C.2.2.1 General

Each valve repair organization shall develop its own quality control program and manual, which shall meet the requirements of the organization. For this reason, it is not possible to develop one quality control program that can apply to more than one organization. At a minimum, the manual shall include the features and address the issues described in [Clauses C.2.2.2 to C.2.2.16](#).

C.2.2.2 Title page of manual

The title page shall include the name and address of the applicant. It should also list the applicable sections of the ASME Code for the repairs.

C.2.2.3 Contents page of manual

The contents page should list the contents by paragraph and page number.

C.2.2.4 Statement of authority and responsibility

A statement of authority and responsibility shall be dated and signed by an officer of the company. It shall include

- (a) a statement that the work shall be performed only on pressure-relief valves that
 - (i) are stamped with an ASME Code V or UV symbol or marked with an ASME Code HV symbol;
 - (ii) have been capacity certified by the National Board or have rating sheets certified by other agencies approved by the regulatory authority; and
 - (iii) have been disassembled, inspected, and repaired by the certificate holder such that the repaired condition and performance are equivalent to the standards for new valves;
- (b) the title of the individual who is responsible for ensuring that the quality control program is followed and who has the authority and freedom to effect the responsibility;
- (c) a statement that if there is a disagreement concerning implementation of the quality control program, the matter is to be referred to a higher authority in the company for resolution; and
- (d) the title of the individual authorized to approve changes to the quality control program and the method by which such changes are to be submitted to the regulatory authority for acceptance before implementation.

C.2.2.5 Organization chart

A chart showing the relationship between management, purchasing, repair, inspection, and quality control personnel shall be included and shall reflect the actual structure of the organization.

C.2.2.6 Scope of work

The scope of work section shall indicate the scope and type of valve repairs of which the organization is capable and that it intends to perform. The location for the repairs (shop, shop and field, or field only), the test medium (air, gas, liquid, steam, or combinations thereof), and special processes (machining, welding, post-weld heat treatment, non-destructive examination (NDE), or combinations thereof), shall be addressed.

The types and sizes of valves to be repaired, pressure ranges, and other limitations, such as engineering and test facilities, shall also be addressed.

C.2.2.7 Drawings and specification control

The drawings and specification control system shall provide procedures to ensure that the most recent required drawings, specifications, and instructions are used for valve repair, inspection, and testing.

C.2.2.8 Parts and materials control

The parts and materials control section shall describe purchasing of parts from the valve manufacturer (if applicable), and purchasing of materials, with requests for mill test certification as required. It shall also describe receiving, storage, and issuing.

The following information shall be provided in this section:

- (a) the title of the individual responsible for purchasing materials;
- (b) the title of the individual responsible for certification and other required records;
- (c) the method used to ensure that all incoming parts and materials are checked for conformance with the purchase order and, where applicable, the material specifications or drawings;
- (d) the means by which parts and materials are identified and identity is maintained; and
- (e) the method used to ensure that all critical parts are fabricated by the valve manufacturer or fabricated to the manufacturer's specifications. Critical parts are those that can affect the valve flow passage capacity function or pressure-retaining integrity.

C.2.2.9 Repair and inspection program

The repair and inspection program section shall refer to a document (e.g., a report, traveller, or checklist) that outlines the procedures used in the repair and inspection of pressure-relief valves.

Arrangements shall be made to retain this document for at least five years. The following requirements shall also apply:

- (a) Each valve or group of valves shall be accompanied by the document referred to in this Clause for processing through the plant. Each valve shall have a unique identifier (e.g., repair serial number, shop order number) on the repair nameplate so that traceability to the document is established.
- (b) The document specified in this Clause shall describe the original nameplate information, including the ASME Code symbol stamp and the repair nameplate information, if applicable. In addition, it shall include information on material check, replacement parts, welding procedure specifications, fit-up, NDE technique, heat treatment, pressure test methods to be used, etc. The text of the repair nameplate shall be recorded in this document. There should be a space for sign-offs for each operation to verify that each step has been properly performed.
- (c) The system shall include a method for controlling the repair or replacement of critical valve parts. The method for identifying each spring shall be indicated.
- (d) The system shall also describe the controls used to ensure that all personnel engaged in repairing pressure-relief valves have been trained and qualified by the manufacturer or the assembler, or through National Board courses.

C.2.2.10 Welding, non-destructive examination, and heat treatment

For circumstances in which weld repairs are made by the repair organization, the quality control program manual shall describe and indicate the title(s) of the person(s) responsible for the system used in the development, approval, and qualification of welding procedure specifications and the qualifications of welders and welding operators in accordance with the requirements of Section IX of the ASME Code. Similarly, NDE and heat treatment techniques shall be covered in the quality control program manual. For circumstances in which outside services are used for NDE and heat treatment, the quality control program manual shall describe the system that ensures that the use of such services meets the requirements of the applicable Code.

C.2.2.11 Valve testing, setting, and sealing

The quality control program shall include provisions that each valve shall be tested and set and that all external adjustments shall be sealed in accordance with the requirements of the applicable ASME Code section and NB-23. The seal shall identify the repair organization making the repair. Abbreviations may be used, provided that they are acceptable to the regulatory authority.

C.2.2.12 Valve repair nameplate

An effective valve identification system shall be established to ensure proper identification of each valve, as required by [Clause C.1.6](#). The manual shall include a description or drawing of the nameplate.

C.2.2.13 Calibration of measurement and performance testing equipment

The following requirements shall apply to measurement and performance testing equipment:

- (a) Calibration of the measurement and test gauge system shall include periodic calibration of measuring instruments and pressure gauges.
- (b) Pressure gauges used for setting valves shall be checked at least every 12 months, by authorized personnel only. The calibration standard used (master gauge or dead weight tester) shall be indicated and the results recorded.
- (c) Calibration standards shall be calibrated against certified equipment having known valid relationships to nationally recognized standards.

C.2.2.14 Manual control

The quality control program shall include

- (a) measures to control the issuance of and revisions to the quality control program manual;
- (b) provisions for a review of the system in order to keep the manual current with the applicable sections of the ASME Code and this Standard (including the provisions of this Annex);
- (c) the title(s) of the individual(s) responsible for control, revision, and review of the manual; and
- (d) a provision for submission of a controlled copy of the manual to the regulatory authority. Revisions shall be submitted to the regulatory authority for acceptance before implementation.

C.2.2.15 Nonconformities

The system shall establish measures for the identification, documentation, evaluation, segregation, and disposition of nonconformities. The title(s) of the individual(s) involved in this process shall be recorded.

Note: A nonconformity is a condition of any material, item, product, or process in which one or more characteristics do not conform to the established requirements. These can include, but are not limited to, data discrepancies, procedural and/or documentation deficiencies, and material defects.

C.2.2.16 Development, addition, and modification of performance testing equipment

The system shall include a means for controlling the development, addition, and modification of performance testing equipment to ensure that the requirements of [Clause C.1.7](#) are met.

Annex D (informative)

Sample forms

Notes:

- (1) *This Annex is not a mandatory part of this Standard.*
- (2) *When a boiler or pressure vessel carries the ASME Code symbol stamp, the appropriate ASME data report form is required in lieu of Figures D.1(b), D.2, D.3, and D.3.1 in all provinces except Québec.*

D.1

The following sample forms are provided in this Annex:

- Figure D.1 — (a) Manufacturer's data report for miniature pressure vessels
— (b) Manufacturer's data report for pressure vessels
- Figure D.2 — Manufacturer's data report for watertube boilers
- Figure D.3 — Manufacturer's data report for all types of boilers except watertube and cast iron sectional boilers
- Figure D.3.1 — Manufacturer's data report for cast iron sectional boilers
- Figure D.4 — Manufacturer's data report for fired process heaters
- Figure D.5 — Construction data report for piping systems
- Figure D.6 — Statutory declaration form for application for registration of fittings in Canada
- Figure D.7 — Installation report for cast iron sectional boilers
- Figure D.8 — Repair/alteration report for boilers and pressure vessels

MANUFACTURER'S DATA REPORT FOR MINIATURE PRESSURE VESSELS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR D'APPAREILS SOUS PRESSION MINIATURES												
Upon shipment of a pressure vessel, this form must be mailed, fully and correctly filled in, to the office of the chief inspector in the province of installation in accordance with the regulations under the Act governing the construction and installation of pressure vessels. <i>Au moment de l'expédition d'un appareil sous pression, ce formulaire complété correctement, doit être envoyé au bureau de l'inspecteur en chef de la province d'installation tel que prévu dans les règlements de la loi sur les appareils sous pression.</i>												
Manufactured by Construit par		Name and address of manufacturer/Nom et adresse du constructeur										
Manufactured for Construit pour		Name and address of purchaser or consignee/Nom et adresse du client ou de son représentant										
Ultimate owner Utilisateur		Name and address/Nom et adresse										
Location of installation Lieu d'installation		Name and address/Nom et adresse										
Pressure vessel / Appareil												
Type/Genre				Overall length/Longueur totale				Serial no./N° de série		Year built/Année de fabrication		
Provincial Registration No. — CRN/N° d'enregistrement provincial — NEC										Drawing no./N° de dessin		
The chemical and physical properties of all parts meet the requirements of material specifications of the ASME Code. <i>Les propriétés chimiques et physiques de toutes les composantes respectent les exigences des spécifications de matériaux de code ASME.</i>												
The design, construction, and workmanship conform to CSA B51. <i>La conception, la construction et la façon sont conformes à CSA B51.</i>				ASME Section VIII		Division 1		Addenda/Supplément		Code case no./N° de cas		
Manufacturer's partial data reports properly identified and signed by authorized inspectors have been furnished for the following items of the report and attached to this report: <i>Les rapports partiels du constructeur adéquatement identifiés et signés par les inspecteurs autorisés ont été produits pour les items suivants du rapport, et attachés à ce rapport :</i>												
Name of parts/Nom de la composante				Item no./N° d'item		Manufacturer's name/Nom du constructeur				Identifying stamp/Estampe d'identification		
Shell / Virole												
Description	Material Matériau	Thickness Épaisseur	Corr. allow. Surépais. de corr.	Diameter Diamètre	Longitudinal joints Joints longitudinaux			P.W.H.T. Traitement therm.		Girth joints Joints de circonférence		Number of courses Nombre de sections
					Type	R.T. Radiog.	Efficiency Efficacité	Temp.	Time Durée	Type	R.T. Radiog.	
Heads / Têtes												
Description	Material Matériau	Min. thickn. Épais. minim.	Corr. allow Surép. corr.	Crown. radius Rayon couron.	Knuckle radius Petit rayon	Ellipse ratio Rapp. ellipse	Conical apex angle Angle conique	Hemisph. radius Ray. hémisph.	Flat diameter Diam. plat	Side to pressure Côte sous pression		
Removable bolts used (describe other fastenings) <i>Boulons amovibles utilisés (décrire tout autre attache)</i>					Mat'l spec./Spéc. du mat.			Grade		Size/Dimension		

Figure D.1(a)
Manufacturer's data report for miniature pressure vessels
 (See [Clauses 4.8.2](#) and [D.1.](#))

(Continued)

Pressure — temperature/Pression — température								
Pressure vessel part <i>Partie de l'appareil</i>	Constructed for max. allowable working pressure <i>Construit pour une pression maximale de marche permise</i>	At max. temp. <i>À une temp. max.</i> °C	Min. temp. @ pressure <i>Temp. min. @ pression</i> °C @ kPa	Test pressure (hydrostatic, pneumatic, or combination) <i>Pression d'épreuve (hydrostatique, pneumatique ou combinaison)</i>				
Tube section/Faisceau tubulaire								
Tubsheet/Plaque tubulaire	Material/Matériau	Diameter/Diamètre	Nominal thickness <i>Épaisseur nominale</i>	Corr. allow. <i>Surépais. corrosion</i>	Attachment <i>Mode d'attachement</i>			
Tube material/Matériau des tubes	Diameter/Diamètre	Nominal thickness (gauge) <i>Épaisseur nominale (calibre)</i>	Number/Nbre	Type (straight or U) <i>Type (Droit ou U)</i>	Heating surface <i>Surface de chauffe</i>			
Jacket/Chemise								
Type of jacket/Genre de chemise	Jacket closure <i>Fermeture de chemise</i>	Proof test <i>Pression d'épreuve</i>	Heating surface <i>Surface de chauffe</i>	Sketch/Schéma				
Safety valve outlets/Soupapes de sûreté								
Number/Nombre	Dimension	Location/Endroit						
Nozzles and openings/ Tubulures et ouvertures								
Purpose/But	Number Nombre	Dimension	Type	Material Matériau	Nominal thickness <i>Épaisseur nominale</i>	Reinforcement material <i>Matériau de renfort</i>	How attached <i>Genre d'attaches</i>	Location/Endroit
Supports/Supports								
Skirt/Jupe Yes/Oui No/Non ☐ ☐	Lugs/Oreilles No./Nbre	Legs/Pieds No./Nbre	Other/Autres (Description)				Attached/Attaches (Where and how/Méthode et endroit)	
Remarks/Observations (Cubical capacity/Volume)								
Certificate of Compliance/Certificat de conformité We certify that the statements made in this data report are correct and that the said vessel has been constructed in accordance with the provincial registered design below and the requirements of CSA Standard B51. <i>Nous certifions que les données de la déclaration de conformité sont correctes et que l'appareil a été construit en accord avec l'enregistrement provincial ci-dessous et les exigences de la norme CSA B51.</i> Provincial registered design <i>Enregistrement provincial</i> _____ Manufacturer <i>Constructeur</i> _____ Signature _____ Date _____								

Figure D.1(a) (Concluded)

MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR D'APPAREILS SOUS PRESSION															
Partial/Partiel ☐															
Upon shipment of a pressure vessel, this form must be mailed, fully and correctly filled in, to the office of the chief inspector in the province of installation in accordance with the regulations under the Act governing the construction and installation of pressure vessels. <i>Au moment de l'expédition d'un appareil sous pression, ce formulaire complété correctement, doit être envoyé au bureau de l'inspecteur en chef de la province d'installation tel que prévu dans les règlements de la loi sur les appareils sous pression.</i>															
Manufactured by Construit par		Name and address of manufacturer/Nom et adresse du constructeur													
Manufactured for Construit pour		Name and address of purchaser or consignee/Nom et adresse du client ou de son représentant													
Ultimate owner Utilisateur		Name and address/Nom et adresse													
Location of installation Lieu d'installation		Name and address/Nom et adresse													
Pressure vessel/Appareil sous pression															
Type/Genre				Overall length/Longueur totale				Serial no./N° de série				Year built/Année de fabrication			
Provincial Registration No. — CRN/N° d'enregistrement provincial — NEC								National Board no./N° de la National Board				Drawing no./N° de dessin			
The chemical and physical properties of all parts meet the requirements of material specifications of the ASME Code. <i>Les propriétés chimiques et physiques de toutes les composantes respectent les exigences des spécifications de matériaux du code ASME.</i>															
The design, construction, and workmanship conform to CSA B51. <i>La conception, la construction et la façon sont conformes à CSA B51.</i>								ASME Sec.		Division		Addenda/Supplément		Code case no./N° de cas	
Manufacturer's partial data reports properly identified and signed by authorized inspectors have been furnished for the following items of the report and attached to this report: <i>Les déclarations de conformité partielles du constructeur adéquatement identifiées et signées par les inspecteurs autorisés ont été produites pour les points suivants de la déclaration, et attachées à cette déclaration :</i>															
Name of parts/Nom de la composante				Item no./N° d'item		Manufacturer's name/Nom du constructeur				Identifying stamp/Estampe d'identification					
Shell/Virole															
Description	Material Matériau	Thickness Épaisseur	Corr. allow. Surépais. corr.	Diameter Diamètre	Longitudinal joints Joints longitudinaux			P.W.H.T. Traitement therm.		Girth joints Joints de circonférence		Number of courses Nombre de sections			
					Type	R.T. Radiog.	Efficiency Efficacité	Temp.	Time Durée	Type	R.T. Radiog.				
Heads/Têtes															
Description	Material Matériau	Min. thickn. Épais. minim.	Corr. allow. Surép. corr.	Crown. radius Rayon couron.	Knuckle radius Petit rayon	Ellipse ratio Rapp. ellipse	Conical apex angle Angle conique	Hemisph. radius Ray. hémisph.	Flat diameter Diam. plat	Side to pressure Côté sous pression					
Removable bolts used (describe other fastenings) <i>Boulons amovibles utilisés (décrire toute autre attache)</i>					Mat'l spec./Spéc. du mat.				Grade		Size/Dimension				

Figure D.1(b)
Manufacturer's data report for pressure vessels
 (See [Clause D.1.](#))

(Continued)

Pressure — temperature/Pression — température								
Pressure vessel part <i>Partie de l'appareil</i>	Constructed for max. allowable working pressure <i>Construit pour une pression maximale de service permise</i>	At max. temp. <i>À une temp. max.</i>	Min. temp. @ pressure <i>Temp. min. @ pression</i>	Test pressure (hydrostatic, pneumatic, or combination) <i>Pression d'épreuve (hydrostatique, pneumatique ou combinaison)</i>				
		°C		°C @ kPa				
Tube section/Faisceau tubulaire								
Tubesheet/Plaque tubulaire	Material/Matériau	Diameter/Diamètre	Nominal thickness <i>Épaisseur nominale</i>	Corr. allow. <i>Surépais. corrosion</i>	Attachment <i>Mode d'attachement</i>			
Tube material/Matériau des tubes	Diameter/Diamètre	Nominal thickness (gauge) <i>Épaisseur nominale (calibre)</i>	Number/Nbre	Type (straight or U) <i>Type (Droit ou U)</i>	Heating surface <i>Surface de chauffe</i>			
Jacket/Chemise								
Type of jacket/Genre de chemise	Jacket closure <i>Fermeture de chemise</i>	Proof test <i>Pression d'épreuve</i>	Heating surface <i>Surface de chauffe</i>	Sketch/Schéma				
Safety valve outlets/Soupapes de sûreté								
Number/Nombre	Dimension	Location/Endroit						
Nozzles and openings/Tubulures et ouvertures								
Purpose/But	Number Nombre	Dimension	Type	Material Matériau	Nominal thickness Épaisseur nominale	Reinforcement material Matériau de renfort	How attached Genre d'attaches	Location/Endroit
Supports/Supports								
Skirt/Jupe Yes/Oui No/Non ☐ ☐	Lugs/Oreilles No./Nbre	Legs/Pieds No./Nbre	Other/Autres (Description)			Attached/Attaches (Where and how/Méthode et endroit)		
Remarks/Observations (Cubical capacity/Volume)								

Figure D.1(b) (Continued)

Certificate of Compliance/Certificat de conformité We certify that the statements made in this data report are correct and that the said vessel has been constructed in accordance with the provincial registered design below and the requirements of CSA Standard B51. <i>Nous certifions que les données de la déclaration de conformité sont correctes et que l'appareil a été construit en accord avec l'enregistrement provincial ci-dessous et les exigences de la norme CSA B51.</i> Provincial registered design Enregistrement provincial _____ Manufacturer Constructeur _____ Signature _____ Date _____	Certificate of Shop Inspection/Certificat d'inspection en usine I, the undersigned, a duly authorized boiler and pressure vessel inspector <i>Je, soussigné, inspecteur autorisé de chaudières et appareil sous pression</i> employed by _____ employé par _____ of _____ de _____ have inspected the above vessel and state that to the best of my knowledge and belief the manufacturer has constructed the vessel in accordance with Canadian Registration No. _____ and the requirements of CSA Standard B51. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the vessel described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>ai inspecté l'appareil précité et, autant que je sache, le constructeur a construit l'appareil en accord avec le numéro d'enregistrement canadien _____ et les exigences de la norme CSA B51. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement à l'appareil décrit dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i> Inspector's Name Nom de l'inspecteur _____ Signature _____ Date _____
Certificate of Compliance — Field Work/ Certificat de conformité — Installation au chantier We certify that the field installation of all parts of the vessel complies with the requirements of provincial regulations. <i>Nous certifions que l'installation au chantier de toutes les composantes de l'appareil est conforme aux règlements provinciaux.</i> Installer's name Nom de l'installateur _____ Signature _____ Date _____	Certificate of Field Inspection/Certificat d'inspection — Installation au chantier I, the undersigned, a duly authorized boiler and pressure vessel inspector <i>Je, soussigné, inspecteur autorisé de chaudières et appareil sous pression</i> employed by _____ employé par _____ have inspected the items not covered by the Certificate of Shop Inspection and the installation of the items and state that to the best of my knowledge and belief the construction and assembly of the items are in accordance with the provincial regulations. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the vessel described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>ai inspecté les composantes non couvertes par le certificat d'inspection en usine et l'installation de l'appareil et, autant que je sache, la construction et l'assemblage de l'appareil sont en accord avec les règlements provinciaux. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement à l'appareil décrit dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i> Inspector's name Nom de l'inspecteur _____ Signature _____ Date _____

Figure D.1(b) (Concluded)

MANUFACTURER'S DATA REPORT FOR WATERTUBE BOILERS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR DE CHAUDIÈRES AQUATUBULAIRES												
Partial/Partiel ☐												
Upon shipment of a boiler, this form must be mailed, fully and correctly filled in, to the office of the chief inspector in the province of installation in accordance with the regulations under the Act governing the construction and installation of boilers. <i>Au moment de l'expédition d'une chaudière, ce formulaire complété correctement, doit être envoyé au bureau de l'inspecteur en chef de la province d'installation tel que prévu dans les règlements de la loi sur les appareils sous pression.</i>												
Manufactured by <i>Construit par</i>		Name and address of manufacturer/Nom et adresse du constructeur										
Manufactured for <i>Construit pour</i>		Name and address of purchaser or consignee/Nom et adresse du client ou de son représentant										
Ultimate owner <i>Utilisateur</i>		Name and address/Nom et adresse										
Location of installation <i>Lieu d'installation</i>		Name and address/Nom et adresse										
Watertube boiler / Chaudière aquatubulaire												
Description						Serial no./N° de série			Year built/Année de fabrication			
Provincial Registration No. — CRN/N° d'enregistrement provincial — NEC						National Board no./N° de la National Board			Drawing no./N° de dessin			
The chemical and physical properties of all parts meet the requirements of material specifications of the ASME Code. <i>Les propriétés chimiques et physiques de toutes les composantes respectent les exigences des spécifications de matériaux du code ASME.</i>												
The design, construction, and workmanship conform to CSA B51. <i>La conception, la construction et la façon sont conformes à CSA B51.</i>						ASME Sec.		Addenda/Supplément		Code case no./N° de cas		
Manufacturer's partial data reports properly identified and signed by authorized inspectors have been furnished for the following items of the report, and attached to this report: <i>Les déclarations de conformité partielles du constructeur adéquatement identifiées et signées par les inspecteurs autorisés ont été produites pour les points suivants de la déclaration, et attachées à cette déclaration :</i>												
Name of parts/Nom de la composante				Item no./N° du point		Manufacturer's name/Nom du constructeur			Identifying stamp/Estampe d'identification			
Drums / Ballons (Shell / virole)												
Material specification no./N° spécification du matériau				Grade/Qualité		Inside length/Long. interne		Inside diameter/Dia. interne		Thickness/Épaisseur		
Tubesheet / Plaque tubulaire				Longitudinal joints <i>Joints longitudinaux</i>				Girth joints <i>Joints de circonférence</i>				
Material specification no. N° spécification du matériau		Grade Qualité	Thickness Épaisseur	Inside diameter Dia. interne	No./Nbre	Seamless Sans soudure	Welded Soudé	Joint Efficiency Efficacité du joint	No./Nbre	Seamless Sans soudure	Welded Soudé	Joint efficiency Efficacité du joint
						☐	☐	%		☐	☐	%
						☐	☐	%		☐	☐	%
Heads / Têtes							Inspection openings <i>Ouvertures d'inspection</i>			Hydro. test pressure <i>Pres. d'épreuve hydro.</i>		
Material specification no. N° spécification du matériau		Grade Qualité	Flat Plate	Dished À calotte	Ellipsoidal Elliptique	Thickness Épaisseur	Radius of dish Ray. de calotte	No./Nbre	Type	Dim.		

Figure D.2
Manufacturer's data report for watertube boilers
 (See [Clause D.1.](#))

(Continued)

Tubes											
No./Nbre	Mat'l spec. no./N° spéc. du matériau				Grade Qualité	Outside diameter/Diamètre extérieur			Gauge/jauge (thickness) (épaisseur)		
Staybolts/Étais											
No./Nbre	Mat'l spec. no. N° spéc. du matériau	Grade Qualité	Diam. Dia.	Size telltale Trou témoin	Net area Section efficace	Pitch/Pas	Net area supported by one staybolt Section supportée par un étai		Max. A.W.P. Pres. max. M. P.		
Waterwall/Murs d'eau											
Headers Collecteurs	No./Nbre	Type	Dimension	Mat'l spec. no. N° spéc. du mat.	Thickness Épaisseur	Heads Têtes	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Type	Thickness Épaisseur
Tubes	No./Nbre	Outside dia./Dia. ext.		Thickness/Épaisseur		Pitch/Pas	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Test pressure/Pression d'épreuve	
Economizer/Économiseur											
Headers Collecteurs	No./Nbre	Type	Dimension	Mat'l spec. no. N° spéc. du mat.	Thickness Épaisseur	Heads Têtes	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Type	Thickness Épaisseur
Tubes	No./Nbre	Outside dia./Dia. ext.		Thickness/Épaisseur		Pitch/Pas	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Test pressure/Pression d'épreuve	
Superheater/Surchauffeur											
Headers Collecteurs	No./Nbre	Type	Dimension	Mat'l spec. no. N° spéc. du mat.	Thickness Épaisseur	Heads Têtes	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Type	Thickness Épaisseur
Tubes	No./Nbre	Outside dia./Dia. ext.		Thickness/Épaisseur		Pitch/Pas	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Test pressure/Pression d'épreuve	
Other/Autres											
Headers Collecteurs	No./Nbre	Type	Dimension	Mat'l spec. no. N° spéc. du mat.	Thickness Épaisseur	Heads Têtes	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Type	Thickness Épaisseur
Tubes	No./Nbre	Outside dia./Dia. ext.		Thickness/Épaisseur		Pitch/Pas	Mat'l spec. no./N° spéc. du mat.		Grade Qualité	Test pressure/Pression d'épreuve	
Openings/Ouvertures				Operation/Fonctionnement							
	No./Nbre	Dimension	Type		Max A.W.P. Pres. max. M. P.	Max. temperature Température max.	Heating surface Surface de chauffe	Field hydrotest pressure Pression d'épreuve à l'installation			
Feed Alimentation				Boiler Chaudière							
Water or steam outlets/Sortie eau ou vapeur				Waterwall Murs d'eau							
Blowoff Vidange				Economizer Économiseur							
Safety valve Soupape de sûreté				Superheater Surchauffeur							
				Others Autres							

Figure D.2 (Continued)

Certificate of Compliance/Certificat de conformité We certify that the statements made in this data report are correct and that the said vessel has been constructed in accordance with the provincial registered design below and the requirements of CSA Standard B51. <i>Nous certifions que les données de la déclaration de conformité sont correctes et que l'appareil a été construit en accord avec l'enregistrement provincial ci-dessous et les exigences de la norme CSA B51.</i> Provincial registered design Enregistrement provincial _____ Manufacturer Constructeur _____ Signature _____ Date _____	Certificate of Shop Inspection/Certificat d'inspection en usine I, the undersigned, a duly authorized boiler and pressure vessel inspector <i>Je, soussigné, inspecteur autorisé de chaudières et appareil sous pression</i> employed by _____ of _____ de _____ have inspected the above boiler and state that to the best of my knowledge and belief the manufacturer has constructed the boiler in accordance with Canadian Registration No. _____ and the requirements of CSA Standard B51. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the boiler described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>ai inspecté la chaudière précitée et, autant que je sache, le constructeur a construit la chaudière en accord avec le numéro d'enregistrement canadien _____ et les exigences de la norme CSA B51. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement à la chaudière décrite dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i> Inspector's Name Nom de l'inspecteur _____ Signature _____ Date _____
Certificate of Compliance — Field Work/ Certificat de conformité — Installation au chantier We certify that the field installation of all parts of the vessel complies with the requirements of provincial regulations. <i>Nous certifions que l'installation au chantier de toutes les composantes de l'appareil est conforme aux règlements provinciaux.</i> Installer's name Nom de l'installateur _____ Signature _____ Date _____	Certificate of Field Inspection/Certificat d'inspection — Installation au chantier I, the undersigned, a duly authorized boiler and pressure vessel inspector <i>Je, soussigné, inspecteur autorisé de chaudières et appareil sous pression</i> employed by _____ employé par _____ have inspected the items not covered by the Certificate of Shop Inspection and the installation of the items and state that to the best of my knowledge and belief the construction and assembly of the items are in accordance with the provincial regulations. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the boiler described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>ai inspecté les composantes non couvertes par le certificat d'inspection en usine et l'installation de l'appareil et, autant que je sache, la construction et l'assemblage de l'appareil sont en accord avec les règlements provinciaux. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement à la chaudière décrite dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i> Inspector's name Nom de l'inspecteur _____ Signature _____ Date _____

Figure D.2 (Concluded)

MANUFACTURER'S DATA REPORT FOR ALL TYPES OF BOILERS EXCEPT WATERTUBE AND CAST IRON SECTIONAL BOILERS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR POUR TOUT GENRE DE CHAUDIÈRE SAUF AQUATUBULAIRES ET CHAUDIÈRES EN FONTE EN SECTIONS												
Partial/Partiel ☐												
Upon shipment of a boiler, this form must be mailed, fully and correctly filled in, to the office of the chief inspector in the province of installation in accordance with the regulations under the Act governing the construction and installation of boilers. <i>Au moment de l'expédition d'une chaudière, ce formulaire complété correctement, doit être posté au bureau de l'inspecteur en chef de la province d'installation tel que prévu dans les règlements de la loi sur les appareils sous pression.</i>												
Manufactured by <i>Construit par</i>		Name and address of manufacturer/Nom et adresse du constructeur										
Manufactured for <i>Construit pour</i>		Name and address of purchaser or consignee/Nom et adresse du client ou de son représentant										
Ultimate owner <i>Utilisateur</i>		Name and address/Nom et adresse										
Location of installation <i>Lieu d'installation</i>		Name and address/Nom et adresse										
Boiler / Chaudière												
Type (HRT, etc.) / <i>Genre (HRT, etc.)</i>						Serial no./N° de série				Year built/Année de fabrication		
Provincial Registration No. — CRN/N° d'enregistrement provincial — NEC						National Board no./N° de la National Board				Drawing no./N° de dessin		
The chemical and physical properties of all parts meet the requirements of material specifications of the ASME Code. <i>Les propriétés chimiques et physiques de toutes les composantes respectent les exigences des spécifications de matériaux du code ASME.</i>												
The design, construction, and workmanship conform to CSA B51. <i>La conception, la construction et la façon sont conformes à CSA B51.</i>						ASME Sec.		Addenda/Supplément		Code case no./N° de cas		
Manufacturer's partial data reports properly identified and signed by authorized inspectors have been furnished for the following items of the report, and attached to this report: <i>Les déclarations de conformité partielles du constructeur adéquatement identifiées et signées par les inspecteurs autorisés ont été produites pour les points suivants de la déclaration, et attachées à cette déclaration :</i>												
Names of parts/Nom de la composante			Item no./N° du point			Manufacturer's name/Nom du constructeur			Identifying stamp/Estampe d'identification			
Boiler shells or drums / Viroles de chaudière ou ballons												
Material specification no./N° spécification du matériau				Grade/Qualité		Inside length/Long. interne		Inside diameter/Dia. interne		Thickness/Épaisseur		
Longitudinal joints <i>Joints longitudinaux</i>			Girth joints <i>Joints de circonférence</i>			Heads / Têtes						
Seamless Sans soudure	Welded Soudé	Joint efficiency* Efficacité du joint	Seamless Sans soudure	Welded Soudé	No. of shell courses Nbre de sect. de virole	Material specification no. N° spécification du matériau	Grade Qualité	Flat Plate	Dished À calotte	Ellipsoidal Elliptique	Thickness Épaisseur	Radius of dish Ray. de calotte
☐	☐	%	☐	☐				☐	☐	☐		
☐	☐	%	☐	☐				☐	☐	☐		
*as compared to seamless / *comparé à un joint sans soudure												

Figure D.3
Manufacturer's data report for all types of boilers except
watertube and cast iron sectional boilers
 (See [Clause D.1.](#))

(Continued)

Firetube boiler only Chaudière ignitubulaire seulement	 Tubesheet / Plaque tubulaire 			 Tube holes Trous de tubes 	 Boiler tubes / Tubes 					
	Mat'l spec. no. N° spéc. du matériau	Grade Qualité	Thickness Épaisseur	Diameter Diamètre	No./Nbre	Mat'l spec. no. N° spéc. du matériau	Grade Qualité	Straight Droit ☐	Bend En U ☐	
				Outside diameter (If various, give min. and max.) Diamètre ext. (Si variable indiquer min. et max.)	Length/Longueur		Gauge (thickness) Jauge (épaisseur)			
Firetube boiler only Chaudière ignitubulaire seulement	Furnace no. N° de foyer	Size (O.D. or W. x H.) Dia. (dia. ext. ou l. x h.)		Length, each section/Longueur de chaque section				Total length/Longueur totale		
	Staybolts no. Nbre d'étais boulons	Mat'l spec. no. N° spéc. du mat.		Grade Qualité	Size telltale Trou témoin	Net area Section efficace	Pitch (hor. and vert.) Pas (hor. et vert.)	Max. A.W.P. Pres. max. M. P.		
	 Stays or braces / Étais ou attaches 									
	Location Localisation	Mat'l spec. no. N° spéc. du mat.	Type	No. & size N° & dim.	Max. pitch Pas max.	Total net area Surf. eff. totale	Fig. PFT-32 L/1	Dist. tubes to shell Dist. tubes à la virole	Area to be stayed Surface à être étayée	Max. A.W.P. Pres. max. M. P.
	a) Above tubes F.H. Au-dessus des tubes T. AV.									
	b) Above tubes R.H. Au-dessus des tubes T. AR.									
	c) Below tubes F.H. Au-dessous des tubes T. AV.									
	d) Below tubes R.H. Au-dessous des tubes T. AR.									
	e) Through stays Étais traversants									
	f) Dome braces Attache du dôme									
 Other parts / Autres composantes 										
Description (dome, boiler, piping, etc.) Description (dôme, chaudière, tuyauterie, etc.).			Mat'l specification Spécification du matériau		Grade Qualité	Size Dimensions	Thickness Épaisseur	Max. A.W.P. Pres. max. M. P.		
 Openings / Ouvertures 										
Water or steam outlets (no., size, and type) Sortie eau ou vapeur (Nbre, dim. et type)			Blowoff (no., size, type, and location) Vidange (Nbre, dim. type et localisation)			Feed (no., size, type, and location) Alimentation (Nbre, dim., type et localisation)				
Manholes (no., size, and location) Trou d'homme (Nbre, dim. et localisation)			Hand holes (no., size, and location) Trou de main (Nbre, dim. et localisation)			Fusible plug (no., diam., location, mfgs. ident.) Bouchon fusible (Nbre, dia., local., fabricant)				
 Safety valves / Soupape de sûreté 					 Boiler supports / Support de chaudière 					
No./Nbre	Size/Dim.	Type	Capacity Capacité	Prov. Regist. No. N° d'enr. prov.	No./Nbre	Type			Fixation	
						Saddles Selles	Legs Pieds	Lugs Oreilles	Bolted Boulonnée Welded Soudée	
Shop hydrostatic test Essai hydrostatique en usine		Max. A.W.P. Pres. max. M. P.	Based on: (Code par. and/or formula) Selon: (Para. du code et/ou formule)		 Firetube boiler only Chaudière ignitubulaire seulement 		Boiler rating. Max. steaming capacity (rated output for hot water boilers) Puissance de la chaudière, capacité d'évaporation max. (Puissance à la sortie pour chaudière à eau chaude)			
					Heating surface / Surface de chauffe					

Figure D.3 (Continued)

Electric boiler only Chaudière électrique seulement	Heating elements/Éléments chauffants							
	No./Nbre	Size Dimensions	Rating/Puissance		Location/Localisation	Openings/Ouverture		
			(kW)	Auth. max. Max. aut.		Installed Installée	No./Nbre	Dimension
	Electrodes/Électrodes							
	No./Nbre	Size Dimensions	Rating/Puissance		Location/Localisation	Openings/Ouverture		
			(kW)	Auth. max. Max. aut.		Installed Installée	No./Nbre	Dimension
Certificate of Compliance/Certificat de conformité We certify that the statements made in this data report are correct and that the said boiler has been constructed in accordance with the provincial registered design below and the requirements of CSA Standard B51. <i>Nous certifions que les données de la déclaration de conformité sont correctes et que la chaudière a été construite en accord avec l'enregistrement provincial ci-dessous et les exigences de la norme CSA B51.</i> Provincial registered design <i>Enregistrement provincial</i> _____ Manufacturer <i>Constructeur</i> _____ Signature _____ Date _____					Certificate of Shop Inspection/Certificat d'inspection en usine I, the undersigned, a duly authorized boiler and pressure vessel inspector <i>Je, soussigné, inspecteur autorisé de chaudières et appareils sous pression</i> employed by _____ <i>employé par</i> _____ of _____ <i>de</i> _____ have inspected the above boiler and state that to the best of my knowledge and belief, the manufacturer has constructed the boiler in accordance with Canadian Registration No. _____ and the requirements of CSA Standard B51. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the boiler described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>ai inspecté la chaudière précitée et, autant que je sache, le constructeur a construit la chaudière en accord le numéro d'enregistrement canadien _____ et les exigences de la norme CSA B51. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement à la chaudière décrite dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i> Inspector's name <i>Nom de l'inspecteur</i> _____ Signature _____ Date _____			

Figure D.3 (Concluded)

MANUFACTURER'S DATA REPORT FOR CAST IRON SECTIONAL BOILERS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR DE CHAUDIÈRES EN FONTE EN SECTIONS									
Partial/Partiel ☐									
Upon shipment of a boiler, this form must be mailed, fully and correctly filled in, to the office of the chief inspector in the province of installation in accordance with the regulations under the Act governing the construction and installation of boilers. <i>Au moment de l'expédition d'une chaudière, ce formulaire complété correctement, doit être posté au bureau de l'inspecteur en chef de la province d'installation tel que prévu dans les règlements de la loi sur les appareils sous pression.</i>									
Manufactured by Construit par		Name and address of manufacturer/Nom et adresse du constructeur							
Manufactured for Construit pour		Name and address of purchaser or consignee/Nom et adresse du client ou de son représentant							
Ultimate owner Utilisateur		Name and address/Nom et adresse							
Location of installation Lieu d'installation		Name and address/Nom et adresse							
Boiler/Chaudière									
Type/Genre				Serial no./N° de série			Year built/Année de fabrication		
Cast iron sectional/En fonte en sections									
Provincial Registration No. — CRN/N° d'enregistrement provincial — NEC				National Board no./N° de la National Board			Drawing no./N° de dessin		
The chemical and physical properties of all parts meet the requirements of material specifications of the ASME Code. <i>Les propriétés chimiques et physiques de toutes les composantes respectent les exigences des spécifications de matériaux du code ASME.</i>									
The design, construction, and workmanship conform to CSA B51. <i>La conception, la construction et la façon sont conformes à CSA B51.</i>				ASME IV		Addenda/Supplément		Code case no./N° de cas	
Sections/Sections									
Material specification no./N° spécification du matériau			Grade Qualité	Inside width/Larg. interne		Inside height/Hauteur interne		Thickness/Épaisseur	
Openings/Ouvertures									
Water or steam outlets (no., size, and type) Sortie eau ou vapeur (Nbre, dim. et type)			Blowoff (no., size, type, and location) Vidange (Nbre, dim., type et localisation)			Feed (no., size, type, and location) Alimentation (Nbre, dim., type et localisation)			
Hand holes (no., size, and location) Trou de main (Nbre, dim. et localisation)				Fusible plug (no., diam., location, mfgs. ident.) Bouchon fusible (Nbre, dia., local., fabricant)					
Safety valves/Soupape de sûreté					Boiler supports/Support de chaudière				
No./Nbre	Size/Dim.	Type	Capacity Capacité	Prov. Regist. No. N° d'enr. prov.	No./Nbre	Type			Fixation
						Saddles Selles	Legs Pieds	Lugs Oreilles	Bolted Boulonnée
									Welded Soudée
Shop hydrostatic test Essai hydrostatique en usine		Max. A.W.P. Pres. max. M. P.		Cubical capacity/Volume		Heating surface/Surface de chauffe			Boiler rating. max. steaming capacity (rated output for hot water boilers) Puissance de la chaudière, capacité d'évaporation max. (Puissance à la sortie pour chaudière à eau chaude)

Figure D.3.1
Manufacturer's data report for cast iron sectional boilers
 (See [Clause D.1.](#))

(Continued)

Certificate of Compliance/Certificat de conformité	
We certify that the statements made in this data report are correct and that the said boiler has been constructed in accordance with the provincial registered design below and the requirements of CSA Standard B51. <i>Nous certifions que les données de la déclaration de conformité sont correctes et que la chaudière a été construite en accord avec l'enregistrement provincial ci-dessous et les exigences de la norme CSA B51.</i>	
Provincial registered design <i>Enregistrement provincial</i> _____	Manufacturer <i>Constructeur</i> _____
Signature _____	Date _____

Figure D.3.1 (Concluded)

MANUFACTURER'S DATA REPORT FOR FIRED PROCESS HEATERS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR DE RÉCHAUFFEURS INDUSTRIELS													
Partial/Partiel ☐													
Upon shipment of a fired process heater unit or part including coil, headers, manifolds and crossovers, this form must be mailed, fully and correctly filled in, to the office of the chief inspector in the province of installation in accordance with Clause 4.6.1 of CSA Standard B51, Part 1. Au moment de l'expédition complète ou partielle d'un réchauffeur industriel à combustible comprenant un serpentin, des tuyaux collecteurs d'admission et d'évacuation et des croisements, ce formulaire, rempli correctement, doit être posté à l'inspecteur en chef de la province ou l'installation est faite, conformément à l'article 4.6.1 de la norme CSA B51, Partie 1.													
Manufactured by Construit par		Name and address of manufacturer/Nom et adresse du constructeur											
Manufactured for Construit pour		Name and address of purchaser or consignee/Nom et adresse du client ou de son représentant											
Ultimate owner Utilisateur		Name and address/Nom et adresse											
Location of installation Lieu d'installation		Address/Adresse											
Description/Type of heater/Part Description/Type d'appareil/Pièce		Prov. CRN no./NEC prov.		Serial no. N° de série		Drawing no. N° de dessin		Year built Année de construction		Owner's ID no. N° ID du propriétaire			
Item/ID no. N° ID de l'article		Design pressure Pression de calcul		Design temp. Température de calcul		Design and/or construction code(s) Code de conception ou de construction				Safety valve/Soupape de sûreté			
										Size/Dimensions		Setting/Consigne	
Coil/Serpentin													
Type	ID no.(s) N° d'identification	Tubes				End closures/Embouts					Openings/Ouvertures		
						Ret. bends/Tubes en U					Nozzles/Fittings/Buses/raccords		
		No./N°	Mat'l spec. Spéc. matériau	O.D. D. E.	Thickness Épaisseur	Mat'l spec. Spéc. matériau	Thickness Épaisseur	Mat'l spec. Spéc. matériau	Size Dimensions	Thickness Épaisseur	Mat'l spec. Spéc. matériau	Type size Type et dimensions	Rating Débit nominal

Figure D.4
Manufacturer's data report for fired process heaters
 (See [Clause D.1.](#))

(Continued)

Headers/Manifolds/Collecteurs									
Type	ID no.(s) N° d'identification	Size Dimensions	Shell/Enveloppe		Ends/Extrémités		Openings/Ouvertures		
			Mat'l spec. Spéc. matériau	Thickness Épaisseur	Mat'l spec. Spéc. matériau	Thickness Épaisseur	No./N°	Type	Size rating Dimensions nominales

Other items (crossovers, etc.)/Autres accessoires (p. ex., croisements)				
Type	ID no.(s) N° d'identification	Size Dimensions	Mat'l spec. Spéc. matériau	Thickness Épaisseur

Non-destructive examination and heat treatment Examen non destructif et traitement thermique						
Item description (coil/manifold/ headers & type) Description de l'accessoire (serpentin, collecteurs et type)	ID no.(s) N° d'identification	NDE/END			Post-weld heat treatment Traitement thermique post soudage	
		Radiograph 100% or % random Radiographie complète ou % au hasard	MAG part (MT) Dye pen (PT). Extent Examen magnétoscopique Examen par ressuage — ampleur	Other (ultrasonic, etc.) Autres examens (par ultrason, etc.)	Temperature Température	Holding time Durée de maintien de la température

Figure D.4 (Continued)

Pressure test/Essai de pression					
Item description (coil/ manifold/ headers & type) <i>Description de l'accessoire (serpentin, collecteurs et type)</i>	ID no.(s) <i>N° d'identification</i>	State whether shop or field <i>En atelier ou sur chantier</i>	Hydrostatic test pressure <i>Pression d'essai hydraulique</i>	Pneumatic test pressure <i>Pression d'essai pneumatique</i>	Alternative/additional tests <i>Essais supplémentaires ou autres e.g., sensitive leak (press and test method) p. ex., détection des fuites (méthode d'essai sous pression)</i>

Remarks — include extent of field assembly
Remarques : préciser l'importance de l'assemblage sur chantier

Certificate of Compliance/Certificat de conformité

We certify that the statements made in this data report are correct and that the said vessel has been constructed in accordance with the provincial registered design below and the requirements of CSA Standard B51.

Nous certifions que les données de la déclaration de conformité sont correctes et que l'appareil a été construit en accord avec l'enregistrement provincial ci-dessous et les exigences de la norme CSA B51.

Provincial registered design
Enregistrement provincial _____

Manufacturer
Constructeur _____

Signature _____ Date _____

Certificate of Shop Inspection/Certificat d'inspection en usine

I, the undersigned, a duly authorized boiler and pressure vessel inspector
Je, soussigné, inspecteur autorisé de chaudières et appareil sous pression
employed by _____
of _____
de _____
have inspected the above vessel and state that to the best of my knowledge and belief the manufacturer has constructed the vessel in accordance with Canadian Registration No. _____ and the requirements of CSA Standard B51. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the heater described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

ai inspecté l'appareil précité et, autant que je sache, le constructeur a construit l'appareil en accord avec le numéro d'enregistrement canadien _____ et les exigences de la norme CSA B51. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement au réchauffeur décrit dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.

Inspector's Name
Nom de l'inspecteur _____

Signature _____ Date _____

**Certificate of Compliance — Field Work/
Certificat de conformité — Installation au chantier**

We certify that the field installation of all parts of the vessel complies with the requirements of provincial regulations.

Nous certifions que l'installation au chantier de toutes les composantes de l'appareil est conforme aux règlements provinciaux.

Installer's name
Nom de l'installateur _____

Signature _____

Date _____

**Certificate of Field Inspection/Certificat d'inspection —
Installation au chantier**

I, the undersigned, a duly authorized boiler and pressure vessel inspector
Je, soussigné, inspecteur autorisé de chaudières et appareil sous pression
employed by _____
have inspected the items not covered by the Certificate of Shop Inspection and the installation of the items and state that to the best of my knowledge and belief the construction and assembly of the items are in accordance with the provincial regulations. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the heater described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection.

ai inspecté les composantes non couvertes par le certificat d'inspection en usine et l'installation de l'appareil et, autant que je sache, la construction et l'assemblage de l'appareil sont en accord avec les règlements provinciaux. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement au réchauffeur décrit dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.

Inspector's name
Nom de l'inspecteur _____

Signature _____ Date _____

Figure D.4 (Concluded)

CONSTRUCTION DATA REPORT FOR PIPING SYSTEMS DÉCLARATION DE CONFORMITÉ DU CONSTRUCTEUR DE TUYAUTERIES											
Field construction/ <i>Construction sur chantier</i> ☐ Shop construction/ <i>Construction en atelier</i> ☐											
1. Constructed by <i>Construit par</i> _____ (Name and address/ <i>Nom et adresse</i>)											
2. Provincial Quality Program No. <i>N° de programme de qualité provincial</i> _____ Expiry date <i>Date d'échéance</i> _____											
3. Constructed for <i>Construit pour</i> _____ (Name and address/ <i>Nom et adresse</i>) Job no. <i>Projet numéro</i> _____											
4. Owner and location of installation <i>Propriétaire et lieu d'installation</i> _____ (Name and location of installation/ <i>Nom et adresse de l'installation</i>)											
5. Provincial piping design reg. no. <i>N° d'enreg. prov. conception tuyauterie</i> _____											
6. Provincial reg. welding proc. nos. and company WPS nos. <i>N° d'enreg. prov. mode opératoire de soudage et n° de SPS de l'entreprise</i> _____											
7. Code ASME B31.1 ☐ B31.3 ☐ B31.5 ☐ Other/ <i>Autre</i> _____											
Line ident. <i>Ident. cana.</i>	Process (air/stm., etc.) <i>Procédé (air/vapeur, etc.)</i>	Design press. kPa <i>Pression de calcul, kPa</i>	Design temp. °C <i>Température de calcul, °C</i>	Test press. Pression d'essai	Test med. Médium d'essai	Mat'l spec. and grade Spécifications du matériau et qualité	Pipe dia. & sch. <i>Diamètre et schedule des tuyaux</i>	Flange primary rating <i>Pression de service nominale des brides</i>	PWHT TTPS	NDE END	Additional exam <i>Examen supplémentaire</i>
Shop constructed data reports have been furnished for the following items detailed in this report. <i>Des déclarations de conformité ont été fournies pour les articles suivants indiqués dans la présente déclaration.</i>											
Line ident. <i>Ident. de canalisation</i>				Spool ident. <i>N° de repère de la pièce</i>				Fabricator <i>Constructeur</i>			
Certificate of Compliance/Certificat de conformité											
We certify that the statements in this data report are correct and that the piping described in this data report was constructed in accordance with the provincial Act and regulations. <i>Nous certifions que les données de cette déclaration de conformité sont correctes et que les tuyauteries décrites dans cette déclaration sont conformes à la loi et aux règlements provinciaux.</i>											
Date _____						by par _____ (Contractor/ <i>Entrepreneur</i>) (Authorized representative/ <i>Représentant autorisé</i>)					
Certificate of Inspection/Certificat d'inspection											
I, the undersigned, employed by _____ have inspected the piping described in this construction data report and state that, to the best of my knowledge and belief, the contractor has constructed this piping in accordance with the applicable sections of the ASME piping code and provincial Act and regulations. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the piping described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>Je, soussigné, employé par _____ ai inspecté la tuyauterie décrite dans cette déclaration de conformité et, autant que je sache, la construction de cette tuyauterie est conforme aux sections pertinentes du code ASME sur la tuyauterie et à la loi et aux règlements provinciaux. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement au tuyauterie décrite dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i>											
Date _____						Date _____					
_____ (Owner's inspector/ <i>Inspecteur du propriétaire</i>)						_____ (Provincial inspector (if required)/ <i>Inspecteur provincial (si exigé)</i>)					

Figure D.5
Construction data report for piping systems
 (See [Clauses 4.16.2](#) and [D.1.](#))

Statutory Declaration Application for Registration of Fittings Déclaration statutaire Demande pour l'enregistrement d'accessoires	In this space, provide a facsimile of the manufacturer's logo or trademark as it will appear on the fitting. <i>Apposer ici une reproduction du logo du fabricant ou de sa marque de commerce tel qu'il figurera sur l'accessoire.</i>
I, _____ <i>Je, _____</i> (Name of applicant*/Nom du demandeur*) *The applicant must be a person in a position of authority, e.g., vice-president, plant manager, or chief engineer. <i>*Le demandeur doit être une personne en position d'autorité, comme un vice-président, un directeur d'usine ou un ingénieur principal.</i> _____ (Title/Titre) of _____ <i>de _____</i> (Name of manufacturer/Nom du fabricant) located at _____ <i>située à _____</i> (Plant address/Adresse de l'entreprise) do solemnly declare that the fittings listed hereunder <i>déclare solennellement que les accessoires ci-après décrits</i> (check one/cochez une case) ☐ comply with the requirements of _____, which specifies the dimensions, (Title of recognized North American standard) construction materials, pressure/temperature ratings, and identification markings of the fittings. <i>sont conformes aux exigences du _____, qui précise leurs dimensions, matériaux de fabrication, pression/température nominales et marquages des accessoires.</i> (Titre de la norme nord-américaine reconnue) ☐ are not covered by the provisions of a recognized North American standard and are therefore manufactured to comply with _____, as supported by the attached information, (Insert title of regulation, code, guideline, or other applicable document) which specifies the dimensions, construction materials, pressure/temperature ratings (and the basis for such ratings), and identification markings of the fittings. <i>ne sont pas visés par une norme nord-américaine reconnue et sont donc conçus conformément à la _____, tel que le démontre les renseignements ci-joints</i> (Insérez le titre de la réglementation, du code, du guide ou autre document pertinent) <i>qui précisent leurs dimensions, matériaux de fabrication, pression/température nominales (et les bases de ces valeurs) et marquages de ces accessoires.</i> I further declare that the manufacturing of these fittings is subject to a quality control program that has been verified by _____ as being suitable for the manufacturing of these fittings to the stated (Name of organization) standard, regulation, code, guideline or other applicable document. The fittings covered by this declaration, for which I seek registration, are _____ (Brief description of fittings) <i>Je déclare de plus que la fabrication de ces accessoires est soumise à un programme de contrôle de la qualité qui a été vérifié par _____ et répond aux exigences de fabrication de ces accessoires tel que stipulé dans</i> (Nom de l'organisme) <i>les normes, réglementation, code, guide ou autre document pertinent.</i> <i>Les accessoires visés par cette déclaration, pour lesquels je demande l'enregistrement sont _____</i> (Brève description des accessoires)	

Figure D.6
Statutory declaration form for application for registration of fittings in Canada
(See [Clauses 4.2.2](#) and [D.1.](#))

(Continued)

In support of this application, the following information, calculations, and/or test data are attached: <i>Pour étayer cette demande, les renseignements, calculs ou feuilles d'approbation suivants sont joints :</i> (Signature of applicant/Signature du demandeur) (Date)	
Declared before me at _____ in the _____ of _____ <i>J'atteste que cette déclaration a été assermentée devant moi _____ à _____ de _____</i> this _____ day of _____ , _____ . <i>le _____ jour de _____ (Month/Mois) , _____ (Year/Année) .</i> Name (please print) _____ <i>Nom (lettres moulées)</i> Signature _____ (A Commissioner of Oaths in and for _____ . My commission expires on _____ .) <i>(Commissaire à l'assermentation _____ . Ma commission expire le _____ .)</i>	
For regulatory authority use only/Réservé à l'organisme de réglementation To the best of my knowledge and belief, this application meets the requirements of the Act and CSA Standard B51, Part 1, Clause 4.2, and is <i>Pour autant que je le sache, cette demande satisfait aux exigences de la Loi et à la norme CSA B51, Partie 1, article 4.2, et est acceptée pour</i> <i>l'enregistrement dans la catégorie _____ .</i> Registration number _____ <i>Numéro d'enregistrement</i> Date registered _____ Expiry date _____ <i>Date d'enregistrement _____ Date d'expiration _____</i> Signature _____ (For the Chief Inspector of _____) <i>(Pour l'inspecteur en chef représentant _____)</i>	

Figure D.6 (Concluded)

	Installation Report for Cast Iron Sectional Boilers Avis d'installation de chaudières en fonte en sections
Note: <i>This form must be filled in and mailed to:</i> Note : <i>Remplir ce formulaire et le faire parvenir à :</i>	
Name and address of regulatory authority <i>Nom et adresse des pouvoirs de réglementation</i>	
Manufacturer <i>Constructeur</i> _____	
Boiler model no. <i>N° de modèle de la chaudière</i> _____	
Serial no. <i>N° de série</i> _____	
CRN <i>NEC</i> _____	
Provincial identification no. (if any) <i>N° d'identification provincial (le cas échéant)</i> _____	
Located at <i>Adresse</i> _____	
This is to certify that the above-mentioned completed unit has been subjected to a hydrostatic test of _____ kPa as per the requirements of the ASME Code, Section IV, and that this test was satisfactory, with no apparent defects observed. <i>Ce document certifie que les appareils mentionnés ci-dessus ont été soumis à une épreuve hydraulique à une pression de _____ kPa, conformément à la section IV du code ASME et qu'ils n'ont subi aucun dommage apparent au terme de cette épreuve.</i>	
Signed <i>Signature</i> _____	
Company <i>Entreprise</i> _____	

Figure D.7
Installation report for cast iron sectional boilers
 (See [Clauses 4.6.5](#) and [D.1.](#))

Boilers and Pressure Vessels Chaudières et appareils sous pression Repair/Alteration Report Déclaration de réparation et de modification	
Provincial I.D. Number <i>N° ID provincial</i> _____ CRN NEC _____	
1. Name of company performing repair/alteration <i>Entreprise chargée d'effectuer les travaux</i> _____ Address <i>Adresse</i> _____ Company quality control program registration no. <i>N° d'enregistrement du programme de contrôle de la qualité de l'entreprise</i> _____	
2. Name of owner <i>Nom du propriétaire</i> _____ Address <i>Adresse</i> _____ Location of installation <i>Lieu de l'installation</i> _____ Owner's identification number/code <i>N° code de propriétaire</i> _____	
3. Type of vessel Dia. Length <i>Type d'appareil</i> _____ <i>Diam.</i> _____ <i>Longueur</i> _____	
4. Design pressure Shell kPa/psi at <i>Pression de calcul</i> <i>Virole</i> _____ <i>kPa/lb/po² à</i> _____ °C/°F Jacket/tubeside kPa/psi at <i>Chemise/côté tubes</i> _____ <i>kPa/lb/po² à</i> _____ °C/°F When repairs involve any of items 5 through 10, complete as applicable: <i>Si les réparations visent un ou plusieurs des points 5 à 10, fournir les renseignements qui suivent, le cas échéant :</i>	
5. Head material specification Thickness <i>Spécification du matériau de la tête</i> _____ <i>Épaisseur</i> _____	
6. Tubesheet material specification Thickness <i>Spécification du matériau de la plaque tubulaire</i> _____ <i>Épaisseur</i> _____	
7. Shell material specification Shell thickness <i>Spécification du matériau de la virole</i> _____ <i>Épaisseur de la virole</i> _____	
8. Tube material specification Tube diameter Thickness <i>Spécification du matériau des tubes</i> _____ <i>Diamètre des tubes</i> _____ <i>Épaisseur</i> _____	
9. Flange standard and rating Fitting rating <i>Pression de service et norme des brides</i> _____ <i>Pression de service des raccords/accessoires</i> _____	
10. Nozzle material specification and schedule <i>Spécification du matériau et n° de schedule des buses</i> _____	

Figure D.8
Repair/alteration report for boilers and pressure vessels
 (See [Clauses 11.1](#) and [D.1.](#))

(Continued)

11.	Details of repair/alteration <i>Détails des réparations ou des modifications</i>	
	(Attach additional sheets as necessary) (Joindre les feuilles additionnelles lorsque nécessaires)	
12.	Partial data reports have been furnished for the following parts: <i>Des déclarations de conformité partielles ont été fournies pour les pièces suivantes :</i>	
13.	Radiography <i>Radiographie</i> _____	
	(specify/spécifier)	
14.	Other NDE <i>Autres END</i> _____	
	(specify/spécifier)	
15.	Post-weld heat treatment <i>Traitement thermique post-soudage</i> _____	
16.	Hydrostatic test pressure <i>Pression d'épreuve hydraulique</i>	Shell <i>Virole</i> _____ Tubes <i>Tubes</i> _____
17.	Alternative or additional tests <i>Autres essais ou essais supplémentaires</i> _____	
18.	Welding procedure registration no. <i>N° d'enregistrement du mode opératoire de soudage</i> _____	
(STATEMENT TO BE MADE ON COMPLETION OF WORK) (DÉCLARATION FINALE À REMPLIR À LA FIN DES TRAVAUX)		
I certify that the statements made in this report are correct and that the repair/alteration complies with the requirements of the regulations. <i>Je certifie que les déclarations contenues dans ce rapport sont exactes et que les réparations et modifications sont conformes aux exigences des règlements.</i>		
	Signed/Signature _____	Date _____
	For/Pour _____	
	(Repair/alteration company/entreprise chargée des travaux)	
I have inspected the repair/alteration described above and state that to the best of my knowledge and belief the repair/alteration has been completed in accordance with the requirements of the regulations. By signing this certificate, neither the inspector nor his or her employer makes any warranty, expressed or implied, concerning the repair/alteration described in this manufacturer's data report. Furthermore, neither the inspector nor his or her employer shall be liable in any manner for any personal injury or property damage or a loss of any kind arising from or connected with this inspection. <i>J'ai procédé à l'inspection des réparations et des modifications précitées et, autant que je sache, les réparations et les modifications ont été effectuées conformément aux exigences des règlements. En signant ce certificat, ni l'inspecteur ni son employeur ne donnent de garantie explicite ou implicite relativement aux réparations et aux modifications décrites dans la présente déclaration. De plus, ni l'inspecteur ni son employeur ne doivent être tenus responsables de quelque manière que ce soit des dommages, matériels ou corporels, ou des pertes de quelque nature que ce soit pouvant résulter de cette inspection.</i>		
	Signed/Signature _____	Date _____
	(Provincial inspector/Inspecteur provincial)	
When not inspected by a provincial inspector <i>Si l'inspection n'a pas été effectuée par un inspecteur provincial</i>		
	Report received by <i>Déclaration reçue par</i> _____	Date _____

Figure D.8 (Concluded)

Annex E (informative)

Inspection of welds in pressure coils exposed to direct radiant heat

Note: This informative Annex has been written in normative language to facilitate its adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

E.1 General

Radiographic, visual, magnetic particle, and liquid penetrant examination of all welds in pressure coils shall be carried out and interpreted in accordance with ASME B31.3.

E.2 Inspection requirements

E.2.1

Inspection of welds in pressure coils, including return bends, fittings, manifolds, and crossover piping inside the internally insulated enclosure, shall comply with the requirements of [Clauses E.2.2 to E.2.8](#).

E.2.2

At least 10% of circumferential butt welds in tubes of material specifications falling within the P-No. 1 and P-No. 8 material groupings of Section IX of the ASME Code shall be fully radiographed in accordance with the random radiography requirements of ASME B31.3. The criteria for welds shall be as specified in ASME B31.3 for random radiography for normal service.

E.2.3

Except for the welds specified in [Clause E.2.2](#), circumferential butt welds shall be 100% radiographed.

E.2.4

Longitudinal seam welds in carbon steel or alloy materials shall be

- (a) 100% radiographed; and
- (b) examined using dye penetrant or magnetic particle methods.

E.2.5

The acceptance criteria for weld radiographs carried out to meet the requirements of [Clauses E.2.3 and E.2.4](#) shall be as specified in ASME B31.3 for 100% radiography.

E.2.6

In cases where radiographic examination is difficult to interpret (e.g., as in nozzle attachment welds), dye penetrant or magnetic particle inspection may be substituted.

E.2.7

Pressure-retaining fillet welds in materials other than carbon steel shall be examined using the liquid penetrant or magnetic particle method.

E.2.8

When post-weld heat treatment is required, radiographic examination shall be performed on completion of the heat treatment.

Annex F (informative)

Quality control program for manufacturers of fittings

Note: This informative Annex has been written in normative language to facilitate its adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

F.1 General

The manufacturer shall maintain a quality control program that will establish that all of the requirements of this Standard and the Standards referenced in this Standard will be met. The program that the manufacturer uses shall be suited to its circumstances and reflect the complexity of the products produced. A written description of the program that addresses, at a minimum, the requirements of [Clauses F.2 to F.10](#), shall be available.

F.2 Authority and responsibility

The authority and responsibility of those in charge of the quality control program shall be clearly established. Persons performing quality control functions shall have sufficient and well-defined responsibilities, as well as the authority and organizational freedom to identify and correct quality control problems.

F.3 Organization chart

A chart showing the relationship between management, engineering, purchasing, manufacturing, inspection, and quality control personnel shall be prepared.

F.4 Drawings, design calculations, and specification control

Measures shall be established to ensure that fittings are produced in accordance with the required drawings and specifications.

F.5 Materials control

Measures shall be established to ensure that only proper and certified materials are used.

F.6 Welding

Measures shall be established to ensure that welding procedures used in the production or repair of fittings comply with Section IX of the ASME Code and the Standards referenced in this Standard.

F.7 Heat treatment

Measures shall be established to ensure that all heat treatment meets the requirements of the material specifications and the Standards referenced in this Standard.

F.8 Calibration of equipment

Measures shall be established for calibrating examination, measuring, and testing equipment used in production.

F.9 Examination, inspection, and testing program

Measures shall be established to provide for examination, inspection, and testing. Such measures shall meet the requirements of the Standards referenced in this Standard. At a minimum, a sample inspection program shall meet the lowest level of ANSI/ASQ Z1.4 requirements.

F.10 Correction of nonconformities

Measures shall be established to provide for a systematic review and correction of nonconformities.

Annex G (normative)

Automotive propane vessel standards

Note: *This Annex is a mandatory part of this Standard.*

G.1 Corrosion allowance

G.1.1

Vessels mounted outside of the interior of a vehicle shall be designed to a pressure of 2150 kPa (312 psig), but rated at 1724 kPa (250 psig). The difference in wall thickness between the two cases shall be considered a corrosion allowance. Such vessels shall have a single Canadian Registration Number (CRN) to cover vessels rated at 1724 kPa (250 psig) with a corrosion allowance and at 2150 kPa (312 psig) with no corrosion allowance.

G.1.2

Vessels mounted within a vehicle and protected from the corrosive and erosive effects of the automotive environment shall not require a corrosion allowance and shall be designed to 2150 kPa (312 psig).

G.1.3

Vessels fabricated from 300 series stainless steel or 5000 or 6000 series aluminum shall be exempt from the corrosion allowance requirements of [Clause G.1.1](#).

G.2 Vessel openings

Except for fittings specifically required by CAN/CSA-B149.5 to have an internal excess flow valve, valves, gauges, and other fittings with openings greater than the diameter of a #54 drill shall be protected from shearing off and releasing the contents of the vessel by being fully recessed within the body of the vessel; by being enclosed within a substantial fitting securely welded to, and forming part of, the vessel structure; or by having an internal excess flow valve integral to the fitting.

A substantial fitting shall have a wall thickness at least equal to the wall thickness of the vessel wall and shall not create crevices that provide corrosion sites.

G.3 Crush test of manifold vessels (See [Figure G.1](#))

Notes:

- (1) *Manifold vessels are defined as two or more vessels fabricated by the original manufacturer; interconnected by rigid, integral, non-removable liquid and vapour passages; and braced to form a single rigid unit.*
- (2) *This Clause applies only to manifold vessels mounted under a vehicle between the rear axle and the rear bumper. Manifold vessels mounted in the trunk of a vehicle, along the side of the chassis, or in the bed of a truck need not comply with the requirements of this Clause.*

G.3.1

Manifold vessels shall be capable of withstanding, prior to developing a leak, a crushing load per unit length at least equal to the unit load withstood by a single vessel of the same diameter, material, wall thickness, and internal pressure. The length of a manifold vessel shall be the exposed length of the vessel, not the sum of the lengths of the individual shells in the manifold.

G.3.2

The unit load results from crush tests of longer single vessels shall be used as the basis for qualifying shorter manifold vessels. The acceptance criterion shall be that the crushing load per unit of length of the manifold vessel shall be at least equal to the load withstood by the longest comparable single vessel of the same diameter, material, wall thickness, etc.

Note: For example, if a vessel 255 mm (10 in) in diameter and 2030 mm (80 in) long is capable of withstanding a unit load of "x" N/m (lbf/in), any 255 mm (10 in) diameter equivalent manifold design will need to be capable of withstanding at least the same unit load.

G.3.3

The load shall be applied along the length of the single vessel with a flat bar of width equal to 20 to 30% of the diameter of the vessel to which the load is applied, and of a thickness such that no significant deflection of the bar shall develop. The width of the bar used to test the manifold vessel shall be not less than the width of the bar used to establish the unit load for the single vessel.

G.3.4

An internal pneumatic pressure of at least 103 kPa (15 psig) and not more than 206 kPa (30 psig) shall be applied to the manifold vessel and monitored with a pressure gauge for evidence of leakage.

G.3.5

The load shall be progressively applied until the manifold vessel develops a leak in its pressure boundary. The rate of application of the load shall be the same in all tests for a given vessel diameter.

G.3.6

If the manifold is fabricated from vessels of different diameters, thicknesses, materials, etc., the qualifying single vessel shall be the corresponding single vessel with the lowest unit load.

Note: For example, if the manifold vessel is composed of a vessel 255 mm (10 in) in diameter by 760 mm (30 in) long, with a second vessel 305 mm (12 in) in diameter by 915 mm (36 in) long, the qualifying single vessel needs to be a 255 mm (10 in) or 305 mm (12 in) diameter vessel, depending on which vessel has the lower unit load when tested as a single vessel.

G.3.7

Shorter manifold vessels may be qualified by longer manifold vessels provided that their designs are substantially the same. Design changes shall include such items as the number, type, shape, and location of crossover connections, and the centre-to-centre spacing of the vessels.

G.3.8

The test results shall be witnessed by a professional engineer. The test reports shall be signed and stamped by this engineer and submitted with the CRN application.

G.4 Brackets

Brackets attached to all vessels shall be designed for the loads specified in CAN/CSA-B149.5. Sample calculations shall be submitted with the CRN application. For alternative styles of brackets, the appropriate calculations shall be performed and retained by the fabricator for review by the regulatory authority.

G.5 Valve guards

G.5.1

Valve guards for bed-mounted and chassis-mounted vessels shall be designed to withstand a direct impact load of 50 kg (110 lb) dropped from a height of 1.5 m (4.92 ft). This impact shall be downward vertically, with the vessel oriented in its normal operating position.

G.5.2

Valve guards for undermounted vessels shall be designed to withstand a direct vertically downward impact load of 50 kg (110 lb) from a distance of 1.5 m (4.92 ft), with the vessel oriented in its normal operating position. The attachment of the guards shall be such that if a guard is pulled horizontally (with reference to the vessel's normal orientation), the attachment of the guard will fail as required in [Clause G.5.3](#).

G.5.3

The attachment of a valve guard shall be such that the valve guard or its attachments will fail before leakage occurs or the vessel is deformed by more than 1.0 times the shell thickness.

G.6 Nameplates

G.6.1

Nameplates shall be mounted on standoffs or seal-welded to the vessel wall to minimize corrosion between the vessel wall and the nameplate. The integrity of the seal weld shall be tested using methods such as the liquid dye penetrant or magnetic particle method. Compliance with this Clause shall be recorded on the manufacturer's data report for the vessel.

G.6.2

Vessels that comply with the requirements of this Annex, with the exception of [Clause G.3](#), shall have "B51 ANX G" stamped on the vessel nameplate. Vessels that comply with all of the requirements of this Annex shall have "B51 ANX G/CT" stamped on the vessel nameplate.

Note: CT means crush tested.

G.7 Vessel appurtenances

Vessel appurtenances shall be made of corrosion-resistant materials compatible with the vessel.

Note: For example, aluminum fittings cannot be used in a carbon steel vessel.

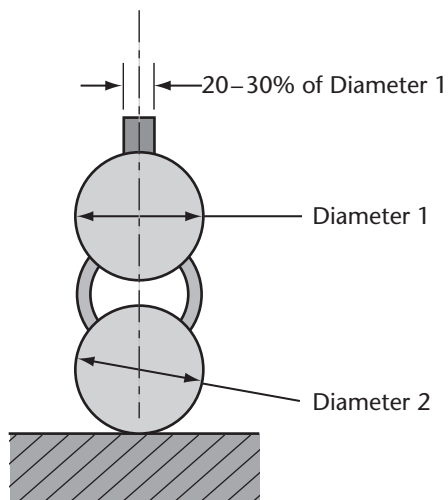
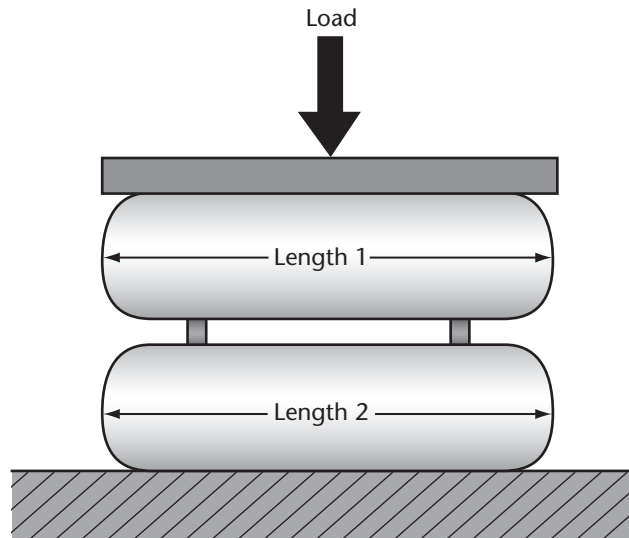


Figure G.1
Crush test set-up
(See [Clause G.3.](#))

Annex H (informative)

Overpressure protection devices

Note: *This informative Annex has been written in normative language to facilitate its adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.*

H.1 General

H.1.1

This Annex provides safety recommendations for overpressure protection devices, including pressure-relief valves (a generic term encompassing safety valves, safety-relief valves, and relief valves) and non-reclosing overpressure-relief devices. It addresses the roles of the regulatory authority, system designer, owner, servicing organization, American Society of Mechanical Engineers (ASME), and National Board of Boiler and Pressure Vessel Inspectors vis-à-vis the maintenance of pressure-relief valves. It also specifies requirements on the servicing of pressure-relief valves. The primary concern of this Annex is the safety of workers, equipment, and the public.

H.1.2

Safe operation of pressure equipment requires that all pressure-retaining systems and components be protected from overpressure by pressure-relief devices. The regulatory functions related to pressure-relief devices include the auditing of companies servicing pressure-relief valves; registration of acceptable overpressure protection device designs; the Canadian Registration Number (CRN) system; and keeping the industry informed of ASME Code and NB-23 (*National Board Inspection Code*) requirements and the roles of the various parties.

H.2 Administration

H.2.1 Role of the regulatory authority

The Act sets requirements for pressure-retaining items by specifying compliance with specified Codes and Standards. The regulatory authority enforces compliance with these requirements.

H.2.2 Role of the system designer

The overpressure protection needs of pressure-retaining systems and components shall be determined by the system designer in accordance with the applicable design code. The relieving capacity for ammonia tanks shall be as specified in ANSI K61.1, for propane tanks by NFPA 58, and for boilers by Sections I and IV of the ASME Code.

H.2.3 Role of the owner

The owner or person in charge of a boiler, pressure vessel, or pressure piping system shall ensure that

- (a) the equipment is provided with overpressure protection devices of a capacity specified by the system designer;
- (b) the overpressure protection devices are registered as fittings and have CRNs;
- (c) at least one overpressure protection device is set to open at a pressure not higher than the maximum allowable working pressure of the equipment it is protecting;
- (d) the overpressure protection devices remain in good working order;
- (e) setting and servicing of overpressure protection devices is performed only by persons authorized in writing by the regulatory authority to perform those functions; and
- (f) no required overpressure protection device is altered, interfered with, or rendered inoperative.

H.2.4 Role of the servicing organization

The servicing organization shall satisfy the regulatory authority that it has servicing facilities and an adequately documented quality control system for setting and servicing pressure-relief valves. The servicing organization shall also have a certificate of authorization from the regulatory authority authorizing it to set and service pressure-relief valves within the scope of its quality control system. An organization holding a National Board VR stamp shall be deemed to have met these requirements.

Servicing organizations shall be limited to operations covered by their quality control system. The aim of servicing shall be to ensure that the pressure-relief valve will be restored to the operating condition required for a new ASME valve (with the exception that the relieving capacity shall not require confirmation). Servicing shall require disassembly of the valve and inspection of all of its internal components. The servicing organization shall affix a dated service nameplate to the pressure-relief valve and use a uniquely embossed seal to seal all adjustable parts of the valve. The servicing organization shall have the valve manufacturer's service manuals for the valves and its employees shall have been trained by the manufacturer or have received equivalent training. The manufacturer's nameplate shall remain on the valve.

H.2.5 Role of ASME and the National Board

ASME and the National Board set overpressure protection device standards. Emphasis is placed by these organizations on the set pressure and capacity rating of the overpressure protection devices. ASME and National Board requirements have the force of law only when adopted by a jurisdiction.

H.3 Markings

H.3.1

Overpressure protection devices used to protect pressure-retaining systems and components shall bear the certified capacity rating and a CRN. Valves built in accordance with ASME rules shall be stamped with the appropriate symbol stamp. Valves with a capacity that is certified by the National Board shall bear the NB mark.

H.3.2

Compliance with the ASME Code is indicated by the applicable symbol stamp, as follows:

- (a) Section I (power boiler valves): V;
- (b) Section IV (heating boiler valves): HV; and
- (c) Section VIII (pressure vessel valves): UV or UD.

H.3.3

Of the three types of valves listed in [Clause H.3.2](#), V-stamped valves are subject to the most stringent ASME Code requirements, and for this reason may be used on pressure vessels and piping in steam service.

H.4 Servicing

H.4.1 General

The owner or user shall maintain pressure-relieving systems and components in a safe working condition. Overpressure protection devices shall be serviced or replaced if there is evidence of a malfunction, including leakage exceeding specified rates. Devices that are returned to service shall be restored to their original condition and recertified. Unsafe or suspect overpressure protection devices shall be replaced immediately.

Note: Servicing of pressure-relief valves consists of the following operations:

- (a) disassembly of the valve;
- (b) inspection of all internal components;

- (c) refurbishing; and
- (d) in some cases, replacement of parts.

H.4.2 Replacement parts

All replacement parts shall be fabricated by the valve manufacturer or to its specifications.

H.4.3 Servicing intervals

The intervals specified in this Clause are maximum servicing intervals; the owner may recommend a longer servicing interval to the regulatory authority if the servicing history of a valve can justify an extension (however, the owner may choose to service pressure-relief valves at more frequent intervals to ensure safe operation). The manufacturer's instructions and recommendations shall be considered for guidance on servicing issues. Corrosive and/or liquid service can require shorter intervals if valves have lifted to relieve pressure. Extreme caution shall be exercised during servicing of pressure-relief valves in toxic or lethal service.

The servicing intervals are as follows:

- (a) for all pressure vessels and piping systems other than those listed in Items (b) through (g), the maximum servicing interval shall be three years;
- (b) power boilers operating above 103 kPa (15 psig) shall have a system test or lift test annually and shall be serviced every five years;
- (c) hot water heating boilers up to 1103 kPa (160 psi) at 121 °C (250°F) shall have a manual lift test or system test every two years. Servicing or replacement is required if there is evidence of malfunction or leakage;
- (d) steam heating boilers up to 103 kPa (15 psig) shall have a manual lift test annually and be serviced every five years;
- (e) vessels in air and steam service shall have a manual lift test annually and be serviced every five years if testing is not possible; and
- (f) vessels in propane (LPG), anhydrous ammonia, cryogenic, and liquefied compressed gas service (except cargo transport) shall be serviced every five years.

Note: Failure to properly install, inspect, and maintain pressure-relief valves can cause injury or property damage.

H.5 Lifting levers

H.5.1

Although Section I of the ASME Code requires manual lifting levers for pressure-relief valves on boilers, Section VIII does not require levers for pressure vessel service (with the exception of valves on air receivers, vessels in steam service, and vessels used for hot water over 60 °C [140°F]).

H.5.2

The primary purpose of a lifting lever is for manually testing a pressure-relief valve to prove that it will function freely. If an owner does not intend to have the valves on pressure vessels manually tested at the plant, in some cases it will be advisable to specify pressure-relief valves without lifting levers (if not required by the ASME Code) when new or replacement valves are ordered. It should be noted that many valve manufacturers and servicing companies strap down the lifting lever before shipping to reduce the possibility of damage by someone using the lever as a handle. These straps should be removed when the valve has been reinstalled.

A lifting lever should not be used as a carrying handle. Using a lifting lever to carry a valve can cause seat damage.

H.6 Non-reclosing overpressure-relief devices

Non-reclosing overpressure-relief devices, e.g., rupture discs and fusible plugs, shall be visually examined in accordance with a program established by the owner or user. The program shall take into account the manufacturer's recommended service life and establish replacement dates (if applicable).

CSA Standard

B51-09, Part 2

***High-pressure cylinders for the on-board
storage of natural gas and hydrogen as
fuels for automotive vehicles***



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B51-09, Part 2

High-pressure cylinders for the on-board storage of natural gas and hydrogen as fuels for automotive vehicles

0 Introduction

Part 2 of this Standard concerns high-pressure cylinders for the on-board storage of natural gas, blends of natural gas and hydrogen (hydrogen blends), and hydrogen as fuels for automotive vehicles. The use of gas cylinders is governed by the Act. Users and manufacturers should note the need to apply to the applicable regulatory authorities for approval of gas cylinders.

1 Scope

1.1

Part 2 of this Standard specifies minimum requirements for serially produced lightweight refillable gas cylinders, both original equipment and conversions, having a water capacity exceeding 20 L (0.71 ft³) but not exceeding 1000 L (35.3 ft³). Part 2 of this Standard applies only to cylinders for the on-board storage of high-pressure compressed natural gas and/or compressed hydrogen as fuels for automotive vehicles to which the cylinders are to be fixed. Cylinders may be of any material (steel, aluminum, or non-metallic) and constructed in accordance with any design or method of manufacture suitable for the specified service conditions.

1.2

The cylinders covered by Part 2 of this Standard are designated as follows:

- (a) Type 1 — metal;
- (b) Type 2 — metal liner reinforced with resin-impregnated continuous filament (hoop-wrapped);
- (c) Type 3 — metal liner reinforced with resin-impregnated continuous filament (fully wrapped); and
- (d) Type 4 — non-metallic liner with resin-impregnated continuous filament (all-composite).

1.3

The service conditions to which the cylinders are subjected are specified in [Clause 4](#). Part 2 of this Standard is based on a working pressure settled at 15 °C (59°F), with a maximum filling pressure of 1.25 times the working pressure.

The service life of a cylinder is defined by the manufacturer and can vary with different applications. This Standard's definition of service life is based on filling a cylinder 750 times a year. The maximum service life of Type 2, Type 3, and Type 4 cylinders is 20 years. For all cylinders, a "safe life" design principle is used.

For metal and metal-lined cylinders, the cylinder life is based on the rate of fatigue crack growth. Ultrasonic or equivalent inspection of each cylinder or liner is necessary to ensure that there are no flaws that exceed the maximum allowable size determined by fracture mechanics. This approach optimizes the design and manufacture of lightweight cylinders for natural gas vehicle service.

For all-composite cylinders with non-metallic non-load-bearing liners, safe life is ensured by appropriate design methods, design qualification testing, and manufacturing controls.

1.4

Part 2 of this Standard does not cover Type 1 or Type 2 welded metal cylinders or liners.

1.5

Where a clause in Part 2 of this Standard is at variance with Codes or Standards referenced in Part 2 of this Standard, the requirements of Part 2 of this Standard govern.

1.6

Type 1 steel cylinders may be requalified for further service in accordance with the procedure described in [Annex B](#).

1.7

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.

1.8

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

2 Reference publications

Part 2 of this Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

CAN/CSA-B108-99 (R2006)

Natural gas fuelling stations installation code

B109-01

Natural gas for vehicles installation code

B339-08

Cylinders, spheres, and tubes for the transportation of dangerous goods

CAN3-Z299.2-85 (R2006)

Quality assurance program — Category 2

ANSI (American National Standards Institute)

ANSI/IAS PRD 1-1998

Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers

Note: This Standard can be obtained from CSA.

ASTM International (American Society for Testing and Materials)

B 117-07a

Standard Practice for Operating Salt Spray (Fog) Apparatus

D 522-93a (2001)

Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings

D 638-03

Standard Test Method for Tensile Properties of Plastics

D 1186-01 (withdrawn Standard)

*Standard Test Methods for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings
Applied to a Ferrous Base*

D 1308-02 (2007)

Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes

D 1400-00 (withdrawn Standard)

*Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Nonconductive Coatings
Applied to a Nonferrous Metal Base*

D 2344/D 2344M-00 (2006)

Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates

D 2794-93 (2004)

Standard Test Method for Resistance of Organic Coatings on the Effects of Rapid Deformation (Impact)

D 3170-03 (2007)

Standard Test Method for Chipping Resistance of Coatings

D 3359-07

Standard Test Methods for Measuring Adhesion by Tape Test

D 4138-07a

*Standard Practices for Measurement of Dry Film Thickness of Protective Coating Systems by Destructive,
Cross-Sectioning Means*

D 4814-07b

Standard Specification for Automotive Spark-Ignition Engine Fuel

E 8-04

Standard Test Methods for Tension Testing of Metallic Materials

E 23-07ae1

Standard Test Methods for Notched Bar Impact Testing of Metallic Materials

E 399-06e1

Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

G 154-06

Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials

BS (British Standards Institution)

EN 13322-2:2003

*Transportable gas cylinders — Refillable welded steel gas cylinders — Design and construction — Part 2:
Stainless steel*

CGSB/ISO (Canadian General Standards Board/International Organization for Standardization)

CAN/CGSB 48.9712-2006/ISO 9712:2005

*Nondestructive Testing; Qualification and Certification of Personnel***ISO (International Organization for Standardization)**

148-1:2006

Metallic materials — Charpy pendulum impact test — Part 1: Test method

306:2004

Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)

6506-1:2005

Metallic materials — Brinell hardness test — Part 1: Test method

6508-1:2005

Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)

7866:1999

Gas cylinders — Refillable seamless aluminum alloy gas cylinders — Design, construction and testing

9001:2000

Quality management systems — Requirements

9809-1:1999

Gas cylinders — Refillable seamless steel gas cylinders — Design, construction and testing — Part 1: Quenched and tempered steel cylinders with tensile strength less than 1 100 MPa

11114-4:2005

Transportable gas cylinders — Compatibility of cylinder and valve materials with gas contents — Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement

11439:2000

Gas cylinders — High pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles

14687:1999

Hydrogen fuel — Product specification

19078:2006

*Gas cylinders — Inspection of the cylinder installation, and requalification of high pressure cylinders for the on-board storage of natural gas as a fuel for automotive vehicles***NACE International (National Association of Corrosion Engineers)**

TM0177-2005

*Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H₂S Environments***UL (Underwriters Laboratories Inc.)**

969 (1995)

*Marking and Labeling Systems***U.S. DOT (United States Department of Transportation)***"Specification 3AA and 3AAX Seamless Steel Cylinders". Title 49, Code of Federal Regulations 178.37, 2007 ed.*

3 Definitions

The following definitions apply in Part 2 of this Standard:

All-composite cylinder — a composite cylinder using a non-metallic liner.

Autofrettage — a pressure application procedure used in manufacturing composite cylinders with metal liners. It strains the liner past its yield point so as to cause permanent plastic deformation, which results in the liner's having compressive stresses and the fibres' having tensile stresses at zero internal pressure.

Autofrettage pressure — the pressure within the overwrapped cylinder at which the required distribution of stresses between the liner and the overwrap is established.

Batch —

Composite cylinders — a group of cylinders successively produced from qualified liners having the same size, design, specified materials of construction, and process of manufacture.

Limits — not more than 202 finished cylinders or liners, or one shift of continuous production as defined by the manufacturer, whichever is greater.

Metal cylinders and liners — a group of successively produced metal cylinders or liners having the same nominal diameter, wall thickness, design, specified materials of construction, process of manufacture, equipment for manufacture and heat treatment, and conditions of time, temperature, and atmosphere during heat treatment.

Non-metallic liners — a group of successively produced non-metallic liners having the same nominal diameter, wall thickness, design, specified materials of construction, and process of manufacture.

Composite cylinder — a cylinder made of resin-impregnated continuous filament wound over a metal or non-metallic liner.

Controlled-tension winding — a process used in manufacturing hoop-wrapped composite cylinders with metal liners.

Note: *Compressive stresses in the liner and tensile stresses in the overwrap at zero internal pressure are obtained by winding the reinforcing filaments under high tension.*

Design pressure — 1.25 times the working pressure.

Note: *The maximum pressure is usually achieved during the fast filling of the cylinder.*

Filling pressure — the gas pressure in a cylinder immediately after completion of filling.

Finished cylinder — a completed cylinder that is ready for use, typical of normal production, and complete with identification marks and external coating, including integral insulation specified by the manufacturer, but free from non-integral insulation or protection.

Full-wrap — an overwrap having a filament wound in both the circumferential and axial directions of a cylinder.

Gas temperature — the temperature of gas in a cylinder.

Hoop-wrap — an overwrap having a filament wound in a substantially circumferential pattern over the cylindrical portion of a liner so that the filament does not carry any significant load in a direction parallel to the cylinder's longitudinal axis.

Hydrogen blend — a mixture of dry natural gas and at least 0.1% by volume of hydrogen gas.

Independent inspection agency — an inspection agency independent of the manufacturer and approved by the regulatory authority as competent to supervise the construction and testing of cylinders.

Liner — a container, used as a gas-tight inner shell, on which reinforcing fibres are filament-wound to reach the necessary strength. Two types of liners are specified in this Standard: metal liners that are designed to share the load with the reinforcement and non-metallic liners that do not carry any part of the load.

Manufacturer — a person or organization responsible for the design, fabrication, and testing of cylinders.

Overwrap — the reinforcement system of filament and resin applied over a liner.

Pre-stressing — the process of applying autofrettage or controlled-tension winding.

Service life — the life in years during which a cylinder can safely be used in accordance with the standard service conditions specified in [Clause 4](#).

Service temperature range — the gas temperature range in cylinders subjected to the standard service conditions specified in [Clause 4](#).

Settled pressure — the gas pressure when a given settled temperature is reached.

Settled temperature — the uniform gas temperature after a change in temperature caused by filling has dissipated.

Test pressure — the pressure at which a cylinder is hydrostatically tested.

Working pressure — the settled pressure at a uniform temperature of 15 °C (59°F).

4 Service conditions

4.1 General

4.1.1 Standard service conditions

The standard service conditions specified in [Clause 4](#) are provided as a basis for the design, manufacturing, inspection, testing, and approval of cylinders that are to be mounted permanently on vehicles and used to store natural gas, hydrogen blends, or hydrogen at ambient temperatures for use as fuel for the vehicles.

4.1.2 Use of cylinders

[Clause 4](#) is also intended to provide information on how cylinders made to this Standard can be safely used by the following:

- (a) owners of cylinders;
- (b) designers or contractors responsible for installing cylinders;
- (c) designers or owners of equipment used to refuel cylinders;
- (d) suppliers of natural gas, hydrogen blends, or hydrogen; and
- (e) regulatory authorities that have jurisdiction over cylinder use.

Note: Regulatory authorities may allow cylinders conforming to this Standard to be used under conditions different from the standard service conditions specified in this Standard.

4.1.3 Service life

The service life shall be specified by the cylinder designer on the basis of use under the service conditions specified in this Standard.

4.1.4 Periodic requalification

4.1.4.1 General

Any requirements for periodic requalification by inspection or testing during the service life shall be specified by the cylinder designer on the basis of use under the service conditions specified in this Standard. Each cylinder shall be visually inspected for external damage and deterioration at least every 36 months and at the time of any reinstallation. Inspections and tests shall be performed by an agency approved by the regulatory authority, in accordance with the inspection procedures specified in ISO 19078, and follow the manufacturer's specifications.

Cylinders without labels containing mandatory information, or with labels containing mandatory information that are illegible in any way, shall be removed from service. If a tank can be positively identified by manufacturer and serial number, a replacement label may be applied to the cylinder, and the cylinder may remain in service.

4.1.4.2 Cylinders involved in collisions

Cylinders that have been involved in a vehicular collision shall be reinspected by an agency authorized by the manufacturer and, if required, by the authority having jurisdiction. A cylinder that has not experienced impact damage from a collision may be returned to service; otherwise, it shall be returned to the manufacturer for evaluation.

4.1.4.3 Cylinders involved in fires

Cylinders that have been subject to the action of fire shall be removed from service and destroyed.

4.2 Maximum pressures

4.2.1 Maximum pressures for natural gas

A cylinder may be filled to a pressure not exceeding

- (a) the working pressure at a settled temperature of 15 °C (59°F);
- (b) 1.25 times the working pressure or a settled pressure of 260 bar (3770 psi), whichever is greater, at 57 °C (135°F); or
- (c) 1.25 times the working pressure or 260 bar (3770 psi), whichever is greater, immediately after filling, regardless of temperature.

Thus, achieve a settled pressure of 200 bar (2900 psi) at a settled temperature of 15 °C (59°F), the dispensed pressure shall be temperature compensated to prevent pressures from exceeding the maximum pressure of 260 bar (3770 psi). This compensation shall be based on a gas for which

$$P(\text{bar}) = P = 178.6 + [1.43T]$$

where

T = temperature, °C

For gas mixtures that do not follow this equation, the dispensed pressure shall be reduced to ensure that the limit specified in Item (b) is not exceeded and to protect the cylinder in case of exposure to heat or fire.

Note: The working pressures commonly used for compressed natural gas service are 200 bar at 15 °C (3000 psig at 70°F) and 240 bar at 15 °C (3600 psig at 70°F).

4.2.2 Maximum pressures for hydrogen blends and hydrogen

Cylinders shall be designed to be filled up to a maximum pressure that

- (a) does not exceed 1.25 times the working pressure, regardless of filling conditions or temperature; and
- (b) settles to a pressure not greater than the working pressure at the settled temperature of 15 °C (59°F).

Note: Working pressures commonly used for compressed hydrogen service are 248 bar (3600 psi), 350 bar (5075 psi), and 700 bar (10 150 psi) at 15 °C (59°F). Other working pressures may be used if the qualification test requirements in Part 2 of this Standard are met.

4.3 Maximum number of filling cycles

The total number of times a cylinder may be filled shall not exceed its years of specified service life multiplied by 750.

4.4 Temperature range

4.4.1 Gas temperatures

The settled temperature of natural gas or hydrogen blends in cylinders may vary from $-40\text{ }^{\circ}\text{C}$ (-40°F) to $57\text{ }^{\circ}\text{C}$ (135°F). The settled temperature of hydrogen in cylinders may vary from $-40\text{ }^{\circ}\text{C}$ (-40°F) to $85\text{ }^{\circ}\text{C}$ (185°F).

4.4.2 Minimum design cylinder temperatures

The temperature of the cylinder materials may vary from $-40\text{ }^{\circ}\text{C}$ (-40°F) to $85\text{ }^{\circ}\text{C}$ (185°F). For natural gas or hydrogen blends, temperatures over $65\text{ }^{\circ}\text{C}$ (149°F) shall be sufficiently local, or of short enough duration, that the temperature of gas in the cylinder shall not exceed $65\text{ }^{\circ}\text{C}$ (149°F). For hydrogen, temperatures over $85\text{ }^{\circ}\text{C}$ (185°F) shall be sufficiently local, or of short enough duration, that the temperature of gas in the cylinder shall not exceed $85\text{ }^{\circ}\text{C}$ (185°F).

4.4.3 Transient temperatures

The developed temperatures during filling and discharge may be outside the ambient limits of [Clause 4.4.2](#).

4.5 Gas composition

Cylinders made to this Standard are intended to be used with natural gas that complies with the gas composition requirements specified in ISO 11439 and with hydrogen that complies with ISO 14687. Methanol or glycol shall not be deliberately added to the natural gas.

4.6 External surfaces

Cylinders are not designed for exposure to leakage from cargo that might be carried on vehicles. The design of cylinders shall take into consideration the exposure of external surfaces to

- (a) water, either by periodic immersion or road spray;
- (b) salt from operation of vehicles near the ocean or where ice-melting salt is used;
- (c) ultraviolet radiation from sunlight;
- (d) the impact of gravel;
- (e) solvents, acids, and alkalis; and
- (f) automotive fluids (including gasoline), hydraulic fluids, glycol, and oils.

4.7 Gas permeation or leakage

Cylinders may be located in enclosed spaces for extended periods of time. For Type 4 cylinders, permeation of gas through the cylinder wall or leakage between the end connections and the liner shall be considered in the design.

4.8 Installation

Cylinder valves, pressure-relief devices, and connections shall be protected against breakage in a collision. If this protection is mounted on the cylinder, the design and method of attachment shall be approved by the cylinder manufacturer. Factors to be considered shall include the ability of the cylinder to support the transferred impact loads and the effect of local stiffening on cylinder stresses and fatigue life.

Cylinders shall be protected from accidental cargo spillage and from mechanical damage. Cylinder locations and mountings shall be designed to provide adequate impact protection to prevent cylinder failure in a collision.

Notes:

- (1) This Standard does not specify requirements for cylinder integrity in a vehicle collision.
- (2) For installation details see CSA B109.

5 Design approval

5.1 General

Cylinder designs shall be registered with the regulatory authority where the cylinders are to be used. The requirements of Part 1 of this Standard on the registration of designs shall apply. The following shall be submitted by the cylinder designer to the appropriate regulatory authority with a request for approval:

- (a) the statement of service;
- (b) the design data;
- (c) the manufacturing data;
- (d) information on the quality control program, including inspection and test plan (unless waived by the regulatory authority);
- (e) the service life, in-service requalification requirements, and rejection criteria; and
- (f) the specification sheet.

5.2 Statement of service

The purpose of the statement of service is to guide users and installers of cylinders as well as to provide information to the regulatory authority receiving the request for approval. The statement of service shall include

- (a) a statement that the cylinder design is suitable for use in the service conditions specified in [Clause 4](#) for the service life of the cylinder;
- (b) a specification of service life;
- (c) information on specification of the minimum in-service test and/or inspection requirement;
- (d) information on protection against fire (the pressure-relief devices and insulation);
- (e) information on support methods, protective coatings, etc., required but not provided;
- (f) a description of the cylinder design; and
- (g) any other information necessary to ensure the safe use of the cylinder.

5.3 Design data

5.3.1 Drawings

At a minimum, drawings shall include the following:

- (a) title, reference number, date of issue, and revision numbers (with their dates of issue, if applicable);
- (b) a reference to this Standard, using the full designation and the cylinder type;
- (c) all dimensions, complete with tolerances, including details of end-closure shapes (with minimum thicknesses and details of openings);
- (d) masses, complete with tolerances of cylinders, liners, and overwraps;
- (e) material specifications, complete with minimum mechanical and chemical properties or tolerance ranges, and, for metal cylinders or metal liners, the specified hardness range; and
- (f) other data, e.g., autofrettage pressure range, minimum test pressure, details of the fire protection system, and details of the exterior protective coating.

5.3.2 Stress analysis report

A finite element or other stress analysis shall be provided that takes temperature into account and provides stress contours to show the stress distributions in the cylinder at

- (a) working pressure;
- (b) 20 bar;
- (c) specified test pressure;
- (d) design burst pressure;
- (e) specified autofrettage pressure (required only for Type 2 or Type 3 autofrettaged designs); and
- (f) zero pressure after pre-stress (required only for Type 2 or Type 3 pre-stressed designs).

A table summarizing the highest stresses at critical locations at the pressures listed in this Clause shall be provided.

5.3.3 Material test data

A detailed description of the materials used in the design shall be provided. Test data characterizing the mechanical properties and the suitability of the materials for service under the conditions specified in [Clause 4](#) shall also be provided.

5.3.4 Design qualification test data

When tested in accordance with the applicable test methods specified in [Clause 14](#), the cylinder material, design, and manufacture shall be proved to be adequate for their intended service by meeting the requirements of the tests required for the particular cylinder design.

The test data shall also document the dimensions, wall thicknesses, and weights of each of the test cylinders.

Note: Other test methods at least as effective as those specified in [Clause 14](#) may be used, subject to satisfactory proof and documentation, as well as the approval of the regulatory authority.

5.3.5 Fire protection

The arrangement of pressure-relief devices and insulation that will protect the cylinder from sudden rupture when exposed to the fire conditions described in [Clause 14.15](#) shall be specified. Test data shall substantiate the effectiveness of the specified fire protection system.

Using the results of the bonfire test described in [Clause 14.15](#), the manufacturer shall specify the registered pressure-relief device and, if applicable, the thickness and thermal properties of any insulation required.

5.3.6 Cylinder supports

Details of cylinder supports or support requirements shall be provided in accordance with [Clause 6.11](#).

5.3.7 Additional supporting data

Additional data that would support the application, e.g., the service history of the material proposed for use, or the use of a particular cylinder design in other service conditions, shall be provided where applicable.

5.4 Manufacturing data

Details of all fabrication processes, non-destructive examinations, production tests, and batch tests shall be provided.

The tolerances for all production processes, e.g., heat treatment, end forming, resin mix ratio, filament winding tension and speed, curing times and temperatures, and autofrettage procedures, shall be specified.

Surface finish, thread details, acceptance criteria for ultrasonic scanning (or equivalent), and maximum lot sizes for batch tests shall also be specified.

5.5 Quality control program

The manufacturer shall specify methods and procedures in accordance with [Clause 13](#) that will ensure that all production cylinders comply with the design. This information shall be submitted in a separate quality control manual.

Arrangements for an independent inspection agency shall also be documented.

5.6 Service life and in-service requalification requirements and rejection criteria

5.6.1 Service life

The manufacturer shall specify the maximum service life of cylinders manufactured to the design.

5.6.2 Retesting

The manufacturer shall specify any required retesting interval, the test method, and the retesting rejection criteria. For metal and metal-lined cylinders (Type 1, Type 2, and Type 3 designs), the frequency of retesting shall be based on the rate of crack growth associated with 750 cycles per year from 20 bar to working pressure. The retesting shall be performed at a frequency that will allow detection of a crack before it leads to a leak condition. Manufacturers may avoid the requirement to specify retesting requirements during the service life of the cylinder by using the 100% ultrasonic scanning examination or an equivalent non-destructive examination (which is a part of the production inspection) to ensure the absence of flaws that would otherwise lead to fatigue failure within the service life of the cylinder. The rejection criteria for ultrasonic scanning or its equivalent shall be calculated using fracture mechanics methods. The ability of the non-destructive inspection system to detect the specified minimum defect size shall be documented.

For all-composite cylinders (Type 4 designs), manufacturers shall provide data, as necessary, to justify an appropriate retesting period. This information shall include, but not be limited to,

- (a) production inspection methods for non-metallic liners, including non-destructive examination of any bonded or fused connections;
- (b) long-term compatibility of the liner material to natural gas vehicle (NGV) environments;
- (c) long-term integrity of the liner/metal boss connection; and
- (d) provision for conducting accelerated cylinder tests under NGV service conditions.

5.6.3 Reinspection

Visual reinspection of the external cylinder surfaces shall be the responsibility of the regulatory authorities; however, the manufacturer shall specify the rejection criteria for visual reinspections and the frequency of reinspection, if the minimum requirement specified in [Clause 4.1.4.1](#) is not sufficient.

For Type 1 designs, the dimensions of allowable defects shall be defined by the fracture mechanics studies required for the design. For Type 2, Type 3, and Type 4 designs, the visual reinspection rejection criteria shall be based on the results of pressure-cycling tests performed on cylinders containing specified visible flaws. The manufacturer shall provide the results of these tests.

5.7 Design specification sheet

A summary of the documents providing the information required by [Clause 5.1](#) shall be listed on a specification sheet for each cylinder design. The title, reference number, revision numbers, dates of original issue, and version numbers of each document shall be given. All documents shall be signed or initialled by the issuer.

The design specification sheet shall be given a number, and revision numbers if applicable, that can be used to designate the cylinder design, and shall carry the signature of the engineer responsible for the design. Space shall be provided on the specification sheet for a stamp indicating registration of the design.

6 Requirements applicable to all cylinder types

6.1 General

The requirements specified in [Clauses 6.2 to 6.17](#) shall be generally applicable to the cylinder types specified in [Clauses 7 to 10](#). The design of cylinders shall take into account all relevant aspects necessary to ensure that every cylinder produced to the design is fit for its purpose for the specified service life.

6.2 Design

This Standard does not provide design formulas or specify permissible stresses or strains, but it does specify requirements on the adequacy of the design, which are established by appropriate calculations and demonstrated by the cylinders' capacity to consistently pass the design qualification, production, and batch tests specified in this Standard.

All designs shall ensure leak-before-break under feasible degradation of pressure parts during normal service. Leaks in metal cylinders or metal liners shall occur by the growth of a fatigue crack.

6.3 Materials

6.3.1 General

The materials used shall be suitable for the service conditions specified in [Clause 4](#). The design shall not bring incompatible materials into contact with each other.

6.3.2 Steel (excluding stainless steels)

6.3.2.1 General

Steels shall be aluminum-killed and produced to predominantly fine-grain practice. The chemical composition of all steels shall be declared and shall be defined at least by

- (a) carbon, manganese, aluminum, and silicon contents in all cases; and
- (b) nickel, chromium, molybdenum, boron, and vanadium contents where these elements are alloying elements intentionally added.

6.3.2.2 Chemical analysis

The following limits shall not be exceeded in the cast analysis:

- (a) sulphur: 0.02%;
- (b) phosphorus: 0.02%; and
- (c) sulphur and phosphorus: 0.03%.

6.3.2.3 Tensile tests

Tensile testing shall be performed in accordance with [Clause 14.1](#) to demonstrate compliance of the materials in accordance with [Clause 5.3.3](#).

6.3.2.4 Impact test

The impact properties of the steel in the finished cylinder shall be determined in accordance with [Clause 14.2](#). Impact values shall not be less than those in specified [Table 1](#).

6.3.2.5 Sulphide stress cracking test

For natural gas and hydrogen blends service, if the upper limit of the specified hardness range for the steel exceeds 22 HRC (240 HB), the steel from a finished cylinder shall be tested in accordance with and meet the requirements of [Clause 14.3](#).

6.3.2.6 Hydrogen compatibility

For hydrogen blends and hydrogen service, if the tensile strength of the steel exceeds the limits specified in ISO 9809-1, the compatibility of the steel with hydrogen at the intended working pressure shall be demonstrated using the test methods specified in ISO 11114-4.

6.3.3 Aluminum

6.3.3.1 General

Aluminum alloys shall be quoted according to the Aluminum Association practice for a given alloy system. The impurity limits for lead and bismuth in an aluminum alloy shall not exceed 0.01%.

6.3.3.2 Stress corrosion cracking tests

Aluminum alloys shall meet the requirements of the stress corrosion cracking tests performed in accordance with [Clause 14.4](#).

6.3.3.3 Sustained load cracking tests

Aluminum alloys shall meet the requirements of the sustained load cracking tests performed in accordance with [Clause 14.5](#).

6.3.3.4 Tensile tests

Tensile testing shall be performed in accordance with [Clause 14.1](#) to demonstrate compliance of the materials in accordance with [Clause 5.3.3](#).

6.3.4 Resins

The materials for impregnation shall be thermosetting or thermoplastic resins. Examples of suitable matrix materials include epoxy, modified epoxy, polyester and vinylester thermosetting plastics, and polyethylene and polyamide thermoplastic material. Resin materials shall be tested on a sample coupon representative of the composite overwrap in accordance with ASTM D 2344/D 2344M. Following a 24 h immersion in boiling water, the composite shall have a minimum shear strength of 13.8 MPa (2000 psi).

6.3.5 Fibres

The structural reinforcing filament material type shall be glass fibre, aramid fibre, or carbon fibre. If carbon-fibre reinforcement is used, the design shall incorporate means to prevent galvanic corrosion of the metal components of the cylinder.

The manufacturer shall keep on file the published specifications for composite materials used, the material manufacturer's recommendations for storage conditions and shelf life, and the material manufacturer's certification that each shipment conforms to the specification requirements. The fibre manufacturer shall certify that the fibre material properties conform to the manufacturer's specifications for the product.

6.3.6 Plastic liners

The polymeric material shall be compatible with the service conditions specified in [Clause 4](#). In accordance with the method specified in ISO 306 (Vicat) or an equivalent method, the softening temperature shall be at least 110 °C (230°F). The tensile yield strength and ultimate elongation shall be determined in accordance with ASTM D 638. Tests shall be conducted to demonstrate the ductile properties of the plastic liner material at temperatures of less than -50 °C (-58°F).

6.4 Manufacture

The manufacturer shall specify manufacturing procedures in detail sufficient to ensure consistent products.

6.5 Test pressure

The minimum test pressure used in manufacturing shall be 1.5 times the working pressure.

6.6 Burst pressures and fibre stress ratios

For all types of cylinders, the minimum burst pressure shall be not less than 2.25 times the working pressure. For Type 2, Type 3, and Type 4 designs, the composite overwrap shall be designed for high reliability under sustained loading and cyclic loading. This reliability shall be achieved by meeting or exceeding the composite-reinforcement stress ratio values specified in [Table 2](#), the stress ratio being the stress in the fibre at the specified minimum burst pressure divided by the stress in the fibre at working pressure.

6.7 Stress analysis

A stress analysis shall be performed to justify the minimum design wall thicknesses. It shall include a determination of the stresses in liners and fibres of composite design and shall be used with the fracture mechanics of metal cylinders and liners to establish inspection rejection criteria during production and to establish the retest or reinspection frequency and rejection criteria during service.

6.8 Inspection and testing

The manufacturer shall specify programs and procedures for

- (a) inspections, tests, and acceptance criteria at the time of manufacture; and
- (b) periodic in-service inspections, tests, and acceptance criteria.

6.9 Fire protection

The cylinder, its materials, pressure-relief devices, and any added insulation or protective material shall be designed to collectively ensure adequate safety during the fire conditions specified in [Clause 14.15](#). A manufacturer may specify alternative pressure-relief device locations for specific vehicle installations in order to optimize safety considerations.

Pressure-relief devices shall be of a registered design that meets the requirements of ANSI/IAS PRD 1.

6.10 Openings

6.10.1 General

Openings shall be located in heads only. The centreline of openings shall coincide with the longitudinal axis of the container.

Threads shall be clean-cut, even, without surface discontinuities, and to gauge.

6.10.2 Tapered threads

Openings with tapered threads may be used only in steel cylinders or steel liners.

Tapered threads shall comply with a recognized international or national Standard.

6.10.3 Straight threads

Openings with straight threads shall comply with a recognized international or national Standard.

6.11 Cylinder supports

The manufacturer shall provide cylinder supports or specify the means by which cylinders shall be supported.

Note: *The manufacturer should consider such factors as the undue stresses created in an overwrap by cylinder expansion against a metal support, the need to specify a gasket material to prevent support damage to cylinders, and the required properties of any gasket material. Type 2, Type 3, and Type 4 designs should be provided with shielding arrangements to protect the composite wrapping from mechanical damage.*

6.12 Exterior protective coatings

The exterior of cylinders shall be protected from environmental effects. Acceptable protection shall meet the requirements of [Clause 14.22](#) and, if applicable, [Clause 14.6](#).

6.13 Design qualification tests

For the approval of each cylinder type, the material, design, and manufacture shall be proved to be adequate for the cylinder's intended service by meeting the applicable requirements specified in [Clause 6.3](#) and the design qualification tests summarized in [Table 3](#), with all tests to be performed in accordance with the applicable test methods specified in [Clause 14](#).

The tests shall be witnessed by the independent inspecting agency or a person acceptable to the regulatory authority. If more cylinders or liners are subjected to the tests than are required by this Standard, all results shall be documented.

6.14 Batch tests

The batch tests specified in this Standard for each cylinder type shall be conducted on cylinders or liners taken from each batch of finished cylinders or liners. Alternatively, heat-treated witness samples shown to be representative of finished cylinders or liners may be used. The batch tests for each cylinder type shall be as specified in [Table 4](#). These tests shall be conducted in accordance with the requirements specified in [Clauses 7 to 10](#) for the applicable cylinder type.

6.15 Production examinations and tests

6.15.1 General

Production examinations and tests shall be performed on all cylinders produced in a batch. Each cylinder shall be examined at all critical stages during manufacturing and after completion, as follows:

- (a) ultrasonic scanning of metal cylinders and liners in accordance with the method described in [Clause B.4](#) or a demonstrated equivalent method to confirm that the maximum defect size does not exceed the size specified in the design;
- (b) verification that the critical dimensions and mass of the completed cylinder and of any liner and overwrapping are within design tolerances;
- (c) verification of compliance with the specified surface finish, with special attention to deep-drawn surfaces and folds or laps in the neck or shoulder of forged or spun end-closures or openings;
- (d) verification of coating quality (if required);
- (e) verification of markings;
- (f) hardness tests, or equivalent, of metal cylinders and liners in accordance with [Clause 14.8](#), performed after the final heat treatment. The values thus determined shall be in the range specified for the design. Alternative methods shall be acceptable, provided that a well-defined correlation is established between the tensile strength and hardness of the materials; and
- (g) hydrostatic pressure proof test, in accordance with [Clause 14.11](#).

6.15.2 Maximum defect size

For Type 1, Type 2, and Type 3 designs, the maximum defect size at any location in the metal cylinder or metal liner that will not grow to a critical size within the specified service life shall be determined (see [Clause 14.7.2](#)). The critical defect size shall be defined as the limiting through-wall (cylinder or liner) thickness defect that would allow stored gas to be discharged without rupturing the cylinder. Defect sizes for the rejection criteria for ultrasonic scanning or its equivalent shall not exceed the maximum calculated allowable defect sizes. For Type 2 and Type 3 designs, the calculations shall assume that there will be no damage to the composite due to time-dependent mechanisms.

6.16 Design changes

A design change shall be defined as any change in the selection of structural materials or any dimensional change not attributable to normal manufacturing tolerances. Minor design changes may be qualified through a reduced testing program. The design changes specified in [Table 5](#) shall require design qualification testing as specified in [Table 5](#). When changes in diameter or pressure are made, the structural wall elements shall operate at the same or lower nominal stress levels as the original design (e.g., if the pressure or diameter increases, the wall thickness shall increase proportionally; if the pressure or diameter decreases, the wall thickness may be decreased proportionally).

6.17 Failure to meet test requirements

In the event of failure to meet test requirements, the cause of the test failure shall be identified. If there is evidence that the failure was caused by a fault in performing a test or an error of measurement, the identified cause shall be corrected and a further test shall be performed. If the result of this test is satisfactory, the first test shall be ignored. If a greater number of cylinders or liners are subjected to the tests than the number required by this Standard, all results shall be documented.

7 Type 1 metal cylinders

7.1 General

For a cylinder operating to the working pressure, the design shall identify the maximum size of an allowable defect at any point in the cylinder that will not grow to a critical size within the specified retesting period, or within the service life if a retest is not specified. Calculations for leak-before-break performance and allowable defect size shall be in accordance with the procedures specified in [Clause 14.7](#).

7.2 Stress analysis

The stresses in the cylinder shall be calculated for 20 bar, working pressure, test pressure, and design burst pressure. The calculations shall employ suitable analytical techniques to establish stress distributions at the neck, transition regions, and cylindrical part of the shell.

7.3 Manufacturing and production tests

7.3.1 General

Metal shall not be added in the process of closure at the end. Ends may be formed by spinning or forging. Each cylinder shall be examined before end-finishing operations for thickness and surface finish.

After forming, the cylinders shall be heat treated to the hardness range specified for the design. There shall be no localized heat treatment.

When a neck ring, foot ring, or attachment for support is provided, it shall be of material compatible with that of the cylinder and securely attached by a method other than welding, brazing, or soldering.

7.3.2 Non-destructive examinations

Non-destructive examinations shall be carried out in accordance with a recognized ISO or equivalent national Standard.

The following tests shall be carried out on each metal cylinder:

- (a) a hardness test in accordance with [Clause 14.8](#). Alternatively, conductivity measurements may be used, provided that a well-defined correlation is established between the tensile strength and hardness of the material; and
- (b) an ultrasonic examination in accordance with the method specified in [Clause B.4](#), or a demonstrated equivalent non-destructive method, to ensure that the maximum defect size does not exceed the size specified in the design as calculated in accordance with [Clause 14.7.2](#).

7.3.3 Hydrostatic pressure proof test

Each finished cylinder shall be hydrostatically pressure tested in accordance with [Clause 14.11](#). The manufacturer shall define the appropriate limit of permanent volumetric expansion for the test pressure used, but the permanent expansion shall not exceed 5% of the total volumetric expansion at test pressure. Cylinders not meeting the defined limit shall be rejected and either destroyed or used for batch test purposes.

7.4 Batch tests

7.4.1 Materials tests

The following shall be performed on a finished cylinder or on a coupon from the same heat treatment that is representative of a finished cylinder:

- (a) the dimensions shall be checked against the design;
- (b) one tensile test in accordance with [Clause 14.1](#) shall be performed;
- (c) for steel cylinders, three impact tests in accordance with [Clause 14.2](#) shall be performed;
- (d) for stainless steel cylinders, a batch test in accordance with BS EN 13322-2 shall be performed; and
- (e) when a protective coating is a part of the design, coating batch tests in accordance with [Clause 14.9](#) shall be performed and the protective coating shall meet the requirements of [Clause 14.9](#).

All cylinders represented by a batch test in which the test cylinder fails to meet the specified materials requirements shall be rejected, except in cases where heat-treated cylinders fail to meet the requirements of mechanical tests, in which event the cause of the failure shall be determined. Two repeat sets of tests may then be carried out on two or more randomly selected cylinders of the same batch. If all repeated test pieces pass, the batch shall be acceptable, provided that each cylinder also meets the manufacturer's specification for hardness, non-destructive examination, and hydrostatic pressure testing. Otherwise, the batch shall be reheat treated and all required batch tests shall be repeated. Cylinders shall not be reheat treated more than once.

When the coating fails to meet the requirements of [Clause 14.9](#), the entire batch shall be inspected to remove similarly defective cylinders. Defective cylinders may be stripped of their coating and recoated. The coating batch test shall then be repeated.

7.4.2 Burst test

One cylinder selected from each batch shall be hydrostatically pressurized to burst in accordance with the test procedure specified in [Clause 14.12](#). The burst pressure shall meet or exceed the minimum required burst pressure; otherwise, the batch shall be rejected.

The container used for the cycle test specified in [Clause 7.4.4](#) may be used for the burst test. If the burst pressure of the cycled container is less than the minimum required burst pressure, an additional burst test shall be conducted on another container selected from the batch. The burst pressure on the additional container shall meet or exceed the minimum required burst pressure; otherwise, the batch shall be rejected.

7.4.3 Periodic burst test

The first five sequential batches of a design family (i.e., with the same materials, processes, and stress levels, but allowing different sizes) shall be burst tested in accordance with [Clause 14.12](#). If a cylinder from any batch fails to meet the minimum required burst pressure, the batch shall be rejected.

If five sequential batches pass the burst test, subsequent burst tests shall be performed on every tenth batch manufactured. If more than three months have passed since the first batch of cylinders was burst tested, a cylinder from the next batch of cylinders manufactured shall be burst tested.

If a cylinder fails to meet the minimum burst test requirement, the batch shall be rejected and a representative cylinder from each of the next ten batches shall be burst tested.

7.4.4 Pressure-cycling test

One cylinder shall be pressure-cycle tested, in accordance with [Clause 14.13](#), for 750 cycles times the specified service life in years. If the cylinder fails to meet the minimum pressure-cycle requirement, the batch shall be rejected.

7.4.5 Periodic pressure-cycling test

The first five sequential batches of a design family (i.e., with the same materials, processes, and stress levels, but allowing different sizes) shall be tested to a minimum of 11 250 cycles at a rate not to exceed 10 cycles/min. If a cylinder from any batch fails to meet this requirement, the batch shall be rejected.

If five sequential batches pass the cycling test, subsequent pressure-cycling tests shall be performed on every tenth batch manufactured. If more than three months have passed since the last batch of cylinders was cycle tested, a cylinder from the next batch of cylinders manufactured shall be cycle tested.

If a cylinder fails to meet the minimum pressure-cycle requirement, the batch shall be rejected and a representative cylinder from each of the next ten batches shall be cycle tested to re-establish confidence.

7.5 Design qualification tests

7.5.1 General

Qualification testing shall be performed on finished cylinders that are representative of normal production and complete with identification marks. Selection, witnessing, and documentation of the results shall be in accordance with [Clause 6.13](#).

7.5.2 Hydrostatic pressure burst test

Three representative cylinders shall be hydrostatically pressurized to failure in accordance with [Clause 14.12](#). The cylinder burst pressures shall exceed the minimum burst pressure calculated in accordance with the stress analysis for the design and shall be at least 450 bar.

7.5.3 Ambient temperature pressure-cycling test

Three finished cylinders shall be pressure cycled to failure or to 2250 cycles times the specified service life in years at an ambient temperature in accordance with [Clause 14.13](#). The cylinders shall not fail before reaching 750 cycles times the specified service life in years. Cylinders exceeding 750 cycles times the specified service life in years shall be allowed to fail by leakage but not by rupture. Cylinders that do not fail within 2250 cycles times the specified service life in years shall be destroyed, either by continuing the cycling until failure occurs or by hydrostatically pressuring to burst. The number of cycles to failure and the location of the failure initiation shall be recorded.

7.5.4 Bonfire tests

Tests shall be performed in accordance with and meet the requirements of [Clause 14.15](#).

7.5.5 Penetration tests

Tests shall be performed in accordance with and meet the requirements of [Clause 14.16](#).

7.5.6 Leak-before-break performance tests

Tests shall be performed in accordance with and meet the requirements of [Clause 14.7.1](#).

8 Type 2 hoop-wrapped cylinders

8.1 General

During pressurization, the Type 2 cylinder behaves in such a way that the displacements of the composite overwrap and the metal liner are linearly superimposed. Because of different manufacturing techniques, this Standard does not provide a definitive method for design.

Calculation of the leak-before-break performance and the critical crack size for the non-destructive examination of the metal liner shall be in accordance with the procedures specified in [Clause 14.7](#).

8.2 Design

8.2.1 Metal liner

The metal liner shall have a minimum burst pressure of 1.25 times the working pressure.

8.2.2 Composite overwrap

The tensile stress in the fibres shall meet the requirements of [Clause 6.6](#).

8.2.3 Stress analysis

After pre-stress, the stresses in the composite and in the liner shall be calculated. The pressures used for these calculations shall be zero, 20 bar, working pressure, test pressure, and design burst pressure. The calculations shall employ suitable analytical techniques to take account of non-linear material behaviour of the liner and to establish stress distributions at the neck, transition regions, and cylindrical part of the liner.

For designs using autofrettage to provide pre-stress, the limits within which the autofrettage pressure needs to fall shall be calculated. For designs using controlled-tension winding to provide pre-stress, the temperature at which controlled-tension winding is performed, the tension required in each layer of composite, and the consequent pre-stress in the liner shall be calculated.

8.3 Manufacturing

8.3.1 General

The composite cylinder shall be fabricated from a liner overwrapped with circumferential continuous filament windings. Filament winding operations shall be computer or mechanically controlled. The

filaments shall be applied under controlled tension to develop the design composite thickness. After winding is complete, thermosetting resins shall be cured by heating, using a predetermined and controlled time–temperature profile.

8.3.2 Liner

The manufacturing of a metal liner shall meet the requirements of [Clause 7.3](#) for the appropriate type of liner construction. The weight of each liner without overwrap shall be documented.

8.3.3 Overwrap

8.3.3.1 General

The cylinders shall be fabricated in a filament-winding machine. During winding, the significant variables shall be documented in a winding record. These variables can include, but are not limited to,

- (a) band width;
- (b) fibre type, including sizing;
- (c) manner of impregnation;
- (d) number of rovings;
- (e) temperature of the liner;
- (f) temperature of the resin;
- (g) type of resin and composition;
- (h) winding speed; and
- (i) winding tension.

8.3.3.2 Curing of thermosetting resins

If a thermosetting resin is used, it shall be cured after filament winding. During curing, the curing cycle (i.e., the time–temperature history) shall be documented.

The curing temperature shall be controlled and not affect the material properties of the liner. The maximum curing temperature for cylinders with aluminum liners shall be 177 °C (350°F).

8.3.4 Autofrettage

Autofrettage, if used, shall be performed before the hydrostatic pressure test. The autofrettage pressure shall be within the limits established in accordance with [Clause 8.2.3](#).

8.4 Production testing

8.4.1 Non-destructive examinations

Non-destructive examinations shall be performed in accordance with a recognized ISO or equivalent national Standard.

The following tests shall be performed on each metal liner:

- (a) a hardness test in accordance with [Clause 14.8](#), at the centre and domed end. Alternatively, conductivity measurements may be used, provided that a well-defined correlation is established between the tensile strength and hardness of the material; and
- (b) an ultrasonic examination in accordance with the method specified in [Clause B.4](#), or a demonstrated equivalent non-destructive method, to ensure that the maximum defect size does not exceed the size specified in the design as calculated in accordance with [Clause 14.7.2](#).

8.4.2 Hydrostatic pressure proof test

Each finished cylinder shall be hydrostatically pressure tested in accordance with [Clause 14.11](#). The manufacturer shall define the appropriate limit of permanent volumetric expansion for the test pressure used, but the permanent expansion shall not exceed 5% of the total volumetric expansion at test pressure. Cylinders not meeting the defined rejection limit shall be rejected and either destroyed or used for batch test purposes.

8.5 Batch tests

8.5.1 Materials tests

Cylinder dimensions and liner mechanical properties shall meet the requirements of [Clause 7.4.1](#).

8.5.2 Burst tests

Batch burst tests shall be performed in accordance with [Clause 7.4.2](#) or [7.4.3](#).

8.5.3 Pressure-cycling tests

Batch pressure-cycling tests shall be performed in accordance with [Clause 7.4.4](#) or [7.4.5](#).

8.6 Design qualification tests

8.6.1 General

Qualification testing shall be performed on finished cylinders that are representative of normal production and complete with identification marks. Selection, witnessing, and documentation of the results shall be in accordance with [Clause 6.13](#).

8.6.2 Hydrostatic pressure burst test

8.6.2.1

One liner shall be hydrostatically pressurized to failure in accordance with [Clause 14.12](#). The burst pressure shall exceed the minimum burst pressure specified for the liner design.

8.6.2.2

Three representative cylinders shall be hydrostatically pressurized to failure in accordance with [Clause 14.12](#). The cylinder burst pressures shall exceed the specified minimum burst pressure established by the stress analysis for the design, in accordance with the requirements of [Clause 6.6](#).

8.6.3 Ambient temperature pressure-cycling test

Two finished cylinders shall be pressure cycled to failure or to 2250 cycles times the specified service life in years at an ambient temperature in accordance with [Clause 14.13](#). One of these cylinders shall be tested with the manufacturer's specified mounting straps attached to the cylinder.

The cylinders shall not fail before reaching 750 cycles times the specified service life in years. Cylinders exceeding 750 cycles times the specified service life in years shall be allowed to fail by leakage and not by rupture; however, cylinders exceeding 2250 cycles times the specified service life in years shall be allowed to fail by rupture. Cylinders that do not fail within 2250 cycles times the specified service life in years shall be destroyed by continuing the cycling until failure occurs or hydrostatically pressurizing to burst. The number of cycles to failure and the location of the failure initiation shall be recorded.

8.6.4 Extreme-temperature pressure-cycling test

One cylinder shall be tested in accordance with and meet the requirements of [Clause 14.14](#).

8.6.5 Bonfire test

Finished cylinders shall be tested in accordance with and meet the requirements of [Clause 14.15](#).

8.6.6 Penetration test

One finished cylinder shall be tested in accordance with and meet the requirements of [Clause 14.16](#).

8.6.7 Flaw tolerance tests

One finished cylinder shall be tested in accordance with and meet the requirements of [Clause 14.17](#).

8.6.8 High-temperature creep test

In designs where the glass-transition temperature of the resin does not exceed the maximum design material temperature by at least 20 °C (68°F), one cylinder shall be tested in accordance with and meet the requirements of [Clause 14.18](#).

8.6.9 Accelerated stress rupture test

One finished cylinder shall be tested in accordance with and meet the requirements of [Clause 14.19](#).

8.6.10 Environmental test

One finished cylinder shall be tested in accordance with and meet the requirements of [Clause 14.22](#).

8.6.11 Leak-before-break performance tests

Three finished cylinders shall be tested in accordance with and meet the requirements of [Clause 14.7.1](#).

9 Type 3 fully wrapped cylinders

9.1 General

During pressurization, the Type 3 cylinder behaves in such a way that the displacements of the composite overwrap and the liner are superimposed. Because of different manufacturing techniques, this Standard does not provide a definitive method for design.

Calculation of the leak-before-break performance and the critical crack size for the non-destructive examination of the metal liner shall be in accordance with the procedures specified in [Clause 14.7](#).

9.2 Design requirements

9.2.1 Composite overwrap

The tensile stress in the fibres shall meet the requirements of [Clause 6.6](#).

9.2.2 Stress analysis

The stresses in the tangential and longitudinal directions of the cylinder, in the composite and liner, shall be calculated for zero pressure, 20 bar, working pressure, test pressure, and design burst pressure. The limits within which autofrettage pressure needs to fall shall be calculated. The calculations shall employ suitable analytical techniques to take account of non-linear material behaviour of the liner and to establish stress distributions at the neck, transition regions, and cylindrical part of the liner.

9.3 Manufacturing

The manufacturing requirements specified in [Clause 8.3](#) shall apply, except that the overwrap shall also include helically wound filaments.

9.4 Production tests

The production test requirements specified in [Clause 8.4](#) shall apply.

9.5 Batch tests

Batch tests shall be performed in accordance with [Clause 8.5](#).

9.6 Design qualification tests

9.6.1 General

Design qualification tests shall be performed in accordance with [Clauses 8.6](#) and [9.6.2](#), except that the test specified in [Clause 8.6.11](#) shall not apply.

9.6.2 Drop test

One or more finished cylinders shall be drop tested in accordance with [Clause 14.20](#).

10 Type 4 all-composite cylinders

10.1 General

Because of the variety of possible cylinder designs, this Standard does not provide a definitive method for the design of cylinders with polymeric liners.

10.2 Design

10.2.1 General

Design calculations shall be used to justify design adequacy. The tensile stress in the fibres shall meet the requirements of [Clause 6.6](#).

Only straight threads in accordance with [Clause 6.10.3](#) shall be used on the metal end-bosses. Metal end-bosses with threaded openings shall be able to withstand a torque force of 500 N•m (370 ft•lb) without damaging the integrity of the connection to the non-metallic liner.

10.2.2 Stress analysis

The stresses in the tangential and longitudinal direction of the cylinder in the composite and in the liner shall be calculated. The pressures used for these calculations shall be zero, working pressure, test pressure, and design burst pressure. The calculations shall employ suitable analytical techniques to establish stress distributions throughout the cylinder.

10.3 Materials — Metal end-bosses

The metal end-bosses connected to the non-metallic liner shall be of a material compatible with the service conditions specified in [Clause 4](#).

10.4 Manufacturing

10.4.1 General

The composite cylinder shall be fabricated from a liner overwrapped with circumferential and helical continuous filament windings. Filament winding operations shall be computer or mechanically controlled. The filaments shall be applied under controlled tension to develop the design composite thickness. After winding is complete, thermosetting resins shall be cured by heating, using a predetermined and controlled time-temperature profile.

10.4.2 Overwrap

The cylinders shall be fabricated in a filament-winding machine. During winding, the significant variables shall be documented in a winding record. These variables can include, but are not limited to,

- (a) band width;
- (b) fibre type, including sizing;
- (c) manner of impregnation;
- (d) number of rovings;
- (e) temperature of the liner;
- (f) temperature of the resin;
- (g) type of resin and composition;
- (h) winding speed; and
- (i) winding tension.

10.4.3 Curing of thermosetting resins

If a thermosetting resin is used, it shall be cured after filament winding. During curing, the curing cycle (i.e., the time–temperature history) shall be documented.

The curing temperature shall be controlled and not affect the material properties of the liner.

10.5 Production testing

10.5.1 Hydrostatic pressure proof test

Each finished cylinder shall be hydrostatically pressure tested in accordance with [Clause 14.11](#). The pressure range over which the elastic expansion is measured shall be from not more than 10% of the working pressure to not less than the test pressure. Cylinders not meeting the defined rejection limit shall be rejected and destroyed.

10.5.2 Leak test

Each finished cylinder with fused liner joints or bonded bases shall be leak tested in accordance with and meet the requirements of [Clause 14.10](#).

10.6 Batch tests

10.6.1 Materials tests

Cylinder dimensions and liner mechanical properties shall meet the requirements of [Clause 7.4.1](#).

10.6.2 Burst tests

Batch burst tests shall be performed in accordance with [Clause 7.4.2](#) or [7.4.2](#).

10.6.3 Pressure-cycling tests

Batch pressure-cycling tests shall be performed in accordance with [Clause 7.4.4](#) or [7.4.5](#). Prior to cycling, the cylinder shall be subjected to the boss torque test in [Clause 14.24](#). Following the cycle test, the cylinder shall be leak tested in accordance with the method described in [Clause 14.10](#) and meet the requirements of that clause.

10.7 Design qualification tests

10.7.1 General

Design qualification tests shall be performed in accordance with [Clauses 9.6](#) and [10.7.2](#) to [10.7.4](#), except that [Clauses 8.6.2.1](#) and [8.6.11](#) shall not apply.

10.7.2 Permeation test

One cylinder shall be tested for permeation in accordance with and meet the requirements of [Clause 14.21](#).

10.7.3 Gas cycling test

One cylinder shall be tested in accordance with and meet the requirements of [Clause 14.23](#).

10.7.4 Boss torque test

One cylinder shall be tested in accordance with and meet the requirements of [Clause 14.24](#).

11 Marking

On each cylinder the manufacturer shall provide clear, permanent markings at least 6 mm (0.25 in) high. The markings shall take the form of labels incorporated into resin coatings, labels attached by adhesive, low-stress stamps used on the thickened ends of Type 1 and Type 2 designs, or a combination of these methods. Adhesive labels and their application shall meet the requirements of UL 969. Multiple labels shall be allowed, and all labels shall be located in such a way that they are not obscured by mounting brackets. Each cylinder complying with this Standard shall be marked with the following:

- (a) **"CNG ONLY"**, **"CNG and HYDROGEN BLENDS ONLY"**, or **"HYDROGEN ONLY"**, as applicable;
- (b) **"DO NOT USE AFTER YYYY/MM"**, i.e., the year and month of expiry (the expiry date shall not exceed the specified service life);
Note: *The expiry date marking may be applied to the cylinder at the time of dispatch, provided that the cylinder has been stored in a dry location without internal pressure.*
- (c) manufacturer's identification;
- (d) cylinder identification (applicable part number and a serial number unique to the cylinder);
- (e) working pressure in bar (psi) at temperature in Celsius (Fahrenheit);
- (f) **"CSA B51"**, along with cylinder type and a Canadian Registration Number (described in [Clause 4.3](#) of Part 1 of this Standard); and
- (g) a statement on how to obtain information on qualified fire protection systems.

Note: *The following information may be provided on a separate label:*

- (a) temperature range, e.g., 40 to 57 °C (40 to 135°F);
- (b) nominal water capacity of the cylinder to two significant numbers, e.g., 60 L (2.1 ft³); and
- (c) date of original pressure test (month and year).

The markings shall be placed in the sequence listed, but the specific arrangement may be varied to match the available space. An acceptable example of mandatory information is

CNG ONLY

DO NOT USE AFTER 2009/03

Manufacturer/Part Number/Serial Number 200 bar (2900 psi) 15 °C (59°F)

CSA B51 Type 2 (Canadian Registration Number)

Use only manufacturer-approved pressure-relief device.

12 Preparation for dispatch

Before dispatch from the manufacturer's shop, every container shall be internally cleaned and dried, and every cylinder shall be inspected as required by the manufacturer. Cylinders not immediately closed by the fitting of a valve, and safety devices if applicable, shall have plugs that prevent entry of fluids and protect threads fitted to all openings. A corrosion inhibitor (e.g., oil-containing) shall be sprayed into all steel cylinders and liners before dispatch.

The statement of service required by [Clause 5.2](#) and all necessary information to ensure proper installation and safe use of the cylinder shall be supplied to the purchaser.

13 Quality control

13.1 General

Quality control programs shall be established and operated to ensure that cylinders will be produced in accordance with the approved

- (a) design; and
- (b) written manufacturing procedures and inspection and test procedures that were used to produce the cylinders that passed the design qualification tests.

Quality control systems shall be approved and monitored by a nationally recognized agency or registrar, e.g., the National Board of Boiler and Pressure Vessel Inspectors, the American Gas Association Laboratories, Underwriters Laboratories, the Quality Management Institute, or the British Standards Institute.

13.2 Manufacturer's quality control system

The manufacturer's quality control system shall comply with the applicable requirements of ISO 9001 or an equivalent Standard, except that if the design is developed by an organization other than the cylinder producer, the design organization shall have a quality control system that meets the requirements of ISO 9001 or an equivalent Standard.

The quality control system shall cover all aspects of cylinder manufacture for which the manufacturer is responsible. If a quality control system other than ISO 9001 is adopted, the equivalency of the adopted quality control system to the ISO system in all respects shall be demonstrated to and approved by the regulatory authority.

13.3 Manufacturer's quality control system manual

The manufacturer's quality control system manual shall document all elements, requirements, and provisions of the quality control system adopted by the manufacturer. The system shall be described in a comprehensive and orderly manner in the form of written policies, procedures, and instructions that will permit a clear and consistent understanding of the manufacturer's intent with respect to quality control.

13.4 Audit of manufacturer's quality control system

13.4.1

A nationally recognized agency shall appoint an audit team to determine whether the manufacturer's system can be approved. The audit team shall have at least one member who is experienced in the relevant cylinder technology and at least one member who is a specialist in quality control.

13.4.2

The audit team shall assess the quality control system described in the manufacturer's manual and shall visit all facilities covered by the manual to determine whether an acceptable quality control system has been implemented. The audit shall include all elements covered by ISO 9001 (see [Clause 13.2](#)).

13.4.3

The manufacturer shall be notified of the audit team's assessment and given the opportunity to correct any deficiencies.

13.4.4

Audits shall be repeated every three years if the manufacturer wishes to maintain certification.

13.4.5

A nationally recognized agency or its agents shall carry out minor reviews of the manufacturer's quality control system every six months or, if considered necessary, shall make unexpected visits to the manufacturer's facilities.

13.4.6

For the purpose of auditing or monitoring the operation of the quality control system, the manufacturer shall allow the nationally recognized agency entrance to locations where cylinders are designed, produced, inspected, tested, stored, or shipped. The manufacturer shall also allow access to all quality control system documentation, including inspection reports, test data, calibration data, and personnel qualification reports.

13.5 Certification of the manufacturer

A nationally recognized agency shall provide appropriate certification to a manufacturer whose quality control system is approved. The certification shall indicate the type of cylinder it covers, any limitations that apply, and the date when it expires and a new audit is required.

13.6 Maintenance of the manufacturer's quality control system

A manufacturer with a certified quality control system shall

- (a) keep the approved system in use and enforce conformity with its provisions with respect to any cylinders made and shipped under this Standard;
- (b) inform the certifying agency of any intended changes to the quality control system and only implement such changes after the agency has evaluated them and determined that the system will still satisfy the requirements of this Standard after the changes have been made; and
- (c) make the documentation of the quality control system, including revisions and records of decisions or reports from the independent inspection agency, accessible to the certifying agency for a period equal to the service life of any approved cylinder produced under the quality control system.

13.7 Independent inspection agency's quality control system

The independent inspection agency's quality control system shall meet the applicable requirements of CSA CAN3-Z299.2, ISO 9001, or an equivalent Standard approved by the nationally recognized agency.

13.8 Third-party inspection of production

13.8.1

The manufacturer shall arrange for third-party inspection of cylinder production to the registered design, either by a nationally recognized authority or its independent inspection agency.

13.8.2

Cylinders may be produced under an approved quality control system that allows for reduced involvement on the part of the independent inspector. The independent inspector shall visit the plant regularly to monitor the ongoing implementation of the quality control system, review documentation, and co-sign report of manufacture forms that have been prepared by the manufacturer's personnel. Independent inspectors shall note after their signature that they did not personally perform the inspections or witness the tests.

14 Test methods

14.1 Tensile tests — Steel and aluminum

Tensile tests shall be conducted in accordance with Clause 7.2 of ISO 9809-1 for steels or Clause 8.2.3 of ISO 7866 for aluminum, or using the test methods specified in ASTM E 8.

14.2 Impact test — Steel cylinders and steel liners

The impact test on steel in the finished cylinder or liner shall be conducted in accordance with ISO 148-1 or ASTM E 23. The impact test pieces shall be taken from the wall of the cylinder in the transverse direction. The notch plane orientation shall be in the centre-line direction (i.e., perpendicular to the circumference and along the length), as shown in ASTM E 399. Test pieces with a width of less than 5 mm (0.2 in) shall be taken from the longitudinal direction. The inside and outside cylinder surfaces of the test piece shall not be machined in the vicinity of the notch; if the wall thickness does not permit a final test piece width of 10 mm (0.4 in), the width shall be as near as practicable to the nominal thickness of the cylinder wall. Impact testing shall be conducted at $-40\text{ }^{\circ}\text{C}$ (-40°F).

14.3 Sulphide stress cracking test — Steel

The ultimate tensile strength of the steel from a finished container shall not exceed 1200 MPa (175 000 psi). If the upper limit of the specified ultimate tensile strength exceeds 950 MPa (138 000 psi), the steel shall be tested in accordance with the procedures specified in "Method A — NACE standard tensile test" of NACE TM0177. Tests shall be conducted on at least three tensile specimens with a gauge diameter of 3.81 mm (0.150 in) machined from the wall of a finished cylinder or liner. The specimens shall

be placed under a constant tensile load equal to 60% of the specified minimum yield strength of the steel and immersed in a solution of distilled water buffered with 0.5% (wt/wt) sodium acetate trihydrate and adjusted to an initial pH of 4.0 using acetic acid. The solution shall be continuously saturated at room temperature and pressure with 0.414 kPa (0.06 psia) hydrogen sulphide (balance nitrogen). The tested specimens shall not fail within the 144 h duration of the test.

14.4 Stress corrosion cracking tests — Aluminum

Corrosion tests for aluminum alloys shall be conducted in accordance with and meet the requirements of Annex A of ISO 7866.

14.5 Sustained load cracking test — Aluminum

The resistance to sustained load cracking test shall be conducted in accordance with and meet the requirements of Annex B of ISO 7866.

14.6 Coating performance tests

Coatings shall be evaluated using the following test methods:

- (a) Adhesion testing shall be conducted in accordance with ASTM D 3359, using Method A or B, as applicable. The coating shall exhibit an adhesion rating of 4A or 4B, as applicable.
- (b) Flexibility shall be in accordance with ASTM D 522, using Test Method B with a 12.7 mm (0.5 in) mandrel at the specified thickness at -20°C (-4°F). Samples for the flexibility test shall be prepared in accordance with ASTM D 522. There shall not be any visually apparent cracks.
- (c) Impact resistance shall be in accordance with ASTM D 2794. The coating at room temperature shall pass a forward impact test of 18 J (160 lbf).
- (d) Chemical resistance shall be in accordance with ASTM D 1308. The tests shall be conducted using the open spot test method and 100 h exposure to a 30% sulphuric acid solution (battery acid with a specific gravity of 1.219) and 24 h exposure to a polyalkylene glycol (e.g., DOT 3 brake fluid). There shall be no evidence of lifting, blistering, or softening of the coating. The adhesion shall meet a rating of 3 when tested in accordance with ASTM D 3359.
- (e) Minimum 1000 h exposure shall be in accordance with ASTM G 154. There shall be no evidence of blistering. Adhesion shall attain a rating of 3 when tested in accordance with ASTM D 3359. The maximum allowable gloss loss shall be 20%.
- (f) Minimum 500 h exposure shall be in accordance with ASTM B 117. Undercutting shall not exceed 2 mm (0.079 in) at the scribe mark, there shall be no evidence of blistering, and adhesion shall attain a rating of 3 when tested in accordance with ASTM D 3359.
- (g) Resistance to chipping at room temperature shall be in accordance with ASTM D 3170. The coating shall have a rating of 7A or better, and there shall not be any exposure of the substrate.

14.7 Fracture performance tests

14.7.1 Leak-before-break performance test

For Type 1 and Type 2 designs, three finished cylinders shall be hydraulically pressure cycled at ambient temperature, between not more than 20 bar and not less than 1.5 times the working pressure, and at a rate not to exceed 10 cycles/min. All cylinders shall either fail by leakage or exceed three times the maximum number of filling cycles.

14.7.2 Determination of non-destructive examination defect size by flawed-cylinder cycling

For Type 1, Type 2, and Type 3 designs, three cylinders containing artificial defects that exceed the defect length and depth detection capability of the non-destructive examination method specified in [Clause 6.15.2](#) shall be pressure cycled to failure in accordance with the test method specified in [Clause 14.13](#). For Type 1 designs with a fatigue-sensitive site in the cylindrical part, external flaws shall be introduced on the side wall. For Type 1 designs with a fatigue-sensitive site outside the side wall, and for

Type 2 and Type 3 designs, internal flaws shall be introduced. Internal flaws may be machined before the heat treatment and closing of the end of the cylinder.

The cylinders shall not leak or rupture in less than 750 cycles times the specified service life in years.

The allowable defect size for non-destructive examination shall be equal to or less than the artificial flaw size for the given location.

14.8 Brinell or Rockwell hardness test

A hardness test shall be conducted at the centre of each cylinder and liner in accordance with ISO 6506-1 or ISO 6508-1. The test shall be conducted after the final heat treatment, and the hardness values thus determined shall be in the range specified for the design.

14.9 Coating batch tests

14.9.1 Coating thickness

The thickness of the coating shall meet the requirements of the design when tested in accordance with one of the following test methods, as applicable:

- (a) ASTM D 1186;
- (b) ASTM D 1400; or
- (c) ASTM D 4138.

14.9.2 Coating adhesion

The coating adhesion strength shall be measured in accordance with ASTM D 3359 and have a minimum rating of 4 when measured in accordance with Test Method A or B, as applicable. An equivalent national Standard may be used in lieu of ASTM D 3359.

14.10 Leak test

Type 4 designs shall be leak tested using the following procedure (or an appropriate alternative):

- (a) Cylinders shall be thoroughly dried and pressurized to 1.25 times the working pressure with inert gas and/or a detectable gas such as natural gas, hydrogen, or helium.
- (b) Cylinders shall be placed in an enclosure to permit detection of leaks.

A leak shall be cause for rejection.

14.11 Hydrostatic pressure proof test

14.11.1

Each cylinder shall be hydrostatically tested to at least 1.5 times the working pressure. The test pressure shall not exceed the autofrettage pressure.

14.11.2

Pressure shall be maintained for 30 s or longer to ensure complete expansion. If the test pressure cannot be maintained because of test apparatus failure, the test may be repeated at a pressure increased by 6.9 bar (100 psig). There shall be not more than two repeat tests.

14.11.3

The manufacturer shall define and record the appropriate limit of elastic and permanent volumetric expansion for the test pressure used. Cylinders not meeting the defined limit shall be destroyed.

14.12 Hydrostatic pressure burst test

14.12.1

The rate of pressurization shall not exceed 14 bar/s (200 psi/s) at pressures exceeding 80% of the design burst pressure. If the rate of pressurization at pressures exceeding 80% of the design burst pressure

exceeds 3.5 bar/s (50 psi/s), either the cylinder shall be placed schematically between the pressure source and the pressure measurement device or there shall be a 5 s hold at the minimum design burst pressure.

14.12.2

The minimum required (calculated) burst pressure shall be at least 2.25 times the working pressure or 450 bar, whichever is greater, and not less than the value necessary to meet the stress ratio requirements. The actual burst pressure shall be recorded. Rupture may occur in the cylindrical or dome region of the cylinder.

14.13 Ambient temperature pressure-cycling test

Pressure cycling shall be performed in accordance with the following procedure:

- (a) The cylinder to be tested shall be filled with a non-corrosive fluid such as oil, inhibited water, or glycol.
- (b) The pressure in the cylinder shall be cycled between not more than 20 bar and not less than 1.25 times the working pressure or 260 bar, whichever is greater, at a rate not to exceed 10 cycles/min. The cylinders shall not fail before reaching 750 cycles times the specified service life in years. Cylinders exceeding 750 cycles times the specified service life in years shall be allowed to fail by leakage and not by rupture; however, for Type 3 and Type 4 designs, cylinders exceeding 2250 cycles times the specified service life in years shall be allowed to fail by rupture. For Type 2, Type 3, and Type 4 designs, the fibres in the overwrap shall not be allowed to fail. Cylinders that do not fail within 2250 cycles times the specified service life in years shall be destroyed by continuing the cycling until failure occurs or hydrostatically pressurizing to burst.

The number of cycles to failure and the location of the failure initiation shall be reported. A description of the failure initiation shall be included in the report.

14.14 Extreme-temperature pressure-cycling test

Finished cylinders with their composite wrapping free of protective coating shall be cycle tested without showing evidence of rupture, leakage, or fibre unravelling, as follows:

- (a) For natural gas or hydrogen blends service:
 - (i) The cylinders shall be conditioned for 48 h at zero pressure, at a temperature of 65 °C (135°F) or higher, in an atmosphere with 95% or greater relative humidity. This requirement shall be deemed to have been met by spraying with a fine spray or mist of water in a chamber kept at 65 °C (135°F).
 - (ii) The cylinders shall be hydrostatically pressurized for 375 cycles times the specified service life in years between not more than 20 bar and not less than 260 bar or 1.25 times the working pressure, whichever is greater, at a temperature of 65 °C (135°F) or higher and 95% humidity.
 - (iii) The cylinders shall be stabilized at zero pressure and ambient temperature.
 - (iv) The cylinders shall be pressurized from not more than 20 bar to not less than working pressure for 375 cycles times the specified service life in years at -40 °C (-40°F) or a lower temperature.
 - (v) The pressure cycling rate specified in Item (ii) shall not exceed 10 cycles/min. The pressure-cycling rate specified in Item (iv) shall not exceed 3 cycles/min unless a pressure transducer is installed directly within the cylinder. Adequate recording instrumentation shall be provided to ensure that the minimum temperature of the fluid is maintained during the low-temperature cycling. Following pressure cycling at extreme temperatures, cylinders shall be hydrostatically pressurized to failure in accordance with the hydrostatic burst test requirements specified in [Clause 14.12](#) and achieve a minimum burst pressure of 85% of the minimum design burst pressure. For Type 4 designs, the cylinder shall be leak tested in accordance with [Clause 14.10](#) before the hydrostatic burst test.
- (b) For hydrogen service:
 - (i) The cylinders shall be conditioned for 48 h at zero pressure, at a temperature of 85 °C (185°F) or higher, in an atmosphere with 95% or greater relative humidity. This requirement shall be deemed to have been met by spraying with a fine spray or mist of water in a chamber kept at 85 °C (185°F).

- (ii) The cylinders shall be hydrostatically pressurized for 375 cycles times the specified service life in years between not more than 20 bar and not less than 1.25 times the working pressure, at a temperature of 85 °C (185°F) or higher and 95% humidity.
- (iii) The cylinders shall be stabilized at zero pressure and ambient temperature.
- (iv) The cylinders shall be pressurized from not more than 20 bar to not less than working pressure for 375 cycles times the specified service life in years at –40 °C (–40°F) or a lower temperature.
- (v) The pressure cycling rate specified in Item (ii) shall not exceed 10 cycles/min. The pressure-cycling rate specified in Item (iv) shall not exceed 3 cycles/min unless a pressure transducer is installed directly within the cylinder. Adequate recording instrumentation shall be provided to ensure that the minimum temperature of the fluid is maintained during the low-temperature cycling. Following pressure cycling at extreme temperatures, cylinders shall be hydrostatically pressurized to failure in accordance with the hydrostatic burst test requirements specified in [Clause 14.12](#) and achieve a minimum burst pressure of 85% of the minimum design burst pressure. For Type 4 designs, the cylinder shall be leak tested in accordance with [Clause 14.10](#) before the hydrostatic burst test.

14.15 Bonfire test

14.15.1 General

The bonfire test is designed to demonstrate that finished cylinders, complete with pressure-relief devices specified in the design, will prevent the rupture of the cylinder when tested under the specified fire conditions.

Because cylinder rupture can occur, extreme caution shall be exercised during fire testing.

14.15.2 Cylinder set-up

The cylinder shall be placed in a horizontal position with its bottom approximately 100 mm (4 in) above the fire source. Metal shielding shall be used to prevent direct flame impingement on cylinder valves, fittings, and pressure-relief devices. The metal shielding shall not be in direct contact with the specified fire protection system (pressure-relief devices or cylinder valve).

Any failure during the testing of a valve, a fitting, or tubing that is not part of the intended protection system for the design shall invalidate the result.

14.15.3 Fire source

A uniform fire source 1.65 m (65 in) in length shall provide direct flame impingement on the cylinder surface across its entire diameter.

Any fuel may be used for the fire source, provided that it supplies uniform heat sufficient to maintain the specified test temperatures. Selection of a fuel should take into consideration air pollution concerns. The arrangement of the fire shall be recorded in sufficient detail to ensure that the rate of heat input to the cylinder is reproducible.

Any failure of or inconsistency in the fire source during a test shall invalidate the result.

14.15.4 Temperature and pressure measurements

Surface temperatures shall be monitored by at least three thermocouples fastened to the bottom of the cylinder and spaced not more than 0.75 m (29.5 in) apart.

Metal shielding shall be used to prevent direct flame impingement on the thermocouples.

Thermocouple temperatures and the cylinder pressure shall be recorded every 30 s during the test.

14.15.5 General test requirements

Cylinders used for natural gas or hydrogen blends service shall be pressurized with natural gas to working pressure and tested in the horizontal position.

Cylinders used for hydrogen service shall be pressurized with hydrogen to working pressure and tested in the horizontal position.

Immediately following ignition, the fire shall produce flame impingement on the surface of the cylinder along the 1.65 m (65 in) length of the fire source and across the cylinder diameter.

Within 5 min of ignition, the temperature of at least one thermocouple shall be at least 590 °C (1100°F). This minimum temperature shall be maintained until the end of the test.

14.15.6 Cylinders 1.65 m (65 in) in length or shorter

The centre of the cylinder shall be positioned over the centre of the fire source.

14.15.7 Cylinders longer than 1.65 m (65 in)

If the cylinder is fitted with a pressure-relief device at one end, the fire source shall originate at the opposite end of the cylinder.

If the cylinder is fitted with pressure-relief devices at both ends, or at more than one location along the length of the cylinder, the centre of the fire source shall be placed midway between the pressure-relief devices that are separated by the greatest horizontal distance.

14.15.8 Acceptable result

The cylinder shall vent through a pressure-release device without bursting.

If venting occurs in less than 5 min, the fire test shall continue for at least 5 min to demonstrate that the minimum test temperature conditions have been achieved.

14.16 Penetration test

A cylinder pressurized to working pressure with compressed gas shall be penetrated by a bullet with a diameter of 7.62 mm (0.3 in) or greater. The bullet shall completely penetrate at least one side wall of the cylinder. For Type 2, Type 3, and Type 4 designs, the bullet shall strike the sidewall at an approximate angle of 45°. The cylinder shall not rupture. The approximate size of the entrance and exit openings and their locations shall be recorded.

14.17 Flaw tolerance test

For Type 2, Type 3, and Type 4 designs only, one finished cylinder, complete with protective coating, shall have two flaws cut into the composite in the longitudinal direction. One flaw shall be a minimum of 25 mm (1 in) long and 1.25 mm (0.05 in) deep, and the other flaw shall be a minimum of 200 mm (8 in) long and 0.75 mm (0.03 in) deep.

The flawed cylinder shall then be pressure cycled from not more than 20 bar to not less than 260 bar or 1.25 times the working pressure, whichever is greater, for 2250 cycles, followed by an additional 9000 cycles at ambient temperature. The cylinder shall not fail within the first 2250 cycles, but shall be allowed to fail by leakage during the last 9000 cycles. All cylinders that complete this test shall be destroyed.

14.18 High-temperature creep test

A high-temperature creep test shall be required for all Type 4 designs and for all Type 2 and Type 3 designs in which the glass-transition temperature of the resin does not exceed the maximum design material temperature by 20 °C (36°F) or more. One cylinder shall be tested as follows:

- (a) After all manufacturing operations but prior to the hydrostatic pressure proof test, the cylinder shall be pressurized to the maximum fill pressure and held at a temperature 20 °C (68°F) above the maximum design material temperature for not less than 200 h.
- (b) Following the test, the cylinder shall meet the requirements of the leak test ([Clause 14.10](#)), the hydrostatic pressure proof test ([Clause 14.11](#)), and the hydrostatic pressure burst test ([Clause 14.12](#)).

14.19 Accelerated stress rupture test

For Type 2, Type 3, and Type 4 designs only, one cylinder free of protective coating shall be hydrostatically pressured to working pressure or 260 bar (3770 psi), whichever is greater. For natural gas and hydrogen blends service, the cylinder shall be held at this pressure and at a temperature of 65 °C (135°F) for 1000 h.

For hydrogen service, the cylinder shall be held at this pressure and at a temperature of 85 °C (185 °F) for 1000 h. The cylinder shall then be pressurized to burst in accordance with the procedure specified in [Clause 14.12](#), except that the burst pressure shall exceed 85% of the minimum design burst pressure.

14.20 Drop test

One or more finished cylinders shall be drop tested at ambient temperature without internal pressurization or attached valves. The surface onto which the cylinders are dropped shall be a smooth and horizontal concrete pad or flooring. One cylinder shall be dropped in a horizontal position, with the bottom 1.83 m (72 in) above the surface onto which it is dropped. One cylinder shall be dropped vertically, on each end, from a height above the floor or pad sufficient to produce potential energy of 488 J (360 ft•lb), but the height of the lower end above the floor or pad shall not be greater than 1.83 m (72 in). One cylinder shall be dropped at a 45° angle onto its dome from a height such that the centre of gravity is at 1.83 m (72 in); however, if the lower end is closer to the ground than 0.6 m (24 in), the drop angle shall be changed to maintain a minimum height of 0.6 m (24 in) and a centre of gravity of 1.83 m (72 in). The cylinder shall be allowed to bounce on the concrete pad or flooring after the initial impact. No attempt shall be made to prevent this secondary impacting.

Following the drop impact, the cylinders shall be pressure cycled from not more than 20 bar (290 psi) to not less than 1.25 times the working pressure or 260 bar (3770 psi), whichever is greater, for 750 cycles times the specified service life in years. The cylinders shall not leak or rupture within the first 2250 cycles but shall be allowed to fail by leakage during further pressure cycling. Cylinders completing the cycling test shall be destroyed.

14.21 Permeation test

The permeation test shall be required only for Type 4 designs. For natural gas service, one finished cylinder shall be filled with compressed natural gas to the working pressure, placed in an enclosed sealed cylinder at ambient temperature, and monitored for leakage for a time sufficient to establish a steady-state permeation rate. The permeation rate shall be less than 0.25 mL of natural gas per hour per litre of the water capacity of the cylinder.

For hydrogen blends or hydrogen service, one finished cylinder shall be filled with hydrogen to the working pressure, placed in an enclosed sealed cylinder at ambient temperature, and monitored for leakage for a time sufficient to establish a steady-state permeation rate. The permeation rate shall be less than 2 mL of hydrogen gas per hour per litre of the water capacity of the cylinder.

14.22 Environmental test

14.22.1 Test cylinder

One cylinder shall be tested, including coating if applicable.

Five distinct areas shall be marked on the upper section of the horizontal cylinder. Each shall be nominally 100 mm (4 in) in diameter. Each area shall be preconditioned with an impact from a pendulum impactor, followed by fluid exposure. To facilitate testing, the five areas need not be oriented along a single line, but they shall not overlap.

Although preconditioning and fluid exposure shall take place on the cylindrical section of the cylinder, all of the cylinder, including the domed ends, shall be as resistant to the exposure environments as the exposed areas.

14.22.2 Pendulum impact preconditioning

The impact body shall be made of steel and be in the shape of a pyramid with equilateral triangular faces and a square base. The summit and the edges shall be rounded to a radius of 3 mm (0.12 in). The centre of percussion of the pendulum shall coincide with the centre of gravity of the pyramid; its distance from the axis of rotation of the pendulum shall be 1 m (39 in). The total mass of the pendulum referred to its centre of percussion shall be 15 kg (33 lb). The energy of the pendulum at the moment of impact shall be not less than 30 N•m or as close to that value as possible.

During pendulum impact, the cylinder shall be held in position by the end-bosses or by the intended mounting brackets. Each of the five marked areas shall be preconditioned by an impact of the pendulum body summit at the centre of the area. The cylinder shall be unpressurized during preconditioning.

14.22.3 Environmental fluids for exposure

Each marked area shall be exposed to one of the following fluids:

- (a) sulphuric acid: 19% solution by volume in water;
- (b) sodium hydroxide: 25% solution by weight in water;
- (c) methanol/gasoline: 5% methanol and 95% gasoline concentration of M5 fuel meeting the requirements of ASTM D 4814;
- (d) ammonium nitrate: 28% by weight in water; or
- (e) windshield washer fluid (50% by volume solution of methyl alcohol and water).

When exposed, the cylinder shall be oriented in such a way that the exposure areas are uppermost. A pad of glass wool approximately 0.5 mm (0.02 in) thick and between 90 and 100 mm (3.5 and 4 in) in diameter shall be placed on each exposure area. An amount of fluid sufficient to ensure that the pad is wetted evenly across its surface and through its thickness for the duration of the test, and to ensure that the concentration of the fluid is not changed significantly during the test, shall be applied to the glass wool.

14.22.4 Pressure cycle and pressure hold

Cylinders shall be hydraulically pressure cycled between 20 bar (290 psi) or less and 1.25 times the working pressure or 260 bar (3770 psi), whichever is greater, for a total of 2250 pressure cycles. The maximum pressurization rate shall be 27.5 bar/s (399 psi/s). After pressure cycling, the container shall be pressurized to 1.25 times the working pressure or 260 bar (3770 psi), whichever is greater, and held at that pressure until the time of exposure to the environmental fluids has elapsed.

14.22.5 Acceptable result

The fuel cylinder shall not rupture or leak during the test. The cylinder shall be hydraulically pressurized to burst following the procedure specified in [Clause 14.12.1](#). The cylinder shall have a burst pressure of at least 85% of the design minimum burst pressure.

14.23 Gas cycling test

One finished cylinder shall be pressure cycled, using compressed natural gas for natural gas service and compressed hydrogen for hydrogen blends and hydrogen service, from less than 20 bar (290 psi) to working pressure for 1000 cycles. Each cycle, consisting of the filling and venting of the cylinder, shall not exceed 1 h. The cylinder shall be leak tested in accordance with [Clause 14.10](#) and meet the requirements of [Clause 14.10](#). Following completion of the gas cycling, the cylinder shall be sectioned and the liner and liner/end-boss interface inspected for evidence of deterioration, e.g., fatigue cracking or electrostatic discharge.

14.24 Boss torque test

The body of the cylinder shall be restrained against rotation and a torque of 500 N•m (370 ft•lb) shall be applied to each end-boss of the cylinder, first in the direction that would tighten the thread connection, then in the opposite direction, and finally again in the tightening direction. The cylinder shall then meet the leak test requirements of [Clause 14.10](#).

Table 1
Impact values
(See [Clause 6.3.2.4.](#))

Width of test piece, mm	Direction of test	Impact energy, J/cm ² *
< 5	Longitudinal	60
5–7.5	Transverse	44
7.6–10	Transverse	50

*Required average of three specimens. Not more than one specimen shall break at less than the average value required and no specimen shall break at less than 70% of the average value.

Table 2
Stress ratios
(See [Clause 6.6.](#))

Material	Type 2 hoop-wrapped	Type 3 fully wrapped	Type 4 all-composite
Aramid	2.25	3.0	3.0
Carbon	2.25	2.25	2.25
Glass	2.65	3.5	3.5

Table 3
Design qualification tests
(See [Clause 6.13.](#))

Test and clause reference	Cylinder type			
	Type 1	Type 2	Type 3	Type 4
14.7.1 Leak-before-break cycle	X	X	—	—
14.12 Burst	X	X	X	X
14.13 Ambient temp. cycle	X	X	X	X
14.14 Extreme-temp. cycle	—	X	X	X
14.15 Bonfire	X	X	X	X
14.16 Penetration	X	X	X	X
14.17 Flaw tolerance	—	X	X	X
14.18 High-temp. creep	—	X	X	X
14.19 Stress rupture	—	X	X	X
14.20 Drop	—	—	X	X
14.21 Permeation	—	—	—	X
14.22 Environmental*	—	X	X	X

*Required only when no protective coating is used.

Table 4
Batch tests
(See [Clause 6.14.](#))

Test and clause reference		Cylinder type			
		Type 1	Type 2	Type 3	Type 4
14.1	Tensile	X	X*	X*	—
14.2	Impact (steel)	X	X*	X*	—
14.9	Coating	X	X†	X†	X*
14.12	Burst	X	X	X	X
14.13	Ambient temp. cycle	X	X	X	X

*Tests on liner material.

†Except where no protective coating is used.

Table 5
Design change qualification tests
 (See [Clause 6.16.](#))

Design change	Test and clause reference										
	Sulphide stress cracking, 14.3	Burst, 14.12	Ambient temp. cycle, 14.13	Extreme-temp. cycle, 14.14	Bonfire, 14.15	Pene-tration, 14.16	Flaw tolerance, 14.17	High-temp. creep, 14.18/ Stress rupture, 14.19	Drop, 14.20	Permeation, 14.21	Environ-mental, 14.22/ Coating performance, 14.6
Manufacturer	—	X	X	—	—	—	—	X*	—	X†	—
Metal cylinder or liner material	X	X	X	X*	X	X	X*	X*	—	—	—
Non-metallic liner material	—	—	X	X	X	—	—	—	—	X	—
Fibre material	—	X	X	X	X	X	X	X	—	X†	—
Resin material	—	X	—	X	—	X	X	X	—	—	—
Diameter change ≤ 20%	—	X‡	X‡	—	—	—	—	—	—	—	—
Diameter change > 20%	—	X	X	—	X	X	X*	—	X	—	—
Length change ≤ 50%	—	X‡	—	—	X§	—	—	—	—	—	—
Length change > 50%	—	X**	X**	—	X§	—	—	—	X	—	—
Dome shape	—	X	X	—	—	—	—	—	—	X†	—
Opening size increase	—	X	X**	—	—	—	—	—	—	—	—
Coating change	—	—	—	—	—	—	—	—	—	—	X
Fire protection system	—	—	—	—	X	—	—	—	—	—	—
Change in manufacturing process	X	X	X	—	—	—	—	—	—	—	—
Working pressure change ≤ 20%	—	X‡	X‡	—	—	—	—	—	—	—	—

*Test not required for metal (Type 1) designs.

†Test required only for all-composite (Type 4) designs.

‡Only one unit required for qualification.

§Test required only when length increases.

**Only one unit required for qualification for fully wrapped (Type 3) and all-composite (Type 4) designs.

Annex A (informative)

Report forms

Note: *This Annex is not a mandatory part of this Standard.*

A.1

The following forms should be used:

- (a) report of manufacturing and certification of conformance, in the format shown in [Figure A.1](#);
- (b) report of chemical analysis of material for metal containers, liners, or bosses, in a format of the manufacturer's choosing;
- (c) report of mechanical properties of material for metal containers and liners, in a format of the manufacturer's choosing; and
- (d) report of physical and mechanical properties of materials for non-metallic liners, in a format of the manufacturer's choosing.

Each form should be signed by representatives of the independent inspection authority and the manufacturer.

REPORT OF MANUFACTURING AND CERTIFICATION OF CONFORMANCE FOR COMPRESSED NATURAL GAS FUEL CYLINDERS RAPPORT DE FABRICATION ET CERTIFICAT DE CONFORMITÉ DES BOUTEILLES DE GAZ NATUREL COMPRIMÉS	
Manufactured by/Construit par _____ Located at/Adresse _____ Canadian Registration Number/Numéro d'enregistrement canadien _____ Manufacturer's mark and number/Marque et numéro du constructeur _____ Serial numbers/Numéros de série _____ to/à _____, inclusive Container description/Description du récipient _____ Size/Dimensions: Diameter/Diamètre _____ mm Length/Longueur _____ mm Marks stamped on shoulder or on labels of the cylinder are <i>Les marques estampées sur l'épaulement ou les étiquettes de la bouteille sont</i>	
a) "CNG ONLY"/«GNC SEULEMENT» b) "DO NOT USE AFTER"/«NE PAS UTILISER APRÈS» _____ YYYY/MM/(année/mois) c) Manufacturer's mark/Marque du constructeur _____ d) Serial or part number/Numéro de série ou de pièce _____ e) Working pressure in bar @ °C/Pression de service en bars @ °C _____ bar @ _____ °C f) CSA B51 cylinder type/Type de bouteille CSA B51 _____ CRN/NEC _____ g) Fire protection/Protection contre le feu _____ type h) Original test (month and year)/Date de l'essai initial (mois-année)* _____ i) Water capacity in L/Capacité en eau en L* _____ L j) Test pressure in bar/Pression d'essai en bars _____ bar k) Any special instructions/Instructions spéciales _____	
*Not mandatory/Pas obligatoire Each container was made in compliance with all of the requirements of CSA Standard B51, Part 2, and in accordance with the CRN specified above. Required reports of test results are attached. <i>La fabrication de chaque récipient est conforme à toutes les exigences de la norme CSA B51, Deuxième partie et au NEC susmentionné. Les rapports exigés à l'égard des résultats des essais sont en annexe.</i> I hereby certify that all of these test results proved satisfactory in every way and are in compliance with the requirements of CSA Standard B51, Part 2, and the CRN specified above. <i>Je certifie par la présente que ces résultats des essais sont satisfaisants de tous points de vue et qu'ils sont conformes aux exigences de la norme CSA B51, Deuxième partie, et au NEC susmentionné.</i> Comments/Commentaires _____ _____ (Authorized body or inspection agency/Organisme autorisé ou organisme d'inspection) _____ (Inspector's signature/Signature de l'inspecteur) _____ (Manufacturer's signature/Signature du constructeur) _____ Place/Lieu _____ Date _____	

Figure A.1
Report of manufacturing and certification of conformance
for compressed natural gas fuel cylinders
 (See [Clause A.1.](#))

Annex B (informative)

Procedure for requalifying all-steel natural gas vehicle storage cylinders

Note: This informative Annex has been written in normative language to facilitate its adoption where users of the Standard or regulatory authorities wish to adopt it formally as additional requirements to this Standard.

B.1 Introduction

This Annex establishes the minimum requirements for requalifying cylinders that are designed or used under Part 2 or 3 of this Standard and have reached the end of the service period specified by their manufacturers.

The design life of an all-metal steel cylinder, which is based on the rate of fatigue crack growth in the cylinder wall, is determined by a variety of factors, including material properties, the number of pressure cycles, the wall stress associated with the pressure cycle amplitude, and the nature of the crack-initiating feature on the cylinder.

B.2 Cylinder types and service conditions

B.2.1 Cylinder types covered

The types of cylinders covered in this Annex are

- (a) steel vehicle cylinders that
 - (i) are designed for use as on-board fuel storage containers for vehicles powered by natural gas; and
 - (ii) are provincially registered in accordance with this Standard;
- (b) steel vehicle cylinders that
 - (i) are designed for use as on-board fuel storage containers for vehicles powered by natural gas;
 - (ii) meet the requirements of Part 2 of this Standard; and
 - (iii) are given a special permit by Transport Canada; and
- (c) steel ground storage cylinders that
 - (i) are designed for the transportation of dangerous goods; and
 - (ii) are
 - (1) registered with Transport Canada in accordance with CSA B339 to the TC-3AAM specification; or
 - (2) approved by the United States Department of Transportation (U.S. DOT) to the 3AA specification.

B.2.2 Service conditions

Part 2 of this Standard specifies the service conditions for cylinders that are used for the on-board storage of natural gas as a fuel for automotive vehicles and designed to comply with the requirements of Part 2.

Part 3 of this Standard and CAN/CSA-B108 specify the service conditions for cylinders used for the storage of gas at natural gas vehicle fuelling facilities as part of a cascade or buffer system. These Standards specify pressures for the most common working pressure used in Canada, i.e., the P30 (200 bar) operating system. Accommodation for higher-pressure systems shall be made in any requalification procedure; the procedure for accommodating higher pressures is described in [Clause 1.3](#) of Part 2 of this Standard.

B.3 Visual inspection procedure

B.3.1 Original markings

The inspector (the person responsible for requalifying the cylinders) shall ensure that the original markings on the cylinder are clearly visible and unambiguous. If the markings do not include an identification of the manufacturer, the cylinder serial number, and the design registration number, the cylinder shall not be requalified under this procedure.

B.3.2 Visual damage

Before ultrasonic inspection, the cylinder shall be visually inspected in accordance with ISO 19078 for heat damage, dents, gouges, or severe external corrosion. A cylinder that fails the visual inspection shall be destroyed.

B.3.3 Cleaning

To ensure the accuracy of the ultrasonic inspection, any surface roughness that would interfere with that inspection shall be removed. All cylinders shall be drained of fluids.

B.4 Ultrasonic inspection

B.4.1 Introduction

Clause B.4 is based on the ultrasonic inspection techniques described in Annex B of ISO 9809-1. Other inspection techniques may be used if they have been demonstrated to be suitable for the detection of the reference notches.

B.4.2 General requirements

The ultrasonic testing equipment shall be capable of detecting, at a minimum, the reference standards specified in [Clauses B.4.3.2](#) and [B.4.5.2](#). The equipment shall be serviced regularly in accordance with the manufacturer's operating instructions to ensure that its accuracy is maintained. Inspection records and approval certificates for the equipment shall be maintained.

The testing equipment shall be operated by trained personnel and supervised by qualified and experienced personnel certified to Level 2 of CAN/CGSB 48.9712/ISO 9712.

The outer and inner surfaces of a cylinder that is to be tested ultrasonically shall be in a condition suitable for an accurate and reproducible test.

For flaw detection, the pulse echo system shall be used. For thickness measurement, the resonance method or the pulse echo system shall be used. Contact or immersion testing techniques shall be used. A coupling method that ensures adequate transmission of ultrasonic energy between the testing probe and the cylinder shall be used.

B.4.3 Flaw detection in the cylinder sidewall

B.4.3.1 Procedure

The cylinder to be inspected and the search unit shall have a rotating motion and translation relative to one another such that a helical scan of the cylinder will be described. The velocity of rotation and translation shall be constant within $\pm 10\%$. The pitch of the helix shall be less than the width covered by the probe (at least 10% overlapping shall be guaranteed) and be related to the effective beam width in a way that ensures 100% coverage at the velocity of rotation and translation used during the calibration procedure.

An alternative scanning method in which the scanning or relative movement of the probes and the work piece is longitudinal may be used for transverse defect detection. The sweeping motion shall ensure 100% surface coverage, with about 10% overlapping of the sweeps.

The cylinder wall shall be tested for longitudinal defects with the ultrasonic energy transmitted in both circumferential directions and for transverse defects in both longitudinal directions.

The effectiveness of the equipment shall be periodically checked by submitting a reference standard to the test procedure. At a minimum, this check shall be carried out at the beginning and end of each shift. If during this check the appropriate reference notch is not detected, all cylinders tested subsequent to the last acceptance check shall be retested after the equipment has been reset.

B.4.3.2 Sidewall reference standard

A reference standard of convenient length shall be prepared from a cylinder sidewall of similar diameter and wall thickness range, and made of material with the same acoustic characteristics and surface finish as the cylinder to be inspected. The reference standard shall be free from discontinuities that could interfere with the detection of the reference notches.

Reference notches, both longitudinal and transverse, shall be machined on the outer and inner sidewall surfaces of the standard. The notches shall be separated in such a way that each notch can be clearly identified.

The dimensions and shape of notches are crucially important for the adjustment of the equipment and shall meet the following requirements:

- (a) The length of a notch shall not be greater than 25 mm.
- (b) The width of a notch shall not be greater than 1 mm.
- (c) The depth of a notch shall be $5 \pm 0.75\%$ of the wall thickness over the full length of the notch. There may be runouts at each.
- (d) A notch shall be sharp-edged at its intersection with the surface of the cylinder wall. The cross-section of a notch shall be rectangular except where spark-erosion machining methods are employed, in which case the bottom of the notch shall be rounded.
- (e) The shape and dimensions of a notch shall be demonstrated by an appropriate method.

B.4.3.3 Calibration of equipment

The equipment shall be adjusted to provide clearly identifiable indications from inner and outer reference notches in accordance with the sidewall reference standard specified in [Clause B.4.3.2](#). The amplitude of the indications shall be as close to identical as possible. The indication of smallest amplitude shall be used as the rejection level and for the setting of visual, audible, recording, or sorting devices. The equipment shall be calibrated with the reference standard or probe, or both, moving in the same manner, direction, and speed as will be used during the inspection of the cylinder. All visual, audible, recording, and sorting devices shall operate satisfactorily at the test speed.

B.4.4 Wall thickness measurement

One hundred per cent of the cylindrical part shall be examined to ensure that the wall thickness is not less than the minimum design thickness and that the reduction in wall thickness is less than 5% of the typical wall thickness of the cylinder being examined. The sidewall reference standard specified in [Clause B.4.3.2](#) shall be used to calibrate the thickness measurement.

B.4.5 Flaw detection in the cylinder ends

B.4.5.1 Procedure

The entire surface of the ends shall be examined using a 45° angle probe.

The scans shall be made as follows:

- (a) with the probe parallel to the longitudinal axis; and
- (b) with the probe at right angles to the longitudinal axis.

Each scan shall be carried out with the probe pointing in one direction and then repeated with the probe reversed. In addition, a scan shall be carried out at the root of the neck with the probe held at an angle of 45° to the longitudinal axis of the cylinder and then repeated with the probe turned to 90°. The scans shall be made using probes with maximum dimensions of 10 to 20 mm (0.4 to 0.8 in), the smaller probes being used to scan the root of the neck.

Scans shall begin or terminate at points 50 mm (2 in) along the parallel part of the cylinder. Each scan shall overlap the previous scan by 25%.

B.4.5.2 End reference standards

A reference standard of convenient length shall be prepared from a cylinder head end and a cylinder base end of similar diameter and wall thickness range, and made of material with the same acoustic characteristics and surface finish as the cylinder to be inspected. The reference standard shall be free from discontinuities that could interfere with the detection of the reference notches.

Reference notches, both longitudinal and transverse, shall be machined on the outer and inner surfaces of the standard head end and base end. The notches shall be separated in such a way that each notch can be clearly identified. At the head end, the notches shall be located in the neck curvature near the base of the threads. At the base end, the notches shall be located in the curved portion of the transition adjacent to the cylinder sidewall.

The dimensions and shape of notches are crucially important for the adjustment of the equipment and shall meet the following requirements:

- (a) The length of a notch shall not be greater than 25 mm.
- (b) The width of a notch shall not be greater than 1 mm.
- (c) The depth of a notch shall be $10 \pm 0.75\%$ of the wall thickness over the full length of the notch. There may be runouts at each end.
- (d) A notch shall be sharp-edged at its intersection with the surface of the cylinder wall. The cross-section of a notch shall be rectangular except where spark-erosion machining methods are employed, in which case the bottom of the notch shall be rounded.
- (e) The shape and dimensions of a notch shall be demonstrated by an appropriate method.

B.4.6 Assessment of results

B.4.6.1 General

If surface defects are removed by grinding, the cylinders shall also be subjected to ultrasonic defect detection and thickness measurement after the grinding. Cylinders continuing to show defects at points of minimum design thickness shall be deemed not to comply with the requirements of this procedure.

B.4.6.2 Acceptance criteria for steel vehicle cylinders

The following acceptance criteria shall apply:

- (a) The acceptance criterion for the sidewall of a cylinder design that meets the requirements of Part 2 of this Standard shall be as specified in [Table B.1](#).
- (b) The acceptance criterion for the ends of a cylinder design that meets the requirements of Part 2 of this Standard shall be the absence of any defect indication that is equal to or greater than the end reference notches.

B.4.6.3 Acceptance criteria for steel storage cylinders

The following acceptance criteria shall apply:

- (a) The acceptance criterion for the sidewall of a storage cylinder that meets the TC-3AAM or U.S. DOT 3AA specification shall be as specified in [Table B.2](#).
- (b) The acceptance criterion for the ends of a cylinder design that meets the TC-3AAM or U.S. DOT 3AA specification shall be the absence of any defect indication that is equal to or greater than the end reference notches.

B.4.6.4 Destruction of cylinders that fail the inspection

Cylinders that fail the sidewall or end inspection shall be destroyed.

B.5 Protective coating

B.5.1 Recoating

Cylinder designs registered to Part 2 of this Standard for vehicle use shall be recoated to meet the requirements of [Clause 14.9](#). Stamping marks shall also be coated.

Cylinders used for dedicated ground storage service in accordance with Part 3 of this Standard shall be recoated with a coating system that is capable of protecting the cylinder for the duration of the requalification period. Stamping marks shall also be coated.

B.5.2 Visibility of markings

Requalifying agencies shall ensure that all markings are visible after a cylinder has been recoated and before the cylinder is shipped.

B.6 Stamping or labelling procedure

B.6.1 Unique marking

A requalified cylinder shall be marked with a unique marking that will identify the agency approved or recognized by the authority having jurisdiction over the cylinder designs covered by this procedure for the requalification of cylinders. This marking shall be registered with the authority having jurisdiction.

B.6.2 Length of requalification period

Cylinders that have been requalified shall be marked with a retest due date that is not more than 15 years from the date of inspection.

The service life of steel vehicle cylinders shall not exceed 30 years from the date of manufacture.

B.6.3 Use after requalification

If not previously marked, a requalified cylinder shall be marked CNG ONLY. The lettering shall be at least 6 mm (0.24 in) high.

B.6.4 Expiry Date — Steel vehicle cylinders

Steel vehicle cylinders that have been requalified shall be labelled with the words DO NOT USE AFTER followed by the year of expiry (at most, 15 years from the date of ultrasonic inspection or 30 years from the date of manufacture, whichever comes first). The lettering shall be at least 6 mm (0.24 in) high. The following is an example:

DO NOT USE AFTER 2023
(Inspector's stamp)

B.6.5 Expiry Date — Steel storage cylinders

Conventional transportation cylinders that have been requalified shall be marked with the letters UE followed by the year of inspection. Immediately underneath that marking shall be a marking consisting of the word DUE followed by a year that is not more than 15 years from the date of ultrasonic inspection. The lettering shall be at least 6 mm (0.24 in) high. The following is an example:

UE 2008
DUE 2023
(Inspector's stamp)

B.7 Storage and shipment procedure

For a cylinder where the valve has been removed, the internal surfaces of the cylinder shall be sprayed with a vapour-phase corrosion inhibitor (or equivalent). The cylinder shall then be sealed to atmosphere for storage or transport.

B.8 Documentation

A record of the inspection and stamping shall be made for each requalified cylinder. An example of an acceptable form is provided in [Figure B.1](#). Records shall be kept for at least 15 years by the agency identified in [Clause B.6.1](#). One copy of the completed form for each cylinder shall be provided to the cylinder owner.

B.9 Quality control system

The quality control system for the inspection of cylinders used by the agency identified in [Clause B.6.1](#) shall comply with the requirements of [Clause 13](#).

Table B.1
Acceptance criteria for steel vehicle cylinders
(See [Clause B.4.6.2](#).)

Crack depth (D) expressed as a % of wall thickness	Permissible crack length, mm
$D \leq 4\%$	No limit
$4\% < D \leq 5\%$	8 or less
$5\% < D \leq 7\%$	6 or less
$7\% < D \leq 10\%$	5 or less
$10\% < D \leq 15\%$	4 or less
$D > 15\%$	Not acceptable

Table B.2
Acceptance criteria for steel storage cylinders
(See [Clause B.4.6.3](#).)

Crack depth (D) expressed as a % of wall thickness	Permissible crack length, mm
$D \leq 4\%$	No limit
$4\% < D \leq 5\%$	36 or less
$5\% < D \leq 6\%$	26 or less
$6\% < D \leq 7\%$	22 or less
$7\% < D \leq 8\%$	18 or less
$8\% < D \leq 9\%$	14 or less
$9\% < D \leq 10\%$	12 or less
$D > 10\%$	Not acceptable

Cylinder owner <i>Propriétaire de la bouteille</i>	Cylinder manufacturer <i>Fabricant de la bouteille</i>	Serial no. <i>N° de série</i>	Date of manufacture <i>Date de fabrication</i>	Retest date <i>Date de reprise des essais</i>	Results <i>Résultats</i>			Inspector <i>Inspecteur</i>	Comments <i>Commentaires</i>
					Sidewall <i>Paroi</i>	Neck <i>Goulot</i>	Base <i>Base</i>		

Inspector
Inspecteur _____

Date _____

Requalification agency
Agence de requalification _____

Figure B.1
Sample form for requalified cylinders
(See [Clause B.8.](#))

CSA Standard

B51-09, Part 3

***Compressed natural gas and hydrogen
refuelling station pressure piping
systems and ground storage vessels***



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B51-09, Part 3

Compressed natural gas and hydrogen refuelling station pressure piping systems and ground storage vessels

1 Scope

1.1

1.1.1

The pressure piping systems covered in Part 3 of this Standard are systems used in compressed natural gas (CNG) and hydrogen refuelling stations

- (a) between the termination of the utility's piping, usually at the meter, and the inlet to the compressor assembly if the design pressure exceeds 414 kPa (60 psi); and
- (b) from the inlet to the compressor assembly through to the dispenser nozzle, except for the mechanical parts of the compressor and any subsystems designed for 414 kPa (60 psi) or less.

1.1.2

The ground storage vessels covered in Part 3 of this Standard are pressure vessels that are installed at CNG and hydrogen refuelling stations and intended to store CNG or hydrogen at pressure for delivery to vehicle fuel tanks.

1.2

Where a clause in Part 3 of this Standard is at variance with Codes or Standards referenced in Part 3 of this Standard, the requirements of Part 3 of this Standard govern.

1.3

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.

1.4

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

2 Reference publications

Part 3 of this Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

ANSI/IAS NGV4.1-1999/CSA 12.5-M99 (R2004)

NGV dispensing systems

12.6-04

Vehicle refuelling appliances

CAN/CSA-B108-99 (R2006)

Natural gas fuelling stations installation code

CAN/CSA-B149.1-05

Natural gas and propane installation code

B339-08

Cylinders, spheres, and tubes for the transportation of dangerous goods

B340-08

Selection and use of cylinders, spheres, tubes, and other containers for the transportation of dangerous goods, Class 2

Z662-07

Oil and gas pipeline systems

ASME (The American Society of Mechanical Engineers)

Boiler and Pressure Vessel Code (2007 ed.)

Section V — Nondestructive Examination

Section VIII — Rules for Construction of Pressure Vessels — Division 1

Section VIII — Rules for Construction of Pressure Vessels — Division 2 — Alternative Rules

Section X — Fiber-Reinforced Plastic Pressure Vessels

B31.1-2007

Power Piping

B31.3-2006

Process Piping

ASTM International (American Society for Testing and Materials)

A 105/A 105M-05

Standard Specification for Carbon Steel Forgings for Piping Applications

A 106/A 106M-06a

Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A 182/A 182M-07a

Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service

A 213/A 213M-07a

Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes

A 216/A 216M-07

Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

A 312/A 312M-07

Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

A 333/A 333M-05

Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service

A 334/A 334M-04a

Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service

A 350/A 350M-07

Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components

A 352/A 352M-06

Standard Specification for Steel Castings, Ferritic and Martensitic, for Pressure-Containing Parts, Suitable for Low-Temperature Service

CGA (Compressed Gas Association)

G-5.4-2005

Standard for Hydrogen Piping Systems at Consumer Locations

3 Definition

The following definition applies in Part 3 of this Standard:

Design pressure — the maximum pressure for the adopted temperatures and cycling conditions for which a system is designed.

4 General requirements

4.1 General

Pressure piping systems and ground storage vessels shall comply with [Clause 4](#) of Part 1 of this Standard, except when the requirements of [Clause 4](#) of Part 1 of this Standard are modified by Part 3 of this Standard. Pressure vessels shall be designed in accordance with

- (a) Part 2 of this Standard;
- (b) CSA B339;
- (a) Section VIII, Division 1 or 2, of the ASME Code; or
- (b) Section X of the ASME Code.

Note: See ASME B31.1 and ASME B31.3 for piping system design and construction details.

4.2 Gas quality

Pressure piping systems and ground storage vessels shall be designed for safe operation with

- (a) natural gas composed mainly of methane but also with other constituents in amounts not exceeding the limits specified in [Clause 4.5](#) of Part 2 of this Standard; and
- (b) the hydrogen gas compositions specified in [Clause 4.5](#) of Part 2 of this Standard.

4.3 Registration

For every refuelling station installation, a site-specific drawing and bill of material for the pressure piping system shall be submitted for registration. Information on the following shall be included in the submission:

- (a) the pressure piping code of construction;
- (b) the design pressure and temperature of systems and subsystems;
- (c) material specifications (as permitted by the code of construction);
- (d) registered fittings;
- (e) registered vessels;
- (f) pre-registered piping sub-assemblies (i.e., shop-built assemblies or buried piping); and
- (g) registered temperature-compensated dispensed-pressure control systems.

Each item shall be clearly identified and all Canadian Registration Numbers shall be shown.

4.4 Inspection

4.4.1

Final inspections at the site shall include, but not be limited to, the following:

- (a) a review of a registered copy of the site-specific drawing of the pressure piping system;
- (b) a review of partial data reports substantiating the shop inspection and the witnessing of shop tests that have been carried out on pre-registered shop-fabricated piping sub-assemblies;
- (c) a review of partial data reports substantiating previous field inspections and/or witnessing field tests of buried pipe sub-assemblies;
- (d) a review of the storage vessel manufacturer's data reports;
- (e) witnessing of hydrostatic or pneumatic pressure tests in accordance with the requirements of the pressure piping code of construction for any items not previously tested in accordance with an acceptable partial data report;
- (f) witnessing of a leak test, at operating pressure, of mechanical joints between previously tested sub-assemblies;
- (g) a review of the temperature-compensated dispensed-pressure control system registration; and
- (h) a check that the temperature-compensated dispensed pressure is adjusted properly and that arrangements for subsequent control have been made.

4.4.2

A piping systems installation and test data report covering the pressure piping system at the site shall be completed and signed by the designer or installer of the system and countersigned by the authorized inspector.

In addition to ensuring that the pressure piping system and ground storage vessels comply with this Standard, owners and operators of CNG and hydrogen refuelling stations shall ensure that their stations comply with the applicable requirements of CAN/CSA-B108 and CAN/CSA-B149.1, and are inspected with respect to those requirements by the regulatory authority.

5 Compressed natural gas and hydrogen refuelling station pressure piping systems

5.1 Design

5.1.1

The design temperature range shall be, at a minimum, -20 to $+65$ °C (-4 to $+149$ °F) for buried piping and -40 to $+65$ °C (-40 to $+149$ °F) for above-ground installations, unless the system is in a temperature-controlled enclosure.

5.1.2

The minimum wall thickness of piping and tubing shall be determined in accordance with the requirements of ASME B31.1, ASME B31.3, or an alternative code acceptable to the regulatory authority.

5.1.3

ASME standard fittings shall be rated for a pressure equal to or greater than the design pressure.

5.1.4

Non-standard fittings shall be capable of withstanding a proof test of at least four times the design pressure.

5.1.5

The design of all piping systems, fittings, and vessels shall be registered as required by [Clause 4](#) of Part 1 of this Standard.

5.2 Materials

5.2.1

Piping and tubing for CNG stations shall be seamless and meet the following specifications or alternatives approved by the regulatory authority:

- (a) ASTM A 106/A 106M, Grade B: seamless carbon-steel pipe (when the pipe is not buried, impact testing shall be performed as required by Section VIII, Division 1, of the ASME Code);
- (b) ASTM A 213/A 213M: alloy-steel tubes, austenitic grades only;
- (c) ASTM A 312/A 312M: austenitic stainless steel pipe;
- (d) ASTM A 333/A 333M, Grade 6: steel pipe for low-temperature service; and
- (e) ASTM A 334/A 334M, Grade 6: steel tubes for low-temperature service.

Note: When alloy-steel tubes are subject to vibration or differential expansion, only the “bright annealed” austenitic grade should be used.

5.2.2

Piping and tubing for hydrogen stations shall conform to CGA G-5.4.

5.2.3

Flanges, fittings, valve bodies, and other piping component material for CNG stations shall meet the following specifications or alternatives approved by the regulatory authority:

- (a) ASTM A 105/A 105M: carbon-steel forgings (when the forgings are not buried, impact testing shall be performed as required by Section VIII, Division 1, of the ASME Code);
- (b) ASTM A 182/A 182M: forged or rolled alloy-steel pipe flanges, fittings, valves, etc., austenitic grades only;
- (c) ASTM A 216/A 216M, Grade WCC: carbon-steel castings;
- (d) ASTM A 350/A 350M, Grade LF2: carbon-steel forgings requiring notch toughness testing;
- (e) ASTM A 352/A 352M, Grade LCC: carbon-steel castings for low-temperature service; and
- (f) non-ferrous materials suitable for the service and meeting an appropriate ASME or ASTM specification.

5.2.4

Flanges, fittings, valve bodies, and other piping component material for hydrogen stations shall conform to CGA G-5.4.

5.3 Installation and welding

5.3.1

Above-ground piping and tubing shall be

- (a) connected by welding, threading, compression fittings, or flanges, but flared connections shall not be used;
- (b) protected against external corrosion by a suitable coating and against other damage from external sources; and
- (c) supported and anchored as required by CSA Z662.

5.3.2

Buried piping shall be connected only by welding and coated, cathodically protected, and monitored in accordance with CSA Z662.

5.4 Non-destructive examination

5.4.1

Except for joints in interstage compressor piping, butt-welded joints shall be examined radiographically over their full length in accordance with procedures specified in Section V of the ASME Code. The acceptance criteria of ASME B31.1 or ASME B31.3 shall be met.

5.4.2

Butt-welded joints in interstage compressor piping shall be examined radiographically, as required by the inspector.

5.4.3

Socket-welded joints shall be examined visually. Weld size and surface finish acceptability shall be determined by the inspector.

5.5 Pressure tests

5.5.1

Pressure testing shall be conducted in accordance with the ASME Code, ASME B31.1, or ASME B31.3, except as required or permitted by [Clauses 5.5.2 to 5.5.5](#).

5.5.2

Except as permitted by [Clause 5.5.3](#), all joints shall be hydrostatically tested to not less than 1.5 times the system design pressure or pneumatically tested to not less than 1.2 times the system design pressure.

5.5.3

Flanged, threaded, or compression-type joints made in the field to connect shop-fabricated, shop-tested sub-assemblies may be leak tested at the operating pressure of the system.

5.5.4

5.5.4.1

Where the entire system is accessible for inspection, the test pressure shall be held for 30 min or longer if necessary to inspect for leakage. When a pneumatic test is conducted, all joints shall be examined for leakage with a suitable leak-detecting solution.

5.5.4.2

If part of a system has been buried or is otherwise inaccessible for inspection, the test pressure shall be held for 24 h and a recording chart shall be used.

5.5.4.3

Any evidence of leakage shall be considered unacceptable.

5.5.5

5.5.5.1

Shop pressure tests for piping sub-assemblies required by this Standard shall be witnessed by an authorized inspector, as required by [Clause 4.8.1](#) of Part 1 of this Standard.

5.5.5.2

Pressure tests of field installations required by this Standard shall be witnessed by an authorized inspector, as required by [Clause 4.8.1](#) of Part 1 of this Standard, or by an inspector required by the authority having jurisdiction.

5.6 Overpressure protection

5.6.1

A safety valve shall be installed on the compressor outlet and set to open at or below the design pressure of the downstream system. The valve discharge capacity shall be sufficient to limit accumulation to 110% of the system design pressure.

5.6.2

Where ground storage vessels can be isolated from the safety valve required by [Clause 5.6.1](#), a protective device as required by the vessel code of construction shall be provided for each group of connected containers.

5.6.3

The pressure of CNG or hydrogen at the point where it is dispensed to cylinders that are mounted permanently on vehicles and used to store natural gas or hydrogen at ambient temperatures for use as a fuel in the vehicles shall be limited by a system that will automatically regulate the dispensed pressure to the filling limits specified in [Clause 4.2](#) of Part 2 of this Standard. The system shall meet the requirements of ANSI/IAS NGV4.1/CSA 12.5 or CSA 12.6, and shall be designed and installed to fail safe if a malfunction or valve leakage should occur and to prevent unauthorized adjustments. Adjustments, repairs, and/or servicing shall be carried out by an organization that meets the requirements of [Clause 4.9.2](#) of Part 1 of this Standard.

6 Compressed natural gas and hydrogen refuelling station ground storage vessels

6.1 Design

6.1.1

Ground storage vessels shall meet the requirements of the Standards referenced in [Clause 6.1.2](#).

"Design pressure", "working pressure", and "service pressure", which are defined terms that are used in various Standards and Codes and stamped or labelled on vessels, shall be defined in accordance with the Standard under which the vessel was produced.

6.1.2

Ground storage vessels may be located in the refuelling station piping system downstream of the compressor and upstream of the overfill protection required by [Clause 5.6.3](#), or in the piping system downstream of the overfill protection required by [Clause 5.6.3](#). Overpressure and temperature protection shall be provided in accordance with the vessel code of design.

Vessels made to the following shall be acceptable for ground storage applications:

- (a) Part 2 of this Standard;
- (b) CSA B339, provided that the vessels are selected, manufactured, and requalified in accordance with CSA B339 and CSA B340;
- (c) Section VIII, Division 1 or 2, of the ASME Code; or
- (d) Section X of the ASME Code.

6.2 Use of cylinders

Cylinders shall not be used for longer than their maximum design life. In addition, a composite cylinder shall not be used beyond the manufacturer's expiry date or for longer than 20 years from the date of its manufacture, whichever is earlier, at which time the vessel shall be removed from service and destroyed.

6.3 Requalification of steel ground storage containers

Steel ground storage containers may be requalified for further service in accordance with the procedure described in [Annex B](#) of Part 2 of this Standard.

6.4 Natural gas storage installations

Natural gas storage installations shall meet the requirements of CAN/CSA-B108.

Proposition de modification

N'hésitez pas à nous faire part de vos suggestions et de vos commentaires. Au moment de soumettre des propositions de modification aux normes CSA et autres publications CSA prière de fournir les renseignements demandés ci-dessous et de formuler les propositions sur une feuille volante. Il est recommandé d'inclure

- le numéro de la norme/publication
- le numéro de l'article, du tableau ou de la figure visé
- la formulation proposée
- la raison de cette modification.

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- Standard/publication number
- relevant Clause, Table, and/or Figure number(s)
- wording of the proposed change
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