B620-14

Highway tanks and TC portable tanks for the transportation of dangerous goods

Legal Notice for Standards

Canadian Standards Association (operating as "CSA Group") develops standards through a consensus standards development process approved by the Standards Council of Canada. This process brings together volunteers representing varied viewpoints and interests to achieve consensus and develop a standard. Although CSA Group administers the process and establishes rules to promote fairness in achieving consensus, it does not independently test, evaluate, or verify the content of standards.

Disclaimer and exclusion of liability

This document is provided without any representations, warranties, or conditions of any kind, express or implied, including, without limitation, implied warranties or conditions concerning this document's fitness for a particular purpose or use, its merchantability, or its non-infringement of any third party's intellectual property rights. CSA Group does not warrant the accuracy, completeness, or currency of any of the information published in this document. CSA Group makes no representations or warranties regarding this document's compliance with any applicable statute, rule, or regulation.

IN NO EVENT SHALL CSA GROUP, ITS VOLUNTEERS, MEMBERS, SUBSIDIARIES, OR AFFILIATED COMPANIES, OR THEIR EMPLOYEES, DIRECTORS, OR OFFICERS, BE LIABLE FOR ANY DIRECT, INDIRECT, OR INCIDENTAL DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES, HOWSOEVER CAUSED, INCLUDING BUT NOT LIMITED TO SPECIAL OR CONSEQUENTIAL DAMAGES, LOST REVENUE, BUSINESS INTERRUPTION, LOST OR DAMAGED DATA, OR ANY OTHER COMMERCIAL OR ECONOMIC LOSS, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), OR ANY OTHER THEORY OF LIABILITY, ARISING OUT OF OR RESULTING FROM ACCESS TO OR POSSESSION OR USE OF THIS DOCUMENT, EVEN IF CSA GROUP HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES, INJURY, LOSS, COSTS, OR EXPENSES.

In publishing and making this document available, CSA Group is not undertaking to render professional or other services for or on behalf of any person or entity or to perform any duty owed by any person or entity to another person or entity. The information in this document is directed to those who have the appropriate degree of experience to use and apply its contents, and CSA Group accepts no responsibility whatsoever arising in any way from any and all use of or reliance on the information contained in this document.

CSA Group is a private not-for-profit company that publishes voluntary standards and related documents. CSA Group has no power, nor does it undertake, to enforce compliance with the contents of the standards or other documents it publishes.

Intellectual property rights and ownership

As between CSA Group and the users of this document (whether it be in printed or electronic form), CSA Group is the owner, or the authorized licensee, of all works contained herein that are protected by copyright, all trade-marks (except as otherwise noted to the contrary), and all inventions and trade secrets that may be contained in this document, whether or not such inventions and trade secrets are protected by patents and applications for patents. Without limitation, the unauthorized use, modification, copying, or disclosure of this document may violate laws that protect CSA Group's and/or others' intellectual property and may give rise to a right in CSA Group and/or others to seek legal redress for such use, modification, copying, or disclosure. To the extent permitted by licence or by law, CSA Group reserves all intellectual property rights in this document.

Patent rights

Attention is drawn to the possibility that some of the elements of this standard may be the subject of patent rights. CSA Group shall not be held responsible for identifying any or all such patent rights. Users of this standard are expressly advised that determination of the validity of any such patent rights is entirely their own responsibility.

Authorized use of this document

This document is being provided by CSA Group for informational and non-commercial use only. The user of this document is authorized to do only the following:

If this document is in electronic form:
- load this document onto a computer for the sole purpose of reviewing it;
- search and browse this document; and
- print this document if it is in PDF format.

Limited copies of this document in print or paper form may be distributed only to persons who are authorized by CSA Group to have such copies, and only if this Legal Notice appears on each such copy.

In addition, users may not and may not permit others to
- alter this document in any way or remove this Legal Notice from the attached standard;
- sell this document without authorization from CSA Group; or
- make an electronic copy of this document.

If you do not agree with any of the terms and conditions contained in this Legal Notice, you may not load or use this document or make any copies of the contents hereof, and if you do make such copies, you are required to destroy them immediately. Use of this document constitutes your acceptance of the terms and conditions of this Legal Notice.

Standards Update Service

B620-14
January 2014

Title: *Highway tanks and TC portable tanks for the transportation of dangerous goods*
Pagination: 189 pages (xiii preliminary and 156 text), each dated **January 2014**

To register for e-mail notification about any updates to this publication

- go to **shop.csa.ca**
- click on **CSA Update Service**

The **List ID** that you will need to register for updates to this publication is **2422518**.

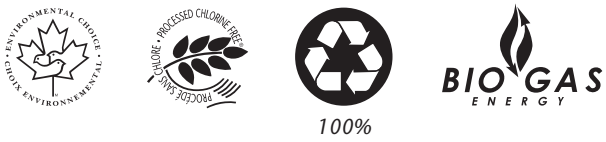
If you require assistance, please e-mail **techsupport@csagroup.org** or call 416-747-2233.

Visit CSA Group's policy on privacy at **csagroup.org/legal** to find out how we protect your personal information.

B620-14

Highway tanks and TC portable tanks for the transportation of dangerous goods

Published in January 2014 by CSA Group
A not-for-profit private sector organization
5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6
1-800-463-6727 • 416-747-4044



CSA Group prints its publications on Rolland Enviro100, which contains 100% recycled post-consumer fibre, is EcoLogo and Processed Chlorine Free certified, and was manufactured using biogas energy.

To purchase standards and related publications, visit our Online Store at ***shop.csa.ca*** *or call toll-free 1-800-463-6727 or 416-747-4044.*

ISBN 978-1-77139-339-3

Contents

Technical Committee on Highway Tanks and TC Portable Tanks for the Transportation of Dangerous Goods *ix*

Preface *xiii*

1 Scope *1*

2 Reference publications *2*

3 Terminology and definitions *5*
3.1 Terminology *5*
3.1.1 General *5*
3.1.2 The term "lethal substance" in the *ASME Boiler and Pressure Vessel Code* (ASME Code) *5*
3.2 Definitions *5*

4 General requirements *10*
4.1 Facility requirements *10*
4.2 Highway tanks *10*
4.3 Portable tanks *10*
4.4 Welding and brazing *10*
4.4.1 Welding/brazing procedure qualification *10*
4.4.2 Welder/brazer performance qualification *10*
4.5 Tank and plate markings *10*
4.6 Certificates and reports *10*

5 Specifications for highway tanks *11*
5.1 Requirements for all highway tanks *11*
5.1.1 The ASME *Code* *11*
5.1.2 Means of containment *13*
5.1.3 Securement *14*
5.1.4 Supports for attachments and appurtenances *14*
5.1.5 Rear-end protection *15*
5.1.6 Inspection, testing, and marking *17*
5.1.7 Certification *20*
5.1.8 Vehicle equipment: Exhaust system considerations *21*
5.2 Highway tanks for the transportation of liquefied compressed gases and refrigerated liquefied gases — Specification TC 331, TC 338, and TC 341 tanks *21*
5.2.1 General *21*
5.2.2 Piping, valves, and fittings *21*
5.2.3 Gauging devices *26*
5.2.4 Safety relief devices *27*
5.2.5 Tank design and test pressures *28*
5.2.6 Inner vessel or tank support pads *29*
5.2.7 Inspection openings and manholes *29*
5.2.8 Ground clearance *29*
5.3 Highway tanks primarily for the transportation of compressed gases as liquefied gas — Specification TC 331 highway tanks *30*
5.3.1 Construction standards *30*
5.3.2 Design *30*
5.3.3 Postweld heat treatment *32*
5.3.4 Material *32*

5.3.5 Material thickness *33*
5.3.6 Structural integrity *33*
5.3.7 Welding *36*
5.3.8 Refrigeration and heating coils *36*
5.3.9 Supports *37*
5.3.10 Inspection and testing *37*
5.3.11 Marking *38*
5.4 Insulated highway tanks — Specification TC 338 tanks *38*
5.4.1 Construction standards *38*
5.4.2 Design *38*
5.4.3 Insulation *39*
5.4.4 Material *39*
5.4.5 Postweld heat treatment *40*
5.4.6 Sketches *40*
5.4.7 Material thickness *40*
5.4.8 Stress calculations *41*
5.4.9 Joints *42*
5.4.10 Manholes *42*
5.4.11 Openings *42*
5.4.12 Holding time *42*
5.4.13 Inner vessel or jacket supports *44*
5.4.14 Supports for protected inner vessel *44*
5.4.15 Gauging devices *45*
5.4.16 Cleanliness *45*
5.4.17 Inspection and testing *45*
5.4.18 Marking *46*
5.4.19 Pressure relief and control *46*
5.5 Highway tanks for the transportation of nonflammable refrigerated liquefied gases — Specification TC 341 tanks *47*
5.5.1 Inner vessel construction *47*
5.5.2 Inner vessel design *47*
5.5.3 Material thickness *50*
5.5.4 Inner vessel interior *50*
5.5.5 Compatibility *50*
5.5.6 Insulation combustibility in oxygen service *50*
5.5.7 Jacket *50*
5.5.8 Materials *53*
5.5.9 Joints *54*
5.5.10 Openings and controls *54*
5.5.11 Pressure-relief devices *54*
5.5.12 Piping, valves, and fittings *55*
5.5.13 Supports and anchoring *55*
5.5.14 Gauging devices *56*
5.5.15 Inspection and testing *56*
5.5.16 Marking *56*
5.6 Highway tanks for the transportation of dangerous goods other than liquefied compressed gases — Specification TC 406, TC 407, TC 412, and TC 423 tanks *57*
5.6.1 General requirements *57*
5.6.2 Multi-tank vehicle connecting structures and drains *57*
5.6.3 Material *57*
5.6.4 Structural integrity *60*
5.6.5 Joints *62*
5.6.6 Manhole assemblies *62*
5.6.7 Supports and anchoring *63*

5.6.8 Circumferential reinforcements *63*
5.6.9 Damage protection *65*
5.6.10 Pumps, piping, hoses, and connections *68*
5.6.11 Pressure relief *69*
5.6.12 Tank outlets *71*
5.6.13 Gauging devices *72*
5.6.14 Connections for FRP tanks *72*
5.7 Highway tank vehicle — Specification TC 406 *72*
5.7.1 General *72*
5.7.2 Maximum allowable working pressure (MAWP) *72*
5.7.3 Material *72*
5.7.4 Pressure relief *73*
5.7.5 Outlets *73*
5.7.6 Specification TC 406 crude tanks *73*
5.8 Highway tank vehicle — Specification TC 407 *74*
5.8.1 General requirements *74*
5.8.2 Material *74*
5.8.3 Manhole assemblies *75*
5.8.4 Vacuum relief *75*
5.9 Highway tank vehicle — Specification TC 412 *75*
5.9.1 General requirements *75*
5.9.2 Material *75*
5.9.3 Vacuum relief *76*
5.9.4 Alternative minimum venting capacity for tanks transporting corrosive materials *76*
5.10 Highway tanks for the transportation of emulsion and water-gel explosives — Specification TC 423 *76*
5.10.1 General *76*
5.10.2 Material and material thickness *77*
5.10.3 Circumferential reinforcement *77*
5.10.4 Insulation system *77*
5.10.5 Pressure- and vacuum-relief devices *78*
5.10.6 Thermometer *79*
5.10.7 Restrictions on valves, fittings, and hardware *79*
5.10.8 Cleaning and drainage *79*
5.10.9 Security *79*
5.10.10 Electrical wires and fixtures *80*
5.10.11 Heating systems *80*
5.10.12 Pumping systems *80*
5.10.13 Structural inspection procedures *80*

6 TC portable tanks *86*
6.1 Requirements for all portable tanks *86*
6.1.1 General *86*
6.1.2 The ASME Code *86*
6.1.3 Means of containment *86*
6.1.4 Inspection, testing, and marking *86*
6.1.5 Tank mountings *88*
6.1.6 Piping, valves, and fittings *88*
6.1.7 Safety relief devices *89*
6.1.8 Certificate of Compliance *91*
6.2 Portable tanks for the transportation of liquid dangerous goods — Specification TC 60 *92*
6.2.1 Construction standards *92*
6.2.2 Postweld heat treatment *92*
6.2.3 Design *92*

6.2.4 Material thickness *92*
6.2.5 Expansion domes *92*
6.2.6 Manhole cover attachments *92*
6.2.7 Bottom openings *92*
6.2.8 Design and closures of openings *92*
6.2.9 Multi-tank units *93*
6.2.10 Lining *93*
6.3 Portable tanks for the transportation of nonflammable atmospheric gases as refrigerated liquefied gases — Specification TC 11 portable tanks *93*
6.3.1 Construction standards *93*
6.3.2 Inner vessel *93*
6.3.3 Insulation *95*
6.3.4 Jacket *96*
6.3.5 Cleanliness *96*
6.3.6 Openings and controls *96*
6.3.7 Pressure-relief devices *97*
6.3.8 Piping, valves, and fittings *97*
6.3.9 Supports and anchoring *97*
6.3.10 Gauging devices *98*
6.3.11 Inspection and testing *98*
6.3.12 Marking *98*
6.4 Portable tanks — Specification TC 44 construction standards *99*

7 Inspection, testing, and maintenance of tanks *99*
7.1 Periodic and obligatory inspection and testing *99*
7.1.1 General requirements for periodic inspection and testing *99*
7.1.2 Obligatory testing *99*
7.1.3 Decontamination *100*
7.2 Inspections and tests *100*
7.2.1 External inspection *100*
7.2.2 Internal inspection *101*
7.2.3 Lining inspection *102*
7.2.4 Upper coupler area inspection *102*
7.2.5 Leakage test *103*
7.2.6 Thickness test *104*
7.2.7 Pressure tests *104*
7.2.8 Internal inspection by the wet fluorescent magnetic particle method *106*
7.2.9 Test of off-truck emergency shutdown system *107*
7.2.10 Hose assembly inspection and testing *107*
7.2.11 Structural inspection *109*
7.3 Test and inspection reports *110*
7.3.1 General *110*
7.3.2 Welding inspection reports *110*
7.3.3 Retention of reports *110*
7.4 Test or inspection marking *110*
7.5 Repairs to tanks *111*
7.5.1 General *111*
7.5.2 Decontamination prior to repairs *111*
7.5.3 Exception — Postweld heat treatment of minor repairs *112*
7.5.4 Repair procedures for pressure tank trucks and trailers *112*
7.5.5 Overlay patches *112*
7.5.6 Field welding *112*
7.5.7 FRP tanks *112*
7.5.8 Testing and inspection of repairs *113*

7.5.9 Additional inspection for pressure tanks *113*
7.5.10 Repair reports *113*
7.5.11 Record retention and transfer *113*
7.6 Modification including remounts of previously certified tanks *113*
7.6.1 General *113*
7.6.2 Registration requirements *113*
7.6.3 Authorizations *114*
7.6.4 Decontamination prior to modifications *114*
7.6.5 Specification requirements *114*
7.6.1 Design review, identification, and approval of modifications *115*
7.6.7 Inspection and testing *116*
7.6.8 Certification *116*
7.6.9 Metal identification plates for modified tanks *116*
7.7 Illegible or missing metal identification plates *116*
7.7.1 General *116*
7.7.2 Supporting documentation *117*
7.7.3 Installation of a replacement metal identification plate *117*
7.7.4 Forms *117*

8 Facility registration, Design Engineer registration, marking, documentation, and design review requirements *123*
8.1 Facility registration *123*
8.1.1 General *123*
8.1.2 Mobile unit limitation *124*
8.1.3 Specific requirements *124*
8.1.4 Application for registration *125*
8.1.5 Design Engineer *126*
8.1.6 Tank Inspector qualification *127*
8.1.7 Tester qualification *127*
8.2 Documentation *127*
8.2.1 Certificate of Compliance *127*
8.2.2 Reports of inspections and tests during manufacture, assembly, or modification *128*
8.3 Design review *129*
8.3.1 General *129*
8.3.2 Manufacturer's Design Identification Number (MDIN) *129*
8.3.3 Transport Canada Registration Number (TCRN) *129*
8.3.4 Changes in design and tank modification *131*
8.3.5 Renewal of a TCRN *131*
8.4 Marking *131*

Annexes
A (normative) — Transition and retrofitting *132*
B (informative) — Sample registration documents *136*
C (informative) — Alternatives to internal inspection of vacuum-insulated TC 341 highway tanks *146*
D (informative) — Tests for off-truck emergency shutdown systems *152*
E (informative) — Highway and portable tank specifications *153*

Tables
5.1 — Minimum total venting capacity — Volume of free air per hour at STP for Specification TC 406, TC 407, TC 412, and TC 423 tanks *80*
5.2 — Minimum thickness of heads or bulkheads and baffles when used as tank reinforcement for mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum alloy (AL) for Specification TC 406 tanks *81*

5.3 — Minimum thickness of shell using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum (AL) for Specification TC 406 tanks *82*
5.4 — Minimum thickness of heads, bulkheads, and baffles when used as tank reinforcement using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum alloy (AL) after forming for Specification TC 407 tanks *82*
5.5 — Minimum thickness of shell using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum alloy (AL) after forming for Specification TC 407 tanks *83*
5.6 — Minimum thickness of heads (or bulkheads and baffles when used as tank reinforcement) using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum (AL) after forming for Specification TC 412 tanks *84*
5.7 — Minimum thickness of shell using steel or aluminum after forming for specification TC 412 tanks *85*
7.0 — TC specifications that apply to modification of corresponding specification tanks *115*
7.1 — Periodic inspection and test intervals *118*
7.2 — Additional periodic inspection and test intervals *119*
7.3 — Test pressures *121*
7.4 — Minimum thickness for TC and MC 306, 307, and 312 specification tanks manufactured with steel and steel alloys *122*
7.5 — Minimum thickness for TC and MC 306, 307, and 312 specification tanks manufactured with aluminum and aluminum alloys *123*

Technical Committee on Highway Tanks and TC Portable Tanks for the Transportation of Dangerous Goods

D. Ferguson	Goldec-Hamm's Manufacturing Ltd., Red Deer, Alberta	*Chair*
D. Stainrod	D.J. Stainrod & Associates Ltd., Bowmanville, Ontario	*Vice-Chair*
F. Afshar	B&M Risk Advice Inc., Markham, Ontario	*Associate*
J. Albrechtsen	Paul's Hauling Ltd., Winnipeg, Manitoba	
R. Bahia	Trimac Transportation Services, Calgary, Alberta	
R. Baker	Cryogenic Vessel Alternatives, Lafayette, Indiana, USA	
S. Bartlett	Air Products and Chemicals Inc., Allentown, Pennsylvania, USA	*Associate*
R. Boies	Gouvernement du Québec Ministère des Transports, Québec, Québec	
A. Bourgault	Gestion Robgroup Inc., Chambly, Québec	
G. Buck	Pro-Par (1978) Inc., Sherbrooke, Québec	
L. Burns	Orica Mining Services, Calgary, Alberta	*Associate*
R. Campbell	Advance Engineered Products Limited, Regina, Saskatchewan	*Associate*
G. Caron	Gibson Energy Ltd., Edmonton, Alberta	
D. Chaplow	Ball Truck and Auto Repair, St. Thomas, Ontario	
A. Chatillon	Tankcon FRP Inc., Blainville, Quebec	
P. Chilukuri	Cusco Fabricators, Inc., Richmond Hill, Ontario	*Associate*

L. Comtois	Trimac Transportation Services, Kirkland, Québec	*Associate*
J. Conley	National Tank Truck Carriers Incorporated, Alexandria, Virginia, USA	*Associate*
M. Denys	ABSA, Edmonton, Alberta	
G. Dickson	LaSalle, Manitoba	*Associate*
R. Dolyniuk	Manitoba Trucking Association, Winnipeg, Manitoba	*Associate*
P. Dubois	Service Remtec Inc., Pointe-aux-Trembles, Québec	*Associate*
B. Durstling	Gibson Energy Ltd., Edmonton, Alberta	*Associate*
A. Eleniak	Xtreme, Sylvan Lake, Alberta	
T. Hagglund	Prosolve Consulting Ltd., Edmonton, Alberta	*Associate*
J. Harpin	Alberta Transportation, Edmonton, Alberta	*Associate*
W. He	Sino-Can Energy, Richmond Hill, Ontario	*Associate*
C. Hochman	U.S. Department of Transportation, Washington, DC, USA	*Associate*
Y. Huang	Royal & SunAlliance Insurance Company of Canada, Toronto, Ontario	
J. Huby	Dixon Group Canada Ltd., Innisfil, Ontario	*Associate*
C. Hughes	Transportation Technical Resources Ltd., Calgary, Alberta	
S. Katz	S. Katz and Associates Inc., North Vancouver, British Columbia	*Associate*
C. Kirk	Tremcar Technologies Inc., St-Jean-sur-Richelieu, Québec	*Associate*
R. Lalonde	Praxair Canada Inc., St-Laurent, Québec	
S. Lam	Technical Standards & Safety Authority, Toronto, Ontario	*Associate*

R. Lloyd	Performance Industries Project and Consulting, Red Deer, Alberta	*Associate*
T. MacLean	Transport Canada, Ottawa, Ontario	*Associate*
N. Malone	Canadian Association of Oilwell Drilling Contractors, Calgary, Alberta	*Associate*
J. Meryo	Amko Service Co., Midvale, Ohio, USA	
A. Mohammed	Ensign Energy Services, Nisku, Alberta	*Associate*
B. Montague	Erleigh Associates, Burlington, Ontario	*Associate*
D. Moore	Canadian Transportation Equipment Association, St. Thomas, Ontario	*Associate*
M. Mullin	Alberta Infrastructure and Transportation, Edmonton, Alberta	
M. Natale	Dependable Truck & Tank Ltd., Brampton, Ontario	*Associate*
C. Nowak	Transport Canada, Ottawa, Ontario	
J. Olson	Olsen Logistics, Nisku, Alberta	
R. Opersko	Air Products Canada Limited, Nanticoke, Ontario	
A. Paaren	Tremcar Technologies Inc., Toronto, Ontario	
A. Park	Compressed Gas Association, Ottawa, Ontario	
R. Reid	Reid Engineering Services, Calgary, Alberta	
T. Rishel	Maxfield Inc., Crossfield, Alberta	*Associate*
T. Rogers	Container Technology Inc., Anton, Texas, USA	*Associate*
D. Savard	Innocar Inc., Lavaltrie, Québec	*Associate*
M. Shah	Technical Safety Authority of Saskatchewan, Regina, Saskatchewan	*Associate*

M. Skinner	Infrastructure Health and Safety Association, Mississauga, Ontario	*Associate*
G. Snider	Heavy Crude Hauling Ltd., Lloydminster, Alberta	*Associate*
E. Snoeberger	Alloy Custom Products, Lafayette, Indiana, USA	*Associate*
G. Stewart	Seaboard / Harmac, North York, Ontario	*Associate*
R. Strelic	Advance Engineering Products Limited, Regina, Saskatchewan	
C. Turylo	Technical Standards & Safety Authority, Toronto, Ontario	
J. Van Benthem	TE Designs, Calgary, Alberta	*Associate*
G. Vincent	Bedard Tankers, Montréal, Québec	
W. Widla	Fulton Engineered Specialties Inc., Caledon, Ontario	*Associate*
F. Zhang	Royal & SunAlliance Insurance Company of Canada, Brampton, Ontario	*Associate*
R. Meyers	CSA Group, Mississauga, Ontario	*Project Manager*

The Technical Committee thanks Kevin Green of Transport Canada (retired) for his contributions to the development of this Standard.

Preface

This is the fifth edition of CSA B620, *Highway tanks and TC portable tanks for the transportation of dangerous goods*. It supersedes the previous edition published in 2009 and editions published in 2003, 1998, and 1987 under the title *Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods*.

This Standard specifies requirements for highway tanks, portable tanks, fibre-reinforced plastic (FRP) highway tanks, and pressure/vacuum liquid waste highway tanks for the transportation of dangerous goods. It is also specifies requirements for hoses used to load or off-load dangerous goods.

It is the intent of the CSA Technical Committee to further develop this Standard in co-operation with industry representation and regulatory authorities in Canada and the United States to meet the needs of Canada and to achieve a maximum degree of uniformity with the United States.

This Standard is one of a series of Standards that have been prepared for use in conjunction with the *Transportation of Dangerous Goods Regulations*. It should be noted that this Standard, by itself, does not have the force of law unless it is officially adopted by a regulatory authority. Since the Standard may be adopted into regulations with certain exceptions or additional requirements, it is recommended that the regulations of the relevant jurisdiction be consulted in order to establish the extent to which this Standard has been adopted. Where an industry practice differs from the requirements of this Standard, an application for a permit for equivalent level of safety may be requested from the regulatory authority.

This Standard was prepared by the Technical Committee on Highway Tanks and TC Portable Tanks for Transportation of Dangerous Goods, under the jurisdiction of the Strategic Steering Committee on Mechanical Industrial Equipment Safety, and has been formally approved by the Technical Committee.

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 Standard 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 Standard.*

(4) *To submit a request for interpretation of this Standard, please send the following information to* ***inquiries@csagroup.org*** *and include "Request for interpretation" in the subject line:*
(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) where possible, phrase the request in such a way that a specific "yes" or "no" answer will address the issue.
Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are available on the* Current Standards Activities *page at* ***standardsactivities.csa.ca****.*

(5) *This Standard is subject to review five years from the date of publication. Suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to* ***inquiries@csagroup.org*** *and include "Proposal for change" in the subject line:*
(a) Standard designation (number);
(b) relevant clause, table, and/or figure number;
(c) wording of the proposed change; and
(d) rationale for the change.

B620-14
Highway tanks and TC portable tanks for the transportation of dangerous goods

1 Scope

1.1
This Standard applies to tanks, other than intermediate bulk containers and tubes, used for the transportation of dangerous goods primarily by road. It considers the design, construction, certification, assembly, modification, repair, testing, inspection and periodic retesting, maintenance, and identification of such tanks. This Standard also applies to the hoses used to load or off-load dangerous goods.

Additional design and construction requirements for tanks intended to carry specific products are provided in CSA B621, CSA B622, and CAN/CGSB-43.151.

1.2
The *Transportation of Dangerous Goods (TDG) Act* and the *Transportation of Dangerous Goods Regulations* can set out requirements that are additional to or different from those in this Standard due to particular characteristics or properties of individual dangerous goods. Where there is an inconsistency between the requirements of this Standard and those of the *Act* or *Regulations*, the *Act* or *Regulations* prevail to the extent of the inconsistency.

1.3
The use of this Standard does not reduce the necessity for competent engineering judgment or complete design calculations that take into account the intended use of the tank. The values of the various parameters in this Standard are the limiting values to which the tank is restricted. It is the responsibility of the tank manufacturer to ensure that the tank will safely carry out its intended function within these constraints.

1.4
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.

1.5
The values given in SI (metric) units are the standard. The values given in parentheses are for information only. Units for pressure refer to gauge pressure unless otherwise noted.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the edition listed below. Where there is an inconsistency between this Standard and a referenced publication other than the *TDG Act* or *Regulations*, the requirements of this Standard shall prevail. Application of a referenced publication shall be made only with careful consideration of this Standard's reference to that particular publication.

CSA Group

CAN/CGA-8.1-M86 (R2011)
Elastomeric composite hose and hose couplings for conducting propane and natural gas

CAN1-8.3-77 (R2011)
Thermoplastic hose and hose couplings for conducting propane and natural gas

B51-09
Boiler, pressure vessel, and pressure piping code

B620-1987 (superseded)
Highway tanks and portable tanks for the transportation of dangerous goods

CAN/CSA-B620-98 (superseded)
Highway tanks and portable tanks for the transportation of dangerous goods

B620-03
Highway tanks and portable tanks for the transportation of dangerous goods

B620-09
Highway tanks and TC portable tanks for the transportation of dangerous goods

B621-14
Selection and use of highway tanks, TC portable tanks, and other large containers for the transportation of dangerous goods, Classes 3, 4, 5, 6.1, 8, and 9

B622-14
Selection and use of highway tanks, TC portable tanks, and ton containers for the transportation of dangerous goods, Class 2

B626-09
Portable tank specification TC 44

ASME (American Society of Mechanical Engineers)

B31.3-2012
Process Piping

Boiler and Pressure Vessel Code, Section II, Part D, and Section VIII, Division 1, UG101 (m) (excluding addenda), 1998

Boiler and Pressure Vessel Code [excluding Section II, Part D, and Section VIII, Division 1, UG101 (m)], 2013

ASTM International (American Society for Testing and Materials)

A240/A240M-13c
Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

A242/A242M-13
Standard Specification for High-Strength Low-Alloy Structural Steel

A514/A514M-13a
Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding

A569/A569M-96 (Discontinued 2000 — see A1011)
Standard Specification for Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip Commercial Quality

A570/A570M-98 (Discontinued 2000 — see A1011)
Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled

A572/A572M-13a
Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

A588/A588M-10
Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in [100 mm] Thick

A606-09a
Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance

A607-98 (Discontinued 2000 — see A1008 and A1011)
Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Columbium or Vanadium, or Both, Hot-Rolled and Cold-Rolled

A622/A622M-97 (Discontinued 2000 — see A1011)
Standard Specification for Drawing Steel (DS), Sheet and Strip, Carbon, Hot-Rolled

A633/A633M-13
Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates

A656/A656M-00a
Standard Specification for Hot-Rolled Structural Steel, High-Strength Low-Alloy Plate with Improved Formability

A715-98 (Discontinued 2000 — see A1008 and A1011)
Standard Specification for Steel Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled, and Steel Sheet, Cold-Rolled, High-Strength, Low-Alloy, with Improved Formability

A790/A790M-13
Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe

A1008/A1008M-13
Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

A1011/A1011M-13
Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

B209M-10
Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric]

D638-10
Standard Test Method for Tensile Properties of Plastics

D651-84 (Discontinued 1989)
Method of Test for Tensile Strength of Molded Electrical Insulating Materials

D790-10
Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

D4762-11a
Standard Guide for Testing Automotive/Industrial Composite Materials

E84-13a
Standard Test Method for Surface Burning Characteristics of Building Materials

E112-12
Standard Test Methods for Determining Average Grain Size

E119-12a
Standard Test Methods for Fire Tests of Building Construction and Materials

E136-12
Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 °C

CGA (Compressed Gas Association)
CGA-341-2007 (R2011)
Specification for Insulated Cargo Tank for Nonflammable Cryogenic Liquids

G-4.1-2009
Cleaning Equipment for Oxygen Service

P-26-1997 (R2009) (formerly CGA TB-2)
Guidelines for Inspection and Repair of MC 330 and MC 331 Anhydrous Ammonia Cargo Tanks

S-1.2-2009
Pressure Relief Device Standards — Part 2 — Portable Containers for Compressed Gases

CGSB (Canadian General Standards Board)
CAN/CGSB-43.146-2002
Design, Manufacture and Use of Intermediate Bulk Containers for the Transportation of Dangerous Goods

CAN/CGSB-43.151-2012
Packaging, handling, offering for transport and transport of Explosives (Class 1)

Government of Canada
Explosives Act, R.S.C. 1985, c. E-17

Motor Vehicle Safety Act, S.C. 1993, c. 16, and *Regulations*

Transportation of Dangerous Goods Act, S.C. 1992, c. 34, and the *Transportation of Dangerous Goods Regulations*, as amended from time to time

Government of USA
US Code of Federal Regulations, Title 49, Parts 107 to 180, as amended from time to time (referenced as 49 CFR)

Natural Resources Canada
Guidelines for Pumping of Water-Based Explosives, 2003

NBBI (National Board of Boiler and Pressure Vessel Inspectors)
National Board Inspection Code (NBIC), 2013 Edition

TTMA (Truck Trailer Manufacturers Association)
Recommended Practice No. 61-98
Performance Recommendations for Manhole and/or Fill Opening Assemblies on MC 306, DOT 406, Non-ASME MC 312 and Non-ASME DOT 412 Cargo Tanks

Recommended Practice No. 81-02
Performance of Spring Loaded Pressure Relief Valves on MC 306, MC 307, MC 312, DOT 406, DOT 407, and DOT 412 Tanks

ULC (Underwriters' Laboratories of Canada)
CAN/ULC-S101-M89 (withdrawn)
Standard Methods of Fire Endurance Tests of Building Construction and Materials

CAN/ULC-S102-M88 (R2000)
Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies

CAN4-S114-M80 (R1997) (withdrawn)
Standard Method of Test for Determination of Non-Combustibility in Building Materials

3 Terminology and definitions

3.1 Terminology

3.1.1 General
The definitions, terms, and abbreviations in the *Transportation of Dangerous Goods Act and Regulations* thereto apply in this Standard.

3.1.2 The term "lethal substance" in the ASME *Boiler and Pressure Vessel Code (ASME Code)*
Wherever the term "lethal substance" is used in the ASME *Code*, for the purposes of this Standard, it refers to any dangerous good with a primary or subsidiary classification of 6.1, Packing Group I or II.

3.2 Definitions
The following definitions apply in this Standard:

Appurtenance — any tank part or accessory that has no product containment function and provides no structural support to the tank.

Assembler — a legal entity registered by Transport Canada for the assembly of highway or portable tanks.

Assembly — a portion of the fabrication process of a highway or portable tank that does not involve welding on the tank wall, on integral structural components of the tank such as the rollover dam, tank sill or baffles, and on any components such as piping that contain lading. Assembly includes any of the following functions that are necessary to meet the specification requirements prior to the certification of a highway or portable tank:
(a) the fabrication and installation of component parts of a highway or portable tank; and
(b) the mounting of one or more tanks onto a vehicle chassis or onto a vehicle suspension component.

Attachment — any part or device attached to the tank or mounting pad, including structural supports to the tank.

Baffle — a non-liquidtight transverse partition device that deflects, checks, or regulates fluid motion in a tank, and that can also provide circumferential reinforcement.

Bulkhead — a liquidtight transverse closure at the ends of or between tanks.

Companion flange — one of two mating flanges where the flange faces are in contact or separated only by a thin leak-sealing gasket and are secured to one another by bolts or clamps.

Connecting structure — the structure joining two tanks in a multi-tank vehicle.

Construction — see **Manufacture**.

Corrosive service — the transport of lading that
(a) meets the criteria for corrosivity specified in Clause 2.40(c) of the *Transportation of Dangerous Goods Regulations* for the material of construction of the tank or valve; or
(b) has been shown through experience to be corrosive to the tank or valve.

Design Engineer — the person who is responsible for the design review of a specification highway tank design and who is qualified and registered in accordance with Clause 8.

Design pressure — the pressure including MAWP, static head, and external vacuum as applicable, corresponding to the coincident design metal temperature, used in the calculations for determining the physical characteristics (such as minimum permissible wall thickness) of the components of the tank.

Director — the Director of Regulatory Affairs, Transport Dangerous Goods Directorate, Transport Canada.

Double backflow check valve — a valve assembly with two seats that is normally closed and allows flow in only one direction.

Effective stress — the maximum principal stress at any point.

Engineer — a person in the engineering profession with related expertise with tanks used in the transportation of dangerous goods who is licensed to practise in a jurisdiction in Canada or in the United States.

External self-closing stop valve — a self-closing stop valve designed so that the self-stored energy source is located outside the tank and welded flange.

Field welding — any welding performed at locations other than the address specified on the Certificate of Registration referenced in Clause 8.1.1(c).

Filling ratio — unless defined otherwise in the appropriate selection and use Standard, the ratio, expressed as a percentage, of the mass of the gas in the tank at 15 °C (59°F) to the mass of water that the tank will hold where the water density is 1000 kg/m^3 (8.33 lb/US gal, 10 lb/Imp. gal).

Fine grain practice — steel having a grain size number of 5 or higher as determined in accordance with ASTM E112.

FRP — fibre-reinforced plastic.

Head (tank) — the portion of a highway or portable tank wall that closes an end of a shell.

Highway tank — a tank intended for the transport of dangerous goods by road, consisting of a tank wall fitted with service equipment and structural equipment necessary for the transport or handling of such dangerous goods, and that
(a) is permanently attached to or forms a part of a truck or trailer; and
(b) is loaded or unloaded without being removed from the vehicle

Hose assembly — a hose and its attached couplings and meeting the requirements of CAN/CGA-8.1 or CAN1-8.3.

Hose assembly working pressure (HAWP) — the anticipated working pressure of the hose assembly, which does not exceed the maximum working pressure of the hose assembly's lowest-rated component.

Hot work — any work involving welding, cutting, grinding, drilling, heating, or exposure to open flame.

Internal self-closing stop valve — a self-closing stop valve designed so that the self-stored energy source is located inside the tank or tank sump, or within the welded flange, and the valve seat is located within the tank or within 2.5 cm (1 in) of the external face of the welded flange or sump of the tank.

Lining — a coating or layer of material adhered to or in intimate contact with the interior surface of a container that is used to protect the container against corrosion or abrasion by its contents, and to protect the contents of the container from contamination by the container material.

Jacket — the cover for any insulation applied to the shell.

Manufacture (construction) — a portion of the fabrication process of a highway or portable tank that involves welding on the tank wall, on integral structural components of the tank such as the rollover dam, tank sill or baffles, and on any components such as piping that contain lading. This term does not include assembly functions (see **Assembly**).

Manufacturer — a legal entity registered by Transport Canada for the manufacture of highway or portable tanks.

Maximum allowable transport pressure (MATP) — the highest permissible internal gauge pressure at the top of the inner vessel at the designated coincident temperature during transport. MATP applies only to TC 341 tanks.

Maximum allowable working pressure (MAWP) — the highest permissible internal gauge pressure at the top of a loaded tank in its normal operating orientation, including the highest internal gauge pressure during tank loading, unloading, or transport, and not exceeding design pressure.

Metered delivery — a highway or portable tank unloading operation conducted
(a) using an on board weighing system; or
(b) at a metered flow rate of 380 L (100 US gal, 85 Imp. gal) per minute or less through an attached delivery hose with a nominal inside diameter of 31.8 mm (1-1/4 in) or less.

MDIN — Manufacturer's or Modifier's Design Identification Number, as applicable; see Clause 8.3.2 or 7.6.6.1.1, respectively.

Modification — a change to the original design of a previously certified highway or portable tank that affects its structural integrity or lading retention capability including but not restricted to
(a) remounts;
(b) tank rebarrelling;
(c) tank stretching;
(d) a change to the design of the rear-end protection or accident damage protection; or
(e) a change to the size or ratings of piping, fittings, and closures.

Modifier — a legal entity registered by Transport Canada to modify highway or portable tanks.

Monitoring feature — a system that automatically activates the off-truck emergency shutdown system during the unloading operation unless the operator, at least once every 5 min, confirms that the product transfer equipment is operating correctly.

Multi-tank vehicle — a vehicle equipped with two or more tanks fabricated to one or more highway tank specifications.

Normal vent — a vent designed to accommodate the expansion and contraction of tank contents under normal operating conditions.

Nozzle — a sub-assembly consisting of a pipe or tubular section with or without a welded or forged flange on one end.

Off-truck emergency shutdown system — a system that enables the operator to remotely stop the flow of product from the highway or portable tank and shut off all motive and auxiliary power equipment to the highway or portable tank from any location between the point of connection to the receiving tank and the highway or portable tank.

Outlet — any opening in the shell or head of a tank, including the opening's closure, except the following:
(a) a threaded opening securely closed during transportation with a threaded plug or a threaded cap;
(b) a flanged opening securely closed during transportation with a bolted or welded blank flange;
(c) a manhole;
(d) a full opening head on a tank designed to be loaded by vacuum;
(e) a gauging device;
(f) a thermometer well;
(g) a safety relief device, and
(h) any opening specifically exempted in this Standard.

Overlay patch — material, other than weld material, added either internally or externally over the parent material without removing the defective material during the process of repair with the intent of reinforcing the repaired area. This does not include pads intentionally installed at the time of manufacture or modification for the installation of components.

Passive emergency shutdown system — a system that automatically shuts off the flow of product without the need for human intervention within 20 s of the release caused by complete hose separation.

Portable tank — a tank intended for the transport of dangerous goods by different modes of transport, consisting of a tank wall fitted with service equipment and structural equipment necessary for the transport or handling of such dangerous goods, and that
(a) is designed to be loaded into or onto and temporarily attached to a transport vehicle or ship;
(b) is equipped with skids, mountings, or accessories to facilitate mechanical handling;
(c) enables the dangerous good to be loaded and unloaded without the removal of structural equipment and without the tank being loaded onto or attached to a transport vehicle;
(d) is capable of being lifted when full, unless otherwise specified in this Standard; and
(e) is not a highway tank, a rail tank car tank, a nonmetallic tank, or an intermediate bulk container (IBC).

Provincial pressure vessel jurisdiction — the body responsible for implementing the boiler and pressure vessel legislation of a province or territory.

Rebarrelling — replacing more than 50% and less than 100% of the combined shell and head material of a highway tank.

Reference steel — steel with a tensile strength of 370 N/mm^2 (53.7 ksi) and elongation at fracture of 27% in a 50 mm (2 in) gauge length.

Remount — mounting a previously certified highway tank onto a different vehicle chassis or vehicle suspension component, or a change to the original means of securement or tank mounting system. A remount is a modification (see **Modification**).

Repair — returning a tank to its original design and specification by welding on the tank wall, on integral structural components of the tank such as the rollover dam, tank sill, or baffles, and on any components such as piping that contain lading. This term does not include

(a) changes to motor vehicle equipment, such as lights, truck or tractor power train components, steering and brake systems, and suspension parts;
(b) changes to appurtenances, such as fender attachments, lighting brackets, and ladder brackets;
(c) replacement of components, such as valves, vents, or fittings, with components of a similar design and of the same size and capacity; and
(d) replacement of an attachment other than an integral structural component of the tank by welding to a mounting pad.

Retrofit — a change to a previously certified highway or portable tank that brings the tank into compliance with the latest revision of the specification to which the tank was originally constructed. Depending on the scope of the change, the retrofit can involve a modification of the highway or portable tank (see **Modification**).

Sacrificial device — a device, such as a shear section, designed to fail under load in order to prevent damage to any lading retention part or device.

Service equipment — devices attached to and forming part of a tank that are necessary for loading, unloading, venting, pressure relief, vacuum relief, internal heating, sampling, and measuring. Such devices include fittings, vacuum- and pressure-relief devices, valves, excess-flow valves, piping, gaskets, and closures.

Shear section — a sacrificial device fabricated in such a manner as to abruptly reduce the wall thickness of the adjacent piping or valve material by at least 30%.

Shell — the cylindrical, or similarly shaped, portion of a tank, excluding closing heads.

Stretching — changing the length, width, or diameter of a tank barrel, or any change to the tank's undercarriage, that will affect the tank's structural integrity.

Tank inspector — a person who inspects tanks in accordance with Clauses 5, 6, and 7 and who is qualified in accordance with Clause 8.

Tank wall — those parts of a highway or portable tank that make up the primary lading retention structure, including heads, shell, bulkheads, and fittings, and when closed, yield the minimum volume of the highway or portable tank.

Tester — a person who is responsible for performing a test required by Clause 7 of this Standard and who is qualified in accordance with Clause 8.

TCRN — Transport Canada Registration Number; see Clause 8.3.3 or 7.6.6.1.1.

Variable specification tank — a tank constructed in accordance with one specification but that may be altered to meet another specification by changing relief devices, closures, lading discharge devices, or other lading retention devices.

Void — the space between adjacent tanks in a multi-tank vehicle.

Volumetric capacity — the maximum volume of water, normally expressed in litres, that a tank can hold at 15 °C and at an absolute pressure of 101.325 kPa.

Welder — a person qualified in accordance with Clause 4.4.

4 General requirements

4.1 Facility requirements

A facility that manufactures, assembles, modifies, repairs, inspects, or tests highway or portable tanks shall conform to Clause 8 of this Standard and shall have, maintain, and adhere to a quality control manual as required by Clause 8.1.1(d).

4.2 Highway tanks

The following requirements shall apply to highway tanks:

(a) TC 406, TC 407, TC 412, and TC 423 highway tanks and associated equipment shall conform to Clauses 5.1 and 5.6 and, as applicable, to Clauses 5.7, 5.8, 5.9, and 5.10.

(b) TC 331, TC 338, and TC 341 highway tanks and associated equipment shall conform to Clauses 5.1 and 5.2 and, as applicable, to Clauses 5.3, 5.4, and 5.5.

Note: *Annex E describes some general features for each tank specification and the products for which it is commonly used.*

4.3 Portable tanks

TC 60, TC 11, and TC 44 portable tanks shall conform to Clause 6.1 and, as applicable, to Clauses 6.2, 6.3, and 6.4.

Note: *Annex E describes some general features for each tank specification and the products for which it is commonly used.*

4.4 Welding and brazing

4.4.1 Welding/brazing procedure qualification

The procedure for welding/brazing on a tank component that retains lading or for welding/brazing that contributes to the structural integrity of the tank shall be qualified in accordance with the ASME *Code*, Section IX, as follows:

(a) for all tanks selected and used as specified in CSA B621 or CSA B622 that are required to be certified to the ASME *Code*, the welding/brazing procedure specifications shall be registered by the applicable pressure vessel jurisdiction; and

(b) for all tanks selected and used as specified in CSA B621 or CSA B622 that are not required to be certified to the ASME *Code*, the welding/brazing procedure specifications shall be qualified by the registered facility performing the weld/brazing.

4.4.2 Welder/brazer performance qualification

A person who performs welding/brazing on a tank component that retains lading or welding/brazing that contributes to the structural integrity of the tank shall be qualified for that weld/braze in accordance with the ASME *Code*, Section IX, as follows:

(a) for all tanks selected and used as specified in CSA B621 or CSA B622 that are required to be certified to the ASME *Code*, the welder/brazer shall be registered to perform the welding/brazing by the applicable pressure vessel jurisdiction; and

(b) for all tanks selected and used as specified in CSA B621 or CSA B622 that are not required to be certified to the ASME *Code*, the welder/brazer shall be qualified for that weld/braze by the registered facility performing the welding/brazing.

4.5 Tank and plate markings

The required markings for tanks and plates may be marked in accordance with either the English or French version of this Standard.

4.6 Certificates and reports

The certificates and reports required by this Standard may be issued in accordance with either the English or French version of this Standard.

5 Specifications for highway tanks

5.1 Requirements for all highway tanks

5.1.1 The ASME *Code*

5.1.1.1

The following portions of the ASME *Code* shall apply to Clause 5:

(a) Section II, Parts A, B, and C, 2013 edition;
(b) Section V, 2013 edition;
(c) Section VIII, Division 1, 2013 edition — excluding UG101(m);
(d) Section IX, 2013 edition;
(e) Section II, Part D, 1998 edition excluding addenda; and
(f) Section VIII, Division 1, UG101(m), 1998 edition excluding addenda.

Where any provision of the ASME *Code* is at variance with this Standard, the provisions of this Standard shall apply.

5.1.1.2

The following tanks shall be designed and constructed in accordance with the ASME *Code* and certified in accordance with the ASME *Code* or the provincial pressure vessel legislation:

(a) TC 331;
(b) TC 338;
(c) TC 341;
(d) TC 407 with a MAWP greater than 240 kPa (35 psi) or designed to be loaded by vacuum, except those made of FRP; and
(e) TC 412 with a MAWP greater than 103 kPa (15 psi) or designed to be loaded by vacuum, except those made of FRP.

5.1.1.3

5.1.1.3.1

All other tanks constructed in accordance with Clause 5 of this Standard, except those made of FRP, shall be designed and constructed in accordance with the ASME *Code*, as modified by Clauses 5.1.1.3.2 to 5.1.1.3.9.

5.1.1.3.2

"Inspector" or "Authorized Inspector" in the ASME *Code* shall correspond to "tank inspector" in this Standard.

5.1.1.3.3

Compliance with the following paragraphs in the Introduction to the ASME *Code* and Parts UG and UW of Section VIII, Division 1, shall not be required:

(a) Scope: U-1(c)(2)(h), Inapplicability for Vessels Operating at less than 103 kPa (15 psi);
(b) Materials:
    (i) UG-11, Prefabricated or Preformed Pressure Parts; and
    (ii) UG-12, Bolts and Studs;
(c) Design:
    (i) UG-22(g), Loadings — Impact Reactions;
    (ii) UG-32(e), Formed Heads, and Sections, Pressure on Concave Side, Torispherical Heads;
    (iii) UG-34, Unstayed Flat Heads and Covers; and
    (iv) UG-35, Other Types of Closures;
(d) Openings and Reinforcements: UG-44, Flanges and Pipe Fittings;

(e) Fabrication:
  (i) UG-76, Cutting Plates and Other Stock;
  (ii) UG-77, Material Identification;
  (iii) UG-80, Permissible Out-of-Roundness of Cylindrical, Conical and Spherical Shells; and
  (iv) UG-81, Tolerance for Formed Heads;
(f) Inspection and Tests:
  (i) UG-90, General;
  (ii) UG-91, The Inspector;
  (iii) UG-92, Access for Inspector;
  (iv) UG-93, Inspections of Materials;
  (v) UG-94, Marking on Materials;
  (vi) UG-96, Dimensional Check of Component Parts; and
  (vii) UG-97, Inspection During Fabrication;
(g) Pressure-Relief Devices:
  (i) UG-129, Marking;
  (ii) UG-130, Use of Code Symbol Stamp;
  (iii) UG-131, Certification of Capacity of Pressure-Relief Valve; and
  (iv) UG-132, Certification of Capacity of Safety and Safety Relief Valve in Combination with Nonreclosing Pressure-Relief Devices;
(h) Attachment Details:
  (i) UW-13(b)(2), Attachment Details — Formed Heads;
  (ii) Sketch UW-13.1(f), Intermediate Head; and
  (iii) the dimensional requirements of Figure UW-13.1, Heads Attached to Shells; and
(i) Marking and Reports:
  (i) UG-115, General;
  (ii) UG-116, Required Marking;
  (iii) UG-117, Certificates of Authorization and Code Symbol Stamps;
  (iv) UG-118, Methods of Marking;
  (v) UG-119, Nameplates; and
  (vi) UG-120, Data Reports.

5.1.1.3.4

The following design, construction, and welding deviations from the ASME *Code* shall apply:
(a) The knuckle radius of flanged heads shall be at least three times the material thickness, and in no case less than 12.5 mm (0.5 in).
(b) Stuffed (inserted) heads may be attached to the shell by a fillet weld.
(c) The knuckle radius and dish radius versus diameter limitations of UG-32 do not apply.

5.1.1.3.5

For TC 406, TC 412, and TC 423 tanks, shell sections of highway tanks designed with a non-circular cross-section need not be given a preliminary curvature as prescribed in UG-79(b).

5.1.1.3.6

The following shall apply to TC 406 or TC 406 Crude tanks:
(a) UW-9(d), Design of Welded Joint — Staggering and Separation of Welded Longitudinal Joints, is not required.
(b) Single, full fillet lap joints, without plug welds, may be used for arc- or gas-welded longitudinal seams, without radiographic examination, under the following conditions:
  (i) in a tank truck
    (1) no more than two of these joints shall be used on the top half and no more than two on the bottom half of the tank; and
    (2) the joints shall not be located further than 16% of the shell circumference from either the top or bottom centreline of the tank; and

(ii) in a self-supporting tank
  (1) no more than two of these joints shall be used on the top half of the tank; and
  (2) the joints shall not be located further than 12.5% of the shell circumference from the top centreline of the tank.

(c) Testing of specimens of these joints is required as follows:
  (i) Two test specimens of the material to be used in the manufacture of the tank shall be tested to failure in tension.
  (ii) The test specimens shall be of the same thicknesses and joint configuration as the tank, and joined by the same welding procedures.
  (iii) The specimens may be used for tanks constructed at the same facility within six months of the completion of the tests if they are made with the same materials, welding procedures, and joint configuration.
  (iv) The fit-up of the joints on the test specimens prior to welding shall represent production conditions that will produce the lowest joint strength.
  (v) Test results and joint fit-up procedures of the test specimens shall be retained by the manufacturer.

(d) The design weld joint efficiency (*JE*) of this joint shall be determined as follows:

$JE = 0.75 (F/p)$

where
F = the lowest value of stress at failure of the two test specimens
p = mechanical properties of the adjacent metal

5.1.1.3.7
Appendix 24 of the ASME *Code* does not apply to manhole assemblies.

5.1.1.3.8
The following deviation from the ASME *Code* shall apply to TC 407 tanks with an MAWP of 35 psi or less: Despite UW-12 in Section VIII, Division 1, of the ASME *Code* for TC 407 tanks with a MAWP of 35 psi or less, the strength of a welded seam in a bulkhead that has not been radiographically examined shall be greater than 0.85 of the strength of the bulkhead under the following conditions:

(a) The welded seam shall be a full penetration butt weld.
(b) No more than one seam shall be used per bulkhead.
(c) The welded seam shall be completed before forming the dish radius and knuckle radius.
(d) Compliance test: Two test specimens of materials representative of those to be used in the manufacture of a cargo tank bulkhead shall be tested to failure in tension. The test specimens shall be of the same thickness and joined by the same welding procedure. The test specimens may represent all the tanks that are made in the same facility within 6 months after the tests are completed. Before welding, the fit-up of the joints on the test specimens shall represent production conditions that would result in the least joint strength. Evidence of joint fit-up and test results shall be retained at the manufacturer's facility for at least 5 years.
(e) Acceptance criteria: The ratio of the actual tensile stress at failure to the actual tensile strength of the adjacent material of all samples of a test lot shall be greater than 0.85.

5.1.1.3.9
Where a burst test is used to establish MAWP, the requirements of the ASME *Code* (1998 edition), Section VIII, Division 1, UG101 (m) shall apply.

5.1.2 Means of containment

5.1.2.1
The design calculations shall consider the weight of the lading, equipment, and other material supported by the tank, the MAWP, and the effect of temperature gradients of lading and the environmental

temperature extremes. Where dissimilar materials are used, their thermal coefficients shall be considered in the calculation of thermal stresses.

5.1.2.2
Welding and brazing shall be performed in a competent manner, using appropriate techniques, materials, and equipment.

5.1.2.3
Materials of construction shall be such that there will be no significant chemical or galvanic reaction between them. These materials shall also be compatible with all ladings to be transported in the tank and suitable for use at the lowest temperature expected to be encountered during transportation.

5.1.2.4
Closures shall be adequate to prevent leakage of the contents under normal conditions of transport and handling.

5.1.2.5
Gasketed closures shall be fitted with gaskets of material that will not deteriorate when in contact with the lading.

5.1.2.6
Hose assemblies connected directly to the tank or any tank-mounted accessory shall
(a) be selected for the appropriate service;
(b) have a HAWP that is suitable for the expected loading and unloading operation, taking into account potential pressure surges; and
(c) be marked with a serial number or identification number and the HAWP.

5.1.3 Securement
Securement of a highway tank to its vehicle chassis (for a vehicle with a frame) or to vehicle suspension and coupler components (where the tank forms all or an integral part of the vehicle frame) shall be designed to withstand static loading, in any direction, equal to twice the weight of the tank when filled with the lading and all tank-mounted accessories, using a design factor of at least 4, based on the specified minimum tensile strength of the material used.

A tank that is not an integral part of a vehicle chassis shall be secured by components that draw the tank down tight to the frame. Anchors, stops, or other components shall restrict relative motion between the tank and the vehicle chassis, except as required to absorb normal chassis flex when the vehicle is in operation. Such components shall be readily accessible for inspection and maintenance, except that insulation and jacketing may cover them.

5.1.4 Supports for attachments and appurtenances

5.1.4.1
Where any tank support is attached to any part of the tank, the stresses imposed on the tank by the support shall be limited to the maximum stress allowed on the tank in the applicable specification.

5.1.4.2
Unless specifically permitted in the specification, no bumper or appurtenance shall be welded directly to the tank or the outer vessel. Such items shall be attached by means of pads of the same material as the tank so that there will be no adverse effect upon the lading retention capability of the tank if any force is applied to the item from any direction or if the appurtenance fails or is damaged.

5.1.4.3
A lightweight appurtenance, such as a conduit clip, brake line clip, skirting structure, lamp mounting bracket, or placard holder, may be secured directly to the tank wall if the device is designed and installed in such a manner that, if damaged, it will not affect the lading retention integrity of the tank.

5.1.4.4
The lightweight appurtenance referred to in Clause 5.1.4.3 shall be of less strength than the tank wall material and shall not be more than 72% of the thickness of the material to which it is attached.

5.1.4.5
The lightweight appurtenance referred to in Clause 5.1.4.3 shall be secured to the tank shell or head by a continuous weld or in such a manner as to preclude formation of pockets that can become sites of incipient corrosion.

5.1.4.6
Clauses 5.1.4.3 to 5.1.4.5 shall not apply to a tank constructed under Part UHT of the ASME *Code*.

5.1.4.7
The thickness of the pad referred to in Clause 5.1.4.2 shall be as follows:
(a) greater than or equal to the thickness of the shell or head to which it is attached;
(b) not more than 1.5 times the shell or head thickness; and
(c) where the shell or head thickness is over
    (i) 0.635 cm (0.250 in) for specification TC 331 highway tanks, a pad of 0.635 cm (0.250 in) or more may be used; and
    (ii) 0.475 cm (0.187 in) for all other tanks, a pad of 0.475 cm (0.187 in) or more may be used.

5.1.4.8
If weep holes or tell-tale holes are used, the pad shall be drilled or punched at its lowest point before it is welded.

5.1.4.9
Each pad shall
(a) for tanks other than TC 338 and TC 341, extend at least 5 cm (2 in) in each direction from any point of attachment of the appurtenance;
(b) for TC 338 and TC 341 tanks, extend not less than four times and not more than eight times the thickness of the pad in each direction from any point of the attachment of the appurtenance;
(c) have rounded corners or be shaped in a manner to minimize stress concentrations on the shell or head; and
(d) be attached by a continuous weld around the pad, except for a small gap at the lowest point for draining, if required.

5.1.5 Rear-end protection

5.1.5.1 General
Nothing in Clause 5.1.5 shall be construed in such a way as to relieve a manufacturer of responsibility for complying with the requirements of any federal or provincial vehicle safety standard.

5.1.5.2 Bumpers and other devices
Every highway tank constructed such that the body has a clearance at the rear end of more than 760 mm (30 in) from the ground when empty shall be provided with bumpers or other devices serving similar purposes, such that
(a) the clearance between the effective bottom of the bumpers or devices and the ground is less than 760 mm (30 in) when the vehicle is empty;

(b) if more than one bumper or device is used, the distance between them does not exceed 590 mm (24 in);
(c) the distance between the widest part of the rear of the vehicle and the outboard edge of the bumper or device does not exceed 460 mm (18 in);
(d) the bumpers or devices are located not more than 590 mm (24 in) forward of the extreme rear of the vehicle; and
(e) the bumpers or devices are substantially constructed and firmly attached.

5.1.5.3 Alternative to bumpers or devices

Highway tanks constructed and maintained so that the body, chassis, or other parts of the vehicle afford the rear-end protection provided by the bumpers or other devices specified in Clause 5.1.5.2 shall be deemed to be in compliance with that clause.

5.1.5.4 Rear-end protection device

5.1.5.4.1

Each tank vehicle shall be provided with a rear-end protection device to protect the tank and piping in the event of a rear-end collision and reduce the likelihood of damage that could result in the loss of lading. The rear-end protection device shall

(a) be designed so that it can deflect at least 15 cm (6 in) horizontally forward without any contact between any part that contains lading during transit and
  (i) any part of the rear-end protection device; or
  (ii) a vertical plane passing through the outboard surface of the rear-end protection device; and
(b) conform to the following:
  (i) The bottom surface of the rear-end protection device shall be at least 10 cm (4 in) below the lower surface of any part located at the rear of the tank that contains lading during transit and not more than 152 cm (60 in) from the ground when the vehicle is empty.
  (ii) The maximum width of a notch, indentation, or separation between sections of a rear-end protection device shall not exceed 61 cm (24 in). A notched, indented, or separated rear-end protection device may be used only when the piping at the rear of the tank is equipped with a sacrificial device outboard of a shut-off valve.
  (iii) The widest part of the vehicle at the rear shall not extend more than 46 cm (18 in) beyond the outermost ends of the device or devices (if separated) on either side of the vehicle.

5.1.5.4.2

The structure of the rear-end protection device and its attachment to the vehicle shall be designed to withstand a forwardforce of two times the gross vehicle weight rating, uniformly distributed and applied in the horizontal plane at an angle of 0° and at an angle of 10° to the longitudinal axis of the vehicle, without damage to the tank, or any product-retaining component, and without deflection beyond that specified in Clause 5.1.5.4.1(a).

Design can be determined using full scale physical testing, classical calculation methods, or suitable finite element analysis.

Where classical calculation methods or linear elastic analysis are used, stresses in the device, other than localized concentrated stresses at discontinuities, shall not exceed the yield strength of the material.

Where plastic non-linear analysis is used, stresses in the device, other than localized concentrated stresses at discontinuities, shall not exceed the ultimate tensile strength of the material.

5.1.6 Inspection, testing, and marking

5.1.6.1 Metal identification plates

5.1.6.1.1
Each tank shall have one or more corrosion-resistant metal identification plates permanently affixed to the tank or its supporting structure by brazing or welding around its perimeter or by means of tamper-resistant fasteners. The plates shall be affixed on the left side of the tank, near the front, in a place readily accessible for inspection. The plates may be attached to a mounting pad welded directly to the tank, but not to bodywork or skirting.

5.1.6.1.2
If the metal identification plate described in Clause 5.1.6.1.1 is not readily visible, a second metal identification plate marked "Duplicate" shall be permanently affixed, in a visible position, directly to the tank or tank structure in a readily accessible location near the front of the tank.

5.1.6.1.3
The metal identification plate and the means of its attachment to the tank or jacket shall be resistant to attack by the lading.

5.1.6.1.4
If a metal identification plate is attached directly to the tank by welding, it shall be attached before the tank is postweld heat treated.

5.1.6.1.5
The metal identification plate(s) shall be plainly marked, in characters at least 5 mm (3/16 in) high, by stamping, embossing, or other means of forming letters in the metal of the plate, and shall be maintained in a legible condition.

5.1.6.1.6
The following information shall appear on the plate(s) (parenthetical abbreviations are authorized):
Note: *This information may be provided and marked in accordance with the ASME* Code.
(a) tank manufacturer (Tank mfr.);
(b) date of tank manufacture — month and year (Date of mfr.);
(c) assembler;
(d) completion and certification date — month and year (Cert. date);
(e) original test date — month and year (Orig. Test Date);
(f) TC Specification (TC Spec.);
(g) Transport Canada Registration Number (TCRN);(1)
(h) Manufacturer's Design Identification Number (MDIN);(2)
(i) tank serial number (Ser. No. or S/N);
(j) vehicle identification number (VIN);
(k) tank maximum allowable working pressure in kPa (MAWP);
(l) tank test pressure in kPa (Test P);
(m) tank design temperature range — ___°C to ___°C (Design temp. range);
(n) maximum design density of lading — in kilograms per litre (Max. lading density);
(o) vessel material specification number(3) — all numbers to be marked where the material for the shell is different from the material for the heads (Shell & Head Matl. yyy zzz or Shell Matl. yyy zzz and Head Matl. yyy zzz, where "yyy" is replaced by the alloy designation and "zzz" by the alloy type);
(p) weld material (Weld Matl.);(3)
(q) minimum allowable thickness of shell — in millimetres (Min. shell thick.). When minimum shell thicknesses are not the same for different areas, mark variances (Top ..... Side..... Bottom.....);
(r) minimum allowable thickness of heads — in millimetres (Min. head thick.);

(s) manufactured thickness of shell — in millimetres (Mfd. shell thick.);[4]
(t) manufactured thickness of heads — in millimetres (Mfd. head thick.);[4]
(u) exposed surface area — in square metres;
(v) volumetric capacity — in litres (Cap. Litres);
(w) maximum product load — in kilograms (Max. payload);
(x) maximum loading rate — in litres per minute and optionally in US gallons per minute [Max load. rate, L/min (US GPM) at maximum loading pressure XX kPa (psi)];[6]
(y) maximum unloading rate — in litres per minute and optionally in US gallons per minute [Max. unload. rate, L/min (US GPM) at maximum unloading pressure XX kPa (psi)];[6]
(z) lining material — if lined (Lining);[5]
(aa) heating system design pressure — in kPa, and optionally in psi, if heating system installed (Heating sys. press.);(and
(bb) heating system design temperature — in °C and optionally in °F if heating system installed (Heating sys. temp.).

Annotations (these annotations are mandatory provisions of this Standard):
[1]Required for all tanks outlined in Clause 5.1.1.2.
[2]Required for all tanks other than those outlined in Clause 5.1.1.2.
[3]For FRP tanks, "NA" shall be marked.
[4]Required when additional material is provided for corrosion allowance
[5]For FRP tanks, the lining manufacturer's name and product designation of the resin or polymer of the interior layer shall be marked.
[6]Does not apply to TC 331 highway tanks.

5.1.6.1.7
The metal identification plate of a tank equipped with a double wall or secondary containment space, other than a tank that is insulated and jacketed, shall be marked
(a) with the words "double wall" or "secondary containment"; and
(b) if the material and thickness of the outer wall differs from that of the primary means of containment, the material and thickness of the outer wall shall also be marked on the metal identification plate.

5.1.6.2 Multi-tank vehicle

5.1.6.2.1
For a multi-tank vehicle that does not have a void between adjacent tanks, the information required by Clause 5.1.6.1 may be combined on one metal identification plate.

5.1.6.2.2
Each tank separated by a void shall have an individual metal identification plate attached to it as required in Clause 5.1.6.1 unless all tanks have been made to the same specification by the same manufacturer with the same materials, minimum thicknesses, and, if applicable, manufactured thicknesses.

5.1.6.2.3
When only one metal identification plate is used, the required information shall be listed on the plate in the order of the corresponding tank location from front to rear.

5.1.6.2.4
For a multi-tank vehicle on which each tank is physically separate and/or can be individually removed, each tank shall have an individual metal identification plate attached to it as required by Clause 5.1.6.1. If the location of the identification plate required by Clause 5.1.6.1 is not readily accessible after vehicle assembly, the plate may be permanently affixed directly to the tank or tank structure in a readily accessible location near the front of the tank.

5.1.6.3 Variable specification tank

5.1.6.3.1
In the case of a variable specification tank, information on the metal identification plate(s) shall be provided identifying each of the specifications the tank has been designed to meet. The mounting of the metal identification plate(s) shall be such that only the applicable specification under which the tank is being operated is legible. The information with regard to the specification under which the tank is being operated at any particular time shall be accessible at that time.

5.1.6.3.2
The following information shall be marked on the metal identification plate(s):
(a) Specification TC XXX — where "XXX" is replaced with the applicable specification number; and
(b) the following equipment, as required, with its required rating:
    (i) pressure-relief devices:
        (1) pressure-actuated type;
        (2) frangible type;
        (3) lading discharge devices;
        (4) top;
        (5) bottom; and
        (6) pressure unloading fitting; and
    (ii) closures:
        (1) manhole;
        (2) fill openings; and
        (3) discharge openings.

5.1.6.3.3
If no change of information on the metal identification plate(s) is required to meet another specification, the letters "NC" shall follow the rating required for the component. If the tank is not equipped with a particular component, the word "None" shall be marked instead of the rating required for the component.

5.1.6.3.4
Those components that are changed or added to meet another specification shall be stamped with appropriate specification markings.

5.1.6.3.5
The alterations that shall be made for the tank to be modified from one specification to another shall be clearly indicated on the manufacturer's certificate and on the metal identification plate(s).

5.1.6.4 Inspection, testing, and markings of new tanks

5.1.6.4.1
On completion and final assembly, a new tank, including piping, valves, and fittings, shall have been inspected, tested, and marked as required in Clause 7 for its specification, except that thickness, lining, and upper coupler area inspections shall not be required. Additional inspections and tests shall be required where indicated in this Standard for the tank specification.

5.1.6.4.2
Hose assemblies connected directly to the tank or to any tank-mounted accessory shall be inspected, tested, and marked in accordance with Clause 7.2.10, either before or after installation on the tank.

5.1.6.4.3
Following repair of any defect discovered as a result of an inspection or test, the inspection or test shall be repeated. In the event of replacement, all piping, valves, or fittings replaced shall be tested in accordance with the requirements of Clause 5.1.6.4.

5.1.7 Certification

5.1.7.1 General
At or before the time of delivery, the highway tank vehicle manufacturer or assembler completing the final construction and certification of the tank shall supply, and the owner shall obtain, the Certificate of Compliance described in Clause 8.2.1 for each highway tank. For a variable specification tank, a Certificate of Compliance shall be issued for each specification.

5.1.7.2 Incomplete and partial construction

5.1.7.2.1
When a manufacturer does not complete the construction of the tank, the manufacturer shall complete the certification in accordance with the requirements of Clause 8 of this Standard for all the construction that has been completed. Those requirements of the specification that have not been met shall be identified on the Certificate of Compliance, and the manufacturer may affix the metal identification plate(s) as required in Clause 5.1.6 without the TC specification mark and the completion and certification date as required in Clause 5.1.6.1. The omitted TC specification mark and the completion and certification date shall not be applied until the tank is complete and in full compliance with the requirements of this Standard.

5.1.7.2.2
Any manufacturer or assembler completing further construction of the tank shall identify the items of further construction on the Certificate of Compliance.

5.1.7.2.3
The manufacturer or assembler completing the final construction of the tank shall be responsible for ensuring that all inspections, marking, and certification have been done in compliance with this Standard.
Note: *The manufacturer or assembler should be aware of the requirements of the Government of Canada's* Motor Vehicle Safety Act *and Regulations, 1993.*

5.1.7.3 Retention

5.1.7.3.1
The owner shall retain a copy of the certificate or certificates referred to in Clause 5.1.7.1, and related documents, throughout the ownership of the tank and for at least one year thereafter.

5.1.7.3.2
In the case of resale, the documents shall be transferred to and retained by the new owner. In the event of such change in ownership, retention by the prior owner of non-fading copies of the documents shall be deemed to satisfy the requirements of Clause 5.1.7.3.1.

5.1.7.3.3
Each person using a tank to transport dangerous goods, if not the owner of the tank, shall obtain a copy of the documents referred to in Clause 5.1.7.3.1 and retain them during the period the person uses the highway tank and for at least one year thereafter. This requirement shall not apply to a person leasing or renting a tank for less than 30 days.

5.1.8 Vehicle equipment: Exhaust system considerations

Highway tanks used for Dangerous Goods of primary Class 2.1 or Class 3 or subsidiary Class 3 shall be designed and constructed such that components that are combustible or that retain flammable or heat-sensitive products are not adversely affected by the hot exhaust system components or effluent. This may be accomplished by locating, rerouting, or shielding either the combustible, product-retaining, or exhaust system components as appropriate.

5.2 Highway tanks for the transportation of liquefied compressed gases and refrigerated liquefied gases — Specification TC 331, TC 338, and TC 341 tanks

5.2.1 General

Unless otherwise provided in the applicable specification, all highway tanks used for the transportation of dangerous goods that are liquefied compressed gases or refrigerated liquefied gases shall be constructed to meet the requirements of Clauses 5.1 and 5.2.

5.2.2 Piping, valves, and fittings

5.2.2.1 Discharge control devices

5.2.2.1.1

Except as required by Clause 5.2.2.1.2, each filling and discharge line for liquid shall be provided with a shut-off valve located as close to the tank as practicable. Unless this valve is manually operable at the valve, each line shall also have a manual shut-off valve.

5.2.2.1.2

Each gas or vapour line on a TC 331 tank and each filling and discharge line for liquid on a TC 331, 338 or 341 highway tank intended for service transporting a dangerous good, other than argon, carbon dioxide, nitrous oxide, helium, krypton, neon, nitrogen, and xenon, shall be provided with an on-truck remotely controlled self-closing shut-off valve. If a TC 331 highway tank is not equipped with these valves, the tank shall be marked and used exclusively for carbon dioxide or nitrous oxide. The following requirements shall apply to the provision and operation of these valves:

(a) If pressure from a reservoir or from an engine-driven pump or compressor opens the valve, the control shall be a fail-safe, fail-close design that provides positive closure of the valve.

(b) If the jacket is not evacuated, the seat of the valve shall be inside the tank, in the opening nozzle or flange, or in a companion flange bolted to the nozzle. If the jacket is evacuated, these valves shall be located as close to the tank as practicable.

(c) On a highway tank with a volumetric capacity in excess of 13 250 L (3500 US gal, 2915 Imp. gal) of water, each of the valves shall be provided with a mechanical means and a thermal means of automatic closure. The remote control for the thermal and mechanical means of closure shall be installed at the ends of the tank in at least two diagonally opposite locations. Except as provided in Item (f), if the loading/unloading connection (where hoses or hose reels are connected to the permanent metal piping) is not in the general vicinity of one of these two locations, additional means of thermal remote closure shall be installed so that heat from a fire in the loading/unloading connection area or the discharge pump will activate the automatic means of closure for the valve. The thermal means shall consist of fusible elements actuated at a temperature not exceeding 121 °C (250°F), or equivalent devices. One means may be used to close more than one of these valves.

(d) On a tank with a volumetric capacity of 13 250 L (3500 US gal, 2915 Imp. gal) of water or less, each of the valves shall be provided with a mechanical means and a thermal means of automatic closure. At least one remote-control station for the thermal and the mechanical means of closure shall be located on the end of the tank opposite the main control station. For TC 331 tanks, a thermal means of remote closure shall also be installed at or near the internal self-closing stop valve, and for TC 338 and TC 341 tanks, at the loading/unloading connection area. The loading/unloading connection area

is where hoses or hose reels are connected to the permanent metal piping. The remote-control station shall provide a manual means of closure.

(e) The remote controls referred to in Items (c) and (d) shall be mounted outside the cab on the tank, its supporting structure, or skirting in a clearly visible location and readily accessible to a person standing on the ground.

(f) A TC 341 tank with all piping, loading, and unloading connections located at one end of the tank may be equipped with a single thermal means of closure at that location and a single mechanical remote control located at the opposite end instead of a thermal and mechanical remote control station at two diagonally opposite locations, as specified in Item (c).

5.2.2.1.3

Despite Clause 5.2.2.1.2, where the flow of the product is only into a TC 331 tank, a backflow check valve may be installed in the tank opening in place of an internal self-closing stop valve. The inner seat shall be located inside the tank or within 2.5 cm (1 in) of the external face of a welded flange. The valve shall be of steel, malleable iron, or ductile iron construction where threaded connections are used.

5.2.2.1.4 Manual bleed valve

Piping or hose used for loading or unloading liquefied gas or refrigerated liquefied gas shall be provided with a manual bleed valve or other means of relieving pressure before the hose is disconnected.

5.2.2.2 Pressure ratings

The following pressure-rating requirements shall apply:

(a) All valves shall be suitable for the tank design pressure at the tank design service temperature.

(b) Fittings shall be rated for the maximum tank pressure and suitable for the coldest temperature to which they will be subjected in actual service.

(c) The bursting pressure of all piping, pipe fittings, hose, and other pressure parts, except pump seals and safety relief devices, shall be at least four times the design pressure of the tank.

(d) In addition to Item (c), the bursting pressure shall be not less than four times any higher pressure to which each pipe, pipe fitting, hose, or other pressure part can be subjected in service by the action of a pump or other device.

(e) The ratings of Items (c) and (d) shall be for the coldest temperature to which the piping, pipe fittings, hoses, and other pressure parts, except pump seals and safety relief devices, will be subjected in actual service coincident with the pressure.

(f) Each hose coupling shall be designed so that there will be no leakage when it is connected and when there is a pressure at least 20% in excess of the hose design pressure.

5.2.2.3 Joints

The following requirements for joints shall apply:

(a) Welded pipe joints shall be used wherever possible.

(b) Where copper tubing is permitted, joints shall be brazed or be of an equally strong metal-union type.

(c) The melting point of brazing material shall be no lower than 535 °C (1000°F).

(d) The method of joining tubing, such as the cutting of threads, shall not decrease its strength.

(e) Screwed fittings shall be at least extra-heavy.

(f) Non-malleable metals shall not be used in the construction of any valve or fitting.

(g) For liquefied petroleum gas service, all valves and fittings that are directly threaded into the tank shall be of steel, malleable iron, or ductile iron construction.

5.2.2.4 Piping and fittings — Location and design

The following requirements shall apply to the design and location of piping and fittings:

(a) Piping design shall include the prevention of damage to piping due to thermal expansion and contraction, jarring, and vibration. Slip joints shall not be used for this purpose.

(b) Piping and fittings shall be grouped in the smallest practicable space and be protected from damage as required by the specification.

5.2.2.5 Testing

The following testing requirements shall apply:

(a) All piping, valves, and fittings on every tank shall be free from leaks at not less than the design pressure for the tank.

(b) The condition in Item (a) shall be met when piping, valves, and fittings have been tested for leakage after installation, with a test medium as specified in Clause 7.2.5.1(e), and proved tight at not less than the design pressure marked on the tank with which they are used.

5.2.2.6 Pressure-building coils

When a pressure-building coil is installed on a tank, the vapour and liquid connection to that coil shall be provided with a valve as close to the tank as practicable, to prevent the loss of vapour or liquid from the tank in case of damage to the coil. In the case of a vapour connection, the valve may be a check valve.

5.2.2.7 Pumps and compressors

The following requirements related to pumps and compressors shall apply:

(a) Liquid pumps or gas compressors shall be of suitable design, adequately supported, protected against breakage resulting from collisions, and kept in good condition.

(b) Any pump that is mounted on a tank truck, tank trailer, or associated truck tractor, and used for loading or off-loading the tank, shall be equipped with a pressure-activated bypass valve or other means of limiting the output pressure of the pump, in order to prevent damage to any component of the product transfer system installed on the tank vehicle.

(c) Aluminum parts subject to abrading in normal service shall not be installed on tanks that transport liquid oxygen.

(d) Pumps for liquid oxygen shall be installed so that power train lubricants or hydraulic fluids do not impinge on the piping system.

(e) Downstream piping shall be protected from overpressurization.

5.2.2.8 Damage protection

The following requirements related to protection from damage shall apply:

(a) All valves, safety devices, fittings, and other accessories that contain lading during transport shall be protected against damage resulting from collision, jackknifing, uncoupling, or overturning.

(b) Each pressure-relief device shall be protected so that in the event of upset onto a hard surface, the opening of the device will not be prevented nor its discharge restricted.

(c) Protective devices shall be able to withstand, or deflect away from the highway tank, a force equal to or greater than 8 times the weight of the tank and attachments when filled with the lading from the front, side, bottom, or rear, uniformly distributed over each surface of the device over
   (i) an area not to exceed 0.56 m^2 (6 ft^2); and
   (ii) a width not to exceed 183 cm (6 ft).

(d) Deformation of the protective device shall be acceptable, provided that the devices or components being protected are not damaged when the protective device is subjected to the force in Item (c), applied in each direction listed in Item (c). Protective devices used for bottom damage protection shall extend at least 15 cm (6 in) beyond any component that can contain lading.

(e) Protective devices that are attached to the tank wall shall be designed to maximize the load distribution in the tank wall and minimize the possibility of any adverse effect on the lading retention integrity of the highway tank. The stress in the tank wall resulting from the design pressure and the loading in Item (c) shall not exceed the ultimate tensile strength of the material.

(f) Suspension components and other adequate structural components may be used to provide all or part of the damage protection

(g) Damage protection devices for pressure-building coils are not required, provided the following conditions are met:
   (i) Pressure building coil lines are equipped with shear sections as outlined in Clause 5.2.2.12.
   (ii) Pressure-building coil circuits are designed such that liquid product is emptied from the pressure building coils upon completion of unloading.

(iii) Products transported are
  (1) Class 2.2 gases; or
  (2) Class 2.1 gases, provided a manual block valve is installed on the vapour side of the coil and the pressure-building coil circuit is depressurized at completion of unloading.

5.2.2.9 Marking

The following marking requirements shall apply:

(a) All tank inlets and outlets shall be marked "vapour" or "liquid" to indicate whether they connect with vapour or liquid when the tank is filled to the maximum permitted filling density.
(b) Item (a) shall not apply to
  (i) safety relief valves;
  (i) pressure-relief devices on TC 338 and TC 341 tanks; and
  (i) pressure-control valves on TC 331 tanks in carbon dioxide service, and TC 338 and TC 341 tanks.
(c) Each pressure-relief valve shall be plainly and permanently marked with the pressure in kPa, and optionally in psi, at which it is set to discharge, the discharge rate of the device in cubic metres per minute (m^3/min) or standard cubic feet per minute (SCFM) of free air, and the manufacturer's name.
(d) Each pressure-control valve shall be plainly and permanently marked with the pressure in kPa, and optionally in psi, at which it is set to discharge.
(e) The marked set-to-discharge pressure value shall be visible with the valve in its installed position.

5.2.2.10 Excess-flow protection

5.2.2.10.1

On Specification TC 331 highway tanks designed to transport liquefied compressed gases with the exception of carbon dioxide, every product inlet and outlet, with the exception of gauging devices, thermometer wells, and safety relief valves, shall be

(a) closed with a plug, cap, bolted flange, or plate;
(b) protected with an automatic excess-flow valve on product discharge openings or a backflow check valve on product inlet openings;
(c) fitted with an internal automatic quick-closing stop valve;
(d) fitted with a remotely controlled self-closing shut-off valve as specified in Clause 5.2.2.1.2: or
(e) for nitrous oxide, in addition to the manual shut-off valve required in Clause 5.2.2.11, fitted with a manual shut-off valve located in the line ahead of the hose connection and closed with a pressure cap or plug during transit.

5.2.2.10.2

Each internal self-closing stop valve and excess-flow valve shall automatically close if any of its attachments are separated or sheared off.

5.2.2.10.3

Valves required by Clause 5.2.2.10.1(c) and (d) shall be

(a) located inside the tank or at a point outside the tank where the line enters or leaves the tank;
(b) furnished with a valve seat located inside the tank, within a welded flange or its companion flange, within a nozzle, or within a coupling; and
(c) protected in such a way that any incident that causes excess flow will not affect the operation of the valves.

5.2.2.10.4

Where the outward flow of tank contents through the opening for a liquid level gauging device will not exceed that passed by a 1.5 mm (0.060 in) diameter opening, the device shall not be required to be equipped with an excess-flow valve.

5.2.2.10.5
Safety device connections shall not be required to be equipped with an excess-flow valve.

5.2.2.10.6
Each excess-flow valve shall close automatically at the rated flow of gas or liquid specified by the valve manufacturer.

5.2.2.10.7
The flow rating of the piping, fittings, valves, and hose on each side of an excess-flow valve shall be such that the excess-flow valve will close if the piping, fittings, valve, or hose is sheared off before the first downstream valve, pump, or fitting that restricts the flow.

5.2.2.10.8
If branching or any other restriction is incorporated in the system so that the flow rating is less than that of an excess-flow valve at the tank, additional excess-flow valves shall be located where flow rates are reduced.

5.2.2.10.9
An excess-flow valve may be designed with a bypass that has a maximum opening diameter of 1.0 mm (0.040 in), to allow equalization of pressures.

5.2.2.10.10
The requirements of Clauses 5.2.2.10.1 and 5.2.2.10.3 shall not apply to
(a) a vapour or liquid discharge opening of less than 1-1/4 in NPT (nominal pipe thread) equipped with an excess-flow valve and a manually operated external stop valve, in place of a remotely controlled internal self-closing stop valve;
(b) a vapour or liquid discharge opening of 1-1/4 in NPT equipped with an excess-flow valve and a manually operated external stop valve installed before 1 October 1984; or
(c) an engine fuel line, on a truck-mounted tank, of not over 3/4 in NPT equipped with a valve having an integral excess-flow valve.

5.2.2.11 Manual shut-off
Each filling and discharge line shall be provided with a manual shut-off valve located as close to the tank as practicable. When an automatically closing internal shut-off valve is used, a manual shut-off valve shall be located in the line ahead of the hose connection.

5.2.2.12 Shear sections and breakage grooves on valves

5.2.2.12.1
The design and installation of each valve, damage to which could result in loss of liquid or vapour, shall incorporate a shear section or breakage groove on the outboard side of the valve except
(a) when the valve is located in a rear cabinet forward of and protected by the rear-end protection described in Clause 5.1.5; or
(b) in the case of tanks carrying carbon dioxide, refrigerated liquid.

5.2.2.12.2
The shear section or breakage groove specified in Clause 5.2.2.12.1 shall yield or break under strain without damage to the valve that would result in loss of liquid or vapour.

5.2.3 Gauging devices

5.2.3.1 General

The following requirements for gauging devices shall apply:

(a) Highway tanks for the transport of compressed gases, except those filled by weight, shall be equipped with one or more gauging devices that indicate accurately the maximum permitted liquid level.
(b) Additional contents-gauging devices may be installed but shall not be used as primary controls for the filling of these highway tanks.
(c) Gauge glasses shall not be permitted on these highway tanks.
(d) Where filling with a product other than carbon dioxide, refrigerated liquid, or nitrous oxide, refrigerated liquid, is to be performed by volume using an adjustable liquid level device, a thermometer and thermometer well shall be installed in a location such that the thermometer will be easily readable.

5.2.3.2 Adjustment and marking

The following requirements shall apply to adjustment and marking of gauging devices:

(a) If the primary gauging device is adjustable, adjustment of the device shall permit the end of the tube to reach the maximum permitted filling level specified in Clause 5.2.3.3(d) at an average loading temperature for at least one of the ladings to be transported. Exterior means shall be provided to indicate this adjustment.
(b) The gauging device shall be legibly and permanently marked in increments not exceeding 7 Celsius degrees (13 Fahrenheit degrees) (or not exceeding 172 kPa (25 psi) on tanks for carbon dioxide and nitrous oxide) to indicate the maximum levels to which the tank may be filled with liquid at temperatures above –7 °C (20°F). If it is not practicable to so mark the gauging device, the information shall be legibly and permanently marked on a plate affixed to the tank adjacent to the gauging device.

5.2.3.3 Dip-tube gauging devices

The following requirements for dip-tube gauging devices shall apply:

(a) A dip-tube gauging device shall consist of a pipe or tube with a valve at or near the shell or jacket, and its intake shall be limited by an orifice no larger than 1.5 mm (0.060 in) in diameter.
(b) If a fixed-length dip-tube is used, the intake shall be located at the midpoint of the tank both longitudinally and laterally and at the maximum permitted filling level.
(c) The volume setting of a fixed-length dip-tube shall be indicated in a visible location at or adjacent to the valve referred to in Item (a).
(d) In tanks for liquefied petroleum gases, the intake shall be located at the level reached by the lading when the tank is loaded to its maximum filling density at 5 °C (40°F).

5.2.3.4 Liquid level gauging devices

If used as a primary control for filling, a liquid level gauging device shall be designed and installed to indicate the maximum permitted filling level of the highway tank when parked on a level surface.

5.2.3.5 Gauging-device valve direction

Each valve on a gauging device shall be arranged to discharge, without obstruction, upward or sideways to the outside of the protective housing to prevent any impingement of escaping gas on the tank.

5.2.4 Safety relief devices

5.2.4.1 General

The following requirements shall apply:

(a) Each tank shall be provided with one or more safety relief devices. Unless otherwise specified, these shall be safety relief valves of the spring-loaded type.
(b) Each safety relief valve shall be arranged to discharge, without obstruction, upward or sideways to the outside of the protective housing to prevent any impingement of escaping gas on the tank.
(c) In addition to the safety relief devices required in Item (a), a highway tank in refrigerated liquefied gas service may be equipped with
    (i) one or more pressure-control valves with set pressures at or below the tank MAWP; or
    (ii) one or more frangible discs set to function at a pressure not less than one and a half times, nor more than two times, the tank MAWP.

5.2.4.2 Flow capacity

The following requirements shall apply to the flow capacity of safety relief valves:

(a) Safety relief valves on each tank shall have a total relieving capacity as determined by the flow formulas contained in Section 5 of CGA S-1.2.
(b) Safety relief valves shall have a total relieving capacity sufficient to prevent a maximum pressure in the tank of more than 120% of the MAWP.
(c) For an insulated tank, the required relieving capacity of the relief valves shall be the same as for an uninsulated tank, unless the insulation will remain in place and will be effective under fire conditions. In this case, each insulated tank shall be covered by a sheet metal jacket of not less than 1.6 mm (16 gauge) thickness.

5.2.4.3 Security from tampering

Each safety relief valve shall be arranged to minimize the possibility of tampering. If the pressure setting or adjustment is external to the valve, the safety relief valve shall be provided with a means for sealing the adjustment, and it shall be sealed.

5.2.4.4 Primary set-to-discharge pressures

The following requirements shall apply to set-to-discharge pressures of primary pressure-relief systems:

(a) Each primary pressure-relief system on a tank shall be designed, constructed, marked, and set to discharge at a pressure no higher than 110% of the tank MAWP and no lower than the MAWP specified in CSA B622 for the gas when transported at ambient temperature.
(b) Where the set-to-discharge pressure is set higher than the tank MAWP, the tank shall be provided with a pressure-regulating device set to operate at or below the MAWP, with a capacity equal to the rate of gas generation caused by the heat leak flux through the insulation at an ambient temperature of 30 °C (86°F).
(c) Pressure-regulating devices shall not be used on tanks transporting ladings that have poison or corrosive primary or secondary classifications.

5.2.4.5 Secondary set-to-discharge pressures

Each pressure-relief device in a secondary pressure-relief system shall be designed to have a set-to-discharge pressure no lower than 130% and no higher than 150% of the MAWP of the tank.

5.2.4.6 Marking

The following marking requirements shall apply to safety relief valves:

(a) Each safety relief valve shall be plainly and permanently marked with
    (i) the pressure in kPa (psi) at which it is set to discharge;
    (ii) the actual rate of discharge in m3 (ft^3)/min of the gas or of air at 15 °C (60°F) and 100 kPa (14.5 psia); and
    (iii) the manufacturer's name or trade name and catalogue number.

(b) The set-to-discharge value shall be visible after the valve is installed.
(c) The rated discharge capacity of the device specified in Item (a) shall be determined at a pressure of 120% of the MAWP of the tank.

5.2.4.7 Location
Each safety relief valve shall be connected to the vapour space in the tank at the top centreline.

5.2.4.8 Valves, connections, and flow capacity
Each connection to a safety relief valve shall be of sufficient size to provide the required relief capacity through the safety relief valve in accordance with Clause 5.2 of CGA S-1.2.

A shut-off valve may be installed in a pressure-relief system only when the required relief capacity is provided in all circumstances.

5.2.4.9 Cleanliness
Each pressure-relief device shall be arranged or protected to prevent the accumulation of dirt or other foreign material between the device and the atmospheric discharge opening in any relief piping.

The arrangement or protection of the pressure-relief device shall not impede flow through it.

5.2.4.10 Piping and hose thermal expansion relief

5.2.4.10.1
To prevent the bursting of piping or a hose as a result of thermal expansion of the gas, each portion of connected liquid piping or hose that can be closed at both ends shall be provided with
(a) an expansion relief device with no intervening shut-off valve; or
(b) a check valve to permit flow from the pipe or hose into the tank.

5.2.4.10.2
Relief devices specified in Clause 5.2.4.10.1 shall be located so as to prevent discharge from impinging on the tank, piping, or personnel.

5.2.4.11 Thermal isolation of devices in refrigerated liquefied gas service
On highway tanks containing refrigerated liquefied gases, each device shall be isolated thermally from the process line to ensure that it does not come in contact with the lading.

5.2.5 Tank design and test pressures
For highway tanks used in refrigerated liquefied gas service, the design and test pressures shall be calculated using the following formulas:
(a) design pressure (P_D)

$$P_D = (MAWP + H + V)$$

(b) test pressure (P_T)
(i) for vacuum-insulated tanks

$$P_T = x\,(MAWP + H + V) - V_a$$

(ii) for all other tanks

$$P_T = x\,(MAWP + H)$$

where
MAWP = the maximum pressure exerted by the gas or vapour at the top of the tank

H = the pressure exerted on the bottom of the tank by the lading when the tank is full to its maximum permitted filling density

V = in the case of a vacuum-insulated vessel, 101.325 kPa (14.7 psia); in all other cases, 0

x = the multiplier to be used in establishing the test pressure in Table 7.3 of this Standard
= 2 for hydro testing TC 338 and TC 341 highway tanks constructed in accordance with Part UHT of the ASME *Code*
= 1.5 for hydro testing all other TC 338 and TC 341 tanks
= 1.25 for pneumatic testing of all TC 338 and TC 341 tanks

V_a = the actual vacuum as measured in kPa (psia), i.e., 101.325 kPa minus the absolute pressure measured in the annular space, in kPa (14.7 psia minus absolute pressure measured in the annular space, in psia)

5.2.6 Inner vessel or tank support pads

The following requirements related to inner vessel or tank support pads shall apply:

(a) Pad thickness shall be
  (i) where the shell is less than or equal to 6.35 mm (0.25 in), equal to the thickness of the shell; and
  (ii) where the shell thickness is greater than 6.35 mm (0.25 in), less than or equal to the thickness of the shell but no less than 6.35 mm (0.25 in).

(b) Each pad shall extend at least four times its thickness, in each direction, beyond the weld attaching the support or bumper.

(c) Each pad shall be preformed to an inside radius no greater than the outside radius of the tank where it is to be attached.

(d) Each pad corner shall be rounded to a radius at least one-fourth the width of the pad and no greater than one-half the width of the pad.

(e) Weep holes or tell-tale holes shall be drilled or punched before the pads are attached to the tank, inner vessel, or jacket.

(f) Each pad shall be attached to the inner vessel or jacket by a continuous fillet weld using filler material recommended by the manufacturer of the shell, head, or jacket material.

(g) A fillet weld discontinuity is permitted to prevent an intersection between a pad fillet weld and an inner vessel or jacket seam weld.

5.2.7 Inspection openings and manholes

The following requirements related to inspection openings and manholes shall apply:

(a) Unless provided with inspection openings as permitted in Item (b), TC 331 highway tanks shall be provided with a manhole conforming to UG-46(g) and the other inspection opening requirements of the ASME *Code*.

(b) Instead of a manhole, highway tanks constructed of NQT steel with a volumetric capacity of 13 250 L (3500 US gal, 2915 Imp. gal) or less may be provided with an inspection opening conforming to paragraph UG-46 and the other inspection opening requirements of the ASME *Code*.

(c) Manholes shall not be located in the front head of TC 331 tanks.

(d) Manholes with bolted closures shall not be permitted on the front head of inner vessels of TC 338 or TC 341 highway tanks.

5.2.8 Ground clearance

The minimum allowable ground clearance of any TC 331, TC 338, and TC 341 highway tank vehicle, attachment, or appurtenance, other than axle assemblies, wheels, and tires, shall be 25 cm (10 in).

5.3 Highway tanks primarily for the transportation of compressed gases as liquefied gas — Specification TC 331 highway tanks

5.3.1 Construction standards

5.3.1.1
TC 331 tanks shall be
(a) of seamless or welded construction, or a combination of both;
(b) designed and constructed in accordance with Clauses 5.1, 5.2, and 5.3; and
(c) made of steel or aluminum; if aluminum, the tank shall be insulated in accordance with CSA B622.

5.3.1.2
If the tank is insulated and used to transport a flammable gas, the insulation shall be covered by a steel jacket.

5.3.2 Design

5.3.2.1 Design pressure
The design pressure of a TC 331 tank shall be such that the MAWP is not less than that prescribed in Clause 5.2.3 of CSA B622, but in no case shall the design pressure of the tank be less than 690 kPa (100 psi) or more than 3450 kPa (500 psi).

Design pressures shall be calculated in accordance with Clause 5.2.5.

5.3.2.2 Outlets
Every tank used for the transportation or handling of liquids or liquefied gases shall be provided with an outlet that makes it possible to completely empty the tank.

5.3.2.3 Reflective colour
Unless covered with a jacket made of aluminum, stainless steel, or other bright nontarnishing metal, every uninsulated tank permanently attached to a transportation vehicle shall be painted white, aluminum colour, or a similar reflecting colour on the upper two-thirds of the surface area of the tank.

5.3.2.4 Insulation

5.3.2.4.1
Table 2 of CSA B622 provides insulation requirements specific to the lading.

5.3.2.4.2 Insulation for highway tanks and portable tanks used in nitrous oxide service

5.3.2.4.2.1
The insulation shall be compatible with the lading. The insulation shall not react with the material of the tank, jacket, or structural components.

5.3.2.4.2.2
The insulation shall be applied, in accordance with the manufacturer's recommendations, to a thickness of at least 5 cm (2 in) and in such a manner that it will not separate from the tank surface or permit product to be trapped beneath it.

5.3.2.4.2.3

The insulation shall meet at least one of the following requirements:

(a) the insulation shall be non-combustible as determined in accordance with ASTM E136 or ULC CAN4-S114;
(b) the insulation shall have a fire endurance rating of at least 15 min determined in accordance with ASTM E119 or CAN/ULC-S101, or
(c) the insulation shall have a flame spread rating of 25 or less determined in accordance with ASTM E84 or CAN/ULC-S102.

5.3.2.4.2.4

The following requirements for jackets shall apply:

(a) Any exposed portions of the insulation shall be protected by a weathertight jacket constructed of stainless steel or aluminum.
(b) Flashing shall be provided around openings in the jacketing to prevent the ingress and entrapment of spilled lading.
(c) Additional protection shall be added, if necessary, to prevent mechanical damage to the jacket and insulation in areas around the manhole covers, behind ladders, and above the tires.

5.3.2.5 Emergency discharge control

The following requirements for emergency discharge control on liquid discharge lines shall apply:

(a) The requirement for an emergency discharge control applies to TC 331 highway tanks designed to transport liquefied compressed gases except those tanks designed to transport Class 2.2 non-flammable and non-toxic gases with no subsidiary class.
(b) Highway tanks with a volumetric capacity of 13 250 L (3500 US gal, 2915 Imp. gal) or less shall be equipped with an off-truck emergency shutdown system.
(c) Highway tanks with a volumetric capacity greater than 13 250 L (3500 US gal, 2915 Imp. gal) shall be equipped with an off-truck emergency shutdown system and either
    (i) a monitoring feature; or
    (ii) a passive emergency shutdown system.
(d) Highway tanks used to deliver Class 2.3 toxic gases shall be equipped with an off-truck emergency shutdown system and either
    (i) a passive emergency shutdown system; or
    (ii) a monitoring feature.
(e) Despite Items (b) and (c), an off-truck emergency shutdown system is not required on highway tanks used to transport nitrous oxide, provided the highway tanks are equipped with
    (i) a passive emergency shutdown system;
    (ii) a passive pump shutdown system that automatically protects the pump from running dry; and
    (iii) controls to shut down the pump from
        (1) the piping cabinet on the highway tank; and
        (2) a remote location (e.g., control station at the loading/unloading facility).
(f) An off-truck emergency shutdown system shall
    (i) function reliably at a distance of 46 m (150 ft); and
    (ii) be incapable of reopening the self-closing valve after emergency activation.
(g) Despite (b), (c), and (d), an emergency discharge control shall not be required for an engine fuel line on a truck-mounted highway tank, if the engine fuel line is not more than 3/4 in NPT and equipped with a valve having an excess-flow feature.
(h) If the passive emergency shutdown system referred to in Items (c)(ii), (d)(i), and (e)(i) is a hose,
    (i) the hose need not be installed on the vehicle except during loading and off-loading operations; and
    (ii) the liquid outlets of the tank shall be marked "Connect to passive emergency shutdown system only", in characters at least 10 mm (0.4 in) high in a contrasting colour and in a clearly visible location as close to the liquid outlets as possible.

5.3.3 Postweld heat treatment

5.3.3.1 General

The following requirements shall apply:

(a) All postweld heat treatment of tanks shall be conducted in accordance with the ASME *Code*.

(b) All tanks constructed in accordance with Part UHT of the ASME *Code* shall be postweld heat treated. Welded attachments to pads may be made after postweld heat treatment.

5.3.3.2 Radiography of chlorine tanks

Each tank intended to transport chlorine shall be fully radiographed and postweld heat treated in accordance with the provisions of the ASME *Code* under which it is constructed.

5.3.3.3 Treatment temperature for ammonia tanks

Tanks intended to transport anhydrous ammonia shall be heat treated at no less than 565 °C (1050°F) tank metal temperature.

5.3.4 Material

5.3.4.1 Specifications

5.3.4.1.1

All material used for construction of the tank shall comply with the requirements of

(a) the ASME *Code*; and

(b) its specification from the American Society for Testing and Materials (ASTM).

5.3.4.1.2

The relevant physical properties of the materials shall be established by a certified test report from the material manufacturer or by testing in accordance with a national standard. In either case, the ultimate tensile strength of the material used in the design calculations shall not exceed 120% of the minimum ultimate tensile strength specified in either the ASME *Code* or the ASTM standard to which the material is manufactured.

5.3.4.2 Steel impact tests

The following test requirements shall apply:

(a) Impact tests shall be required for steel used in fabrication of tanks constructed in accordance with Part UHT of the ASME *Code*.

(b) The tests shall be made on a lot basis. A lot is defined as 99 tonnes (100 tons) or less of the same heat treatment processing lot having a thickness variation no greater than ± 25%.

(c) The minimum impact energy required for full-size Charpy V-Notch specimens shall be 27 J (20 ft•lb) in the longitudinal direction at –34 °C (–30°F) and 20 J (15 ft•lb) in the transverse direction at –34 °C (–30°F).

(d) The required values for subsize specimens shall be reduced in direct proportion to the cross-sectional area of the specimen beneath the notch.

(e) If a lot does not meet this requirement, individual plates may be accepted if they individually meet this requirement.

5.3.4.3 Sketches

The fabricator shall record the heat and the slab numbers, and the certified Charpy impact values, where required, of each plate used in each tank, on a sketch showing the location of each plate in the shell and heads of the tank.

Copies of each sketch shall be retained for at least five years by the fabricator.

5.3.4.4 Orientation of shell steel plate

The circumferential orientation of the tank shell shall be in the direction of final rolling of the steel plate of which it is constructed.

5.3.4.5 Anhydrous ammonia service

When tanks are manufactured for use with anhydrous ammonia, all carbon steel plates used as pressure-retaining parts shall be constructed of materials made to fine grain practice in accordance with the requirements of Section II, Part A, of the ASME *Code* and shall be fusion welded.

5.3.5 Material thickness

The following requirements for material thickness shall apply:

(a) The material thickness shall be such that the maximum calculated design stress at any point in the tank will not exceed the lesser of
  (i) the maximum allowable stress value prescribed in Section VIII of the ASME *Code*; and
  (ii) 25% of the tensile strength of the material used.

(b) The minimum thickness of the shell or heads of the tank shall be 5 mm (0.187 in) for steel and 7 mm (0.270 in) for aluminum.

5.3.6 Structural integrity

5.3.6.1 General requirements

5.3.6.1.1

The maximum calculated design stress at any point in the tank wall shall not exceed the lesser of

(a) the maximum allowable stress value prescribed in Section VIII of the ASME *Code*; and

(b) 25% of the tensile strength of the material used in design conditions.

5.3.6.1.2

The maximum design stress at any point in the tank shall be calculated separately for the loading conditions described in Clauses 5.3.6.3.2 and 5.3.6.3.3. Alternative test or analytical methods, or a combination thereof, may be used in place of the procedures described in these clauses if the methods are accurate and verifiable.

5.3.6.1.3

Material added for corrosion allowance shall not be included to satisfy any design calculation requirements of this Standard.

5.3.6.2 Stresses

Stress concentrations in tension, bending, and torsion that occur at pads, cradles, or other supports shall be considered in accordance with Appendix G of Division 1, Section VIII, of the ASME *Code*.

Longitudinal compressive buckling stresses shall be calculated using UG-23(b), Division 1, Section VIII, of the ASME *Code*.

5.3.6.3 Shell design

5.3.6.3.1 General

Shell stresses resulting from static or dynamic loadings, or combinations thereof, are not uniform throughout the highway tank vehicle.

The vertical, longitudinal, and lateral normal operating loadings in Clause 5.3.6.3.2 can occur simultaneously and shall be combined. The vertical, longitudinal, and lateral extreme dynamic loadings in Clause 5.3.6.3.3 occur separately and need not be combined.

5.3.6.3.2 Normal operating loadings

The maximum principal stress at any point shall be determined by the following formula:

$$S = 0.5\ (S_y + S_x) \pm [0.25\ (S_y - S_x)^2 + S_s^2]^{0.5}$$

where

S = effective stress at any given point under the combination of static and operating loadings that can occur at the same time

S_y = circumferential stress generated by the *MAWP* and external pressure, when applicable, plus static head

S_x = $S_{xa} + S_{xb} + S_{xc}$, psi, being the sum of the following longitudinal stresses from static and normal operating loads:

$S_{xa} = S_{xap} + S_{xab}$

where

S_{xap} = the longitudinal stress resulting from
- (a) the *MAWP*;
- (b) the external pressure, when applicable; and
- (c) the static head

S_{xab} = the bending stress generated by the static weight of the fully loaded highway tank, and structural elements, equipment, and appurtenances supported by the highway tank wall

S_{xb} = for a truck, the greater of
- (a) the axial and bending stresses due to the horizontal accelerative force, F_a, applied at the anchoring and support members; and
- (b) the axial and bending stresses due to the horizontal decelerative force, F_d, applied at the anchoring and support members

where

F_a = 0.35 times the vertical reaction at the anchoring and support members

F_d = 0.35 times the vertical reaction at the rear suspension assembly, where the vertical reaction is based on the static weight of the fully loaded highway tank and all structural elements, equipment, and appurtenances supported by the highway tank wall

= for a trailer, the greater of
- (a) the axial and bending stresses due to the horizontal accelerative force, F_a, applied at the horizontal pivot of a tractor or converter dolly fifth wheel or the drawbar hinge on a fixed dolly; and
- (b) the axial and bending stresses due to the horizontal decelerative force, F_d, applied at the horizontal pivot of a tractor or converter dolly fifth wheel or the drawbar hinge on a fixed dolly

where

F_a = 0.35 times the vertical reaction at the horizontal pivot of the upper coupler (fifth wheel) or turntable

F_d = 0.35 times the vertical reaction at the rear suspension assembly, where the vertical reaction is based on the static weight of the fully loaded highway tank and all structural elements, equipment, and appurtenances supported by the highway tank wall

S_{xc} = for a truck, the bending stress due to a vertical accelerative force equal to 0.35 times the vertical reaction at the suspension assembly and the anchoring or support members

= for a trailer, the bending stress due to a vertical accelerative force equal to 0.35 times the vertical reaction at the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable

S_s = $S_{sa} + S_{sb} + S_{sc} + S_{sd}$, psi, being the sum of shear stresses generated by the static and normal operating loads

where

S_{sa} = the static shear stress due to the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

S_{sb} = the vertical shear stress due to a vertical accelerative force equal to 0.35 times the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

S_{sc} = the lateral shear stress due to a lateral accelerative force equal to 0.2 times the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

S_{sd} = the torsional shear stress due to a lateral accelerative force applied at the road surface equal to 0.2 times the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

5.3.6.3.3 Extreme dynamic loadings

The formulas in Clause 5.3.6.3.2 shall be used to calculate extreme dynamic loadings, except that

(a) S shall be resolved to the worst case of the following:
- (i) $S_x = S_{xa} + S_{xb}$ and $S_s = S_{sa} + S_{sb}$ (longitudinal acceleration and deceleration);
- (ii) $S_x = S_{xa} + S_{xc}$ and $S_s = S_{sa} + S_{sc}$ (vertical acceleration); and
- (iii) $S_x = 0$ and $S_s = S_{sa} + S_{sc} + S_{sd}$ (lateral acceleration); and

(b) 0.35 is replaced by 0.7 in calculating S_{xb}, S_{xc}, and S_{sb}, and 0.2 is replaced by 0.4 in calculating S_{sc} and S_{sd}.

5.3.6.4 Frames or integral structural supports

For a highway tank mounted on a frame or built with integral structural supports, the calculation of effective stresses for the loading conditions in Clause 5.3.6.3 may include the structural contribution of the frame or the integral structural supports.

5.3.6.5 Additional calculations for accidents

5.3.6.5.1

Calculations for the tank shell and heads shall include the load resulting from the design pressure in combination with the dynamic pressure resulting from a longitudinal deceleration of 2 *g* to account for stresses due to impact in an accident.

5.3.6.5.2

For the loading condition in Clause 5.3.6.5.1

(a) the stress value used shall not exceed the lesser of the yield strength and 75% of the ultimate tensile strength of the material of construction; or

(b) for a highway tank constructed of stainless steel, the stress value shall not exceed 75% of the ultimate tensile strength of the material of construction.

5.3.6.6 Calculations for appurtenances

Each appurtenance on a tank shall be designed, constructed, and installed so that if it is damaged or fails, the lading retention integrity of the tank will not be adversely affected.

5.3.7 Welding

5.3.7.1 General

Joints shall be made as required by the ASME *Code*, with all undercutting in shell and head material repaired as specified in that *Code*.

5.3.7.2 Welding requirements — Tanks constructed in accordance with Part UHT of the ASME *Code*

The following requirements for welding tests shall apply:

(a) Welding procedure and welder performance qualifications shall be made in accordance with Section IX of the ASME *Code* or the requirements of the competent authority of the province of manufacture.
(b) In the welding procedures, the additional variables specified in UHT-82 shall also be considered essential, as shall the supplementary essential variables specified in Section IX of the ASME *Code*.
(c) Records of the qualifications shall be retained for at least five years by the tank manufacturer.

5.3.7.3 Welding requirements

The following requirements for welding shall apply:

(a) When fabrication is done in accordance with Part UHT of the ASME *Code*, filler material containing more than 0.08% vanadium shall not be used.
(b) The number of passes, thickness of plate, and heat input per pass shall not vary more than 25% from the procedure or welder qualifications.

5.3.7.4 Location of longitudinal shell welds

All longitudinal shell welds shall be located in the upper half of the tank.

5.3.7.5 Weld preparation and practices

The following requirements shall apply:

(a) Edges of shell and head components may be prepared by machine heat processes if such surfaces are remelted in the subsequent welding process. If there is no subsequent remelting of the prepared surface, as in a tapered section, the final 1.25 mm (0.050 in) of material shall be removed by mechanical means.
(b) Substructures shall be properly fitted before attachment, and the welding sequence shall minimize stresses due to shrinkage of welds.
(c) The maximum tolerance for misalignment and butting up shall be in accordance with the ASME *Code*.

5.3.7.6 Weld joints

Tanks to be used with anhydrous ammonia or any other material lading that can cause stress corrosion cracking manufactured in accordance with Part UHT in Section VIII, Division I of the ASME *Code*, shall only use type (1) joints of table UW-12 and shall be fusion welded.

5.3.8 Refrigeration and heating coils

The following requirements shall apply:

(a) Refrigeration and heating coils shall be securely anchored and allow for thermal expansion.
(b) The coils shall be tested
    (i) externally to at least the tank test pressure; and
    (ii) internally to the higher of
        (1) the tank test pressure; and
        (2) twice the working pressure of the heating or refrigeration system.
(c) The tank shall not be placed in or returned to transportation service if any leakage or other evidence of damage is found during the tests referred to in Item (b).

(d) The refrigerant or heating medium to be circulated through the coils shall be compatible with the tank materials and all ladings to be handled or transported in the tank.
(e) Where any medium susceptible to freezing is used for heating or refrigeration, the heating or refrigeration system shall permit complete drainage.

5.3.9 Supports

5.3.9.1

A tank shall be supported
(a) by external cradles where it functions, in whole or in part, as the stress member replacing the frame of a vehicle; and
(b) by external cradles or longitudinal members where it is mounted on the frame of a vehicle.

Cradles shall extend to at least 120° of the tank shell circumference.

5.3.9.2

Support design calculations shall include
(a) beam stress;
(b) shear stress;
(c) torsion stress;
(d) bending moment; and
(e) acceleration stress.

5.3.9.3

The support design calculations in Clause 5.3.9.2 shall satisfy
(a) the loading conditions of Clause 5.3.6.3 when based on the ultimate strength of the material and using a design factor of 4; and
(b) the loading conditions and maximum stress values of Clause 5.3.6.5.

5.3.9.4

Where any tank support is attached to any part of a tank head, the stresses imposed on the head shall be provided for as required in Clauses 5.3.9.2 and 5.3.9.3.

5.3.10 Inspection and testing

5.3.10.1 General

In addition to the requirements in Clause 5.1.6.4, the following requirements shall apply:
(a) Inspection of materials of construction of the tank and its appurtenances shall comply with the ASME *Code* and any additional requirements of this Standard.
(b) Original test and inspection of the finished tank and its appurtenances shall comply with the ASME *Code*.
(c) In addition to Item (b), the original test pressure shall be at least twice the tank design pressure for tanks constructed in accordance with Part UHT of the ASME *Code*.

5.3.10.2 Weld testing and inspection

5.3.10.2.1

For each tank constructed in accordance with Part UHT of the ASME *Code*, all welds in or on the tank shell and heads, both inside and out, shall be inspected using a magnetic particle method conforming to Section V and Section VIII, Division 1, Appendix 6, paragraphs 6-1 to 6-4, of the ASME *Code* after postweld heat treatment and hydrostatic testing. The choice of the magnetic particle examination method shall be as follows:
(a) On the inside of the tank shell, the welds shall be inspected using the wet fluorescent magnetic particle method; and

(b) On the outside of the tank shell, the welds shall be inspected using any magnetic particle examination method.

5.3.10.2.2

For tanks of over 13 250 L (3500 US gal, 2915 Imp. gal) volumetric capacity, all welds in or on the shell and heads, both inside and outside, shall be tested by one of the following:

(a) the wet fluorescent magnetic particle method, conforming to Section V and Section VIII, Division 1, Appendix 6, paragraphs 6-1 to 6-4, of the ASME *Code*;
(b) the liquid dye penetrant method; or
(c) ultrasonic testing in accordance with Section VIII, Division 1, Appendix 12 of the ASME *Code.*

This shall not apply to tanks that have been fully radiographed or those referred to in Clause 5.3.10.2.1.

5.3.10.2.3

Permanent magnets shall not be used to perform the wet fluorescent magnetic particle inspection referred to in Clauses 5.3.10.2.1 and 5.3.10.2.2(a).

5.3.10.2.4

All defects found shall be repaired. If the tank was postweld heat treated prior to repair, postweld heat treatment shall be repeated. Repaired areas shall be retested in accordance with Clause 5.3.10.2.

5.3.11 Marking

5.3.11.1

Each specification TC 331 tank shall be marked

(a) "QT" where the tank is constructed of quenched and tempered steel; or
(b) "NQT" where the tank is constructed of other than quenched and tempered steel.

5.3.11.2

The tank shall be marked as specified in Clause 5.3.11.1 in letters not less than 50 mm (2 in) in height, near the metal identification plate(s) described in Clause 5.1.6.1.

5.4 Insulated highway tanks — Specification TC 338 tanks

5.4.1 Construction standards

TC 338 tanks shall consist of

(a) a supported welded inner vessel enclosed within a jacket;
(b) insulation between the inner vessel and jacket; and
(c) piping, valves, supports, and appurtenances as required by this specification.

5.4.2 Design

5.4.2.1 Inner vessel design pressure

The design pressure of the inner vessel shall be at least 180 kPa (26 psi) and not more than 3450 kPa (500 psi), calculated in accordance with Clause 5.2.5.

5.4.2.2 Jacket design pressure

The jacket shall be designed in accordance with Clause 5.4.3.5.

5.4.2.3 Design service temperature

The design service temperature of the tank, piping, and valves shall not be higher than the liquefaction temperature, at one atmosphere, of the lading to be transported.

5.4.2.4 Inner vessel interior

The design and construction details of the inner vessel interior shall not allow collection and retention of cleaning materials or contaminants. To preclude the entrapment of foreign material, the design and construction of the inner vessel shall allow washing of all interior surfaces by the normal surging of the lading during transportation.

5.4.3 Insulation

5.4.3.1 Compatibility

The exterior surface of the inner vessel shall be insulated with a material compatible with the lading.

5.4.3.2 Insulation effectiveness

The insulation system shall prevent the inner vessel pressure from exceeding the pressure-relief valve set pressure within the specified holding time when

(a) the inner vessel is loaded with the specific refrigerated liquefied gas at the specified temperature and pressure of the refrigerated liquefied gas; and
(b) the insulation system is exposed to an average ambient temperature of 30 °C (85°F).

5.4.3.3 Insulation combustibility in oxygen service

When contacted with a continuously heated, glowing platinum wire, the insulation in highway tanks used to transport oxygen shall not sustain combustion in a 99.5% oxygen atmosphere at atmospheric pressure.

5.4.3.4 Vacuum gauge

Each vacuum-insulated highway tank shall be provided with a connection for a vacuum gauge to indicate the absolute pressure within the insulation space.

5.4.3.5 Jacket

The following requirements shall apply to jackets:

(a) The insulation shall be completely covered by a metal jacket.
(b) The jacket shall be constructed and sealed to prevent moisture from contacting the insulation.
(c) The minimum metal thicknesses of the jacket shall be as follows:

	Jacket evacuated			Jacket not evacuated		
Metal	Gauge	mm	(in)	Gauge	mm	(in)
Stainless steel	18	1.09	(0.0428)	22	0.68	(0.0269)
Low-carbon mild steel	12	2.40	(0.0946)	14	1.72	(0.0677)
Aluminum	—	3.18	(0.1250)	—	2.54	(0.1000)

(d) An evacuated jacket shall
  (i) sustain a minimum critical collapsing pressure of 207 kPa (30 psi); and
  Note: *Stiffening rings may be used to meet this requirement.*
  (ii) not be subjected to a combined stress computed according to the formula in Clause 5.4.8.2 of more than 25% of the minimum specified tensile strength if the jacket also supports additional loads such as the weight of the inner vessel and lading.

5.4.4 Material

The following requirements related to materials shall apply:

(a) All material used for inner-vessel pressure parts shall conform to the requirements of the ASME *Code*.

(b) All material used for evacuated jacket pressure parts shall conform to the chemistry and steel-making practices of one of the material specifications of
   (i) Section II of the ASME *Code*; or
   (ii) the following ASTM Specifications: A242, A514, A572, A588, A606, A633, A1008 HSLAS (formerly A 607), A1008 HSLAS-F (formerly A 715), A1011 HSLAS (formerly A607), or A1011 HSLAS-F (formerly A715).
(c) All tie rods, mountings, and other appurtenances within the jacket, and all piping, valves, and fittings, shall be of a material suitable for use at the lowest temperature of the intended ladings.
(d) All inner vessel materials, except aluminum, shall be impact tested using the procedure prescribed in the ASME *Code*.
(e) The circumferential orientation of the inner vessel shell shall be in the direction of final rolling of the steel plate of which it is constructed.

5.4.5 Postweld heat treatment

The following requirements for postweld heat treatment shall apply:
(a) All postweld heat treatment of inner vessels shall be conducted in accordance with the ASME *Code*.
(b) All inner vessels constructed in accordance with Part UHT of the ASME *Code* shall be postweld heat treated.

Welded attachments to pads may be made after postweld heat treatment.

5.4.6 Sketches

The manufacturer shall record, on a sketch showing the location of each plate in the shell and heads of the inner vessel, the heat and the slab numbers and the certified Charpy impact values of each plate used in each inner vessel. Copies of each sketch shall be retained for at least five years by the manufacturer.

5.4.7 Material thickness

5.4.7.1 Minimum thickness

5.4.7.1.1

The maximum calculated design stress at any point in the inner vessel shall not exceed the lesser of the maximum allowable stress value prescribed in Section VIII of the ASME *Code* and 25% of the tensile strength of the material used.

5.4.7.1.2

The minimum thickness of the shell or heads of the inner vessel shall be 5 mm (0.187 in) for steel and 7 mm (0.270 in) for aluminum. However, the minimum thickness for steel may be 3 mm (0.110 in), provided that the tank is
(a) vacuum-insulated; or
(b) double-walled, with a load-bearing jacket designed to carry a proportionate amount of the structural loads.

5.4.7.2 Tensile strength of material

The relevant physical properties of the materials used in each inner vessel shall be established either by a certified test report from the material manufacturer or by testing in accordance with a national standard. In either case, the ultimate tensile strength of the material used in the design shall not exceed 120% of the minimum ultimate tensile strength specified in either the ASME *Code* or the ASTM standard to which the material is manufactured.

5.4.8 Stress calculations

5.4.8.1 General

The following requirements shall apply:

(a) The maximum design stress at any point in the inner vessel may be calculated separately for the loaded conditions described in Items (c), (d), (e), and (f) and Clauses 5.4.8.2 and 5.4.8.3. Alternative tests or analytical methods, or a combination thereof, may be used in lieu of the procedures described in Items (c), (d), (e), and (f) and Clauses 5.4.8.2 and 5.4.8.3, if the methods are accurate and verifiable.

(b) Corrosion-allowance material shall not be included to satisfy any of the requirements of Item (a).

(c) The static design and construction of each inner vessel shall be in accordance with Section VIII of the ASME *Code*.

(d) Design pressures shall be calculated in accordance with Clause 5.2.5.

(e) For inner vessels constructed of dissimilar materials, the thermal coefficients of each shall be considered in the calculation of thermal stresses.

(f) Stress concentrations in tension, bending, and torsion that occur at pads, cradles, or other supports shall be considered in accordance with Appendix G of the ASME *Code*.

5.4.8.2 Calculations

The maximum principal stress at any point shall be determined by the following formula:

$$S = 0.5\ (S_y + S_x) \pm [0.25\ (S_y - S_x)^2 + S_s^2\ ]^{0.5}$$

where

S = effective stress at any given point under the most severe combination of static and dynamic loadings that can occur at the same time

S_y = circumferential stress generated by internal and external pressure, when applicable

S_x = the net longitudinal stress, generated by the following loading conditions:

- (a) the longitudinal tensile stress generated by internal pressure; and
- (b) using applicable static loads specified in Clauses 5.4.13.4 and 5.4.14(e), the tensile or compressive stress generated by
  - (i) the axial load resulting from a decelerative force applied independently to each suspension assembly at the road surface;
  - (ii) the bending moment resulting from a decelerative force applied independently to each suspension assembly at the road surface;
  - (iii) the axial load resulting from an accelerative force applied to the horizontal pivot of the fifth wheel supporting the vehicle;
  - (iv) the bending moment resulting from an accelerative force applied to the horizontal pivot of the fifth wheel supporting the vehicle; and
  - (v) a bending moment produced by a vertical force

S_s = shear stresses as follows, using applicable static loads specified in Clauses 5.4.13.4 and 5.4.14(e):

- (a) the vectorial sum of the applicable shear stresses in the plane under consideration, including direct shear generated by the static vertical loading; and
- (b) direct lateral and torsional shear generated by a lateral accelerative force applied at the road surface.

5.4.8.3 Additional calculations for accident loads

5.4.8.3.1

Calculations for the inner vessel shell and heads shall include the load resulting from the design pressure in combination with the dynamic pressure resulting from a longitudinal deceleration of 2 *g* to account for stresses due to impact in an accident.

5.4.8.3.2

For the loading condition specified in Clause 5.4.8.3.1

(a) the stress value used shall not exceed the lesser of the yield strength and 75% of the ultimate tensile strength of the material of construction; or

(b) for a highway tank constructed of stainless steel, the stress value shall not exceed 75% of the ultimate tensile strength of the material of construction.

5.4.8.4 Calculations for appurtenances

Each appurtenance on an inner vessel or jacket shall be designed, constructed, and installed so that if it is damaged or fails, the lading retention integrity of the tank will not be adversely affected.

5.4.9 Joints

The following requirements for joints shall apply:

(a) All joints in the inner vessel and in an evacuated jacket shall be in accordance with the ASME *Code*. Butt welds with one plate edge offset shall not be permitted.

(b) Welding procedures and welder performance tests shall be in accordance with Section IX of the ASME *Code*. Records of the qualification shall be retained by the tank manufacturer for at least five years.

(c) All longitudinal welds in inner vessels and load-bearing jackets shall be located so as not to intersect nozzles or supports other than load rings and stiffening rings.

(d) Attachments shall be properly fitted before welding, and the welding sequence shall minimize stresses due to shrinkage of welds.

(e) Filler material containing more than 0.05% vanadium shall not be used with quenched and tempered steel.

(f) All inner vessel nozzle-to-shell and nozzle-to-head welds shall be full-penetration welds.

5.4.10 Manholes

Manholes as prescribed in the ASME *Code* shall be required on TC 338 tanks transporting oxygen. Each inner vessel having a manhole shall

(a) be provided with a means of entrance and exit through the jacket; or

(b) be marked on its jacket to indicate the access location on the inner vessel.

5.4.11 Openings

TC 338 tanks transporting flammable ladings shall have

(a) all liquid product outlets located on the bottom centreline of the tank; and

(b) double shut-off valves on all lines in direct communication with lading. The valves shall be leaktight at the tank design pressure. This requirement for double shut-off valves shall not apply to openings for a pressure-relief valve, a pressure-control valve, or a full trycock or gas phase manual vent valve.

5.4.12 Holding time

5.4.12.1 Rated holding time (RHT) and marked rated holding time (MRHT)

The rated holding time (*RHT*) and the marked rated holding time (MRHT) shall be determined as follows:

(a) The tank shall be charged

  (i) with a test refrigerated liquefied gas having a boiling point, at a pressure of one atmosphere, absolute, no lower than the design service temperature of the tank; and

  (ii) to its maximum permitted filling density with the refrigerated liquefied gas specified in Item (i) and stabilized to the lowest practical pressure equal to or less than the pressure to be used for loading.

(b) The highway tank and its contents shall then be exposed to ambient temperature until the pressure of the refrigerated liquefied gas reaches the lowest set-to-discharge pressure of the pressure-control valve or pressure-relief valve.

(c) The tank pressure and ambient temperature shall be recorded at 3 h intervals during the process described in Item (b).
(d) The measured holding time for the refrigerated liquefied gas is the total time for the refrigerated liquefied gas to reach the set-to-discharge pressure during the process described in Item (b) at the average ambient temperature during that time.
(e) For each refrigerated liquefied gas identified on or adjacent to the specification plate, the RHT of that refrigerated liquefied gas shall be determined by calculating its equivalent holding time at an average ambient temperature of 29 °C (85°F), based on the measured holding time established in accordance with Item (d).
(f) The MRHT for each refrigerated liquefied gas displayed on or adjacent to the specification plate (see Clause 5.1.6) shall not exceed the RHT for that refrigerated liquefied gas as determined in accordance with Item (e).

5.4.12.2 RHT and MRHT for tanks made to the same design

Instead of determining the RHT and MRHT using the procedure described in Clause 5.4.12.1, the RHT and MRHT of a tank previously determined according to that clause may be used for tanks of the same design if

(a) during its first trip, the actual holding time of each tank of the same design is established for the lading using the method for determination of actual holding time of flammable cryogenic liquids in CSA B622; and
(b) this holding time is not less than 90% of the MRHT for the lading.

5.4.12.3 Alternative method — RHT and MRHT for tanks carrying nonflammable refrigerated liquefied gases

Instead of determining the RHT and MRHT using the procedure described in Clause 5.4.12.1 or 5.4.12.2, the RHT and MRHT of a tank used to transport nonflammable refrigerated liquefied gases may be determined as

$$RHT = [(U_2 - U_1)W]/q$$

where

RHT = rated holding time, h

U_2 = the internal energy for the combined liquid and vapour lading at the set pressure of the applicable pressure-control valve or pressure-relief valve, kJ/kg (Btu/lb)

U_1 = the internal energy for the combined liquid and vapour lading at the pressure offered for transportation, kJ/kg (Btu/lb)

W = total weight of the combined liquid and vapour contents in the tank, kg (lb)

q = $[n\,(\Delta h)(29.44 - t_1)]/(t_s - t_f)$ (metric)

= $[n\,(\Delta h)(85 - t_1)]/(t_s - t_f)$ (US customary units)

where

q = calculated heat transfer rate to tank with lading, kW (Btu/h)

n = normal evaporation rate (NER), which is the rate of evaporation determined by the test of a refrigerated liquefied gas, preferably the lading, in a stationary tank, maintained at a pressure of approximately one atmosphere, absolute, kg/h (lb/h)

Δh = latent heat of vaporization of the liquid at test pressure, kJ/kg (Btu/lb)

t_1 = equilibrium temperature of the liquid at maximum loading pressure, °C (°F)

t_f = equilibrium temperature of the liquid at one atmosphere, °C (°F)

t_s = average temperature of outer shell during test, °C (°F)

The MRHT shall not exceed the RHT.

5.4.13 Inner vessel or jacket supports

5.4.13.1

The inner vessel or jacket shall be supported

(a) by external cradles or load rings where it functions, in whole or in part, as the stress member replacing the frame of a vehicle; and

(b) by external cradles, load rings, or longitudinal members where it is mounted on the frame of a vehicle.

Cradles shall extend to at least 120° of the inner vessel or jacket shell circumference.

5.4.13.2

Design calculations for the support and its attachment shall include

(a) beam stress;

(b) shear stress;

(c) torsion stress;

(d) bending moment; and

(e) acceleration stress.

5.4.13.3

The support design calculations specified in Clause 5.4.13.2 shall be based on the ultimate strength of the material using a design factor of 4, taking into account the effects of fatigue and thermal cycling, and considering the following loads independently:

(a) for a vacuum-insulated highway tank, a longitudinal, lateral, upward vertical, and downward vertical loading of twice the weight of the loaded vehicle; and

(b) for a non-vacuum-insulated highway tank, a longitudinal, lateral, and upward vertical loading of twice the weight of the loaded vehicle and a downward vertical loading of three times the weight of the loaded vehicle.

5.4.13.4

Where any tank support is attached to any part of an inner vessel head, the stresses imposed on the head shall be provided for as required in Clauses 5.4.13.2 and 5.4.13.3.

5.4.14 Supports for protected inner vessel

When a loaded inner vessel is fully supported within the vacuum jacket by structural members

(a) the design calculations for the inner vessel and its structural members shall be based on the tensile strength of the material at ambient temperature, using a design factor of 4;

(b) the enhanced tensile strength of the material at actual operating temperature may be substituted for the tensile strength at ambient temperature to the extent recognized in the ASME *Code* for static loadings;

(c) static loadings shall take into consideration the weight of the inner vessel and the structural members for an inner vessel filled to the design weight of lading;

(d) load rings in the jacket used for supporting the inner vessel shall be designed to carry the fully loaded inner vessel at the specified static loadings and external pressure; and

(e) a longitudinal, a lateral, and an upward vertical loading of 1.5 times the weight of the inner vessel filled to the design weight of lading and the structural members for an inner vessel, and a downward vertical loading of twice the weight of the inner vessel filled to the design weight of lading and the structural members for an inner vessel, shall each be used independently in the design calculations.

5.4.15 Gauging devices

5.4.15.1 Filling gauges

The following requirements for filling gauges shall apply:

(a) Only a fixed-length dip-tube, a fixed trycock line, or a differential pressure liquid level gauge shall be used as the primary control for filling.
(b) Gauge glasses shall not be permitted.
(c) For tanks carrying flammable cryogenic liquids, openings for dip-tube gauging devices and pressure gauges shall be restricted, at or inside the jacket, to a diameter of no more than 1.5 mm (0.060 in).
(d) A trycock line shall not be larger than 1/2 in nominal pipe size.
(e) Any liquid level gauge shall be adjusted to ensure a minimum 2% outage below the inlet of any pressure-control valve or pressure-control device at the set-to-discharge pressure of the valve or device.

5.4.15.2 Driver-readable pressure devices

Each highway tank shall be provided with a device that indicates the lading pressure and that is readable from the driver's driving position.

Each device shall have a reference mark or give an audible or visual alarm at the tank design pressure or the set pressure of the pressure-relief valve or pressure-control valve, whichever is lowest.

5.4.16 Cleanliness

The following requirements for cleanliness shall apply:

(a) A highway tank constructed for oxygen service shall be thoroughly cleaned in accordance with CGA G-4.1.
(b) All loose particles from fabrication, such as weld beads, dirt, grinding wheel debris, and other loose materials, shall be removed prior to the final closure of the manhole of the inner vessel.
(c) Any contaminants in the inner vessel likely to react with the lading shall be removed by cleaning with a chemical or solvent compatible with the intended lading.
(d) Where a test results in the deposit of a material on the interior of the tank, it shall be cleaned by scrubbing or other equally effective means.

5.4.17 Inspection and testing

5.4.17.1 General

In addition to the requirements in Clause 5.1.6.4, the material and construction of a tank and its associated product-retaining components shall be inspected for conformance with the ASME *Code*.

5.4.17.2 Radiography

All inner vessel shell and head welds shall be radiographed in accordance with the ASME *Code*.

5.4.17.3 Repair

All cracks and other defects shall be repaired in accordance with the ASME *Code*. The welder and the welding procedure for the repair shall be qualified in accordance with the ASME *Code*. After the repair, the inner vessel shall be postweld heat treated, if required by the ASME *Code*, and pressure tested.

5.4.17.4 Inspection for cleanliness

After all inspections and tests, tanks shall be inspected for cleanliness, and any foreign materials removed in accordance with Clause 5.4.16.

5.4.18 Marking

5.4.18.1

In addition to the requirements of Clause 5.1.6, the metal identification plate(s) shall be marked with the following information (parenthetical abbreviations are authorized):

(a) design service temperature (Design Serv. Temp.);

(b) "Insulation for Oxygen Service" or "Not Authorized for Oxygen Service", depending on the combustibility of the insulation determined according to Clause 5.4.3.3;
Note: *The marking INSULATION FOR OXYGEN SERVICE does not imply oxygen compatibility of other parts of the highway tank. This marking is for insulation only.*

(c) for tanks carrying a single cryogenic liquid, the marked rated holding time, in hours, and the name of the liquid (MRHT _____ hrs, name of cryogenic liquid); and

(d) for tanks that may carry more than one cryogenic liquid, the marked rated holding time, in hours, and the names of the liquids (MRHT _____ hrs, names of cryogenic liquids).

Note: *This marking may be displayed adjacent to the metal identification plate(s).*

5.4.18.2

The maximum product load required by Clause 5.1.6 shall be the design weight of lading used in determining the loadings in Clauses 5.4.8, 5.4.13, and 5.4.14.

5.4.18.3

Despite the definition in Clause 3.2, the volumetric capacity required by Clause 5.1.6 shall be that of the tank at its coldest operating temperature, after deduction for

(a) the volume above the inlet to the pressure-relief device or pressure-control valve; and

(b) the volume of structural members, baffles, piping, and appurtenances inside the inner vessel.

5.4.19 Pressure relief and control

5.4.19.1 Types of pressure-relief systems

5.4.19.1.1

Tanks transporting oxygen and flammable cryogenic liquid shall be protected by two independent pressure-relief systems that are not in series. The pressure-relief systems shall consist of

(a) a primary system of one or more pressure-relief valves; and

(b) a secondary system of one or more frangible discs or pressure-relief valves.

5.4.19.1.2

Tanks transporting carbon monoxide shall be protected by two independent pressure-relief systems that are not in series. The pressure-relief systems shall consist of

(a) a primary system of one or more pressure-relief valves; and

(b) a secondary system of one or more pressure-relief valves.

5.4.19.1.3

Each tank transporting helium, air, nitrogen, argon, krypton, neon, and xenon as cryogenic liquids shall be protected by one or more pressure-relief systems consisting of at least one pressure-relief valve.

5.4.19.1.4

Pressure-relief devices shall be located and installed on the tank in such a way that cooling effects generated from flow of lading through the device do not impair their operation.

5.4.19.2 Flow capacities

5.4.19.2.1

For tanks transporting oxygen or flammable cryogenic liquid

(a) the primary and the secondary systems of pressure-relief devices shall each have a flow capacity equal to or greater than that calculated by the applicable formula in Clause 5.3.2 or 5.3.3 of CGA S-1.2;
(b) the primary system shall allow its total flow capacity at 120% or less of the tank MAWP;
(c) the secondary system shall allow its total flow capacity at 150% or less of the tank MAWP; and
(d) the flow capacity and rating of each pressure-relief device shall be verified and marked on the device by the device manufacturer in accordance with CGA S-1.2.

5.4.19.2.2

For each tank transporting helium, air, nitrogen, argon, krypton, neon, and xenon as cryogenic liquids

(a) the pressure-relief system shall have a flow capacity equal to or greater than that specified in Clause 5.3.2 or 5.3.3 of CGA S-1.2; and
(b) if the pressure-relief system consists of a combination of pressure-relief valves and frangible discs, the pressure-relief valves shall have a total venting capacity equal to or greater than that specified in Clause 4.1.1.10.1.1 of CGA S-1.2.

5.4.19.3 Pressure-relief devices for vacuum-insulated jackets

The following requirements shall apply to pressure-relief devices for vacuum-insulated jackets:

(a) The jacket of a vacuum-insulated highway tank shall be protected by a relief device that releases internal pressure.
(b) The discharge area of the relief device shall be at least 0.34 mm^2/kg (0.00024 in^2/lb) of volumetric capacity of the inner vessel.
(c) The relief device shall function at the lesser of
    (i) the internal design pressure of the jacket calculated in accordance with the ASME *Code*; and
    (ii) 172 kPa (25 psi).

5.5 Highway tanks for the transportation of nonflammable refrigerated liquefied gases — Specification TC 341 tanks

5.5.1 Inner vessel construction

The inner vessel shall be of welded construction, designed, and constructed in accordance with the requirements of the ASME *Code*.

5.5.2 Inner vessel design

5.5.2.1

The MAWP of the inner vessel shall be at least 174.4 kPa (25.3 psi) and no more than 1034.2 kPa (150 psi).

5.5.2.2

Stress values of the inner vessel and inner support system shall not exceed

(a) those calculated in accordance with UG-23 and UG-54 of the ASME *Code*, Section VIII, Division 1;
(b) 1.25 times the maximum allowable stress value calculated in accordance with the ASME *Code*, Section VIII, Division 1, at a temperature of 38 °C (100°F) for the combination of general inner vessel shell stress and local inner vessel shell stress; and
(c) the lesser of the maximum allowable stress value prescribed in Section VIII, Division 1, of the ASME *Code* and 25% of the tensile strength of the material used.

5.5.2.3

The maximum principal stresses shall be calculated using the following load cases:

(a) for the static load case, considering design pressure and the mass of the lading, the inner vessel, all inner vessel attachments, inner vessel piping, inner vessel supports, and insulation supported or attached to the inner vessel; and

(b) for the dynamic load cases, considering design pressure, the mass of the lading, the inner vessel, all inner vessel attachments, inner vessel piping, inner vessel supports, and insulation supported or attached to the inner vessel, and the following dynamic loads:
   (i) 1.5 *g* longitudinal;
   (ii) 1.5 *g* lateral;
   (iii) 1.5 *g* vertical upward; and
   (iv) 2 *g* vertical downward.

5.5.2.4

Despite Clause 5.2.5, the design pressure and test pressure shall be calculated as follows:

(a) design pressure (P_D)

$$P_D = (MAWP + H + V)$$

(b) test pressure (P_T)

$$P_T = x\,(MAWP + H + V) - V_a$$

where

$MAWP$ = the maximum allowable working pressure (as defined in Clause 3.2)

H = the pressure exerted on the bottom of the tank by the lading when the tank is full to its maximum permitted filling density

V = in the case of a vacuum-insulated vessel, 101.325 kPa (14.7 psia); in all other cases, 0

x = the multiplier to be used in establishing the test pressure in Table 7.3 of this Standard
= 2 for hydro testing TC 341 highway tanks constructed in accordance with part UHT of the ASME *Code*
= 1.5 for hydro testing all other TC 341 tanks
= 1.25 for pneumatic testing of all TC 341 tanks

V_a = in the case of a vacuum-insulated vessel, the actual vacuum as measured in kPa (psia), i.e., 101.325 kPa minus the absolute pressure measured in the annular space, in kPa (14.7 psia minus absolute pressure measured in the annular space, in psia); in all other cases, 0

5.5.2.5

The maximum principal stress in the inner vessel shall be calculated according to the following equations or using other equally suitable verifiable analytical methods:

$$S = 0.5\,(S_y + S_x) \pm [0.25\,(S_y - S_x)^2 + S_s^2]^{0.5}$$

where

S = effective stress at any given point under the loadings specified in Clause 5.5.2.3

S_y = circumferential stress generated by MAWP and external pressure plus static head

S_x = the net longitudinal stress, generated by the following loading conditions:
   (a) the longitudinal tensile stress generated by MAWP and external pressure plus static head; and
   (b) using applicable loads specified in Clause 5.5.2.3, the tensile or compressive stress generated by
      (i) the axial load resulting from a decelerative force applied independently to each suspension assembly at the road surface;

(ii) the bending moment resulting from a decelerative force applied independently to each suspension assembly at the road surface;
(iii) the axial load resulting from an accelerative force applied to the horizontal pivot of the fifth wheel supporting the vehicle;
(iv) the bending moment resulting from an accelerative force applied to the horizontal pivot of the fifth wheel supporting the vehicle; and
(v) a bending moment produced by a vertical force

S_s = shear stresses as follows, using applicable loads specified in Clause 5.5.2.3:
(a) the vectorial sum of the applicable shear stresses in the plane under consideration, including direct shear generated by the static vertical loading; and
(a) direct lateral and torsional shear generated by a lateral accelerative force applied at the road surface

5.5.2.6 Additional calculations for accident loads

5.5.2.6.1

Calculations for the inner vessel shell and heads shall include the load resulting from the design pressure in combination with the dynamic pressure resulting from a longitudinal deceleration of 2 *g* to account for stresses due to impact in an accident.

5.5.2.6.2

For the loading condition specified in Clause 5.5.2.6.1
(a) the stress value used shall not exceed the lesser of the yield strength and 75% of the ultimate tensile strength of the material of construction; or
(b) for a highway tank constructed of stainless steel, the stress value shall not exceed 75% of the ultimate tensile strength of the material of construction.

5.5.2.7 Inner vessel design with optional transport pressure control system

The following requirements shall apply to the optional transport pressure control system:
(a) When the highway tank is equipped with an optional transport pressure control system as described in Item (b)
(i) the design pressure for the static load case in Clause 5.5.2.3(a) shall be calculated in accordance with Clause 5.5.2.4; and
(ii) the design pressure for the dynamic load cases in Clauses 5.5.2.3(b) and 5.5.2.6.1 shall be calculated by substituting MATP for MAWP in the equations of Clauses 5.5.2.4 and 5.5.2.5. MATP shall be 174.4 kPa (25.3 psi).
The design shall accommodate the highest resulting stress.
(b) When equipped with an optional transport pressure control system, this system shall
(i) be of a fail-safe design that will prevent the pressure in the inner vessel from exceeding an MATP of 174.4 kPa (25.3 psi) during transport;
(ii) include one or more re-closing pressure-relief valves with set pressure no greater than 174.4 kPa (25.3 psi) and sized in accordance with CGA S-1.2 for loss of vacuum. These pressure-relief valves are separate from and in addition to the pressure-relief valves referred to in Clause 5.5.11. The requirements of Clauses 5.2.4.4 and 5.2.4.5 shall not apply to these pressure-relief valves;
(iii) include a pressure-control valve with venting capacity equal to or greater than the gas generated by the heat flux through the insulation system, piping, and support system with the insulation system intact. Set pressure for this pressure-control valve shall be 174.4 kPa (25.3 psi) or less;
(iv) be configured such that the pressure-relief valve(s) in Item (ii) and the pressure-control valve in Item (iii) are separated from the inner vessel by an automatic fail-open isolation valve with an interlock that will prevent the vehicle from being moved while the valve is closed;
(v) include controls that are tamper-resistant and equipped with a safety wire and seal; and

(vi) be designed and installed to minimize the effects of continuous venting of cold gases and the formation of ice that might prevent proper operation of the pressure-relief valve(s), pressure-control valve, and isolation valve.

5.5.3 Material thickness

Inner vessel shell or heads shall be constructed of metals thicker than
(a) 2.5 mm (0.098 in) for inner vessels enclosed in an evacuated or load-bearing jacket; and
(b) 4.5 mm (0.177 in) for all other inner vessels.

5.5.4 Inner vessel interior

Design and construction details of the inner vessel interior shall not allow collection and retention of cleaning materials or contaminants. To preclude the entrapment of foreign material, the design and construction of the inner vessel shall allow washing of all interior surfaces by the normal surging of the lading during transportation.

5.5.5 Compatibility

The exterior surface of the inner vessel shall be insulated with a material compatible with the lading.

5.5.6 Insulation combustibility in oxygen service

When contacted with a continuously heated, glowing platinum wire, the insulation in highway tanks used to transport oxygen shall not sustain combustion in a 99.5% oxygen atmosphere at atmospheric pressure.

5.5.7 Jacket

5.5.7.1 General

The following requirements shall apply:
(a) The insulation shall be completely covered by a metal jacket.
(b) The jacket shall be constructed and sealed to prevent moisture from contacting the insulation.
(c) Minimum metal thicknesses of the jacket shall be as follows:

	Jacket evacuated			Jacket not evacuated		
Metal	Gauge	mm	(in)	Gauge	mm	(in)
Stainless steel	18	1.09	(0.0428)	22	0.68	(0.0269)
Low-carbon mild steel	12	2.40	(0.0946)	14	1.72	(0.0677)
Aluminum	—	3.18	(0.1250)	—	2.54	(0.1000)

(d) The maximum principal stress in the jacket shall be calculated for the load cases in Clause 5.5.2.3 according to the equation in Clause 5.5.2.5 or using other equally suitable verifiable analytical methods, except considering internal vacuum only for the pressure terms for vacuum-insulated tanks and no pressure terms for tanks with non-evacuated jackets.

5.5.7.2 Design for minimum collapsing pressure — Evacuated jacket

5.5.7.2.1

An evacuated jacket shall be designed to sustain a minimum critical collapsing pressure of 207 kPa (30 psi).

5.5.7.2.2

5.5.7.2.2.1
For an evacuated jacket excluding the jacket heads, the design referred to in Clause 5.5.7.2.1 shall meet the requirements in Clauses 5.5.7.2.2.2 to 5.5.7.2.2.8.

5.5.7.2.2.2
For the cylindrical portion of the jacket between stiffening rings, the critical collapsing pressure, P_c, shall be calculated using the formula

$$P_c = [2.6E\,(t/D)^{2.5}]/[(L/D) - 0.45(t/D)^{0.5}]$$

where
P_c = critical collapsing pressure, kPa (psi)
E = modulus of elasticity of outer jacket material, kPa (psi)
t = thickness of outer jacket material, mm (in)
D = outside diameter of outer jacket, mm (in)
L = distance between stiffening ring centres, mm (in)

Note: *For the purposes of the calculations, heads are deemed to be stiffening rings located one-third the head depth from the head-to-shell tangent line.*

5.5.7.2.2.3
Where stiffening rings are included in the calculations in Clause 5.5.7.2.2.2
(a) outside rings shall be attached by continuous fillet welds;
(b) inside rings shall be attached by fillet welds having a total length of
  (i) one-third of the outer jacket circumference on each side of the ring if welded on two sides of the ring; or
  (ii) two-thirds of the outer jacket circumference if welded on one side of the ring; and
(c) the distance between the welds in Item (b) shall not exceed 12 times the thickness of the jacket.

5.5.7.2.2.4
A portion of the outer jacket may be included in calculating the moment of inertia of the ring, and the width of this portion on each side of the ring shall be calculated as follows:

$$W = 0.78\,(Rt)^{0.5}$$

where
W = width of the portion to be included in the calculations, mm (in)
R = outside radius of the outer jacket, mm (in)
t = thickness of the outer jacket material, mm (in)

The portion of the jacket between two webs of a closed-section stiffening ring may be included up to a limit of twice the value of W for each web.

5.5.7.2.2.5
A flange of a closed-section stiffening ring, if not of a standard structural shape, may be included, up to a value of 2*W*, using the formula in Clause 5.5.7.2.2.4, except that
R = radius of the flange, mm (in)
t = thickness of the flange, mm (in)

5.5.7.2.2.6
Two separate stiffening rings less than $2W$ apart may be included in calculations as a single stiffening ring, and the outer jacket may be included, up to a total maximum of $4W$.

5.5.7.2.2.7
A drain opening shall be furnished to each outside closed section stiffening ring.

5.5.7.2.2.8
The minimum moment of inertia of each stiffening ring shall be greater than or equal to

$I = 7.24D^3L/E$ (metric) [$I = 1.05D^3L/E$ (US customary units)]; or

$I' = 9.51D^3L/E$ (metric) [$I' = 1.38D^3L/E$ (US customary units)]

where

I = the moment of inertia of the stiffener about a centroidal axis parallel to the outer jacket axis, mm^4 (in^4)

I' = the moment of inertia of the combined section of stiffener and the portion of the outer jacket plate about a centroidal axis parallel to the outer jacket axis, mm^4 (in^4)

D = outside diameter of the outer jacket, mm (in)

L = one-half the sum of the distances from the centre of the stiffening ring to each of the adjacent rings, measured parallel to the axis of the jacket (for this purpose, heads are deemed to be stiffening rings located one-third the head depth from the head-to-shell tangent line), mm (in)

E = modulus of elasticity of the stiffener material, kPa (psi)

5.5.7.2.3
For the jacket heads, the design referred to in Clause 5.5.7.2.1 shall be based on the following formula:

$P_c = 0.25E\,(t/R)^2$

where

P_c = critical collapsing pressure of 200 kPa (30 psi) or more, kPa (psi)

E = modulus of elasticity of head material, kPa (psi)

t = thickness of head material after forming, mm (in)

R = (a) for circular heads, the inside dish radius of head, mm (in); and

(b) for ellipsoidal heads

$R = K_1D_o$

where

K_1 = value derived from Table UG-37 in the ASME *Code*

D_o = the outside diameter of head

5.5.7.3 Design for non-evacuated jacket
When used as a primary structural member, a non-evacuated jacket shall be circumferentially reinforced as follows:

(a) Circumferential reinforcement shall be located at most 1524 mm (60 in) apart.

(b) A ring stiffener used as circumferential reinforcement shall

(i) provide uninterrupted support to the circumference of the jacket; and

(ii) result in a section modulus about the neutral axis of the ring section parallel to the shell greater than or equal to the following:

(1) for steel

$I/C = 0.00686\,DL$ (metric) [$I/C = 0.00027\,DL$ (US customary units)]

(2) for aluminum

$I/C = 0.001186\,DL$ (metric) [$I/C = 0.000467\,DL$ (US customary units)]

where

I/C = section modulus, mm^3 (in^3)

D = jacket diameter, mm (in)

L = one-half the sum of the distances from the centre of the stiffening ring to each of the adjacent rings, measured parallel to the axis of the jacket (for this purpose, supporting bulkheads shall be deemed to be ring stiffeners, and heads shall be deemed to be ring stiffeners located one-third the head depth from the head tangent line), mm (in)

(c) A portion of the jacket shall be included as part of the ring section in determining the ring section modulus if
   (i) the ring stiffener is welded to the jacket;
   (ii) each circumferential weld covers not less than 50% of the total circumference; and
   (iii) each unwelded space on the circumferential weld does not exceed 40 times the shell thickness.

(d) The portion specified in Item (c) shall be determined as follows:

Number of circumferential welds between ring stiffener and jacket	Distance between the welds	Portion to be included
1	—	$20t$
2	less than $20t$	$20t + L_1$
2	$20t$ or more	$40t$

where

t = jacket thickness, mm (in)

L_1 = measured distance between welds, mm (in)

(e) A drain opening shall be furnished to each outside closed section stiffening ring, and each internal closed section stiffening ring shall be furnished with a vent.

(f) Stiffening rings that support the inner vessel shall conform to the design calculation of Clause 5.5.2.

(g) Where loads are applied to the outer jacket stiffening rings from the support system used to support the inner container within the outer jacket, additional stiffening rings or an increased moment of inertia of the stiffening rings designed for the external pressure shall be provided to carry the support loads.

(h) Loads applied directly to the jacket shall be analyzed in accordance with Appendix G of the ASME *Code*.

5.5.8 Materials

5.5.8.1 Inner vessel and appurtenances

Construction materials that contact the lading shall be compatible with all ladings to be transported in the tank and shall conform to the ASME *Code*.

5.5.8.2 Jacket

Jacket pressure parts shall be constructed of material of one of the following specifications:

(a) one of the specifications in Section II of the ASME *Code*; or

(b) ASTM Specification A242, A514, A572, A588, A606, A633, A1008 HSLAS (formerly A607), A1008 HSLAS-F (formerly A715), A1011 HSLAS (formerly A607), or A1011 HSLAS-F (formerly A715).

5.5.8.3 Cleanliness

The following requirements for cleanliness shall apply:

(a) All loose particles from fabrication, such as weld beads, dirt, grinding wheel debris, and other loose materials, shall be removed prior to the final closure of the manhole of the tank.

(b) Any contaminants in the inner vessel likely to react with the lading shall be removed by cleaning with a chemical or solvent compatible with the intended lading.
(c) A highway tank constructed for oxygen service shall be thoroughly cleaned in accordance with CGA G-4.1.

5.5.9 Joints

The following requirements related to joints shall apply:
(a) All joints in the inner vessel shall be in accordance with the ASME *Code*.
(b) Welding procedures and qualification shall be in accordance with Section IX of the ASME *Code*.
(c) All longitudinal welds in inner vessels and load-bearing jackets shall be located so as not to intersect nozzles or supports other than load rings and stiffening rings.
(d) Attachments shall be properly fitted before welding, and the welding sequence shall minimize stresses due to shrinkage of welds.

5.5.10 Openings and controls

5.5.10.1 Manholes

Manholes shall comply with the ASME *Code*. Inner vessel manholes are optional and shall be bolted or welded.

5.5.10.2 Outlets

Each inner vessel opening, with the exception of openings for gauges, manual vents, pressure-relief devices, or pressure-control devices, shall be provided with a plug, cap, bolted flange, plate, or valve.

5.5.11 Pressure-relief devices

5.5.11.1 Tank

5.5.11.1.1

The tank shall be provided with pressure-relief devices
(a) in accordance with CGA S-1.2, Part 2;
(b) installed in accordance with Clause 5.2.4; and
(c) located and installed in such a way that cooling effects generated from the flow of the lading through the device do not impair their operation.

5.5.11.1.2

The pressure-relief devices referred to in Clause 5.5.11.1.1 shall conform to the following:
(a) The combined flow capacity of the primary and secondary pressure-relief systems shall be determined at a pressure of not more than 121% of the inner vessel's MAWP.
(b) The total flow capacity of the primary pressure-relief system shall be determined at a pressure of not more than
    (i) 110% of the inner vessel's MAWP if the system is composed of a single relief device; and
    (ii) 115% of the inner vessel's MAWP if the system is composed of multiple relief devices.
(c) Despite Clause 5.2.4.5, the set-to-discharge pressure of the secondary pressure-relief system shall be greater than that of the primary pressure-relief system and no higher than 150% of the inner vessel's MAWP.
(d) All rupture discs shall
    (i) be marked with a rupture pressure at 20 °C (68°F) not exceeding the test pressure of the inner vessel; and
    (ii) have a coincident disc temperature of 427 °C (800°F) or less.

5.5.11.1.3
The requirements for the pressure-relief valve(s) in the optional transport pressure control system described in Clause 5.5.2.7 shall be independent of and not considered for the total flow capacity calculation requirements in Clauses 5.5.11.1.1 and 5.5.11.1.2.

5.5.11.2 Jacket
The following requirements related to pressure-relief devices for jackets shall apply:
(a) The jacket of a vacuum-insulated highway tank shall be protected by a relief device to release internal pressure.
(b) The discharge area of the relief device shall be at least 0.34 mm^2/kg (0.00024 in^2/lb) of the volumetric capacity of the inner vessel.
(c) The relief device shall function at the lesser of
    (i) the internal design pressure of the jacket, calculated in accordance with the ASME *Code*; and
    (ii) 172 kPa (25 psi).

5.5.12 Piping, valves, and fittings
Aluminum parts that retain lading during transportation or are subject to abrading in normal service shall not be installed on tanks that transport liquid oxygen.

5.5.13 Supports and anchoring

5.5.13.1
The inner vessel or jacket shall be supported by external cradles or other suitable supporting devices, such as load rings, where it functions, in whole or in part, as the structural member replacing the frame of a vehicle. Cradles shall extend to at least 120° of the inner vessel or jacket shell circumference.

5.5.13.2
Support design calculations shall include
(a) beam stress;
(b) shear stress;
(c) torsion stress;
(d) bending moment; and
(e) acceleration stress.

5.5.13.3
The provisions of Clause 5.5.2 shall apply to the calculations in Clause 5.5.13.2 for supports, load-bearing jacket areas, and inner vessel support attachments to the jacket.

5.5.13.4
For attachments from the jacket to the vehicle suspension system, the support and anchoring design calculations in Clause 5.5.13.2 shall be based on the ultimate strength of the material, using a design factor of 4, and taking into account the effects of fatigue and thermal cycling, with a longitudinal, lateral, upward vertical, and downward vertical loading of twice the weight carried by the supports and anchoring, including the lading, inner vessel, jacket, insulation, piping, attachments, and appurtenances.

5.5.13.5
Where any inner vessel support is attached to any part of an inner vessel head, the stresses imposed on the head shall be provided for as required in Clauses 5.5.13.2 to 5.5.13.4.

5.5.13.6
All attachments of supports to inner vessels and to jackets shall be
(a) by pads of materials similar to that of the inner vessel or jacket, as the case may be;

(b) by stiffening rings; or
(c) by bosses so designed or gusseted as to distribute the load.

5.5.14 Gauging devices

5.5.14.1 Pressure gauges

All tanks shall be provided with a pressure gauge located in the operating compartment. A shut-off valve shall be installed between the pressure gauge and the tank.

5.5.14.2 Vacuum gauge connections

Each vacuum-insulated tank shall be provided with a connection for a vacuum gauge to the insulation space.

5.5.15 Inspection and testing

5.5.15.1 General

In addition to the requirements in Clause 5.1.6.4, the materials and construction of the tank, its associated product-retaining components, and its appurtenances, excluding the jacket, shall be inspected in accordance with the ASME *Code*. The tank shall be subjected to a pressure test at the test pressure calculated in accordance with Clause 5.5.2.4.

5.5.15.2 Piping, valves, and fittings

The provisions of Clause 5.2.2.5 apply to piping and other product-retaining components at 110% of their operating pressure.

5.5.16 Marking

5.5.16.1

In addition to the requirements of Clause 5.1.6, the metal identification plate(s) shall be marked with the following information (parenthetical abbreviations are authorized):
(a) design service temperature in °C (or optionally in °F) — (Design Serv. Temp.);
(b) "Insulation for Oxygen Service" or "Not Authorized for Oxygen Service", depending on the combustibility of the insulation determined according to Clause 5.5.6; and
Note: *The marking INSULATION FOR OXYGEN SERVICE does not imply oxygen compatibility of other parts of the highway tank. This marking is for insulation only.*
(c) "MATP — 174.4 kPa", when the highway tank is equipped with an optional transport pressure control system, and MATP is used for dynamic loading calculations.

5.5.16.2

The maximum product load required by Clause 5.1.6 shall be the design weight of lading used in determining the loadings in Clause 5.5.2.3.

5.5.16.3

Despite the definition in Clause 3.2, the volumetric capacity required by Clause 5.1.6 shall be the tank at its coldest operating temperature, after deduction for
(a) the volume above the inlet to the pressure-relief device or pressure-control valve; and
(b) the volume of structural members, baffles, piping, and appurtenances inside the inner vessel.

5.6 Highway tanks for the transportation of dangerous goods other than liquefied compressed gases — Specification TC 406, TC 407, TC 412, and TC 423 tanks

5.6.1 General requirements

Unless otherwise permitted by the particular specification, all highway tanks built to TC 406, TC 407, TC 412, and TC 423 specifications shall comply with Clauses 5.1 and 5.6.

When the material is FRP, the words "weld" or "welded" shall mean "physically bonded".

5.6.2 Multi-tank vehicle connecting structures and drains

The following requirements related to connecting structures and drains on multi-tank vehicles shall apply:

(a) The strength of the connecting structure joining multiple tanks on a single vehicle shall meet the structural design requirements in Clause 5.6.4.
(b) Any void between the tanks shall be vented to the atmosphere by a drain on the bottom centreline.
(c) Each drainage opening shall be accessible and kept open at all times.
(d) Voids in a carbon steel self-supporting multi-tank vehicle shall consist of at least
    (i) a single drain of at least 2.5 cm (1 in) diameter; or
    (ii) two or more drains of at least 1.25 cm (0.5 in) diameter, 15 cm (6 in) apart, one of which shall be located on the bottom centreline.

5.6.3 Material

5.6.3.1 General

5.6.3.1.1

All material of construction for shell, heads, bulkheads, and baffles shall conform to Section II, Parts A and B, of the ASME *Code*, or the requirements in Clause 5.6.3.1.4, except that TC 406 highway tanks, TC 407 highway tanks with a MAWP less than or equal to 240 kPa (35 psi), TC 412 highway tanks with a MAWP less than or equal to 103 kPa (15 psi), and TC 423 highway tanks may also be constructed

(a) of steels conforming to one of the following ASTM standards:
    (i) ASTM A240;
    (ii) ASTM A572;
    (iii) ASTM A656;
    (iv) ASTM A1008 HSLAS (formerly ASTM A607);
    (v) ASTM A1008 HSLAS-F (formerly ASTM A715);
    (vi) ASTM A1011 CS (formerly ASTM A569);
    (vii) ASTM A1011 SS (formerly ASTM A570);
    (viii) ASTM A1011 HSLAS (formerly ASTM A607);
    (ix) ASTM A1011 DS (formerly ASTM A622); or
    (x) ASTM A1011 HSLAS-F (formerly ASTM A715); or
(b) of aluminum alloys suitable for fusion welding and conforming with the 0, H32, or H34 tempers of one of the following ASTM specifications:
    (i) ASTM B209 Alloy 5052;
    (ii) ASTM B209 Alloy 5083;
    (iii) ASTM B209 Alloy 5086;
    (iv) ASTM B209 Alloy 5154;
    (v) ASTM B209 Alloy 5254;
    (vi) ASTM B209 Alloy 5454; or
    (vii) ASTM B209 Alloy 5652.

5.6.3.1.2

All aluminum heads, bulkheads, and baffles shall be of 0 temper (annealed) or stronger tempers.

5.6.3.1.3
All aluminum shell materials shall be of H32 or H34 tempers, except that lower ultimate strength tempers may be used if the minimum shell thickness from Table 5.3, 5.5, or 5.7 for TC 406, TC 407, or TC 412 tanks, respectively, or from Clause 5.10.2.3 for TC 423 highway tanks is increased in inverse proportion to the lesser ultimate strength of the material.

5.6.3.1.4
FRP shall have
(a) a minimum ultimate tensile strength of 124 MPa (18 000 psi);
(b) a minimum tensile modulus of 8280 MPa (1 200 000 psi);
(c) a minimum flexural strength of 152 MPa (22 000 psi);
(d) a minimum flexural modulus of 6900 MPa (1 000 000 psi);
(e) for structural elements, a fibre content by weight between 30 and 75%;
(f) a minimum Barcol hardness of 90% of the manufacturer's value for a fully cured resin system; and
(g) for a corrosion barrier, a resin rich mixture as described in Clause 5.6.3.3.4. The corrosion barrier shall not be considered in determining the properties of Items (a) to (f).

5.6.3.2 Minimum thickness for the heads and shells
The minimum thickness for the heads and shells shall ensure that the maximum stress levels specified in Clause 5.6.4 are not exceeded and in no case shall the head or shell thickness be less than that required in Tables 5.2 and 5.3, 5.4 and 5.5, or 5.6 and 5.7 for TC 406, TC 407, or TC 412 tanks, respectively, or in Clause 5.10.2.2 or 5.10.2.3 for TC 423 highway tanks.

5.6.3.3 Corrosion allowance and linings

5.6.3.3.1
A highway tank, or any part of it, subject to thinning by corrosion or mechanical abrasion by the lading shall be protected by providing an increase in thickness of material, a lining, or some other method of protection.

5.6.3.3.2
Material added for corrosion allowance need not be of uniform thickness if different rates of attack can reasonably be expected for various areas of the tank.

5.6.3.3.3
Lining material shall consist of a non-porous, homogeneous material that is not less elastic than the parent material and substantially immune to attack by the lading. The lining material shall be bonded or attached by appropriate means to the tank wall and shall have no perforations when complete. Joints or seams in the lining shall be made by fusing the materials together, or by other satisfactory means.

5.6.3.3.4
Every tank constructed of FRP shall be lined by an internal layer, suitable for the materials to be transported in the tank, that
(a) is resin rich and at least 0.254 cm (0.1 in) thick when the thickness is calculated from the aggregate thickness of
  (i) the surfacing veil; and
  (ii) random chop strand mat when saturated with resin; or
(b) is thermoplastic.

The internal layer shall not be considered part of the tank wall when the minimum required thickness and the physical properties of the FRP are determined, and when the design calculations are performed.

5.6.3.4 FRP material testing

Manufacturers of tanks constructed of FRP shall test the FRP used in construction prior to the start of initial production and at least once per year in the following manner:

(a) samples shall be obtained from tanks under construction or fabricated using identical procedures and material used for construction of tanks; and
(b) samples shall be tested in accordance with
    (i) for tensile strength, ASTM D638 and ASTM D651;
    (ii) for tensile modulus, ASTM D638;
    (iii) for flexural strength, ASTM D790;
    (iv) for flexural modulus, ASTM D790; and
    (v) for any other physical property required by the design calculation for the tank, the appropriate ASTM standard test procedure as recommended in ASTM D4762.

5.6.3.5 External protection for FRP

The exterior surface of the tank wall of FRP tanks and attachments or appurtenances constructed of FRP shall be coated with a paint or pigment layer that protects against environmental and chemical degradation of the surface layer.

5.6.3.6 Electrical grounding for FRP tanks

5.6.3.6.1

If used to transport dangerous goods with a primary or subsidiary classification of Class 3, each tank constructed of FRP shall be equipped with one or more areas of metal that are

(a) in total, not less than 0.186 m^2/3785 L (2 ft^2/1000 US gal, 835 Imp. gal) of volumetric capacity;
(b) in direct contact with the lading; and
(c) electrically connected to a grounding knob.

5.6.3.6.2

No part of the lading shall be farther than 198 cm (78 in) from one of the metal areas referred to in Clause 5.6.3.6.1.

5.6.3.6.3

The metal area referred to in Clause 5.6.3.6.1 shall take the form of

(a) a metal foot valve, pipe outlet, or plate situated in the base of the tank; or
(b) a metallic grille of wire with
    (i) a thickness of not less than 0.1 cm (0.04 in) in diameter; and
    (ii) apertures greater than 4.128 cm^2 (0.64 in^2).

5.6.3.6.4

Each metal area referred to in Clause 5.6.3.6.1 on a tank and on a multi-tank vehicle shall be electrically interconnected using stranded copper cables or a continuous metal frame, so that each grounding knob will act as a common ground for all areas.

5.6.3.7 Fire resistance for FRP tanks

5.6.3.7.1

Each tank constructed of FRP may be provided with a fire-resistant exterior surface layer, of at least 0.5 mm (0.020 in) thickness, of fire-retardant resins meeting the requirements of Class 2 of ASTM E84.

5.6.3.7.2

Where the fire-resistant exterior referred to in Clause 5.6.3.7.1 meets the requirements of Clause 5.6.3.1.4, it may be included in the determination of minimum thickness and the physical properties of the material of construction.

5.6.4 Structural integrity

5.6.4.1 General requirements

5.6.4.1.1

The maximum calculated design stress at any point in the tank wall shall not exceed

(a) for metal tanks
  (i) the maximum allowable stress value prescribed in Section VIII of the ASME *Code*; or
  (ii) 25% of the tensile strength of the material used at design conditions; and
(b) for FRP tanks, 14.3% of the ultimate strength of the laminate
  (i) used at design conditions; and
  (ii) in the direction of the stress in cases where the laminate possesses different ultimate strength properties depending on the direction of the stress.

5.6.4.1.2

The relevant physical properties of the materials shall be established

(a) for metal tanks, by a certified test report from the material manufacturer or by testing in accordance with a national standard. In either case, the ultimate tensile strength of the material used in the design shall not exceed 120% of the minimum ultimate tensile strength specified in either the ASME *Code* or the ASTM standard to which the material is manufactured; and
(b) for tanks made from FRP, by testing of laminates of identical construction to those used in the tank, in accordance with ASTM D4762.

5.6.4.1.3

The maximum design stress at any point in the tank shall be calculated separately for the loading conditions described in Clauses 5.6.4.2 and 5.6.4.3. Alternative test or analytical methods, or a combination thereof, may be used in place of the procedures described in these clauses, if the methods are accurate and verifiable.

5.6.4.1.4

Material added for corrosion allowance or lining in accordance with Clause 5.6.3.3 shall not be included to satisfy any design calculation requirements of this Standard.

5.6.4.2 Stresses

The following requirements shall apply:

(a) Stress concentrations in tension, bending, and torsion that occur at pads, cradles, or other supports shall be considered in accordance with Appendix G, Division 1, Section VIII, of the ASME *Code*.
(b) Longitudinal compressive buckling stresses for highway tanks certified to ASME requirements shall be calculated using paragraph UG-23(b), Division 1, Section VIII, of the ASME *Code*.
(c) For tanks not certified to the ASME requirements, these stresses shall be calculated using
  (i) UG-23(b), Division 1, Section VIII, of the ASME *Code*; or
  (ii) alternative methods that are accurate and verifiable.
(d) The alternative method referred to in Item (c)(ii) shall include in the calculations the static loadings described in Clause 5.1.2.1 and the dynamic loadings described in Clause 5.6.4.3.

5.6.4.3 Shell design

5.6.4.3.1 General

Shell stresses resulting from static or dynamic loadings, or combinations thereof, are not uniform throughout the highway tank vehicle. The vertical, longitudinal, and lateral normal operating loadings in Clause 5.6.4.3.2 can occur simultaneously and shall be combined. The vertical, longitudinal, and lateral extreme dynamic loadings in Clause 5.6.4.3.3 occur separately and need not be combined.

5.6.4.3.2 Normal operating loadings

The maximum principal stress at any point shall be determined by the following formula:

$$S = 0.5\ (S_y + S_x) \pm [0.25\ (S_y - S_x)^2 + S_s^2]^{0.5}$$

where

S = effective stress at any given point under the combination of static and operating loadings that can occur at the same time

S_y = circumferential stress generated by the *MAWP* and external pressure, when applicable, plus static head

S_x = $S_{xa} + S_{xb} + S_{xc}$, being the sum of the following longitudinal stresses from static and normal operating loads:

$S_{xa} = S_{xap} + S_{xab}$

where

S_{xap} = the longitudinal stress resulting from
(a) the *MAWP*;
(b) the external pressure, when applicable; and
(c) the static head

S_{xab} = the bending stress generated by the static weight of the fully loaded highway tank, and all structural elements, equipment, and appurtenances supported by the highway tank wall

S_{xb} = for a truck, the greater of
(a) the axial and bending stresses due to the horizontal accelerative force, F_a, applied at the anchoring and support members; and
(b) the axial and bending stresses due to the horizontal decelerative force, F_d, applied at the anchoring and support members

where

F_a = 0.35 times the vertical reaction at the anchoring and support members

F_d = 0.35 times the vertical reaction at the rear suspension assembly, where the vertical reaction is based on the static weight of the fully loaded highway tank and all structural elements, equipment, and appurtenances supported by the highway tank wall

= for a trailer, the greater of
(a) the axial and bending stresses due to the horizontal accelerative force, F_a, applied at the horizontal pivot of a tractor or converter dolly fifth wheel or the drawbar hinge on a fixed dolly; and
(a) the axial and bending stresses due to the horizontal decelerative force, F_d, applied at the horizontal pivot of a tractor or converter dolly fifth wheel or the drawbar hinge on a fixed dolly

where

F_a = 0.35 times the vertical reaction at the horizontal pivot of the upper coupler (fifth wheel) or turntable

F_d = 0.35 times the vertical reaction at the rear suspension assembly, where the vertical reaction is based on the static weight of the fully loaded highway tank and all structural elements, equipment, and appurtenances supported by the highway tank wall

S_{xc} = for a truck, the bending stress due to a vertical accelerative force equal to 0.35 times the vertical reaction at the suspension assembly and the anchoring or support members

= for a trailer, the bending stress due to a vertical accelerative force equal to 0.35 times the vertical reaction at the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable

S_s = $S_{sa} + S_{sb} + S_{sc} + S_{sd}$, being the sum of shear stresses generated by the static and normal operating loads

where

S_{sa} = the static shear stress due to the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

S_{sb} = the vertical shear stress due to a vertical accelerative force equal to 0.35 times the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

S_{sc} = the lateral shear stress due to a lateral accelerative force equal to 0.2 times the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

S_{sd} = the torsional shear stress due to a lateral accelerative force applied at the road surface equal to 0.2 times the vertical reaction at
- (a) for a trailer, the suspension assembly and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or
- (a) for a truck, the anchoring or support members

5.6.4.3.3 Extreme dynamic loadings

The formulas in Clause 5.6.4.3.2 shall be used to calculate extreme dynamic loadings, except that

(a) S shall be resolved to the worst case of the following:
- (i) $S_x = S_{xa} + S_{xb}$ and $S_s = S_{sa}$ (longitudinal acceleration and deceleration);
- (ii) $S_x = S_{xa} + S_{xc}$ and $S_s = S_{sa} + S_{sb}$ (vertical acceleration); and
- (iii) $S_x = 0$ and $S_s = S_{sa} + S_{sc} + S_{sd}$ (lateral acceleration); and

(b) 0.35 is replaced by 0.7 in calculating S_{xb}, S_{xc}, and S_{sb}, and 0.2 is replaced by 0.4 in calculating S_{sc} and S_{sd}.

5.6.4.4 Frames or integral structural supports

For a highway tank mounted on a frame or built with integral structural supports, the calculation of effective stresses for the loading conditions in Clause 5.6.4.3 may include the structural contribution of the frame or the integral structural supports.

5.6.5 Joints

The following requirements for joints shall apply:

(a) All joints between tank shell, heads, baffles, baffle-attaching rings, and bulkheads shall be
- (i) for metal tanks, welded in conformance with Section IX of the ASME *Code*; and
- (ii) for FRP tanks, as strong or stronger than adjoining areas of the tank.

(b) Where practical, all welds shall be easily accessible for inspection.

5.6.6 Manhole assemblies

5.6.6.1

Each highway tank with volumetric capacity greater than 1514 L (400 US gal, 330 Imp. gal) shall be accessible through a manhole at least 38 cm (15 in) in diameter.

5.6.6.2

Each manhole, fill opening, and washout assembly shall withstand the greater of a static internal fluid pressure of 248 kPa (36 psi) and tank test pressure, without leakage or permanent deformation affecting its structural integrity.

5.6.6.3
The assembly shall be deemed to meet the requirement in Clause 5.6.6.2 if the manufacturer of the assembly has hydrostatically tested at least 1% (or one assembly, whichever is greater) of all assemblies of that design produced every three months, according to the following requirements:
(a) The assembly shall be tested with the venting devices blocked, and any leakage or deformation that would affect the product retention capability of the assembly shall constitute a failure.
(b) If the assembly has failed the test, then five more assemblies from the same lot shall be tested.
(c) If one of these five assemblies fails the test, then every assembly from that lot shall be tested and not fail before it is marked in accordance with Clause 5.6.6.6.

5.6.6.4
Each manhole, filler, and washout cover shall be fitted with a safety device that prevents the cover from fully opening when under internal pressure.

5.6.6.5
Each manhole and fill cover shall be secured with fastenings that will prevent opening from
(a) vibration under normal transportation conditions; or
(b) a shock impact due to a rollover accident, except where the manhole or fill cover strikes or is struck by a substantial obstacle.

5.6.6.6
Each manhole cover shall be permanently marked with
(a) the manufacturer's name;
(b) the test pressure — XXX kPa (psi); and
(c) a statement certifying that the manhole cover meets the testing requirements of
  (i) this clause; or
  (ii) §178.345-5 of 49 CFR.

5.6.6.7
All fittings and devices mounted on the manhole cover that come in contact with the lading shall comply with the requirements of Clause 5.6.6.2. These fittings and devices shall be marked in accordance with the manhole cover marking requirements of Clause 5.6.6.6, unless they are fittings of 1 in NPT or less or are pressure-relief devices marked as specified in Clause 5.6.11.6(h).

5.6.7 Supports and anchoring
The design calculations of the supports described in Clauses 5.1.3 and 5.1.4 shall include the stresses identified in Clauses 5.1.2 and 5.6.4.3.

5.6.8 Circumferential reinforcements

5.6.8.1 General
A tank with a shell that is less than 1 cm (3/8 in) thick shall be circumferentially reinforced with bulkheads, baffles, ring stiffeners, or any combination thereof, in addition to the heads, as follows.
(a) Reinforcement shall be located in such a manner that the maximum unreinforced longitudinal portion of the shell does not exceed 152.5 cm (60 in).
(b) The requirement of Item (a) shall not apply to tanks designed to be loaded by vacuum if the unreinforced longitudinal portion of the shell that exceeds 152.5 cm (60 in) conforms with the requirements of Section VIII, Division 1, of the ASME *Code*.
(c) Unless otherwise reinforced with structural members capable of maintaining the shell stress levels required by Clause 5.6.4, circumferential reinforcement shall be located within 2.5 cm (1 in) of a shell joint with an angle of 160° or less between
  (i) two conical shell sections; or

(ii) conical and cylindrical shell sections.

(d) The angle referred to in Item (c) shall be measured
   (i) outside the shell when the joint is between the small end of a conical shell section and a cylindrical shell section; and
   (ii) inside the shell when the joint is between
      (1) the large ends of two conical shell sections; or
      (2) the large end of a conical shell section and a cylindrical shell section.

5.6.8.2 Separation between circumferential joints and reinforcements

No reinforcement shall cover any circumferential joint except for doubler plates and knuckle pads.

5.6.8.3 Extent of welding of baffle or baffle attachment ring

A baffle or baffle attachment ring used as a circumferential reinforcement member shall be welded to 50% or more of the circumference of the tank, and any unwelded portion shall not exceed 40 times the shell thickness unless externally reinforced.

5.6.8.4 Ring stiffener as circumferential reinforcement

5.6.8.4.1

A ring stiffener used as a circumferential reinforcement member shall be continuous around the tank shell and shall

(a) result in a section modulus about the neutral axis of the ring section parallel to the shell greater than or equal to the following:
   (i) for steel
      $I/C = 0.00686\ WL$ (metric units)
      $I/C = 0.00027\ WL$ (US customary units);
   (ii) for aluminum
      $I/C = 0.001186\ WL$ (metric units)
      $I/C = 0.000467\ WL$ (US customary units); or
   (iii) for FRP
      $I/C = 3.757\ WL/E^{0.5}$ (metric units)
      $I/C = 1.479\ WL/E^{0.5}$ (US customary units)

   where
   I/C = section modulus, mm^3 (in^3)
   W = tank width or diameter, mm (in)
   L = one-half the sum of the centre-to-centre distances to each of the adjacent rings, measured parallel to the axis of the tank shell, mm (in)
   E = the Young's (tensile) modulus of the FRP

(b) include a portion of the shell as part of the ring section in determining the ring section modulus if
   (i) the ring stiffener is welded to the tank shell;
   (ii) each circumferential weld covers not less than 50% of the total circumference;
   (iii) each unwelded space on the circumferential weld does not exceed 40 times the shell thickness; and

(iv) the portion included is determined as follows:

Number of circumferential ring stiffener-to-shell welds	W	Portion to be included
1	—	20*t*
2	less than 20*t*	20*t* + *W*
2	20*t* or more	40*t*

where
W = width of the stiffener between parallel circumferential ring stiffener-to-shell welds, mm (in)
t = shell thickness, mm (in)

5.6.8.4.2
For metal tanks, ring stiffeners shall be as prescribed in the ASME *Code* when used to meet the vacuum requirements of Clause 5.6.8.4.

5.6.8.4.3
Each external and internal closed-section stiffening ring enclosing an air space shall be furnished with a drain opening and a vent. The drain shall be kept operative at all times.

5.6.8.4.4
Hat-shaped or open-sectioned ring stiffeners or other open-sectioned structures whose installation forms an enclosed space that traps moisture and air directly against the tank wall and precludes visual inspection of the tank shell surface shall be prohibited on carbon steel tanks. Stiffeners or structures in which the enclosed space is separated from the tank's shell by a pad or by a wall of the stiffener may be used, provided that a drain is present at the bottom of the stiffener or structure.

5.6.9 Damage protection

5.6.9.1 Accident damage protection

5.6.9.1.1
Outlets, valves, closures, piping, or any devices that if damaged in an accident could result in a loss of lading shall be protected by accident damage protection.

5.6.9.1.2
Any accident damage protection attached to the tank wall shall consist of a device that
(a) is able to withstand or deflect the loads specified in Clause 5.6.9.2; deformation of the protection device shall be acceptable, provided that the devices being protected are not damaged;
(b) is designed and installed to
  (i) maximize the load distribution to the tank wall; and
  (ii) minimize the possibility of any adverse effect on the lading retention integrity of the highway tank; and
(c) does not result in a wall stress exceeding the ultimate tensile strength of the material, using a design factor of 1.3, when subjected to
  (i) stresses resulting from the design loads acting on the protection device; and
  (ii) the stresses arising from the MAWP.

5.6.9.1.3
Any dome, sump, or washout cover plate that projects from the tank and communicates with the lading or vapour space shall
(a) be as strong and tough as the tank wall;
(b) have a thickness at least equal to the tank wall; and
(c) be protected as required in Clause 5.6.9.1.4 if
    (i) located in the lower one-third of the tank and projecting from the tank wall more than the lesser of
        (1) 10 cm (4 in); and
        (2) one-half of the diameter of the opening in the tank wall for the device; and
    (ii) located in the upper two-thirds of the tank and projecting from the tank wall more than the lesser of
        (1) 5 cm (2 in); and
        (2) one-quarter of the diameter of the opening in the tank wall for the device.

5.6.9.1.4
The accident damage protection referred to in Clause 5.6.9.1.3 shall consist of a device that
(a) is 125% as strong as the accident damage protection in Clause 5.6.9.1.2; and
(b) otherwise complies with the requirements of Clause 5.6.9.1.2.

5.6.9.1.5
Any piping that extends beyond accident damage protection shall be equipped within the accident damage protection with
(a) a stop valve; and
(b) a sacrificial device outboard of the stop valve, which will break at no more than 70% of the load that would cause the failure of any part inboard of the sacrificial device.

5.6.9.1.6
The minimum allowable road clearance of any highway tank vehicle component or protection device located between any two adjacent axles on a vehicle or vehicle combination shall be at least 1.25 cm (0.5 in) for every 30 cm (12 in) separating such axles, but not less than 30 cm (12 in), except, in the case of landing gear, the minimum allowable road clearance shall be 25 cm (10 in).

5.6.9.2 Bottom damage protection

5.6.9.2.1
Each outlet, projection, or section of piping located in the lower one-third of a tank that if damaged in an accident would result in a loss of lading shall be provided with bottom damage protection, unless protected by accident protection as described in Clause 5.6.9.1.

5.6.9.2.2
Based on the ultimate strength of the material, bottom damage protection shall consist of a device that
(a) is able to withstand, or deflect away from the highway tank, a force of 689 474 N (155 000 lb) from the front, side, or rear, uniformly distributed over each surface of the device over
    (i) an area not to exceed 0.56 m^2 (6 ft^2); and
    (ii) a width not to exceed 183 cm (6 ft); and
(b) extends at least 15 cm (6 in) beyond any component that can contain lading, and enough distance that the device or component being protected will not be damaged when the bottom damage protection device is subjected to the force in Item (a).

5.6.9.2.3
Suspension components and structural mounting members may be used to provide all or part of the bottom damage protection.

5.6.9.2.4
A discharge opening need not be provided with bottom damage protection if it is provided with a sacrificial device that
(a) will break at no more than 70% of the load that would cause the failure of any device or part inboard of the sacrificial device; and
(b) is located
  (i) outboard of a self-closing stop valve; and
  (ii) within
    (1) 10 cm (4 in) of the tank shell; or
    (2) 10 cm (4 in) of a sump, but not more than 20 cm (8 in) from the tank shell.

5.6.9.3 Rollover damage protection

5.6.9.3.1
Each closure for openings, including but not limited to manhole and filling or inspection openings, and each valve, fitting, pressure-relief device, vapour recovery stop valve, or other lading-retaining fitting located in the upper two-thirds of a highway tank shall be
(a) protected by being enclosed within, or between, adjacent rollover damage protection devices; or
(b) 125% as strong as the accident damage protection in Clause 5.6.9.1.2.

5.6.9.3.2
Rollover damage protection shall consist of a device or devices that
(a) are designed and installed to withstand a load, uniformly distributed and independently applied, of twice the weight of the loaded vehicle from any angle to the tank shell; deformation of the device or devices shall be acceptable, provided that the devices being protected are not damaged; and
(b) are constructed of a material capable of withstanding this stress.

5.6.9.3.3
The design of the rollover damage protection shall be proven capable of carrying the required loads by calculations, tests, or a combination of tests and calculations.

5.6.9.3.4
Where two or more devices provide rollover damage protection, each shall be designed and installed to withstand
(a) not less than one-quarter of the load specified in Clause 5.6.9.3.2; and
(b) its proportionate share of that load.

5.6.9.3.5
Any rollover damage protection device shall be designed to discharge rainwater or any other liquids from the top of the tank away from any structural component of the vehicle, and any discharge lines shall not pass through the tank.

5.6.9.4 Longitudinal deceleration protection
The following requirements shall apply:
(a) Tank shell and heads shall be designed to withstand the combined load of
  (i) the design pressure; and
  (ii) a dynamic pressure from a longitudinal deceleration of 2 *g*.
(b) The allowable stress value used in Item (a) shall not exceed the ultimate strength of the material of construction, using a design factor of 1.3.
(c) Performance testing, analytical methods, or a combination of the two may be used to satisfy the requirements in Item (a), as long as the methods are accurate and verifiable.
(d) The longitudinal decelerative force in Item (a) may be reduced by 0.25 *g* for each baffle assembly in the tank, but to no less than 1.0 *g*.

5.6.10 Pumps, piping, hoses, and connections

5.6.10.1
All piping and each stop valve, lading retention fitting, and closure shall be designed for a MAWP not less than 172 kPa (25 psi) and not less than the MAWP of the tank. The bursting pressure shall be not less than four times the MAWP.

5.6.10.2
Each hose shall be designed for a MAWP of not less than 690 kPa (100 psi) and not less than four times the MAWP of the tank.

5.6.10.3
In addition to the requirements in Clauses 5.6.10.1 and 5.6.10.2 , the bursting pressure shall be not less than four times that of any higher pressure to which each pipe, pipe fitting, hose, or other pressure part can be subjected in service by the action of a pump or other device.

5.6.10.4
Each hose assembly component shall be
(a) designed for a working pressure of four times the MAWP of the tank and not less than
    (i) 690 kPa (100 psi); or
    (ii) for 15.24 cm (6 in) camlock fittings, 518 kPa (75 psi);
(b) marked by the hose assembly component manufacturer in a manner such that the working pressure can be determined by the end user; and
(c) designed so that there will be no leakage when it is connected.

5.6.10.5
Despite Clauses 5.6.10.1, 5.6.10.2, and 5.6.10.4, gravity off-load hoses and couplings (drop hoses) may have a MAWP of 345 kPa (50 psi).

5.6.10.6
Design of piping, hose, hose couplings, stop valves, lading retention fittings, and closures shall include an allowance for prevention of damage due to expansion, contraction, jarring, and vibration. The lading retention system shall not include slip joints for this purpose.

5.6.10.7
Any heating device shall be constructed in such a way that the breaking of its external connections will not cause leakage of the tank lading.

5.6.10.8
Any gauging, loading, or charging device, including associated valves, shall be provided with an adequate means of secure closure to prevent leakage.

5.6.10.9
Each loading, unloading, or charging line shall be furnished with accident damage protection conforming to Clause 5.6.9.1.4.

5.6.10.10
A non-metallic pipe, valve, or connection that is not as strong and as heat resistant as the tank material shall be authorized only if located outboard of the lading retention system.

5.6.10.11
Any pump mounted on a tank truck, tank trailer, or associated truck tractor, and used for loading or off-loading the tank, shall be equipped with a pressure-actuated bypass valve or other means of limiting the output pressure of the pump in order to prevent damage to any component of the product transfer system installed on the tank vehicle.

5.6.11 Pressure relief

5.6.11.1 General

5.6.11.1.1
Each highway tank shall be provided with
(a) a primary pressure-relief system or primary and secondary pressure-relief systems that
  (i) consist of one or more reclosing pressure-relief valves; and
  (ii) have sufficient venting capacity to limit the tank internal pressure to the tank test pressure; and
(b) a vacuum-relief system designed to operate and have sufficient capacity to prevent tank collapse due to vacuum resulting from loading, unloading, or heating and cooling of lading.

5.6.11.1.2
Except as provided in Clause 5.6.11.1.3 or the tank specification, non-reclosing pressure-relief devices and gravity-actuated reclosing valves shall not be permitted in any highway tank.

5.6.11.1.3
Non-reclosing pressure-relief devices shall be permitted where in series with a reclosing pressure-relief valve.

5.6.11.1.4
Each reclosing pressure-relief valve shall be constructed and installed to prevent unauthorized adjustment of the relief-valve setting.

5.6.11.1.5
No device that could prevent venting through the primary or secondary pressure-relief system shall be installed in that system.

5.6.11.1.6
Each primary and secondary pressure-relief system shall be mounted, shielded, and drained in such a way that foreign material and lading will not adversely affect the operation or discharge capability of the system.

5.6.11.2 Set-to-discharge pressure

5.6.11.2.1
The set pressure is the pressure at which a pressure-relief system starts to open, allowing discharge. Each reclosing pressure-relief valve in a primary pressure-relief system shall
(a) have a set pressure not less than 120% of the MAWP and not more than 132% of the MAWP; and
(b) reclose at not less than 108% of the MAWP, and remain closed at any lower pressure.

5.6.11.2.2
Each reclosing pressure-relief valve in a secondary pressure-relief system shall have a set pressure not less than 120% of the MAWP.

5.6.11.3 Transient internal pressures

Each pressure-relief system shall be able to withstand a dynamic pressure surge of 210 kPa (30 psi) above the set pressure for at least 60 ms with a total loss of liquid not exceeding 1 L (1 US quart), before it recloses with no further leaking. This requirement shall be met regardless of vehicle orientation, and demonstrated by testing. An acceptable test is contained in TTMA RP No. 81.

5.6.11.4 Location of pressure-relief devices

Each pressure-relief device shall be connected as near to the top of the vapour space as is practicable. Protective or other devices that affect the flow from the device shall not lessen the vent capacity below that required by Clause 5.6.11.5.

5.6.11.5 Venting capacity

5.6.11.5.1 Total venting capacity

Unless the specification for the tank provides otherwise, the primary and secondary pressure-relief systems shall provide a minimum total venting capacity as specified in Table 5.1 rated at not more than the tank test pressure.

Where the exposed area of the tank equals an amount between two adjacent amounts specified in column 1 of Table 5.1, the minimum total venting capacity shall be interpolated from the values in column 2.

5.6.11.5.2 Primary pressure-relief system venting capacity

Unless otherwise provided in the applicable specification, the primary pressure-relief system shall have a minimum venting capacity of the greater of

(a) 104.3 standard cubic metres per hour per 10 m^2 (12 000 SCFH per 350 ft^2) of exposed tank area, where "standard" means 15 °C and 1 atm (60°F and 14.7 psia); and

(b) one-quarter of the minimum total venting capacity in Clause 5.6.11.5.1.

5.6.11.5.3 Secondary pressure-relief system venting capacity

If the primary pressure-relief system does not provide the minimum total venting capacity required in Clause 5.6.11.5.1, the secondary pressure-relief system venting capacity shall provide the remainder.

5.6.11.6 Testing, certification, and marking of pressure-relief devices

All pressure-relief devices on a tank, including valves, frangible (rupture) disks, vacuum vents, and combination devices shall be tested, certified, and marked in accordance with §178.345-10(f), (g), and (h) of 49 CFR, which read as follows:

(f) *Certification of pressure relief devices.* The manufacturer of any pressure relief device, including valves, frangible (rupture) disks, vacuum vents and combination devices must certify that the device model was designed and tested in accordance with this section and the appropriate cargo tank specification. The certificate must contain sufficient information to describe the device and its performance. The certificate must be signed by a responsible official of the manufacturer who approved the flow capacity certification.

(g) *Rated flow capacity certification test.* Each pressure relief device model must be successfully flow capacity certification tested prior to first use. Devices having one design, size and set pressure are considered to be one model. The testing requirements are as follows:

(1) At least 3 devices of each specific model must be tested for flow capacity at a pressure not greater than the test pressure of the cargo tank. For a device model to be certified, the capacities of the devices tested must fall within a range of plus or minus 5 percent of the average for the devices tested.

(2) The rated flow capacity of a device model may not be greater than 90 percent of the average value for the devices tested.

(3) The rated flow capacity derived for each device model must be certified by a responsible official of the device manufacturer.

(h) *Marking of pressure relief devices*. Each pressure relief device must be permanently marked with the following:
  (1) Manufacturer's name;
  (2) Model number;
  (3) Set pressure, in psi; and
  (4) Rated flow capacity, in SCFH at the rating pressure, in psi.

5.6.12 Tank outlets

5.6.12.1
In Clause 5.6.12, "outlet" means any opening in the highway tank wall used for loading or unloading of lading but does not include manholes, vents, vapour recovery devices, and similar openings.

5.6.12.2
Each tank outlet shall be equipped with
(a) an internal self-closing stop valve; or
(b) an external self-closing stop valve located as close as practicable to the tank wall.

5.6.12.3
Each outlet shall be provided with a self-closing system that
(a) closes all the outlets in an emergency within 30 s of actuation;
(b) includes a remotely actuated means of closure located
  (i) more than 3 m (10 ft) from the outlet or, if vehicle length does not allow this distance, on the end of the highway tank furthest from the outlet; and
  (ii) outside the cab on the tank, its supporting structure, or skirting in a clearly visible location and readily accessible to a person standing on the ground;
(c) consists of an actuated mechanism that
  (i) is corrosion-resistant; and
  (ii) operates in all climatic conditions;
(d) ensures that each outlet remains securely closed and capable of retaining lading if the actuating system is accidentally damaged or sheared off during transportation, unless the valve and actuator are protected by bottom damage protection described in Clause 5.6.9.2 and any piping extending beyond the accident damage protection is protected as described in Clause 5.6.9.1.5;
(e) includes a means of thermal activation that
  (i) is located as close to the outlet as is practicable; and
  (ii) closes the outlet at a temperature of 122 °C (250°F) or less; and
(f) is capable of being manually or mechanically closed remotely.

5.6.12.4
Clauses 5.6.12.2 and 5.6.12.3 shall not apply to outlets that discharge lading into the tank above the maximum liquid level.

5.6.12.5
Any outlet that extends beyond an internal self-closing stop valve or an external stop valve that forms part of the self-closing system shall be equipped with a leaktight closure at the end of the outlet.

5.6.12.6
Each opening that is not an outlet shall be equipped with a leaktight closure located as close to the tank opening as is practicable, and any connection extending beyond this closure shall be fitted with another closure at the end of the connection.

5.6.12.7
Openings commonly referred to as dump gates or mud gates shall comply with the self-closing valve requirements specified in Clause 5.6.12.3 unless they are
(a) not used for off-loading dangerous goods;
(b) marked "Gate not for off-loading dangerous goods" on the gate in letters at least 25 mm (1 in) high; and
(c) bolted shut whenever the tank contains dangerous goods.

5.6.12.8
Booms may be used on tanks designed to be loaded by vacuum, if the tank outlet is equipped with a self-closing stop valve that is protected as specified in Clause 5.6.9.

5.6.13 Gauging devices
Each highway tank may be equipped with a gauging device that indicates the maximum permitted liquid level to within 0.5% of the volumetric capacity as measured by volume or liquid level. Gauge glasses shall not be permitted.

5.6.14 Connections for FRP tanks
Neither screwed connections nor metal insert threaded connections shall be allowed in the shell or head of a FRP tank.

5.7 Highway tank vehicle — Specification TC 406

5.7.1 General
Vacuum-loaded highway tanks shall not be constructed to this specification.

5.7.2 Maximum allowable working pressure (MAWP)
TC 406 highway tanks shall have a MAWP
(a) between 18 kPa abs (2.65 psi) and 28 kPa (4 psi); or
(b) between 18 kPa abs (2.65 psi) and 100 kPa (14.7 psi) if used to transport petroleum crude oil, UN1267.

5.7.3 Material

5.7.3.1 Heads or bulkheads and baffles
If providing tank reinforcement
(a) for metal tanks, heads or bulkheads and baffles shall meet or exceed the thickness specified in row 3 of Table 5.2, depending on the volume per cm (in) of length in row 1 and the material of construction in row 2; and
(b) for FRP tanks
  (i) the geometry of the head shall be hemispherical or ellipsoidal with a major-to-minor axis ratio less than 2 to 1; and
  (ii) the heads, bulkheads, and baffles shall have a minimum thickness of 9.5 mm (3/8 in) excluding the corrosion allowance outlined in Clause 5.6.3.3.4.

5.7.3.2 Shell
The following requirements for shells shall apply:
(a) For metal tanks, the shell thickness shall meet or exceed that specified in row 3 of Table 5.3, depending on the volumetric capacity in row 1 and the material of construction in row 2.
(b) For FRP, the shell shall have a minimum thickness of 9.5 mm (3/8 in) excluding the corrosion allowance outlined in Clause 5.6.3.3.4.

(c) For FRP tanks of layered or "sandwich" construction, shell thickness may be the aggregate of all FRP laminate layers that form an integral part of the load-bearing wall if the laminate layers are permanently attached together.

5.7.4 Pressure relief

5.7.4.1 Vacuum relief

The vacuum-relief system shall be set to open at no more than 3 kPa (6 oz/in2) vacuum and shall have sufficient capacity to limit the vacuum to 7 kPa (1 psi).

5.7.4.2 Set-to-discharge pressure of relief valves

Each reclosing primary pressure-relief valve shall

(a) have a set pressure of
  (i) the greater of
    (1) more than 110% of the MAWP; and
    (2) 23 kPa (3.3 psi); and
  (ii) less than 138% of the MAWP; and

(b) reclose at not less than the MAWP.

5.7.4.3 Venting capacity

5.7.4.3.1

The primary pressure-relief valve shall have a venting capacity of at least 170 m3/h (6000 SCFH) of free air, rated at no more than the lesser of

(a) 125% of the tank test pressure; and

(b) 20 kPa (3 psi) above the MAWP.

5.7.4.3.2

The minimum total venting capacity required in Clause 5.6.11.5 may be rated at the pressure in Clause 5.7.4.3.1.

5.7.4.4 Normal venting

A normal vent with a set pressure of 7 kPa (1 psi) or more shall be permitted on a TC 406 tank if

(a) designed to prevent loss of lading through the vent in case of vehicle overturn; and

(b) the vapour pressure of
  (i) the lading does not exceed 7 kPa (1 psi) at 46 °C (115°F); or
  (ii) the lading, if gasoline, and ambient loading temperature do not exceed those determined by Specific Requirement 6 of CSA B621.

5.7.5 Outlets

External self-closing stop valves shall not be permitted as an alternative to internal self-closing stop valves on outlets used for loading and unloading, except as permitted in Clause 5.7.6.3.1.

5.7.6 Specification TC 406 crude tanks

5.7.6.1 General

TC 406 crude tanks shall be constructed in accordance with Clauses 5.7.1 to 5.7.5, except as modified by Clauses 5.7.6.2 to 5.7.6.4.

5.7.6.2 Pressure-relief devices

5.7.6.2.1
TC 406 crude tanks may use pressure-relief devices that
(a) do not comply with Clause 5.6.11.3; and
(b) do not comply with Clause 5.7.4 where the MAWP is above 28 kPa (4 psi).

5.7.6.2.2
If TC 406 crude tanks include a secondary pressure-relief system as referred to in Clauses 5.6.11.1 and 5.6.11.2.2, it may be composed of
(a) fusible devices of a minimum area of 81 mm2 (1.25 in2) that open at a temperature of 121 °C (250°F) or less when the pressure is between the MAWP and 1.3 times the MAWP; or
(b) frangible devices that burst between 130 and 150% of the MAWP.

5.7.6.3 Tank outlets for TC 406 crude tanks

5.7.6.3.1
Despite Clause 5.7.5, external self-closing stop valves shall be permitted on outlets used for loading and unloading.

5.7.6.3.2
The requirements for outlets in Clause 5.6.12.3 shall not apply to valves on outlets of TC 406 crude tanks designed for dump unloading over an open pit.

5.7.6.3.3
The valves referred to in Clauses 5.7.6.3.1 and 5.7.6.3.2 shall be protected in accordance with the requirements of Clause 5.6.9.

5.7.6.4 Marking and certification
The following requirements shall apply:
(a) TC 406 crude tanks shall be marked with “TC 406 Crude” in the line provided for the TC specification on the metal identification plate(s) referred to in Clause 5.1.6.
(b) The Certificate of Compliance required by Clause 8.2.1 shall show the description “TC 406 Crude” as the highway tank specification.

5.8 Highway tank vehicle — Specification TC 407

5.8.1 General requirements
The following requirements shall apply:
(a) Each tank shall be circular in cross-section and have a MAWP of at least 172 kPa (25 psi).
(b) Tanks loaded by vacuum shall have an external design pressure of at least 103 kPa (15 psi).

5.8.2 Material

5.8.2.1 Heads or bulkheads and baffles
If providing tank reinforcement
(a) for metal tanks, heads or bulkheads and baffles shall meet or exceed the thickness specified in row 3 of Table 5.4, depending on the volume per cm (in) of length in row 1 and the material of construction in row 2; and

(b) for FRP tanks
  (i) the geometry of the head shall be hemispherical or ellipsoidal with a major-to-minor axis ratio less than 2 to 1; and
  (ii) the heads, bulkheads, and baffles shall have a minimum thickness of 9.5 mm (3/8 in), excluding the corrosion allowance outlined in Clause 5.6.3.3.4.

5.8.2.2 Shell

The following requirements for shells shall apply:
(a) For metal tanks, the shell thickness shall meet or exceed the thickness specified in row 3 of Table 5.5, depending on the volume per cm of length in row 1 and the material of construction in row 2.
(b) For FRP, the shell shall have a minimum thickness of 9.5 mm (3/8 in), excluding the corrosion allowance outlined in Clause 5.6.3.3.4.
(c) For FRP tanks of layered or "sandwich" construction, shell thickness may be the aggregate of all FRP laminate layers that form an integral part of the load-bearing wall if the laminate layers are permanently attached together.

5.8.3 Manhole assemblies

Each manhole shall withstand the greater of a static internal fluid pressure of 276 kPa (40 psi) and tank test pressure, without leakage or permanent deformation affecting its structural integrity.

5.8.4 Vacuum relief

The vacuum-relief system shall limit the vacuum to less than 80% of the design vacuum capability of the tank.

The vacuum-relief system required by Clause 5.6.11.1.1(b) shall not be required for highway tanks designed to be loaded by vacuum and built to withstand full vacuum.

5.9 Highway tank vehicle — Specification TC 412

5.9.1 General requirements

The following requirements shall apply:
(a) Each tank shall have a MAWP of at least 35 kPa (5 psi), and those with a MAWP of 104 kPa (15 psi) or more shall be circular in cross-section.
(b) Tanks loaded by vacuum shall have an external MAWP of at least 103 kPa (15 psi) and an internal MAWP of at least 172 kPa (25 psi).

5.9.2 Material

5.9.2.1 Heads, bulkheads, and baffles

If providing tank reinforcement
(a) for metal tanks, heads or bulkheads and baffles shall meet or exceed the thicknesses specified for steel in row 3 and for aluminum in row 4 of Table 5.6, depending on the volume per cm (in) of length in row 1 and lading density in row 2; and
(b) for FRP tanks
  (i) the geometry of the head shall be hemispherical or ellipsoidal with a major-to-minor axis ratio less than 2 to 1; and
  (ii) the heads, bulkheads, and baffles shall have a minimum thickness of 9.5 mm (3/8 in), excluding the corrosion allowance outlined in Clause 5.6.3.3.4.

5.9.2.2 Shell

The following requirements for shells shall apply:
(a) For metal tanks, the shell thickness shall meet or exceed the thicknesses specified for steel in row 3 and aluminum in row 4 of Table 5.7, depending on the volume per cm (in) of length in row 1, the

lading density in row 2, and the distance between heads and, when used as tank reinforcement, bulkheads, baffles, and ring stiffeners specified by column 2.

(b) For FRP, the shell shall have a minimum thickness of 9.5 mm (3/8 in) excluding the corrosion allowance outlined in Clause 5.6.3.3.4.

(c) For FRP tanks of layered or "sandwich" construction, shell thickness may be the aggregate of all FRP laminate layers that form an integral part of the load-bearing wall if the laminate layers are permanently attached together.

5.9.3 Vacuum relief

The vacuum-relief system shall limit the vacuum to less than 80% of the design vacuum capability of the tank.

The vacuum-relief system required by Clause 5.6.11.1.1(b) is not required for highway tanks designed to be loaded by vacuum and built to withstand full vacuum.

5.9.4 Alternative minimum venting capacity for tanks transporting corrosive materials

5.9.4.1

The venting capacity for highway tanks transporting Class 8 materials, with no subsidiary classification, shall be equal to or greater than

(a) for metric units: $Q = 5\ 660\ 000\ A^{0.82}\ (ZT)^{0.5}/(LC)(M^{0.5})$; or

(b) for US customary units: $Q = 37\ 980\ 000\ A^{0.82}\ (ZT)0.5/(LC)(M^{0.5})$

where

Q = the minimum venting capacity, m^3 (ft^3) of air per hour at standard conditions of 15 °C (60°F) and 1 atm

A = the exposed surface area of the tank shell, m^2 (ft^2)

Z = the compressibility factor for the vapour; if unknown, 1.0

T = the absolute temperature of the vapour at the venting condition, kelvins (degrees Rankine)

L = the latent heat of the lading, calories per gram (Btu/lb)

$C = 520\ [k(2/k+1)^{[(k+1)/(k-1)]}]^{1/2}$

where

$k = C_p / C_v$

where

C_p = the specific heat at constant pressure, cal/g °C (Btu/lb°F)

C_v = the specific heat at constant volume, cal/g °C (Btu/lb°F)

If k cannot be determined by this method, C shall equal 315

M = the molecular mass of the vapour

5.9.4.2

Approximate values in the formula in Clause 5.9.4.1 shall be permitted.

5.10 Highway tanks for the transportation of emulsion and water-gel explosives — Specification TC 423

5.10.1 General

The following requirements shall apply to TC 423 tanks:

(a) Each tank shall have a MAWP of at least 35 kPa (5 psi) but no greater than 103 kPa (15 psi).

(b) Each tank shall comply with the provisions of Clauses 5.1 and 5.6 except as specified in Clause 5.10.

Note: *Requirements for the selection and use of tanks transporting explosives can be found in CAN/CGSB-43.151.*

5.10.2 Material and material thickness

5.10.2.1 Material

The following requirements for material shall apply:

(a) All material of construction for the shell, heads, bulkheads, baffles, and jackets shall be either stainless steel or aluminum.
(b) Stainless steel shall comply with ASTM A240.
(c) Aluminum shall comply with Clause 5.6.3.1.

5.10.2.2 Head, bulkhead, and baffle thickness

The minimum thickness after forming of heads, bulkheads, and baffles shall be not less than 3.99 mm (0.157 in) for stainless steel and not less than 5.77 mm (0.227 in) for aluminum.

5.10.2.3 Shell thickness

5.10.2.3.1

The bottom one-third of the tank shell shall have a thickness after forming of not less than 3.99 mm (0.157 in) for stainless steel and not less than 5.77 mm (0.227 in) for aluminum.

5.10.2.3.2

For tanks with hopper-type bottoms or with lower sections composed substantially of inverted conic or modified conic sections on a vertical axis, the minimum thickness after forming of these entire sections shall be not less than 3.99 mm (0.157 in) for stainless steel and not less than 5.77 mm (0.227 in) for aluminum.

5.10.2.3.3

For the upper two-thirds of the shell, excluding those sections described in Clause 5.10.2.3.2, the thickness after forming shall be not less than 3.28 mm (0.129 in) for stainless steel and not less than 4.29 mm (0.169 in) for aluminum.

5.10.3 Circumferential reinforcement

The following exceptions to Clause 5.6.8 shall be permitted provided that the requirements of Clause 5.6.4 are otherwise met:

(a) Despite Clause 5.6.8.1(a), the maximum spacing between circumferential reinforcement may be 203.3 cm (80 in) rather than 152.5 cm (60 in).
(b) Despite Clause 5.6.8.1(c), reinforcement need not be within 25 mm (1 in) of conical and cylindrical transitions.
(c) Despite Clause 5.6.8.4.1, ring stiffeners need not be continuous around hopper portions of the shell provided that the shell is otherwise reinforced at transitions to hopper sections or that ring stiffeners are tied into longitudinal reinforcement members on the sides of the shell.

5.10.4 Insulation system

5.10.4.1 General

An insulation system is optional on TC423 tanks. The following requirements shall apply when an insulation system is installed:

(a) The exterior of all surfaces of the tank in contact with the lading, except the manhole/spill dam area, shall be covered with an insulation system that consists of insulation, a vapour barrier, and a metal jacket.
(b) The insulation system shall have a thermal conductivity not greater than 1.5333 kJ/h•m^2/°C (0.075 Btu/h•ft^2/°F) at 15.5 °C (60°F).

5.10.4.2 Insulation

5.10.4.2.1
The insulation shall be compatible with the lading (i.e., with emulsion and water-gel explosives). The insulation shall not react with the material of the tank, jacket, or structural components. Compatibility shall be demonstrated using test methods approved by the Chief Inspector of Explosives designated under the *Explosives Act*.

5.10.4.2.2
The insulation shall be rigid and non-porous so that it will not absorb spilled explosives residue.

5.10.4.2.3
The insulation shall be applied, in accordance with the manufacturer's recommendations, to a thickness of at least 5 cm (2 in) and in such a manner that it will not separate from the tank surface or permit product to be trapped beneath it.

5.10.4.2.4
The insulation shall meet at least one of the following requirements:
(a) the insulation shall be non-combustible as determined in accordance with ASTM E136 or ULC CAN4-S114;
(b) the insulation shall have a fire endurance rating of at least 15 min determined in accordance with ASTM E119 or CAN/ULC-S101. The vapour barrier referred to in Clause 5.10.4.3 may be considered in meeting this requirement; or
(c) the insulation shall have a flame spread rating of 25 or less determined in accordance with ASTM E84 or CAN/ULC-S102. The vapour barrier referred to in Clause 5.10.4.3 may be considered in meeting this requirement.

5.10.4.3 Vapour barrier
The following requirements for vapour barriers shall apply:
(a) A vapour barrier shall be provided between the insulation and jacket to render the insulation impervious to weather and spills. The vapour barrier shall be smooth and flexible.
(b) The vapour barrier shall have a flame spread rating of 25 or less determined in accordance with ASTM E84 or CAN/ULC-S102.

5.10.4.4 Jacket
The following requirements for jackets shall apply:
(a) Any exposed portions of the insulation shall be protected by a weathertight jacket constructed of stainless steel or aluminum.
(b) Flashing shall be provided around openings in the jacketing to prevent the ingress and entrapment of spilled lading.
(c) Additional protection shall be added, if necessary, to prevent mechanical damage to the jacket and insulation in areas around the manhole covers, behind ladders, and above the tires.
(d) Pop rivets shall not be used as fasteners on the jacket or flashing.

5.10.5 Pressure- and vacuum-relief devices

5.10.5.1 Pressure relief
Despite Clause 5.6.11.2.1, the set-to-discharge pressure of the primary pressure-relief system shall not exceed 103 kPa (15 psi) for tanks with a MAWP greater than 86 kPa (12.5 psi).

5.10.5.2 Vacuum relief
The vacuum-relief system shall limit the vacuum to less than 80% of the vacuum capability of the tank, taking into account maximum unloading rates and changes in product temperature and volume.

5.10.6 Thermometer

A thermometer shall be provided for monitoring lading temperature and shall be mounted flush with the jacket or otherwise protected from damage.

5.10.7 Restrictions on valves, fittings, and hardware

5.10.7.1

Threaded pipe fittings, valves, caps, or joints that can come into contact with the lading can present a hazard involving trapped lading and shall be avoided whenever possible in favour of flanged components.

5.10.7.2

Discharge valves shall be

(a) ball valves with polytetrafluoroethylene (PTFE, commonly known as Teflon™) inserts; or
(b) butterfly valves with nitrile rubber (commonly known as BUNA-n™) seating.

Discharge valves shall not be gate valves.

5.10.7.3

Brass and bronze shall not be permitted on any component, including valve seats, relief devices, housings, and cam ears on dust caps, that can contact the lading during normal product handling.

5.10.7.4

All hardware directly exposed to the lading shall be designed or modified to prevent any piece or component of the hardware from falling into the lading or potentially ending up in process pumps. Nuts shall be drilled and wired (bonded), or have nylon inserts, and shall not be reused.

5.10.8 Cleaning and drainage

The following requirements related to cleaning and drainage shall apply:

(a) The areas surrounding the manhole assembly and vents including the rollover damage protection described in Clause 5.6.9.3 and surrounding the discharge valves shall be designed for ease of cleaning and drainage to prevent any liquid, including spilled lading, from becoming trapped or contacting the insulation.
(b) Valves shall not be permitted on any drainage lines.
(c) All closed section reinforcement and doubler pads shall be provided with a vent opening near the top and a drain opening near the bottom to permit steam cleaning prior to inspections or repairs. Vents shall be tapped and plugged with a 1/4 in or larger NPT nylon fitting, and drains shall be left open.

5.10.9 Security

5.10.9.1

All manhole covers and discharge openings shall be provided with a means for locking with non-brass heavy-duty padlocks. Fasteners and hinge pins, etc., shall be substantial and tamper-proof. Where a secondary cover or hatch that covers one or more openings is supplied, it shall also be substantial, tamper-proof, and lockable with non-brass heavy-duty padlocks.

5.10.9.2

All discharge valves shall have a secondary closure consisting of a non-threaded locking dust cap. Locking the rings on dust cap cam ears shall not be acceptable.

5.10.9.3

Hose tubes, where installed, shall be fully enclosed and secured as specified in Clause 5.10.9.1.

5.10.10 Electrical wires and fixtures

All electrical wires and fixtures for lighting, etc., shall be enclosed inside a sealed harness or closed conduit that is firmly attached and sealed into the fixtures.

5.10.11 Heating systems

Where lading heating systems are installed, they shall be designed so that the heating system cannot be used during transport and all connections to the heating source are mounted at the rear of the tank vehicle.

Heating systems that are internal or that have projections into the interior of the tank shall not be permitted.

5.10.12 Pumping systems

Pumping systems, if installed, shall comply with the safety requirements outlined in the Natural Resources Canada (NRCan) publication "Guidelines for Pumping of Water-Based Explosives". All pumping equipment shall be approved by the Explosives Regulatory Division of NRCan.

5.10.13 Structural inspection procedures

The manufacturer or assembler shall provide to the owner a procedure for the structural inspection referred to in Clause 7.2.11. The procedure shall include a drawing identifying all critical joints and areas of high stress or stress concentration to be inspected.

Table 5.1
Minimum total venting capacity — Volume of free air per hour at STP* for Specification TC 406, TC 407, TC 412, and TC 423 tanks

(See Clause 5.6.11.5.1.)

Column 1	Column 2
Exposed area of the tank, m^2 (ft^2)	Minimum total venting capacity, m^3 (ft^3)
1.86 (20)	447.41 (15 800)
2.79 (30)	671.11 (23 700)
3.72 (40)	894.82 (31 600)
4.65 (50)	1 118.52 (39 500)
5.58 (60)	1 342.23 (47 400)
6.50 (70)	1 565.93 (55 300)
7.44 (80)	1 792.47 (63 300)
8.36 (90)	2 016.17 (71 200)
9.30 (100)	2 239.87 (79 100)
11.16 (120)	2 687.28 (94 900)
13.00 (140)	3 134.69 (110 700)
14.88 (160)	3 582.10 (126 500)
16.72 (180)	4 029.51 (142 300)
18.60 (200)	4 476.92 (158 100)
20.90 (225)	5 417.04 (191 300)
23.23 (250)	5 751.18 (203 100)

(Continued)

Table 5.1 (Concluded)

Column 1	Column 2
Exposed area of the tank, m^2 (ft^2)	Minimum total venting capacity, m^3 (ft^3)
25.50 (275)	6 068.33 (214 300)
27.90 (300)	6 374.16 (225 100)
32.52 (350)	6 957.49 (245 700)
37.20 (400)	7 504.00 (265 000)
41.80 (450)	8 019.37 (283 200)
46.46 (500)	8 512.09 (300 600)
51.00 (550)	8 984.98 (317 300)
55.80 (600)	9 438.06 (333 300)
60.39 (650)	9 876.97 (348 800)
65.04 (700)	10 298.89 (363 700)
69.68 (750)	10 709.49 (378 200)
74.40 (800)	11 105.93 (392 200)
78.97 (850)	11 493.87 (405 900)
83.60 (900)	11 873.32 (419 300)
88.26 (950)	11 986.59 (432 300)
92.90 (1000)	12 601.07 (445 000)

**STP (standard temperature and pressure) is defined as* 15.55 °C *(60°F) and* 101.325 kPa *abs. (14.7 psia).*

Table 5.2
Minimum thickness of heads or bulkheads and baffles when used as tank reinforcement for mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum alloy (AL) for Specification TC 406 tanks

(See Clauses 5.6.3.2 and 5.7.3.1 and Tables 7.4 and 7.5.)

Row 1	Volumetric capacity per unit length of tank in litres per cm (US gal per in)	21 (14) or less			Over 21 (14) to 34.5 (23)			Over 34.5 (23)		
Row 2	Type of steel	MS	HSLA SS	AL	MS	HSLA SS	AL	MS	HSLA SS	AL
Row 3	Thickness in millimetres (decimals of an inch) after forming	2.54 (0.100)	2.54 (0.100)	4.06 (0.160)	2.92 (0.115)	2.92 (0.115)	4.39 (0.173)	3.28 (0.129)	3.28 (0.129)	4.75 (0.187)

Table 5.3
Minimum thickness of shell using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum (AL) for Specification TC 406 tanks

(See Clauses 5.6.3.1.3, 5.6.3.2, and 5.7.3.2 and Tables 7.4 and 7.5.)

Row 1	**Total volumetric capacity of all compartments, in litres (US gal)**	More than 0 to 17 000 (4500)			More than 17 000 (4500) to 30 300 (8000)			More than 30 300 (8000) to 53 000 (14 000)			More than 53 000 (14 000)		
Row 2	**Type of steel**	MS	HSLA SS	AL	MS	HSLA SS	AL	MS	HSLA SS	AL	MS	HSLA SS	AL
Row 3	**Thickness in millimetres (decimals of an inch) after forming**	2.54 (0.100)	2.54 (0.100)	3.84 (0.151)	2.92 (0.115)	2.54 (0.100)	4.06 (0.160)	3.28 (0.129)	3.28 (0.129)	4.39 (0.173)	3.63 (0.143)	3.63 (0.143)	4.75 (0.187)

Table 5.4
Minimum thickness of heads, bulkheads, and baffles when used as tank reinforcement using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum alloy (AL) after forming for Specification TC 407 tanks

(See Clauses 5.6.3.2 and 5.8.2.1 and Tables 7.4 and 7.5.)

Row 1	**Volumetric capacity per unit length of tank in litres per cm (US gal per in)**	21 (14) or less			Over 21 (14) to 27 (18)			Over 27 (18) to 33 (22)			Over 33 (22) to 39 (26)			Over 39 (26) to 45 (30)			Over 45 (30)		
Row 2	**Type of material**	MS HSLA SS		AL	MS HSLA SS		AL	MS HSLA SS		AL	MS HSLA SS		AL	MS HSLA SS		AL	MS HSLA SS		AL
Row 3	**Thickness in millimetres (decimals of an inch) after forming**	2.54 (0.100)		4.06 (0.160)	2.92 (0.115)		4.39 (0.173)	3.28 (0.129)		4.75 (0.187)	3.28 (0.129)		4.93 (0.194)	3.63 (0.143)		5.49 (0.216)	3.96 (0.156)		6.02 (0.237)

Table 5.5
Minimum thickness of shell using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum alloy (AL) after forming for Specification TC 407 tanks

(See Clauses 5.6.3.1.3, 5.6.3.2, and 5.8.2.2 and Tables 7.4 and 7.5.)

Row 1	**Volumetric capacity per unit length of tank in litres per cm (US gal per in)**	21 (14) or less		Over 21 (14) to 27 (18)		Over 27 (18) to 33 (22)		Over 33 (22) to 39 (26)		Over 39 (26) to 45 (30)		Over 45 (30)	
Row 2	**Type of material**	MS HSLA SS	AL	MS HSLA SS	AL	MS HSLA SS	AL	MS HSLA SS	AL	MS HSLA SS	AL	MS HSLA SS	AL
Row 3	**Thickness in millimetres (decimals of an inch) after forming**	2.54 (0.100)	3.84 (0.151)	2.92 (0.115)	4.06 (0.160)	3.28 (0.129)	4.39 (0.173)	3.28 (0.129)	4.93 (0.194)	3.63 (0.143)	5.49 (0.216)	3.96 (0.156)	6.02 (0.237)

Table 5.6
Minimum thickness of heads (or bulkheads and baffles when used as tank reinforcement) using mild steel (MS), high-strength low-alloy steel (HSLA), austenitic stainless steel (SS), or aluminum (AL) after forming for Specification TC 412 tanks

(See Clauses 5.6.3.2 and 5.9.2.1 and Tables 7.4 and 7.5.)

Row 1	**Volumetric capacity per unit length of tank in litres per cm (US gal per in)**	15 or less (10 or less)				Over 15 to 21 (Over 10 to 14)				Over 21 to 27 (Over 14 to 18)			Over 27 (Over 18)		
Row 2	**Lading density at 15.5 °C (60°F) in kg per L (lb per US gal)**	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)	Over 1.9 (Over 16)	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)	Over 1.9 (Over 16)	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)
Row 3	**Thickness (steel), mm (in)**	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	6.35 (0.250)	3.99 (0.157)	6.35 (0.250)	6.35 (0.250)	3.99 (0.157)	6.35 (0.250)	7.92 (0.312)
Row 4	**Thickness (aluminum), mm (in)**	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	9.14 (0.360)	5.77 (0.227)	9.14 (0.360)	9.14 (0.360)	5.77 (0.227)	9.14 (0.360)	11.43 (0.450)

Table 5.7
Minimum thickness of shell using steel or aluminum after forming for specification TC 412 tanks

(See Clauses 5.6.3.1.3, 5.6.3.2, and 5.9.2.2 and Tables 7.4 and 7.5.)

	Volumetric capacity per unit length of tank in litres per cm (US gal per in)	Distance between heads and, when used as tank reinforcement, bulkheads, baffles, and ring stiffeners	Volumetric capacity in litres per cm (US gal per in)													
Row 1			15 or less (10 or less)				Over 15 to 21 (Over 10 to 14)				Over 21 to 27 (Over 14 to 18)			Over 27 (Over 18)		
Row 2	**Lading density at 15.5 °C (60°F) in kg per L (lb per US gal)**		1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)	Over 1.9 (Over 16)	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)	Over 1.9 (Over 16)	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)	1.2 or less (10 or less)	Over 1.2 to 1.5 (Over 10 to 13)	Over 1.5 to 1.9 (Over 13 to 16)
Row 3	**Thickness (steel), mm (in)**	91.5 cm (36 in) or less	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	3.29 (0.129)	3.99 (0.157)	4.75 (0.187)
		Over 91.5 cm (36 in) to 137 cm (54 in)	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	3.99 (0.157)	6.35 (0.250)	6.35 (0.250)
		Over 137 cm (54 in) to 152.5 cm (60 in)	2.54 (0.100)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	3.28 (0.129)	3.99 (0.157)	4.75 (0.187)	6.35 (0.250)	3.99 (0.157)	6.35 (0.250)	6.35 (0.250)	4.75 (0.187)	6.35 (0.250)	7.92 (0.312)
Row 4	**Thickness (aluminum), mm (in)**	91.5 cm (36 in) or less	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)
		Over 91.5 cm (36 in) to 137 cm (54 in)	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	5.77 (0.227)	9.14 (0.360)	9.14 (0.360)
		Over 137 cm (54 in) to 152.5 cm (60 in)	3.66 (0.144)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	4.75 (0.187)	5.77 (0.227)	6.86 (0.270)	9.14 (0.360)	5.77 (0.227)	9.14 (0.360)	9.14 (0.360)	6.86 (0.270)	9.14 (0.360)	11.43 (0.450)

6 TC portable tanks

6.1 Requirements for all portable tanks

6.1.1 General

All portable tanks used for the transportation of dangerous goods, other than those exempted by the TDG Regulations or CSA B621, shall be constructed to meet the requirements of Clause 6.1, unless otherwise specified in the applicable specification.

6.1.2 The ASME *Code*

Portable tanks shall be designed and constructed in accordance with the ASME *Code* and, unless otherwise specified in the applicable specification, certified in accordance with the ASME *Code* or the provincial pressure vessel legislation. Where any provision of the ASME *Code* is at variance with this Standard, the provisions of this Standard shall apply.

6.1.3 Means of containment

6.1.3.1

Welding and brazing shall be performed in a competent manner, using appropriate techniques, materials, and equipment.

6.1.3.2

Materials of construction shall be such that there will be no significant chemical or galvanic reaction between them. These materials shall be also compatible with all ladings to be transported in the tank and suitable for use at the lowest temperature expected to be encountered during transportation.

6.1.3.3

Closures shall be adequate to prevent leakage of the contents under normal conditions of operation.

6.1.3.4

Gasketed closures shall be fitted with gaskets that are made of material that will not deteriorate when in contact with the lading.

6.1.3.5

Hose assemblies connected directly to the tank or any tank-mounted accessory shall

(a) be selected for the appropriate service;
(b) have a HAWP that is suitable for the expected loading and unloading operation, taking into account potential pressure surges; and
(c) be marked with its serial number or identification number and its HAWP.

6.1.4 Inspection, testing, and marking

6.1.4.1

Each tank shall have one or more corrosion-resistant metal identification plates permanently affixed to one of the tank heads or the tank's supporting structure by soldering, brazing, or welding around its perimeter, in a place readily accessible for inspection. The plates may be attached to a mounting pad welded directly to the tank.

6.1.4.2

The metal identification plate and the means of its attachment to the tank or jacket shall be resistant to attack by the lading.

6.1.4.3
If a metal identification plate is attached directly to the tank by welding, it shall be attached before the tank is postweld heat treated.

6.1.4.4
If a metal identification plate is not readily visible, a second metal identification plate marked "Duplicate" shall be permanently attached, in a visible position, to the jacket or bodywork, i.e., directly fastened to the tank or tank structure, on the left side near the front of the tank.

6.1.4.5
The metal identification plate described in Clause 6.1.4.1 shall be maintained in a legible condition.

6.1.4.6
The metal identification plate(s) shall be plainly marked in characters at least 3.175 mm (1/8 in) high by stamping, embossing, or other means of forming letters into the metal of the plate.

6.1.4.7
The following information shall appear on the plate(s) (parenthetical abbreviations shall be permitted):
(a) tank manufacturer (Tank mfr.);
(b) date of tank manufacture — month and year (Date of mfr.);
(c) assembler where applicable;(1)
(d) completion and certification date — month and year (Cert. date);
(e) original test date — month and year (Orig. Test Date);
(f) TC Specification (TC Spec);
(g) Manufacturer's Design Identification Number (MDIN);(1)
(h) Transport Canada Registration Number (TCRN);(2)
(i) tank serial number (Ser. No. or S/N);
(j) tare weight in kg;
(k) tank maximum allowable working pressure in kPa (MAWP);
(l) tank test pressure in kPa (Test P);
(m) tank design temperature range — ___°C to ___°C (Design temp. range);(1)
(n) maximum design density of lading — in kilograms per litre (Max. lading density);(1)
(o) vessel material specification number — all numbers to be marked where the material for the shell is different from the material for the heads (Shell & Head Matl. yyy zzz or Shell Matl. yyy zzz and Head Matl. yyy zzz, where "yyy" is replaced by the alloy designation and "zzz" by the alloy type);
(p) weld material (Weld Matl.);
(q) minimum allowable thickness of shell — in millimetres (Min. shell thick.). When minimum shell thicknesses are not the same for different areas, mark variances (Top ..... Side..... Bottom.....);
(r) minimum allowable thickness of heads — in millimetres (Min. head thick.);
(s) manufactured thickness of shell — in millimetres (Mfd. shell thick.);(3)
(t) manufactured thickness of heads — in millimetres (Mfd. head thick.);(3)
(u) exposed surface area — in square metres;(1)
(v) volumetric capacity — in litres (Cap. Litres);
(w) maximum product load — in kilograms (Max. payload);(1)
(x) maximum loading rate — in litres per minute and optionally in US gallons per minute [Max load. rate, L/min (US GPM) at maximum loading pressure XX kPa (psi)];(1)
(y) maximum unloading rate — in litres per minute and optionally in US gallons per minute [Max. unload. rate, L/min (US GPM) at maximum unloading pressure XX kPa (psi)];(1) and
(z) lining material — if lined (Lining).

Note: *This information may be provided and marked in accordance with the ASME* Code.

Annotations (these annotations are mandatory provisions of this Standard):
(1)Required for TC 44 portable tanks only.

(2)Required for portable tanks other than TC 44.
(3)Required when additional material is provided for corrosion allowance.

6.1.4.8 Inspection, testing, and marking of new tanks

6.1.4.8.1
On completion and final assembly, a new tank, including piping, valves and fittings, shall have been inspected, tested, and marked as required in Clause 7 for its specification, except that thickness, lining, and upper coupler area inspections shall not be required. Additional inspections and tests shall be required where indicated in this Standard for the tank specification.

6.1.4.8.2
Hose assemblies connected directly to the tank or to any tank-mounted accessory shall be inspected, tested, and marked in accordance with Clause 7.2.10.

6.1.4.8.3
Following repair of any defect discovered as a result of an inspection or test, the inspection or test shall be repeated. In the event of replacement, all piping, valves, or fittings replaced shall be tested in accordance with the requirements of Clause 6.1.4.8.

6.1.4.9 Double wall tank marking
The metal identification plate of a tank equipped with a double wall or secondary containment space, other than a tank that is insulated and jacketed, shall be marked
(a) with the words “double wall” or “secondary containment”; and
(b) if the material and thickness of the outer wall differs from that of the primary means of containment, the material and thickness of the outer wall shall also be marked on the metal identification plate.

6.1.5 Tank mountings
The following requirements shall apply to tank mountings:
(a) Tank mountings shall be designed to prevent the concentration of excessive loads on the tank shell and to provide a secure base in transit.
(b) Tank mountings such as skids, fastenings, brackets, cradles, lifting lugs, and any other mountings intended to carry loadings shall be secured to tanks in accordance with the ASME *Code* and designed to withstand static loading, in any direction, equal to twice the weight of the tank and attachments when filled with the lading, using a design factor of not less than 4, based on the ultimate strength of the material used.
(c) The means of securement of the tank to the vehicle shall be designed to withstand static loading, in any direction, equal to twice the weight of the tank and attachments when filled with the lading, using a design factor of at least 4, based on the ultimate strength of the material being used.
(d) The tank manufacturer or final assembler shall provide specifications for or a description of at least one means of securing the tank to the vehicle in a manner that complies with Item (c) and that can be used by the owner for the securement of the tank to the vehicle.

6.1.6 Piping, valves, and fittings

6.1.6.1 Pressure ratings
The following requirements for pressure ratings shall apply:
(a) The bursting pressure of all piping, pipe fittings, hose, and other pressure parts, except pump seals and safety relief devices, shall be at least four times the MAWP of the tank.
(b) In addition to Item (a), the bursting pressure shall be not less than four times any higher pressure to which each pipe, pipe fitting, hose, or other pressure part can be subjected in service by the action of a pump or other device.

6.1.6.2 Joints

The following requirements for joints shall apply:

(a) Welded pipe joints shall be used wherever possible.
(b) Where copper tubing is permitted, joints shall be brazed or be of equally strong metal union type.
(c) The melting point of brazing material shall be no lower than 535 °C (1000°F).
(d) The method of joining tubing shall not decrease its strength, such as by the cutting of threads.
(e) Fittings shall be at least extra-heavy.
(f) Non-malleable metals shall not be used in the construction of any valve or fitting.

6.1.6.3 Piping and fittings — Location and design

The following requirements shall apply:

(a) Piping design shall preclude damage to piping due to thermal expansion and contraction, jarring, and vibration. Slip joints shall not be used for this purpose.
(b) Piping and fittings shall be grouped in the smallest practicable space.

6.1.6.4 Damage protection

The following requirements shall apply:

(a) All piping, fittings, valves, safety devices, and other accessories shall be protected against damage.
(b) The protective devices shall be designed to withstand a static loading equal to twice the weight of the tank and attachments when filled with the lading, using a design factor of not less than 4, based on the ultimate strength of the material used.
(c) Each pressure-relief device shall be protected so that, in the event of upset onto a hard surface, the opening of the device will not be prevented nor its discharge be restricted.

6.1.6.5 Testing

The following testing requirements shall apply:

(a) All piping, valves, and fittings on every tank shall be free from leaks at not less than the design pressure for the tank.
(b) The condition specified in Item (a) shall be met when piping, valves, and fittings have been tested for leakage after installation, with a test medium as specified in Clause 7.2.5.1(e), and proved tight at not less than the MAWP marked on the tank with which they are used.

6.1.7 Safety relief devices

6.1.7.1 General

The following requirements shall apply:

(a) Each tank shall be provided with one or more safety relief devices. Unless otherwise specified, these shall be safety relief valves of the spring-loaded type.
(b) Each safety relief valve shall be arranged to discharge upward or sideways, without obstruction, to the outside of the protective housing in order to prevent any impingement of escaping gas on the tank.

6.1.7.2 Flow capacity

Safety relief valves on each tank shall have a total relieving capacity as determined by the flow formulas contained in Section 5 of CGA S-1.2.

6.1.7.3 Security from tampering

Each safety relief valve shall be arranged to minimize the possibility of tampering. If the pressure setting or adjustment is external to the valve, the safety relief valve shall be provided with a means for sealing the adjustment, and it shall be sealed.

6.1.7.4 Primary set-to-discharge pressure

Each primary pressure-relief system on a tank shall be designed, constructed, marked, and set to discharge at a pressure no higher than the tank MAWP and no lower than the MAWP specified in CSA B621 or CSA B622 for the dangerous goods being transported.

6.1.7.5 Secondary set-to-discharge pressure

Each pressure-relief device in a secondary pressure-relief system shall be designed to have a set-to-discharge pressure no lower than 130% and no higher than 150% of the MAWP of the tank.

6.1.7.6 Marking

The following marking requirements shall apply:

(a) Each safety relief valve shall be plainly and permanently marked with
  (i) the pressure in kPa (psi) at which it is set to discharge;
  (ii) the actual rate of discharge of the device in m3/min (ft3/min) of the gas or of air at 15 °C (60°F) and 100 kPa (14.5 psia);
  (iii) the Canadian Registration Number (CRN) for the valve; and
  (iv) the manufacturer's name or trade name and catalogue number.
(b) The set-to-discharge value shall be visible after the valve is installed.
(c) The rated discharge capacity of the device specified in Item (a) shall be determined at a pressure of 120% of the MAWP of the tank.

6.1.7.7 Location

Each safety relief valve shall have direct communication with the vapour space in the tank.

6.1.7.8 Valves, connections, and flow capacity

Each connection to a safety relief valve shall be of sufficient size to provide the required relief capacity through the safety relief valve.

A shut-off valve may be installed in a pressure-relief system only when the required relief capacity is provided in all circumstances.

6.1.7.9 Cleanliness

Each pressure-relief device shall be arranged or protected to prevent the accumulation of dirt or other foreign material between the device and the atmospheric discharge opening in any relief piping.

The arrangement or protection of the pressure-relief device shall not impede flow through it.

6.1.7.10 Piping and hose thermal expansion relief

6.1.7.10.1

To prevent the bursting of piping or a hose as a result of thermal expansion of the gas, each portion of connected liquid piping or hose that can be closed at both ends shall be provided with

(a) an expansion relief device with no intervening shut-off valve; or
(b) a check valve to permit flow from the pipe or hose into the tank.

6.1.7.10.2

Relief devices specified in Clause 6.1.7.10.1 shall be located so as to prevent discharge from impinging on the tank, piping, or personnel.

6.1.7.10.3

Safety relief valves shall have a total relieving capacity sufficient to prevent a maximum pressure in the tank of more than 120% of the MAWP.

6.1.7.10.4
For an insulated tank, the required relieving capacity of the relief valves shall be the same as for an uninsulated tank, unless the insulation will remain in place and will be effective under fire conditions. In this case, each insulated tank shall be covered by a sheet metal jacket of not less than 1.6 mm (16 gauge) thickness.

6.1.7.10.5 Manual bleed valve
Piping or hose used for loading or unloading liquefied gas or refrigerated liquefied gas shall be provided with a manual bleed valve or other means of relieving pressure before the hose is disconnected.

6.1.8 Certificate of Compliance

6.1.8.1 General
The portable tank manufacturer or assembler completing the final construction and certification of the tank shall, at or before the time of delivery, supply, and the owner shall obtain, the Certificate of Compliance described in Clause 8.2.1 for each portable tank. For a variable specification tank, a Certificate of Compliance shall be issued for each specification.

6.1.8.2 Incomplete and partial construction

6.1.8.2.1
When a manufacturer does not complete the construction of the tank, the manufacturer shall complete the certification in accordance with the requirements of Clause 8 for all the construction that has been completed. Those requirements of the specification that have not been met shall be identified on the Certificate of Compliance, and the manufacturer may affix the metal identification plate(s) as required in Clause 6.1.4 without the TC specification mark and certification date as required in Clause 6.1.4.7. The omitted TC specification mark and certification date shall not be applied until the tank is complete and in full compliance with the requirements of this Standard.

6.1.8.2.2
Any manufacturer or assembler completing further construction of the tank shall identify the items of further construction on the Certificate of Compliance.

6.1.8.2.3
The manufacturer or assembler completing the final construction of the tank shall be responsible for ensuring that all inspections, marking, and certification have been done in compliance with this Standard.

6.1.8.3 Retention

6.1.8.3.1
The owner shall retain a copy of the certificate or certificates referred to in Clause 6.1.8.1, and related documents, throughout the ownership of the tank and for at least one year thereafter.

6.1.8.3.2
In the case of resale, the documents shall be transferred to and retained by the new owner. In the event of such change in ownership, retention by the prior owner of non-fading copies of the documents shall be deemed to satisfy the requirements of Clause 6.1.8.3.1.

6.2 Portable tanks for the transportation of liquid dangerous goods — Specification TC 60

6.2.1 Construction standards

In addition to conforming to the requirements of Clause 6.1, TC 60 tanks shall be

(a) of fusion-welded construction;
(b) cylindrical in shape, with seamless heads concave to the pressure; and
(c) designed and constructed in accordance with Clause 6.2.

6.2.2 Postweld heat treatment

The following requirements for postweld heat treatment shall apply:

(a) All postweld heat treatment of tanks shall be conducted in accordance with the ASME *Code*.
(b) All tanks, including their permanent attachments, shall be postweld heat treated.

6.2.3 Design

The MAWP of a tank constructed to this specification shall be not less than 415 kPa (40 psi).

6.2.4 Material thickness

The minimum thickness of the shell or heads of the tank shall be

(a) 6.5 mm (1/4 in) for tanks with a volumetric capacity of 4540 L (1200 US gal, 1000 Imp. gal) or less;
(b) 7.9 mm (5/16 in) for tanks with a volumetric capacity of more than 4540 L (1200 US gal, 1000 Imp. gal) and less than or equal to 6810 L (1800 US gal, 1500 Imp. gal); and
(c) 9.5 mm (3/8 in) for tanks with a volumetric capacity of more than 6810 L (1800 US gal, 1500 Imp. gal).

6.2.5 Expansion domes

All expansion domes shall have a minimum volumetric capacity greater than or equal to 1% of the combined capacity of the tank and dome.

6.2.6 Manhole cover attachments

If not permanently attached to the tank by a hinge or other device, the manhole cover shall be fastened to the tank by a 3 mm (1/8 in) chain or its equivalent.

6.2.7 Bottom openings

Where they are permitted by CSA B621, bottom discharge outlets or bottom washout chambers shall be

(a) constructed of metal that is not subject to rapid deterioration by the lading;
(b) equipped with a
    (i) valve or plug at the upper end; and
    (ii) liquidtight closure at the lower end;
(c) adequately protected against handling damage; and
(d) designed and constructed so that they or their attachments and appurtenances are located at least 2.5 cm (1 in) from the ground when the tank is placed directly on a level surface.

The valve or plug referred to in Item (b)(i) shall be designed to prevent unseating due to stresses or shocks arising from transportation.

6.2.8 Design and closures of openings

6.2.8.1

Any heating device shall be so constructed that the breaking of its external connections will not cause leakage of the tank lading.

6.2.8.2
Any gauging, loading, or charging device, including associated valves, shall be provided with an adequate means of secure closure to prevent leakage.

6.2.8.3
The design of piping, hose, hose couplings, stop valves, lading retention fittings, and closures shall include allowances for and means to prevent damage due to expansion, contraction, jarring, and vibration. The lading retention system shall not include slip joints for this purpose.

6.2.9 Multi-tank units
Where multiple tanks are welded or permanently attached to each other as a multi-compartment unit, the thickness of the shell and heads of each tank shall be established on the basis of the combined volumetric capacity of all tanks.

6.2.10 Lining
The following requirements for lining shall apply:
(a) Lining material shall be a non-porous, homogeneous material that is not less elastic than the parent material and substantially immune to attack by the lading. The lining material shall be bonded or attached by appropriate means to the tank wall and shall have no perforations when complete. Joints or seams in the lining shall be made by fusing the materials together or by other satisfactory means.
(b) The thickness of the lining shall be
    (i) greater than or equal to 4.8 mm (3/16 in) if composed of rubber;
    (ii) greater than or equal to 1.6 mm (1/16 in) if composed of a non-metallic substance other than rubber; or
    (iii) greater than or equal to 0.8 mm (1/32 in) if composed of a metallic substance.
(c) The interior of the tank shall be free from scale, oxidation, moisture, and all foreign matter during the lining operation.

6.3 Portable tanks for the transportation of nonflammable atmospheric gases as refrigerated liquefied gases — Specification TC 11 portable tanks

6.3.1 Construction standards
TC 11 tanks shall
(a) have a design pressure of not less than 174.3 kPa (25.3 psi);
(b) conform to Section VIII, Division 1, of the ASME *Code*;
(c) have a minimum volumetric capacity of 450 L (120 US gal, 100 Imp. gal);
(d) be constructed so that materials that contact the lading are compatible with all ladings to be transported in the tank; and
(e) be designed, constructed, and certified in accordance with Clauses 6.1 and 6.3.

6.3.2 Inner vessel

6.3.2.1 Construction
The inner vessel shall
(a) be of seamless or welded construction; and
(b) have a circular cross-section.

6.3.2.2 Design
The following requirements for design shall apply:
(a) The design pressure of the inner vessel shall be calculated in accordance with Clause 5.2.5.
(b) Stress values of the inner vessel shell at the inner support system shall not exceed those calculated in accordance with UG-23 and UG-54 of the ASME *Code*, Section VIII, Division 1.

(c) The wall thickness of a vessel calculated according to Item (b) shall be determined in such a way that, for any combination of loadings listed in UG-22 of the ASME *Code*, Section VIII, Division 1, that induce primary stress and are expected to occur simultaneously during normal operation of the vessel, the induced maximum general primary membrane stress does not exceed the maximum allowable stress value in tension.
(d) The loadings referred to in Item (c) shall not induce a combined maximum primary membrane stress plus primary bending stress across the thickness that exceeds 1-1/2 times the maximum allowable stress value in tension.
(e) The maximum design stress at any point in the inner vessel shall be calculated for the loading conditions described in Clause 6.3.2.4, taking into consideration the mass of the inner vessel and the lading.

6.3.2.3 Interior

Design and construction details of the inner vessel interior shall not allow collection and retention of cleaning materials or contaminants. To preclude the entrapment of foreign material, the design and construction of the inner vessel shall allow washing of all interior surfaces by the normal surging of the lading during transportation.

6.3.2.4 Support systems

The support design calculations shall be based on the ultimate strength of the material, using a design factor of 4, and taking into account the effects of fatigue and thermal cycling with a longitudinal, lateral, upward vertical, and downward vertical loading of twice the weight of the loaded inner vessel and its attachments.

6.3.2.5 Material

6.3.2.5.1 Specifications

All material used for construction of the inner vessel shall comply with the requirements of the ASME *Code*.

6.3.2.5.2 Material thickness

The following requirements for material thickness shall apply:
(a) The minimum thickness of inner vessel shells or heads constructed of the reference steel and enclosed in an evacuated jacket shall be
  (i) 3 mm (0.118 in) for inner vessel diameters of 1.80 m (70.87 in) or less; and
  (ii) 4 mm (0.157 in) for inner vessel diameters of more than 1.80 m (70.87 in).
(b) The minimum thickness of inner vessel shells or heads constructed of the reference steel and not enclosed in an evacuated jacket shall be
  (i) 5 mm (0.197 in) for inner vessel diameters of 1.80 m (70.87 in) or less; and
  (ii) 6 mm (0.236 in) for inner vessel diameters of more than 1.80 m (70.87 in).
(c) The minimum thickness of a metal other than the reference steel shall be determined as follows:

$$e_1 = (21.4e_0)/(Rm_1A_1)^{1/3}$$

where

e_1 = required minimum thickness of the metal to be used, mm
e_0 = minimum thickness of reference steel specified in Item (a) or (b), mm
Rm_1 = specified minimum tensile strength of the metal to be used, N/mm^2
A_1 = specified minimum per cent elongation at fracture in a gauge length of 50 mm (2 in) of the metal to be used (for example, 20%)

(d) Despite Item (c), the minimum thickness of the inner vessel shall not be less than 3 mm (0.118 in), regardless of the material of construction.
(e) The minimum thicknesses prescribed by this clause shall be exclusive of any corrosion allowance.

6.3.2.6 Welding

6.3.2.6.1 General

The following requirements shall apply:

(a) Welding procedure and welders' and welding operators' performance tests shall be conducted in accordance with Section IX of the ASME *Code* or the requirements of the provincial pressure vessel legislation in the province of manufacture.
(b) All longitudinal welds in inner vessels and load-bearing jackets shall be located so as not to intersect nozzles or supports other than baffles, load rings, or stiffening rings.
(c) Attachments shall be properly fitted before welding, and the welding sequence shall minimize stresses due to shrinkage of welds.

6.3.2.6.2 Welding requirements — Inner vessels constructed in accordance with Part UHT of the ASME *Code*

The following requirements shall apply:

(a) In the procedures and tests referred to in Clause 6.3.2.6.1(a), the following variables shall be considered essential variables, in addition to the essential variables specified in Section IX of the ASME *Code*:
    (i) number of passes;
    (ii) thickness of plate; and
    (iii) manufacturer's identification of electrodes, filler materials, and flux or gas, as applicable.
(b) The number of passes, thickness of plate, and heat input per pass shall not vary more than 25% from the procedure or welder qualifications. The heat input per pass shall not exceed the value specified in the welding procedure.
(c) Records of the qualifications shall be retained for at least five years by the tank manufacturer.
(d) Filler material containing more than 0.08% vanadium shall not be used.

6.3.2.7 Postweld heat treatment

The following requirements for postweld heat treatment shall apply:

(a) All postweld heat treatment of tanks shall be conducted in accordance with the ASME *Code*.
(b) All tanks constructed in accordance with Part UHT of the ASME *Code* shall be postweld heat treated.
(c) Where postweld heat treatment is required, the inner vessel shall be treated as a unit after completion of all the welds to the shell and heads.

Welded attachments to pads may be made after postweld heat treatment.

6.3.3 Insulation

6.3.3.1 General

The following requirements for insulation shall apply:

(a) The thermal insulation of the system shall include a complete covering of the inner vessel.
(b) Insulating materials shall not deteriorate unduly in service.
(c) The insulation material shall be compatible with the lading.

6.3.3.2 Insulation combustibility in oxygen service

The insulation in portable tanks used to transport oxygen shall not sustain combustion in a 99.5% oxygen atmosphere at atmospheric pressure when contacted with a continuously heated, glowing platinum wire.

6.3.4 Jacket

6.3.4.1 General

The following requirements shall apply:

(a) The insulation shall be completely covered by a metal jacket so as to prevent the ingress of moisture or other damage under normal transport conditions.

(b) For vacuum-insulated tanks (evacuated jackets), the aggregated thickness of the jacket and the inner vessel shall correspond to the minimum thickness prescribed in Clause 6.3.2.5.2(b) for a tank not enclosed in an evacuated jacket.

(c) Minimum metal thickness of a jacket that is not evacuated shall be as follows:

Metal	Gauge	mm	(in)
Stainless steel	22	0.68	(0.0269)
Low-carbon mild steel	14	1.72	(0.0677)
Aluminum	—	2.54	(0.1000)

6.3.4.2 Design for minimum collapsing pressure

The minimum design collapsing pressure of the jacket shall be calculated in accordance with

(a) Clause 5.5.7.2 for tanks with an evacuated jacket; or

(b) Clause 5.5.7.3 for tanks with a non-evacuated jacket.

6.3.4.3 Materials

Jacket pressure parts shall be constructed of a metal of one of the following specifications:

(a) one of those specified in Section II of the ASME *Code*; or

(b) ASTM Specification A242, A514, A572, A588, A606, A 633, A 1008 HSLAS (formerly A607), A1008 HSLAS-F (formerly A715), A1011 HSLAS (formerly A607), or A 1011 HSLAS-F (formerly A715).

6.3.5 Cleanliness

The following requirements for cleanliness shall apply:

(a) All loose particles from fabrication, such as weld spatter, dirt, grinding wheel debris, and other loose materials, shall be removed prior to the final closure of the tank.

(b) Any contaminants in the inner vessel, other than those described in Item (a), that are likely to react with the lading shall be removed by cleaning with a chemical or solvent compatible with the intended lading.

(c) A tank constructed for oxygen service shall be thoroughly cleaned in accordance with CGA G-4.1.

6.3.6 Openings and controls

6.3.6.1 Manholes

Each inner vessel having a volumetric capacity of 2350 L (620 US gal, 515 Imp. gal) or more shall be equipped with bolted or welded manholes in accordance with the ASME *Code* or shall have other openings permitting internal inspection of the tank.

6.3.6.2 Outlets

The following requirements shall apply:

(a) Each filling and discharge opening to the inner vessel shall be fitted with at least two mutually independent shut-off devices in series. One shall be a stop valve situated as close as is reasonably practicable to the jacket.

Note: *The requirements in Item (a) do not apply to openings for gauges, manual vents, or pressure-relief or pressure-control devices, unless otherwise specified.*

(b) Each stop valve shall be rated for a pressure of at least the inner vessel MAWP, taking into account the temperature expected during transport, and shall be designed to prevent unintentional opening.
(c) Each valve shall be clearly marked to indicate its function and the direction of closure.

6.3.7 Pressure-relief devices

6.3.7.1

The following requirements for pressure-relief devices shall apply:
(a) Each tank shall be provided with not fewer than two independent spring-loaded pressure-relief devices. The pressure-relief devices shall conform to the following:
  (i) They shall be set to open at the MAWP and be fully open at a pressure equal to 110% of the MAWP.
  (ii) The location and installation of devices shall not impair their operation by cooling effects generated from flow of the lading through the device.
  (iii) The combined flow capacity of the pressure devices shall be determined in accordance with CGA S-1.2 at a pressure of not more than 121% of the inner vessel's MAWP.
  (iv) The total flow capacity of the pressure-relief devices shall be determined at a pressure of not more than 110% of the inner vessel's MAWP.
(b) Rupture discs shall not be used in tanks transporting oxygen.
(c) All pressure-relief device inlets shall be situated at the top of the inner vessel in a position as near the longitudinal and transverse centre of the inner vessel as is reasonably practicable.

6.3.7.2

The following requirements for jacket relief devices shall apply:
(a) The jacket of a vacuum-insulated portable tank shall be protected by a relief device that releases internal pressure.
(b) The discharge area of this device shall be at least 0.34 mm2/kg (0.00024 in2/lb) of the volumetric capacity of the inner vessel.
(c) This device shall function at the lesser of
  (i) the internal design pressure of the jacket, calculated in accordance with the ASME *Code*; and
  (ii) 172 kPa (25 psi).

6.3.8 Piping, valves, and fittings

The following requirements shall apply:
(a) Aluminum parts that retain lading during transportation or that are subject to abrading in normal service shall not be installed on tanks that transport liquid oxygen.
(b) To prevent leakage due to fire, only steel piping and welded joints shall be used between the first joint after the jacket and the connection to the first closure of any outlet. This joint shall be as close as is practicable to the exit from the jacket.
(c) When pressure-building units are used, the liquid and vapour connections to those units shall be provided with valves as close to the jacket as is reasonably practicable to prevent the loss of contents in case of damage to the pressure-building units. In the case of the vapour connection, the valve may be a check valve.

6.3.9 Supports and anchoring

The following requirements shall apply:
(a) Tanks shall be designed and constructed with supports to provide a secure base during transport and with suitable tie-down attachments.
(b) The tank shall be attached by suitable means to a frame that can be attached to the vehicle. When attached, the portable tank shall be completely within the length of the vehicle.
(c) The tank shall be protected against damage to the shell and service equipment resulting from lateral and longitudinal impact and overturning as specified in Clause 6.1.6.4(b).

(d) The provisions of Clause 6.3.2.4 shall apply to the calculations for attachments connecting the jacket to the suspension system, lifting and tie-down attachments, supports, load-bearing jacket areas, and attachments of inner vessel support to the jacket.
(e) Where any inner vessel support is attached to any part of an inner vessel head, the stresses imposed on the head shall be provided for as required in Item (d).
(f) All attachments of supports to inner vessels and to jackets shall be made
  (i) by pads of materials compatible with the materials of the inner vessel or jacket, as applicable;
  (ii) by stiffening rings; or
  (iii) by bosses so designed or gusseted as to distribute the load.
(g) Permanent lifting and tie-down attachments designed to allow lifting in a full condition shall be fitted to the outer jacket or supporting structure.
(h) The combined stresses caused by the tank mountings and lifting and tie-down attachments shall not cause excessive stress in any portion of the tank.
(i) In the design of supports and framework, the effect of environmental corrosion shall be taken into account.

6.3.10 Gauging devices

6.3.10.1 General

Unless a tank is intended to be filled by weight, it shall be equipped with one or more gauging devices. If the gauges are in direct communication with the contents of the shell, glass level-gauges and gauges made of other fragile material shall not be used.

6.3.10.2 Pressure gauges

The following requirements for pressure gauges shall apply:
(a) All tanks shall be provided with a pressure gauge located for clear visibility.
(b) A shut-off valve shall be installed between the pressure gauge and the tank.

6.3.10.3 Vacuum gauge connection

Each vacuum-insulated portable tank having a volumetric capacity of more than 2350 L (620 US gal, 515 Imp. gal) shall be provided with a connection for a vacuum gauge to indicate the absolute pressure within the insulation space.

6.3.11 Inspection and testing

In addition to the requirements in Clause 6.1.4.8, the following requirements shall apply:
(a) Materials of the tank and its appurtenances, excluding the jacket, shall be inspected in accordance with the ASME *Code*.
(b) Inner vessels shall be radiographed to provide a joint efficiency of 1.0 in accordance with the ASME *Code*.
(c) The tank shall be pressure tested in accordance with Clause 7.2.7 at a test pressure determined from Clause 5.2.5, using an "x" value defined for TC 341 highway tanks.

6.3.12 Marking

The following marking requirements shall apply:
(a) In addition to the requirements of Clause 6.1.4, the metal identification plate(s) shall be marked with the following information:
  (i) design service temperature in °C (or optionally in °F) — (Design Serv. Temp.);
  (ii) "Insulation for Oxygen Service" or "Not Authorized for Oxygen Service", depending on the combustibility of the insulation determined according to Clause 6.3.3; and
  Note: *The marking INSULATION FOR OXYGEN SERVICE does not imply oxygen compatibility of other parts of the portable tank. This marking is for insulation only.*
  (iii) design weight of lading used in determining the loadings in Clauses 6.3.2.2 and 6.3.2.4.

(b) The volumetric capacity required by Clause 6.1.4 shall be that of the tank at its coldest operating temperature, after deductions for
  (i) the volume above the inlet to the pressure-relief device or pressure-control valve; and
  (ii) the volume of structural members, baffles, piping, and appurtenances inside the inner vessel.
(c) The following information shall be durably marked either on the portable tank or on a metal plate firmly secured to the portable tank:
  (i) name of the refrigerated liquefied gas being transported (and minimum mean bulk temperature);
  (ii) maximum permissible gross mass (MPGM) in kg; and
  (iii) unladen (tare) mass in kg.

6.4 Portable tanks — Specification TC 44 construction standards

In addition to the applicable requirements specified in this Standard, TC 44 tanks shall meet the requirements specified in CSA B626.

7 Inspection, testing, and maintenance of tanks

7.1 Periodic and obligatory inspection and testing

7.1.1 General requirements for periodic inspection and testing

The following requirements shall apply:

(a) All tanks shall be inspected and tested in accordance with Tables 7.1 and 7.2 subject to the annotations to the Tables and any other provision of Clause 7 or Annex A. If more than one test or inspection interval is prescribed for a particular inspection or test for a given tank in a particular service, the shortest interval for that inspection or test shall apply. The due dates for the first periodic retest and inspection are measured from the original test and inspection date marked on the tank or, if no test date is marked, the certification date.
(b) Inspection in accordance with Clause 7 shall be performed by a tank inspector for a facility registered in accordance with Clause 8 of this Standard, except as provided for in Annex A.
(c) Testing in accordance with Clause 7 shall be performed by a tank tester for a facility registered in accordance with Clause 8 of this Standard, except as provided for in Annex A.
(d) A tank which fails a prescribed test or inspection shall
  (i) be repaired, inspected, and tested in accordance with Clause 7 of this Standard; or
  (ii) be removed from dangerous goods service.

7.1.2 Obligatory testing

In addition to the periodic retesting or inspection requirements of Clause 7.1.1, hydrostatic or pneumatic retesting and inspection shall be required prior to further use if

(a) a tank shows evidence of bad dents, corroded or abraded areas, leakage, or any other condition that might render the tank unsafe for transportation service;
(b) the tank has been involved in an accident in which it could have been dented, torn, or otherwise damaged so as to affect its lading retention capability;
(c) the tank has not been used for transporting dangerous goods for one year or more; or
(d) the tank is new or modified from its original design, and the modification involves work on product-retaining components (see Clause 7.6.6).

If product-retaining components of piping have been modified or repaired, a leak test shall also be required.

A tank successfully tested and inspected in accordance with this Clause may be marked in accordance with Clause 7.4 if all the requirements of the applicable test or inspection in Clause 7.2 are also met.

7.1.3 Decontamination

7.1.3.1
For all tanks that are to be inspected or tested, the inspector or tester shall ensure that all precautions are taken to ensure that there is no hazard to personnel performing the inspection or test, or to persons in the general vicinity.

7.1.3.2
Tanks that most recently contained Class I explosives shall be decontaminated by a manufacturer of explosives licensed by the Explosives Regulatory Division of Natural Resources Canada (NRCan).

7.1.3.3
The person performing the decontamination of a tank that most recently contained explosives shall place a numbered seal on each outlet of the tank to indicate that it has been decontaminated.

7.1.3.4
The manufacturer of explosives shall supply a document of decontamination to the inspection and test facility in order to satisfy the requirements of Clause 7.1.3.1. The document of decontamination shall include

(a) the name and address of the tank owner;
(b) the tank serial number;
(c) the name, address, and NRCan licence number of the facility performing the decontamination;
(d) the date and time of the decontamination;
(e) the numbers of any seals placed on the tank outlets as specified in Clause 7.1.3.3;
(f) the name and signature of the person performing the decontamination;
(g) a statement, signed by a representative of the tank owner or a representative of the licensed explosive manufacturer, that the tank is free of residue that could create a hazard during any work on the tank vehicle, including hot work or impact; and
(h) the name, title, and company name of the person(s) signing the statement specified in Item (g).

7.2 Inspections and tests

7.2.1 External inspection

7.2.1.1
External inspections shall include the following:

(a) without removing insulation or jacketing, checking for corroded areas, dents, distortions, defects in welds, defects in piping, and any other condition, including leakage, that indicates weakness in the tank that might render it unsafe for transportation;
(b) ensuring that devices for tightening manhole covers are operative and that the covers are leaktight;
(c) ensuring proper functioning of all valves, vents, and emergency devices, including self-closing stop valves, excess-flow valves, and remote closure devices, and ensuring that they are free of corrosion, distortion, or any other damage that would prevent their normal operation;
(d) ensuring that all bolts or nuts on any flanged connection or blank flange are in place and properly tightened;
(e) ensuring that specification and other markings on the tank are legible; if metal identification plates are missing or illegible, the requirements of Clause 7.7 shall apply;
(f) ensuring that all major appurtenances and attachments, connecting structures, and those elements of the upper coupler (fifth wheel) assembly that can be inspected without dismantling that assembly are not damaged or corroded so as to affect safe operation of the vehicle; and
(g) ensuring that hose assemblies mounted on or accompanying the tank do not display any defects listed in Clause 7.2.10.4 and have legible markings meeting the requirements of Clause 7.2.10.6 and,

where applicable, Clause 7.2.10.8, indicating that they were pressure tested within the prescribed period.

(h) Specification TC 44 tanks need not be suspended nor removed from supporting or adjacent structures, provided that all accessible surfaces are examined for damage or evidence of leakage.

7.2.1.2

For multi-compartment vehicles, the drain shall be uncapped or unplugged. If there is no evidence of leakage from the drain or void space, the external inspection requirements for the tank wall in that void space shall be deemed to be satisfied.

7.2.1.3

Corroded or abraded areas of the tank wall shall have their thickness tested in accordance with Clause 7.2.6.

7.2.1.4

All reclosing pressure-relief valves

(a) shall be externally inspected for any corrosion or damage that could prevent their safe operation; and

(b) on tanks that carry lading corrosive to the valves shall be either replaced or tested in accordance with Clause 7.2.7.6(b).

7.2.1.5

The gaskets on any full opening rear head shall be

(a) visually inspected for cuts, cracks, or splits; and

(b) replaced if cuts, cracks, or splits that are likely to cause leakage, or are of a depth of 12.7 mm (0.5 in) or more, are found.

7.2.1.6

The internal self-closing valve and off-truck emergency shutdown system shall be tested in accordance with Clause 7.2.9.

7.2.1.7

A written report shall be completed in accordance with Clause 7.3.

7.2.1.8 Rejection criteria for external inspections

In addition to any other criteria in Clause 7.2.1, tanks shall be rejected when any of the following defects are found during an external inspection:

(a) less than the minimum thickness remaining under a cut, dig, or gouge;

(b) any dent with a depth of more than 12.7 mm (0.5 in) where it includes a weld;

(c) any dent with a depth of greater than 10% of the length of the dent;

(d) any weld defect, including a crack, pinhole, or incomplete fusion of the weld;

(e) any structural defect;

(f) any source of leakage; or

(g) repairs made to liquid-retaining components using overlay patches.

7.2.2 Internal inspection

7.2.2.1 General

Internal inspections shall include the following:

(a) checking tank shell, heads, and baffles for cracks, corroded areas, dents, distortion, defects in welds, defects in piping, and any other condition, including leakage, that might render the tank unsafe for transportation service;

(b) in accordance with Clause 7.2.6, thickness testing of corroded or abraded areas of the tank wall;

(c) if the tank is lined, a lining inspection in accordance with Clause 7.2.3; and
(d) a written report completed in accordance with Clause 7.3.

7.2.2.2 Rejection criteria for internal inspections

In addition to any other criteria in Clause 7.2.2.1, tanks shall be rejected when any of the following defects are found during an internal inspection:
(a) less than the minimum thickness remaining under a cut, dig, or gouge;
(b) any dent with a depth of more than 12.7 mm (0.5 in) where it includes a weld;
(c) any dent with a depth of greater than 10% of the length of the dent;
(d) any weld defect, including a crack, pinhole, or incomplete fusion of the weld;
(e) any structural defect;
(f) any source of leakage; or
(g) repairs made to liquid-retaining components using overlay patches.

7.2.3 Lining inspection

7.2.3.1

Integrity of linings shall be verified as follows:
(a) For rubber (elastomeric) linings
    (i) Equipment — inspection equipment shall include
        (1) a high-frequency spark tester capable of producing sufficient voltage to ensure proper calibration;
        (2) a probe with an L-shaped 2.4 mm (0.09 in) diameter wire, with up to 30.5 cm (12 in) of bottom leg (end bent to a 12.7 mm (0.5 in) radius), or an equally sensitive probe; and
        (3) a steel calibration coupon 30.5 × 30.5 cm (12 × 12 in) covered with the same type and thickness of material as the lining that is to be tested. The material on the coupon shall have a test hole to the metal substrate made by puncturing the material with a 22 gauge hypodermic needle or comparable piercing tool.
    (ii) Calibration — the probe shall be passed over the surface of the calibration coupon in a constant, uninterrupted manner until the hole is found. The hole is detected by the white or light blue spark that appears. (A sound lining causes a dark blue or purple spark.) The voltage shall be adjusted to the lowest setting that will produce a minimum 12.7 mm (0.5 in) spark measured from the top of the lining to the probe. To ensure that the setting on the probe does not change, the spark tester shall be calibrated periodically, using the same test calibration coupon, power source, probe, and cable length.
    (iii) Inspection procedure — the inspection shall be performed as follows:
        (1) After calibration, the probe shall be passed over the lining in an uninterrupted stroke.
        (2) Defects shall be repaired using equipment and procedures recommended by the lining manufacturer or installer.
(b) For linings other than rubber — inspection of linings other than rubber (elastomeric material) shall conform with the procedures and equipment specified by the lining manufacturer or installer.

7.2.3.2

Degraded or defective areas of the tank lining shall be removed, and the tank wall below the defect shall be inspected. Corroded areas of the tank shall be thickness tested in accordance with Clause 7.2.6.

7.2.3.3

Following the inspection, a written report shall be completed by the inspection facility in accordance with Clause 7.3.

7.2.4 Upper coupler area inspection

Areas covered by the upper coupler (i.e., king pin plate) or turntable assembly shall be inspected for corroded or abraded areas, cracks, dents, distortions, defects in welds, and any other condition that might

render the tank unsafe for use in transportation. The upper coupler assembly shall be removed for this inspection. A turntable assembly need not be removed if the areas of the tank where it is attached are clearly visible for inspection. Following the inspection, a written report shall be completed by the inspection facility in accordance with Clause 7.3.

7.2.5 Leakage test

7.2.5.1

The leakage test shall ensure that the tank closures, piping, valves, and gaskets are in good condition and do not leak within the piping or to the exterior. The leakage test shall be performed in conjunction with the external inspection (see Clause 7.2.1.1) in accordance with the following:

(a) Any venting devices set to relieve at less than the test pressure shall be removed or rendered inoperative.
(b) Product piping and all associated valves and accessories shall be in place and operative.
(c) Each valve and closure shall be tested in sequence.
(d) A combination of test methods may be used to test tank components and accessories, provided that all requirements of this Clause are met.
(e) One of the following shall be used as the test medium:
    (i) the normal lading of the tank;
    (ii) a less hazardous lading of equal or less viscosity;
    (iii) water;
    (iv) inert gas;
    (v) air; or
    (vi) vacuum.

    Note: *When using air as a test medium, the tester should be aware of the need for proper purging and ensure that there is no possibility of creating a mixture of product and air within the explosive limits of the product.*
(f) When air or other gas is used as the test medium,
    (i) a soapy water mixture or other material that will foam or bubble to indicate the presence of leaks shall be used to locate leaks; or
    (ii) another method that is at least as sensitive as the method specified in Item (f)(i) shall be used to locate leaks.
(g) During the test, precautions shall be taken to prevent overpressurization of the tank
(h) The test pressure shall be not less than 80% of the tank design pressure or MAWP, whichever is less, and shall be marked on the certification plate, except that
    (i) if a tank with a MAWP of 690 kPa (100 psi) or more is used in dedicated service or services, the test pressure shall be the maximum normal operating pressure of the tank; and
    (ii) if an MC 330, MC 331, or TC 331 tank is used in liquefied petroleum gas or anhydrous ammonia service, the test pressure shall be not less than 414 kPa (60 psi).
(i) The test pressure shall be maintained for at least 5 min.

All leaks shall be repaired before the tank is marked as specified in Clause 7.4. A report shall be completed as specified in Clause 7.3.

7.2.5.2

The secondary containment space of a TC 406 tank that is double-walled or otherwise constructed to provide secondary containment shall be tested for leaks using pressure or vacuum as follows:

(a) A pressure or vacuum differential of at least 14 kPa (2 psi), gauged at the top of the tank, shall be applied to all secondary containment spaces.
(b) Once the test pressure or vacuum is achieved, the secondary containment space shall be disconnected from the source, and the pressure or vacuum shall be held for at least 10 min without change or other signs of leakage.
(c) To avoid possible damage to the secondary containment while using vacuum, or to the inner containment while using external pressure, 14 kPa (2 psi) may be maintained in the inner containment while the secondary containment space is being pressure tested.
(d) The results of this test shall be noted on the leakage test report specified in Clause 7.2.5.1.

(e) A tank shall be marked as specified in Clause 5.1.6.1.7(a) or 6.1.4.9(a) on the metal identification plate or on the non-specification marking plate specified in CSA B621.

Note: *Clause 7.2.5.2 does not apply to the void space between double bulkheads on multi-compartment tanks.*

7.2.6 Thickness test

7.2.6.1 Test requirements

Thickness testing shall be performed in accordance with the following:

(a) Any person performing a thickness test shall follow the instructions of the testing device manufacturer with respect to the use of that device.

(b) The testing device shall be capable of accurately measuring thickness to within ± 0.05 mm (0.002 in).

(c) The thickness test shall be performed on the tank head and shell in at least the following areas:
   (i) around any piping that retains lading;
   (ii) high-stress areas of the shell such as the bottom of the tank;
   (iii) around openings, weld joints, shell reinforcements, and locations where appurtenances are attached;
   (iv) near the upper coupler (fifth wheel), suspension system attachments, and any connecting structures;
   (v) any known thin areas in the tank and nominal liquid level lines; and
   (vi) structures joining multiple carbon steel tanks on a self-supporting transport unit.

7.2.6.2 Rejection criteria

The tank shall be rejected if any thickness measured in Clause 7.2.6.1 is below

(a) the minimum thickness specified on the nameplate;

(b) for MC , 306, 307,, and 312 and TC 306, 307, and 312 tanks that do not have a minimum thickness specified on the nameplate, the “in service thickness” specified in Table 7.4 or 7.5; or

(c) for other tanks that do not have a minimum thickness specified on the nameplate, 10% less than the nominal thickness.

7.2.6.3 Consequences of rejection

7.2.6.3.1

Except as provided for in Clause 7.2.6.3.2, a tank rejected for insufficient thickness shall

(a) not be used in dangerous goods service; and

(b) not display a metal identification plate identifying it as a TC, MC, or DOT specification tank.

7.2.6.3.2

A tank that has been rejected for insufficient thickness may be returned to dangerous goods service with modified minimum thickness or loading parameters if it fulfills the requirements of Clauses 8.2 to 8.4 for modified tanks.

7.2.6.4 Report

Following the test, a written report shall be completed by the testing facility in accordance with Clause 7.3.

7.2.7 Pressure tests

7.2.7.1 General

Prior to conducting a pressure test, the tank shall have a satisfactory external visual inspection. If required in accordance with Tables 7.1 and 7.2, the tank shall also have a satisfactory internal visual inspection prior to conducting a pressure test.

Pressure tests include
(a) the hydrostatic test in Clause 7.2.7.7 or the pneumatic test in Clause 7.2.7.8;
(b) the pressure-relief device test or replacement in Clause 7.2.7.6;
(c) if the tank is furnished with a heating system, the test in Clause 7.2.7.9; and
(d) in tanks with refrigerating or heating coils for carbon dioxide or nitrous oxide, the test in Clause 7.2.7.10.

7.2.7.2 Multi-tank motor vehicle
Each tank of a multi-tank motor vehicle shall be separately pressure tested, and during the test, adjacent tanks shall be empty and at atmospheric pressure.

7.2.7.3 Tank closures and relief devices
Pressure tests shall be conducted with
(a) all relief devices set to operate at or below test pressure clamped, plugged, or otherwise rendered inoperative; and
(b) all closures in place.
All relief devices shall be returned to operating condition immediately after the test is completed.

7.2.7.4 Criteria for a successful test
A tank shall have successfully completed the test if
(a) when isolated from the pressure supply, the test pressure is retained for at least 10 min; and
(b) a visual examination of all external surfaces reveals no defects, leakage, or deformation.
Note: *It is advisable to remove the upper coupler and to support the front of the tank prior to filling the tank for a hydrostatic test.*

7.2.7.5 Removal of insulation and jacketing
Despite Clause 7.2.7.4(b), tank insulation and its jacket need not be removed from insulated tanks unless this is necessary to determine the source of a leak.

7.2.7.6 Reclosing pressure-relief device testing or replacement
All reclosing pressure-relief devices shall be
(a) replaced; or
(b) tested to ensure that they open at the required set-to-discharge pressure for the tank's MAWP and reseat at not less than 90% of that pressure or at the reseat pressure prescribed for the tank specification.

7.2.7.7 Hydrostatic test
The hydrostatic test shall be conducted as follows:
(a) The tank, including its domes, shall be completely filled with water, or other liquid having similar properties, at a temperature not exceeding 38 °C (100°F).
(b) During the test, precautions shall be taken to prevent overpressurization of the tank.
(c) Pressure shall be gauged at the top of the tank.
(d) Tank test pressure shall be established in accordance with Table 7.3.
(e) All piping and accessories shall be pressure tested at not less than 80% of the tank's MAWP.
(f) Following the test, a written report shall be completed by the tester in accordance with Clause 7.3.

7.2.7.8 Pneumatic test
Note: *The energy stored by pressurized air or other gas during pneumatic testing can result in severe damage and personal injury in the event of tank or component failure. The risk associated with the use of air or other gas as the test medium (pneumatic testing) is much higher than the risk associated with the use of a liquid (hydrostatic testing).*
The following requirements for pneumatic tests shall apply:
(a) The pneumatic test shall be used only where
    (i) there is no suspicion of weakness in the tank; and

(ii) the presence of residual water in the tank after the hydrostatic test would
(1) react with the lading or the tank or any lading retention component; or
(2) result in the formation of ice, causing damage or adversely affecting the proper functioning of the tank.

(b) Tests shall be performed in accordance with detailed written procedures.
(c) During the test, precautions shall be taken to
(i) prevent overpressurization of the tank; and
(ii) protect persons in the vicinity of the test or control their access to the tank during pressurization and test pressure hold periods.
(d) Pressure may be gauged anywhere on the tank. During pressurization and test pressure hold periods, however, the tank tester shall read the pressure from a protected location or from a safe distance.
(e) Tank test pressure shall be established in accordance with Table 7.3.
(f) Prior to surface visual inspection of the tank, tank pressure shall be reduced to MAWP.
(g) Where the duration of the test is less than 1 h
(i) with the tank pressure at MAWP, the tank shall be inspected for leaks by coating the entire surface of all joints under pressure with a solution of soap and water, heavy oil, or other material that will foam or bubble to indicate the presence of leaks; or
(ii) the tank shall be inspected for leaks using a detection method that is as sensitive as the method specified in Item (g)(i).
(h) All piping and accessories shall be pressure tested at not less than 80% of the tank's MAWP.
(i) Following the test, a written report shall be completed by the tester in accordance with Clause 7.3.

7.2.7.9 Tests of heating systems

The following requirements for tests of heating systems shall apply:
(a) All pressure-retaining parts of a highway tank heating system shall be hydrostatically tested at least once every five years.
(b) The test pressure shall be at least 1.5 times the heating system MAWP and maintained for 5 min.
(c) The tank shall not be pressurized during the test.
(d) Heating systems employing flues for heating the lading shall be tested to ensure against lading leakage into the flues or the atmosphere.
(e) Following the test, a written report shall be completed by the tester in accordance with Clause 7.3.

7.2.7.10 Carbon dioxide or nitrous oxide refrigeration or heating coils

Refrigerating or heating coils that are installed in tanks for carbon dioxide or nitrous oxide shall be tested
(a) externally to at least the same pressure as the test pressure of the tank; and
(b) internally to at least twice the working pressure of the heating or refrigerating system, or the test pressure of the tank, whichever is greater.

7.2.8 Internal inspection by the wet fluorescent magnetic particle method

Note: *This clause does not apply to tanks that do not have manholes.*

The following requirements for internal inspection using the wet fluorescent magnetic particle method shall apply:
(a) Each TC 331, TC 51, or applicable equivalent or substitute tank referred to in CSA B622;
(i) constructed of quenched and tempered steel in accordance with Part UHT in Section VIII of the ASME *Code*); or
(ii) constructed of other than quenched and tempered steel and used for the transportation of anhydrous ammonia liquefied petroleum gas with a higher corrosiveness than Classification 1 of ASTM D1838, or any other lading that can cause stress corrosion cracking shall be internally inspected by the wet fluorescent magnetic particle method immediately prior to and in conjunction with the performance of the pressure test prescribed in Clause 7.2.7.
(b) The wet fluorescent magnetic particle inspection shall be performed in accordance with Section V and Section VIII, Division 1, Appendix 6, paragraphs 6-1 to 6-4 of the ASME *Code* and CGA P-26. Clause 7.2.8 does not apply to highway tanks that do not have manholes.

(c) Following the inspection, a written report shall be completed by the inspector in accordance with Clause 7.3.

7.2.9 Test of off-truck emergency shutdown system

7.2.9.1
The test of the off-truck emergency shutdown system shall apply to those tanks that are required to have an off-truck emergency shutdown system.

7.2.9.2
At least once each calendar month that a highway or portable tank is in service, the operator of the tank shall check
(a) the off-truck emergency shutdown system for operation in accordance with Clause 5.3.2.5; and
(b) the internal self-closing (ISC) valve in the liquid discharge opening for leakage through the valve.
For tanks equipped with a meter, the meter creep test outlined in Clause D.1 of Annex D or a test providing equivalent accuracy may be used. For tanks that are not equipped with a meter, the test outlined in Clause D.2 of Annex D may be used.

7.2.9.3
Despite Clause 8.1.1, a facility need not be registered to test the off-truck emergency shutdown system.

7.2.9.4
A tank equipped with an off-truck emergency shutdown system that fails to stop the flow of product from the tank or fails to stop motive power to the tank transfer pump shall be taken out of service, and the system shall be repaired and retested in accordance with Clause 7.2.9.2 before being returned to service.

7.2.9.5
Following the monthly test specified in Clause 7.2.9.2, a report outlining the results of the test shall be prepared by the person performing the off-truck emergency shutdown system test, and shall be retained for at least one year by the operator or the tank owner. The report need not comply with Clause 7.3 but shall identify the name and address of the owner and the person performing the test, a reference traceable to the tank serial number, the date of the test, the nature of the test, and the result of the test.

7.2.10 Hose assembly inspection and testing

7.2.10.1
The hose testing requirements specified in Clauses 7.2.10.4 to 7.2.10.9 shall apply to product delivery and vapour return hose assemblies that are temporarily connected between the tank or any tank-mounted accessory and the point of supply or receipt during loading or off-loading but shall not apply to hose assemblies that are part of the piping system and are pressure tested in accordance with Clause 7.2.7.7.

7.2.10.2
Despite Clauses 7.1.1 and 8.1.1, a competent facility that has knowledge of the hose testing requirements need not be registered to test and inspect a hose assembly.

7.2.10.3
Personnel performing the inspections and test specified in Clauses 7.2.10.4 and 7.2.10.5, respectively, shall be trained in product and hose safety, inspection and test procedures, and rejection criteria. A record of this training shall be kept in the employment files of those personnel.

7.2.10.4

Hose assemblies shall be inspected annually for

(a) damage to the hose cover that exposes the reinforcement;
(b) kinked, flattened, or permanently deformed wire braid;
(c) soft spots when not under pressure, bulging under pressure, or loose outer covering;
(d) damaged, slipping, or excessively worn hose couplings;
(e) loose or missing bolts or fastenings on bolted hose coupling assemblies; and
(f) deteriorated legibility or absence of the serial or identification number and HAWP.

7.2.10.5

Each hose assembly shall be pressure tested annually in accordance with the following:

(a) A hose assembly having any damage identified in Clause 7.2.10.4 shall be taken out of service and not be pressure tested until repaired.
(b) The test pressure shall be
    (i) for CSA-certified hose assemblies, not less than 2400 kPa (350 psi);
    (ii) for gravity off-load hose assemblies (drop hoses), not less than 69 kPa (10 psi);
    (iii) for vapour recovery hose assemblies on TC 406 tanks and the equivalent and substitute tanks identified in CSA B621, not less than 69 kPa (10 psi);
    (iv) for vacuum hose assemblies on tanks loaded by vacuum, used exclusively for vacuum loading, and marked "vacuum only" in place of HAWP as specified in Clause 7.2.10.6, not be less than 69 kPa (10 psi); and
    (v) not applicable to vacuum hoses that are
        (1) an integral part of a boom assembly or vacuum system on tanks loaded by vacuum; and
        (2) used exclusively for vacuum loading; and
    (vi) for all other hose assemblies, the greater of 120% of the marked HAWP of the hose assembly and 518 kPa (75 psi).
(c) The following shall not be used to pressurize the hose assembly:
    (i) compressed gas;
    (ii) compressed air;
    (iii) flammable liquid; or
    (iv) corrosive liquid.

    Note: *Water is the recommended test fluid.*
(d) The requirements of Item (c) shall not apply to
    (i) hose assemblies used to handle aircraft fuel;
    (ii) CSA-certified hose assemblies; or
    (iii) hose assemblies used in refrigerated liquefied gas service that are manufactured and documented as conforming to CSA B51 or ASME B31.3 and marked "CSA B51" or "ASME B31.3" by the hose assembly manufacturer.
(e) Provisions shall be made to protect personnel during testing should failure occur.
(f) To pass the pressure test, the hose assembly shall hold the pressure without bulging, distortion, or leaks for at least 5 min when isolated from the pressure supply.

7.2.10.6

A hose assembly that has passed the inspection and pressure test shall be marked in a manner that will endure the rigours of daily use, either by stamping on an end fitting or by using a securely attached metal tag or washer, in letters not less than 5 mm (0.2 in) high, with the month and year of the test and inspection. The depth and location of the stamping shall not degrade the pressure rating of the hose. A hose assembly not already marked in accordance with the requirements of Clause 5.1.2.6 or 6.1.3.5 shall be marked as specified in Clause 7.2.10.10.

7.2.10.7

Following an inspection or test, a report outlining the results shall be prepared by the facility performing the hose testing and inspection and shall be retained for at least two years by this facility and by the hose assembly owner. The report need not comply with Clause 7.3 but shall identify the name and address of

the facility responsible for the inspection and test, the hose assembly serial or identification number, the HAWP, the date, and the nature of the inspection or test.

7.2.10.8
A hose assembly that is held in stock following an inspection and test shall be marked as described in Clause 7.2.10.6 with the letters "IS" and the date that it is returned to service, if it is visually inspected in accordance with Clause 7.2.10.4 immediately prior to its return to service. The next annual inspection and pressure test shall be performed within twelve months of this in-service date. If the hose assembly is stored for more than a year, the test and inspection reports shall be retained by the owner until the next annual inspection and test are completed.

7.2.10.9
New or repaired hose assemblies shall be visually inspected as specified in Clause 7.2.10.4, tested as specified in Clause 7.2.10.5, and marked as specified in Clause 7.2.10.6 or 7.2.10.8.

7.2.10.10
The HAWP for a hose assembly that is not already marked may be determined by referring to documentation provided by the hose and coupling manufacturer or supplier or by inspecting the hose and couplings for markings applied during manufacturing that indicate the maximum working pressure for the component. A HAWP that corresponds to the maximum working pressure of the lowest rated component of the hose assembly, or the maximum anticipated pressure that the hose is expected to see in service, whichever is less, shall be marked on a hose that is successfully tested in accordance with Clause 7.2.10.5. Hose assemblies for which ratings cannot be determined shall not be marked. If not already marked on the hose assembly, markings shall also be applied to indicate the serial number or identification number of the hose assembly.

7.2.11 Structural inspection
Tank trailers shall be subjected to an inspection of all structural components, structural welds, structural components in spaces between or adjacent to compartments in compartmentalized tanks, and areas of high stress or stress concentration in the tank and frame for cracks and other defects as follows:

(a) Prior to inspection, the tank shall be decontaminated as prescribed in Clause 7.1.3.
(b) The jacketing and insulation shall be removed as necessary, or inspection ports in the jacketing and insulation shall be used to conduct the required inspection.
(c) Areas to be inspected shall include but are not restricted to
    (i) points of attachment between the tank wall and frame components for the suspension system, upper coupler, and landing gear;
    (ii) points of attachment between the ring stiffeners and frame components for the suspension system, upper coupler, and landing gear;
    (iii) seams near the bottom centre of the tank;
    (iv) critical areas of shape transition such as the bottom of the circumferential seam on dual conic designs;
    (v) structural compartments or connecting structures;
    (vi) discontinuities in the frame or tank wall;
    (vii) areas surrounding a centre bottom outlet; and
    (viii) any areas identified by the manufacturer or assembler in accordance with Clause 5.10.13.
(d) Welds in critical areas shall be inspected for cracks using dye penetrant or magnetic particle testing.
(e) Following inspection, repair of any defects found, and subsequent re-inspection, the jacketing and insulation shall be replaced in a manner that will facilitate future inspection of critical areas.
(f) Following the inspection, a written report shall be completed by the inspection facility in accordance with Clause 7.3. The report shall include a drawing identifying all critical joints and high stress areas inspected.

7.3 Test and inspection reports

7.3.1 General

Following a test or an inspection, a written report shall be delivered by the registered testing or inspection facility to the tank owner or the owner's agent. The report shall include the following:

(a) the owner's name, address, and telephone number;
(b) the name and business address of the registered facility or individual performing the test or inspection, their registration number, the dates of the inspection or test, the test medium and test pressure where applicable, and test or inspection results;
(c) the owner's and manufacturer's tank serial numbers;
(d) the tank specification;
(e) the type of test or inspection performed and a listing of all items either tested or inspected (a checklist is acceptable);
(f) a statement that
    (i) no defect or damage was discovered; or
    (ii) describes the location, nature, and severity of damage or defects found, how they were discovered, and the nature of any repair or replacement to rectify the damage or defect, and the results of any subsequent test or inspection;
(g) a statement of the disposition of the tank after test or inspection, such as "tank scrapped" or "tank returned to service";
(h) for TC 331, MC 330, MC 331, TC 51, CTC 51, and DOT 51 tanks, the following information:
    (i) a statement indicating whether the tank is constructed of quenched and tempered steel (QT) or other than quenched and tempered steel (NQT);
    (ii) a statement indicating whether the tank was stress relieved after manufacture; and
    (iii) a statement indicating whether the tank was stress relieved after repair and, if so, whether complete or local stress relieving was performed; and
(i) the name and signature of the tank inspector or tester.

7.3.2 Welding inspection reports

When welding inspection is required, a written welding inspection report shall be prepared and included with the test or inspection report.

7.3.3 Retention of reports

Reports of all tests and inspections required by this Standard shall be retained by the tank owner or the owner's agent until the next periodic test or inspection has occurred or until one year after the disposal of the tank. In the event of a change of ownership, all test and inspection reports required to be retained by the owner or the owner's agent shall be delivered at the time of sale to the purchaser, and the prior owner shall retain non-fading photocopies for at least one year thereafter. Except as required by Clause 8.2.2, copies of all test and inspection reports shall also be retained by the test or inspection facility at least until the due date of the next such test or inspection.

7.4 Test or inspection marking

7.4.1

When a tank has successfully passed a test or inspection, the information in Clause 7.4.2 shall be durably and legibly marked in letters not less than 32 mm (1-1/4 in) high on the tank shell or jacket near the metal identification plate or anywhere on the front head where it will be clearly visible from the ground.

7.4.2

The following information shall be provided:

(a) the month and year of the inspection or test;
(b) a letter defined in Clause 7.4.3 indicating the type of inspection or test; and

(c) the last four digits (except that leading zeros may be omitted) of the facility registration number of the facility conducting the test or inspection.

In the sample marking "10/95 P,V,L 1762", "10/95" means October 1995, "P", "V", and "L" mean the pressure test, visual inspection, and lining test, and "1762" are the last four digits of the facility registration number.

7.4.3

The following letters shall indicate the type of inspection or test:

(a) "V" shall signify external inspection;
(b) "I" shall signify internal inspection;
(c) "P" shall signify pressure test;
(d) "T" shall signify thickness test;
(e) "L" shall signify lining test;
(f) "K" shall signify leakage test;
(g) "UC" shall signify upper coupler area inspection;
(h) "WF" shall signify wet fluorescent magnetic particle inspection; and
(i) "S" shall signify structural inspection.

7.5 Repairs to tanks

7.5.1 General

7.5.1.1

Repairs to a tank shall be made in compliance with the specification of its original design and construction by a facility registered in accordance with Clause 8 except as provided in Clause 7.5.1.2. No tank shall be repaired or changed by repair in a way that could cause leakage or cracks, or the likelihood of leakage or cracks, in areas of stress concentration.

7.5.1.2

A TC specification highway tank may be repaired in the US at a facility registered pursuant to 49, CFR, Part 107, Subpart F, for repair of the corresponding DOT or MC specification, as though it was the corresponding MC or DOT specification, provided the requirements for repair reports in Clause 7.5.10 and record retention and transfer in Clause 7.5.11 are complied with.

7.5.2 Decontamination prior to repairs

7.5.2.1

For all tanks that require repairs, the person performing repairs shall ensure that all precautions are taken to ensure that there is no hazard to the personnel performing the repairs or to persons in the general vicinity.

7.5.2.2

Tanks that most recently contained Class I explosives shall be decontaminated by a manufacturer of explosives licensed by the Explosives Regulatory Division of Natural Resources Canada (NRCan).

7.5.2.3

The person performing the decontamination of a tank that most recently contained Class I explosives shall place a numbered seal on each outlet of the tank to indicate that it has been decontaminated.

7.5.2.4
The manufacturer of explosives shall supply a document of decontamination to the repair facility in order to satisfy the requirements of Clause 7.5.2.1. The document of decontamination shall include
(a) the name and address of the tank owner;
(b) the tank serial number;
(c) the name, address, and NRCan licence number of the facility performing the decontamination;
(d) the date and time of the decontamination;
(e) the numbers of any seals placed on the tank outlets as specified in Clause 7.5.2.3;
(f) the name and signature of the person performing the decontamination;
(g) a statement, signed by a representative of the tank owner or a representative of the licensed explosive manufacturer, that the tank is free of residue that could create a hazard during any work on the tank vehicle including hot work or impact; and
(h) the name, title, and company name of the person(s) signing the statement specified in Item (g).

7.5.3 Exception — Postweld heat treatment of minor repairs
Each tank having cracks and defects requiring repairs by welding shall meet all of the requirements of Clause 7.5, except that postweld heat treatment is not required after minor weld repairs. Weld repairs are defined as minor when they do not penetrate the tank wall.

7.5.4 Repair procedures for pressure tank trucks and trailers
All cracks and other defects found on highway tanks TC 331, MC 330, or MC 331 shall be repaired in accordance with the repair procedures described in CGA P-26 and Section VIII of the edition of the ASME *Code* under which the tank was built.

7.5.5 Overlay patches
Repair by overlay patch shall not be permitted on metal tanks. This shall not apply to jackets.

7.5.6 Field welding

7.5.6.1
No field welding of tanks listed in Clause 8.1.3.2 shall be performed unless
(a) The facility is specifically authorized to perform field welding in the Certificate of Authorization referred to in Clause 8.1.3.3 and 8.1.3.4 as applicable.
(b) The registered facility is specifically authorized to perform mobile repairs on their certificate of registration as specified in Clause 8.1.1.
(c) The mobile repairs are made in compliance with Clause 4.4, the quality control manual, and the original specification.

7.5.6.2
For tanks other than those listed in Clause 8.1.3.2, no field welding of tanks shall be performed unless
(a) The registered facility is specifically authorized to perform mobile repairs on their certificate of registration as specified in Clause 8.1.1.
(b) The mobile repairs are made in compliance with Clause 4.4, the quality control manual, and the original specification.

7.5.7 FRP tanks
Repairs to FRP tanks shall be carried out under the guidance and supervision of a manufacturer of tanks constructed of similar materials.

7.5.8 Testing and inspection of repairs

The efficacy of repairs shall be confirmed by the tests and inspections required for the new construction of a tank of the same specification or by pressure testing of repaired lading retention components. The tank shall not be marked as specified in Clause 7.4 unless

(a) the tank has been inspected or tested by a registered facility; and
(b) the applicable tank test or inspection from Clause 7 has been successfully performed.

7.5.9 Additional inspection for pressure tanks

After any repairs that require grinding or welding are made on TC 331, MC 330, MC 331, TC 51, DOT 51, TC 60, or DOT 60 tanks, the repairs shall be inspected by the wet fluorescent magnetic particle method in accordance with Clause 7.2.8(b) after hydrostatic or pneumatic testing, to ensure that any defect has been removed. A written report shall be completed in accordance with Clause 7.3.

7.5.10 Repair reports

Upon completion of any repairs covered by this Clause 7.5, the facility shall prepare a repair report including the following information:

(a) owner's name, address and telephone number;
(b) name of registered facility;
(c) facility registration number;
(d) date of repair;
(e) tank specification and serial number;
(f) description of repair;
(g) weld procedures used; and
(h) the name and signature of authorized welder.

The report shall be retained by the facility conducting the repairs for 20 years.

7.5.11 Record retention and transfer

The following requirements shall apply:

(a) Records of all repairs to a tank shall be retained by the owner or the owner's agent until one year after the disposal of the tank.
(b) All repair records retained by the owner or the owner's agent shall be delivered at the time of sale by the seller of a tank to the purchaser.
(c) In the event of a change in ownership, retention by the prior owner of non-fading copies of the records shall be deemed to satisfy the requirements of Item (a).

7.6 Modification including remounts of previously certified tanks

7.6.1 General

This clause sets out the requirements for modifications, including remounts of existing highway and portable tanks previously certified to a TC, DOT, MC, or CGA specification. No person shall modify a tank unless the modification is carried out in accordance with the requirements of this Standard.

7.6.2 Registration requirements

7.6.2.1

No person shall modify or remount a tank unless he/she is registered in accordance with this standard as a modifier of those tanks or for the corresponding tanks identified in column 2 of Table 7.0.

7.6.2.2

Despite Clause 7.6.2.1, a remount that meets the conditions of Clause 7.6.6.2 may also be performed by a registered assembler of those tanks in accordance with this Standard or for the corresponding tanks identified in column 2 of Table 7.0.

7.6.3 Authorizations

No person shall modify a tank in a manner that involves welding on a component that retains lading or contributes to the structural integrity of the tank unless the welding requirements of Clause 4.4 and the applicable authorizations prescribed in Clauses 8.1.3.2 and 8.1.3.4 are met.

7.6.4 Decontamination prior to modifications

7.6.4.1

For all tanks that require modifications, the person performing modifications shall ensure that all precautions are taken to ensure that there is no hazard to the personnel performing the modifications or to persons in the general vicinity.

7.6.4.2

Tanks that most recently contained Class I explosives shall be decontaminated by a manufacturer of explosives licensed by the Explosives Regulatory Division of Natural Resources Canada (NRCan).

7.6.4.3

The person performing the decontamination of a tank that most recently contained Class I explosives shall place a numbered seal on each outlet of the tank to indicate that it has been decontaminated.

7.6.4.4

The manufacturer of explosives shall supply a document of decontamination to the modification facility in order to satisfy the requirements of Clause 7.6.4.1. The document of decontamination shall include

(a) the name and address of the tank owner;
(b) the tank serial number;
(c) the name, address, and NRCan licence number of the facility performing the decontamination;
(d) the date and time of the decontamination;
(e) the numbers of any seals placed on the tank outlets as specified in Clause 7.6.4.3;
(f) the name and signature of the person performing the decontamination;
(g) a statement, signed by a representative of the tank owner or a representative of the licensed explosive manufacturer, that the tank is free of residue that could create a hazard during any work on the tank vehicle including hot work or impact; and
(h) the name, title, and company name of the person(s) signing the statement specified in Item (g).

7.6.5 Specification requirements

Modifications to the TC specification tanks listed in column 1 of Table 7.0 shall comply with the requirements for that specification in effect at the time of modification. Modifications to the corresponding TC, MC, DOT, and other specifications listed in column 2 of the table shall also comply with the requirements for the specification listed in column 1 that are in effect at the time of modification. Modifications to the MC and DOT specification tanks listed in column 2 may also be made in compliance with the corresponding specification requirements in 49 CFR in force at the time of modification, provided that

(a) the person performing the modification in Canada is duly registered for modification of those tanks in accordance with both 49 CFR and CSA B620; and
(b) the requirements of Clause 7.6 are met.

Table 7.0
TC specifications that apply to modification of corresponding specification tanks
(See Clauses 7.6.2.1, 7.6.2.2 and 7.6.5.)

Applicable TC specification	Corresponding TC, MC, DOT, and other specifications
TC 406	TC 306, DOT 406, MC 306
TC 406 Crude	TC 306 Crude
TC 407	TC 307, TC 350, DOT 407, MC 307
TC 412	TC 312, TC 350, DOT 412, MC 312
TC 423	None
TC 331	MC 331, MC330
TC 338	MC 338
TC 341	CGA 341
TC 11	None
TC 44	None
TC 51	DOT 51
TC 60	DOT 60

7.6.6 Design review, identification, and approval of modifications

7.6.6.1 General

7.6.6.1.1
A modification shall require a review of the relevant parts of the design that have been modified or are affected by the modification as follows:

(a) The design for the modification of a tank with a TCRN for the original design shall be prepared by an engineer and shall be submitted to a Designated Agency for review in accordance with Clauses 8.3.1(a), 8.3.3 and 8.3.4. A new TCRN or revision to the original TCRN shall be obtained in accordance with Clause 8.3.3.2. Only approved drawings shall be used in performing the modification.

(b) The design for the modification of a tank that is not or was not at the time of certification required to have a TCRN shall be reviewed and approved in accordance with Clause 8.3.1(b) by a Design Engineer registered in accordance with Clause 8.1.5. The design for the modification, including all applicable drawings, calculations, and component specifications and ratings, shall be identified with a unique MDIN for the modification design. Only approved drawings shall be used in performing the modification.

7.6.6.1.2
The calculations and drawings shall be retained by the modifier for a minimum of 20 years after the date of tank modification.

7.6.6.1.3
Despite Clause 7.6.6.1.1, modifications to piping do not require a design review provided that

(a) the modified section of piping does not exceed 25 L internal volume ;

(b) modified components are of the same or higher rating as the original design and have no negative impact on the operation or capacity of pressure-relief devices, excess-flow valves, loading and unloading vents, or damage protection of the piping; and
(c) there is no alteration to overpressure protection functions.

7.6.6.2
Remounts shall not be required to undergo a design review as described in Clause 7.6.6.1 if
(a) the remount does not involve a change to the mounting system;
(b) the tank is remounted onto a vehicle of the same or smaller gross vehicle weight; and
(c) the original tank design, including piping and damage and rear-end protection, is not changed.

7.6.7 Inspection and testing
On completion of any modification, the tank shall be inspected and tested in accordance with Clause 7 as follows:
(a) an external visual inspection for all modifications;
(b) a pressure test and a leak test for modifications involving work to product-retaining components; and
(c) an internal inspection for modifications involving work to the tank wall or any internal component.

7.6.8 Certification
On completion of the modification and applicable testing, the modifier shall, at or before the time of delivery, supply, and the owner shall obtain, the Modification Certificate of Compliance described in Clause 8.2.1 for each tank. For a variable specification tank, a Modification Certificate of Compliance shall be issued for each specification affected by the modification.

7.6.9 Metal identification plates for modified tanks
A modified tank shall be marked with an additional identification plate, titled "Modification Plate", meeting the requirements of Clause 5.1.6.1, except Clause 5.1.6.1.6 for highway tanks, and the requirements of Clause 6.1.4, except Clause 6.1.4.7 for portable tanks. The following minimum information shall appear on the additional plate:
(a) tank modifier and facility registration number;
(b) date of modification and recertification date;
(c) test date after modification;
(d) a description of the modification;
(e) the TCRN or MDIN, as applicable, for the modification as required by Clause 7.6.6.1.1; and
(f) for highway tanks
  (i) remounted tanks shall be marked with "remount — design change" for all remounts except those that meet the requirements of Clause 7.6.6.2, which shall be marked "remount — no design change", where applicable;
  (ii) any information listed in Clause 5.1.6.1.6 that has changed due to the modification; and
  (iii) the name of the original tank manufacturer and the tank vehicle serial number; and
(g) for portable tanks
  (i) any information listed in Clause 6.1.4.7 that has changed due to the modification; and
  (ii) the name of the original tank manufacturer and the tank serial number.

The original identification plate shall remain affixed to the tank.

7.7 Illegible or missing metal identification plates

7.7.1 General
When the metal identification plate(s) on a highway or portable tank is illegible or missing, the owner of the tank shall obtain a replacement metal identification plate in accordance with Clauses 7.7.2, 7.7.3, and 7.7.4 prior to further use of the tank.

7.7.2 Supporting documentation

Prior to installation of a replacement plate, the original or replacement Certificate of Compliance shall be obtained as proof that the tank was previously certified to a TC or equivalent or substitute specification. If no documentation can be obtained, a replacement plate shall not be applied. The facility performing the installation of the replacement plate shall be responsible for verifying that the tank in its present condition meets the specification to which it was originally certified and is indeed the tank listed in the supporting documentation.

7.7.3 Installation of a replacement metal identification plate

7.7.3.1

The re-stamping of a metal identification plate shall be done by the tank's original manufacturer or assembler, or his/her representative. In cases where the original manufacturer or assembler is no longer able to provide the replacement plate, it shall be stamped and installed in accordance with Clauses 5.1.6.1.1, 5.1.6.1.3, and 5.1.6.1.4 by any facility registered to manufacture, assemble, modify, or repair tanks of that specification. Assemblers shall not install a plate if the installation involves welding to the tank wall.

Replacement of nameplates required for pressure vessel certification shall be performed in accordance with the requirements of the applicable pressure vessel authorities.

7.7.3.2

The replacement plate shall be marked "Replacement" and contain all of the information that appeared on the original plate or as a minimum the items originally specified in the version of this Standard in effect at the time of the tank fabrication. It shall also include the name and registration number of the facility installing the plate and the date of installation. It shall be installed as near as possible to the original metal identification plate.

If the original plate is present in any condition, it shall not be removed.

7.7.4 Forms

A metal identification plate replacement form shall be completed and signed by the registered facility installing the plate and by the tank owner. This metal identification plate replacement form and a copy of the information on the replacement metal identification plate shall be kept by the owner or the owner's designate throughout the ownership of the tank, and a copy shall be retained for at least one year thereafter. Copies shall also be retained by the facility installing the plate for a minimum of 20 years from the date of delivery.

The metal identification plate replacement form shall include the following:

(a) original tank manufacturer;
(b) original tank vehicle assembler;
(c) original date of manufacture;
(d) tank serial number;
(e) vehicle identification number;
(f) owner's name and signature;
(g) owner's address;
(h) registered facility installing replacement plate and its facility registration number;
(i) registered facility address;
(j) name and signature of compliance officer at registered facility;
(k) date of installment of replacement plate;
(l) a facsimile or rubbing of the replacement plate; and
(m) a copy of the supporting documentation specified in Clause 7.7.2 as an attachment.

Table 7.1
Periodic inspection and test intervals

(See Clauses 7.1.1, C.1, C.2, and C.6.)

Description of tank	Clause 7.2.1 External inspection	Clause 7.2.2 Internal inspection[1]	Clause 7.2.3 Lining inspection	Clause 7.2.5 Leakage test	Clause 7.2.7 Pressure test, hydrostatic or pneumatic	Clause 7.2.11 Structural inspection
TC 306 or TC 406 tanks	1 year	5 years[2]	—	1 year	5 years[3]	—
TC 306 Crude or TC 406 Crude tanks	2.5 years	5 years	—	2.5 years	5 years[3]	
TC 307 or TC 407 tanks	1 year	5 years	—	1 year	5 years	—
TC 312 or TC 412 tanks	1 year	5 years	—	1 year	5 years[3]	—
TC 423 tanks	1 year	1 year	—	1 year	5 years	5 years
TC 350 tanks	6 months	1 year	—	1 year	2 years	—
TC 350 Crude tanks	1 year	1 year	—	1 year	2 years	—
TC 331 tanks	1 year	5 years	—	1 year[4]	5 years[4][10][11]	—
TC 338 tanks	1 year	—	—	—	5 years	—
TC 341 tanks[5]	1 year	10 years	—	—	10 years	—
TC 11 portable tanks	1 year	10 years[6]	—	1 year	5 years	—
TC 44 portable tanks	1 year	5 years	—	1 year	5 years	—
TC 51 portable tanks[9]	2.5 years[7]	5 years	5 years	—	5 years[10][11]	—
TC 56 and 57 portable tanks[8]	2.5 years	—	—	—	2.5 years	—
TC 60 portable tanks	2 years	Initial: 4 years Next 8 years: every 2 years After 12 years: annually	Initial: 4 years Next 8 years: every 2 years After 12 years: annually		Initial: 4 years Next 8 years: every 2 years After 12 years: annually	—

Notes:

(1) *Where a tank, other than a TC 341 tank, is not equipped with a manhole or inspection ports, a hydrostatic or pneumatic pressure test shall be performed at the interval for internal inspections. See also Note 5.*

(2) *Highway tanks used only to refuel aircraft and that operate only on airport property shall be exempt from internal inspection, provided that they are clearly marked "Restricted to Use on Airport Property" in letters not less than* 25 mm *(1 in) high in a contrasting colour on each side of the tank where they will be clearly visible from the ground.*

(3) *For TC 306, TC 406, TC 306 Crude, TC 406 Crude, TC 312, or TC 412 tanks, the pressure tests specified in Clause 7.2.7 shall not be required for uninsulated lined tank trucks and trailers with a design pressure or MAWP of* 103 kPa *(15 psi) or less, if an external inspection and a lining inspection have been performed annually.*

(4) *TC 331 tanks in chlorine service shall be leak tested as specified in Clause 7.2.5 and pressure tested as specified in Clause 7.2.7 every two years. Pressure tests shall not be required on TC 331 tanks when in sodium metal service.*

(5) *As an alternative to the inspection and test requirements of this Table for TC 341 tanks, owners may perform the tests and inspections described in Annex C.*

(6) *The internal inspections specified in Clause 7.2.2 do not apply to TC 11 tanks that are less than* 2350 L *(620 US gal) and that do not have inspection openings.*

(7) *The external inspection period for tanks described in CSA B622, Clause 6.3, Specific Requirement 55, is one year.*

(8) *TC 56 and TC 57 tanks shall be inspected and retested in accordance with Section 7 of CAN/CGSB-43.146.*

(9) *A TC 51 portable tank that is loaded and off-loaded without being removed from the vehicle shall be inspected and tested according to the requirements for TC 331 tanks specified in this Table.*

(10) *The pressure test period for tanks described in CSA B622, Clause 6.3, Specific Requirement 54 and Specific Requirement 55, is three years.[Approved Jan 2012 TC34]*

(11) *TC 331 and TC 51 tanks shall be subjected to an internal inspection by the wet fluorescent magnetic particle method in accordance with Clause 7.2.8 when the conditions of Clause 7.2.8(a) are met.*

Table 7.2
Additional periodic inspection and test intervals

(See Clauses 7.1.1 and C.6.)

Description of tank	Clause 7.2.1 External inspection	Clause 7.2.2 Internal inspection[1]	Clause 7.2.3 Lining inspection	Clause 7.2.5 Leakage test	Clause 7.2.7 Pressure test, hydrostatic or pneumatic	Clause 7.2.6 Thickness test[6]	Clause 7.2.4 Upper coupler inspection
All tanks designed to be loaded by vacuum, with full opening rear heads	6 months[5]	—	—	—	2 years	—	—
All lined tank trucks and tank trailers in corrosive service	—	1 year	1 year	—	—	—	—
All lined tank trucks and tank trailers not in corrosive service[7]	—	—	5 years	—	—	—	—
All unlined tank trucks and tank trailers in corrosive service[2]	—	1 year	—	—	—	2 years[4]	—
All insulated tank trucks and tank trailers[3]	—	1 year	—	—	—	—	—
All insulated highway and portable tanks, lined or without manholes[2]	—	—	—	—	1 year	—	—

Table 7.2 (Concluded)

Description of tank	Clause 7.2.1 External inspection	Clause 7.2.2 Internal inspection(1)	Clause 7.2.3 Lining inspection	Clause 7.2.5 Leakage test	Clause 7.2.7 Pressure test, hydrostatic or pneumatic	Clause 7.2.6 Thickness test(6)	Clause 7.2.4 Upper coupler inspection
All tank trailers Not in corrosive service equipped with an upper coupler	—	—	—	—	—	—	5 years
All tank trailers in corrosive service equipped with an upper coupler							2 years

Notes:

(1) *Where the tank is not equipped with a manhole or inspection ports, a hydrostatic or pneumatic test shall be performed at the interval for internal inspections.*

(2) *Except TC 338 and 341 tanks.*

(3) *Except TC 331, 338, and 341 tanks.*

(4) *If the thickness is such that less than 20% of the corrosion allowance remains, a thickness test shall be performed annually.*

(5) *Except TC 350 crude tanks.*

(6) *The thickness test does not apply to FRP tanks.*

(7) *Lined tanks not in corrosive service shall have their lining visually inspected but the marking requirements of Clause 7.4.3(e) shall not apply.*

Table 7.3
Test pressures

(See Clauses 5.2.5, 5.5.2.4, 7.2.7.7, and 7.2.7.8.)

Tank specification	Pressure, kPa (psi)
TC 306 or MC 306	21 kPa (3 psi) or design pressure, whichever is greater
TC 307 or MC 307	275 kPa (40 psi) or 1.5 × design pressure, whichever is greater
TC 312 or MC 312	21 kPa (3 psi) or 1.5 × design pressure, whichever is greater
TC 331, MC 330, or MC 331	1.5 × design pressure
TC 406	34.5 kPa (5 psi) or 1.5 × MAWP, whichever is greater
TC 407	275.8 kPa (40 psi) or 1.5 × MAWP, whichever is greater
TC 412	1.5 × MAWP
TC 423	1.5 × MAWP
TC 338	According to calculation in Clause 5.2.5
TC 341	According to calculation in Clause 5.5.2.4
TC 350	155 kPa (22.5 psi) or 1.5 × MAWP, whichever is greater
TC 11	According to calculation in Clause 6.3.11(c)
TC 44	27 kPa (4 psi) or 1.5 × MAWP, whichever is greater
TC 51 or DOT 51	1.5 × design pressure
TC 60 or DOT 60	415 kPa (60 psi)
TC Type 1, 2, and 3	1.5 × MAWP

Table 7.4
Minimum thickness for TC and MC 306, 307, and 312 specification tanks manufactured with steel and steel alloys

(See Clause 7.2.6.2.)

Minimum thickness required in Tables 5.2 or 5.3, 5.4 or 5.5, and 5.6 or 5.7, as applicable, for the specification, US gauge or mm (in)	Nominal decimal equivalent for reference, mm (in)	In-service minimum thickness, mm (in)
19	1.06 (0.0418)	0.97 (0.038)
18	1.21 (0.0478)	1.09 (0.043)
17	1.37 (0.0538)	1.22 (0.048)
16	1.52 (0.0598)	1.37 (0.054)
15	1.71 (0.0673)	1.55 (0.061)
14	1.90 (0.0747)	1.70 (0.067)
13	2.28 (0.0897)	2.06 (0.081)
12	2.66 (0.1046)	2.39 (0.094)
11	3.04 (0.1196)	2.74 (0.108)
10	3.42 (0.1345)	3.07 (0.121)
9	3.80 (0.1495)	3.43 (0.135)
8	4.18 (0.1644)	3.76 (0.148)
7	4.55 (0.1793)	4.09 (0.161)
4.76 (3/16)	4.76 (0.1875)	4.29 (0.169)
6.35 (1/4)	6.35 (0.2500)	5.72 (0.225)
7.94 (5/16)	7.94 (0.3125)	7.14 (0.281)
9.53 (3/8)	9.53 (0.3750)	8.59 (0.338)

Table 7.5
Minimum thickness for TC and MC 306, 307, and 312 specification tanks manufactured with aluminum and aluminum alloys
(See Clause 7.2.6.2.)

Minimum thickness required in Tables 5.2 or 5.3, 5.4 or 5.5, and 5.6 or 5.7, as applicable, for the specification, US gauge or mm (in)	In-service minimum thickness, mm (in)
1.98 (0.078)	1.78 (0.070)
2.21 (0.087)	1.98 (0.078)
2.44 (0.096)	2.18 (0.086)
2.77 (0.109)	2.49 (0.098)
3.30 (0.130)	2.97 (0.117)
3.58 (0.141)	3.23 (0.127)
3.84 (0.151)	3.54 (0.136)
4.37 (0.172)	3.94 (0.155)
4.39 (0.173)	3.96 (0.156)
4.93 (0.194)	4.45 (0.175)
5.49 (0.216)	4.93 (0.194)
6.02 (0.237)	5.41 (0.213)
6.86 (0.270)	6.17 (0.243)
9.14 (0.360)	8.23 (0.324)
11.43 (0.450)	10.29 (0.405)
13.72 (0.540)	12.34 (0.486)

8 Facility registration, Design Engineer registration, marking, documentation, and design review requirements

8.1 Facility registration

8.1.1 General

The following requirements for facility registration shall apply:

(a) The manufacture, modification, assembly, repair, test, or inspection of highway or portable tanks in accordance with this Standard shall be performed at a facility registered with the Director.

(b) In Canada, the repair, test, or inspection of the following specification tanks shall be performed at a facility registered with the Director:
  (i) those equivalent or substitute tanks referred to in Clause 5 of CSA B621;
  (ii) those equivalent or substitute tanks referred to in Clause 4 of CSA B622; and
  (iii) those tanks manufactured in accordance with the edition of CGA 341 in effect at the time of manufacture.

(c) A facility is registered on the Director's issuance of a Certificate of Registration similar to that shown in Figure B.3, until expiry on the expiry date on the Certificate, withdrawal, or other disposition. The registered facility shall manufacture, modify, assemble, repair, test, or inspect tanks only at the

location stipulated on the Certificate of Registration, but the Certificate of Registration may authorize mobile units to conduct these activities elsewhere.

(d) Every registered facility shall have, maintain, and adhere to a quality control manual that covers all those activities for which the facility is registered. The quality control manual shall include a cover page similar to the sample provided in Figure B.2 and those sections referred to in Clause B.2.2.3 for the activities to be performed. Clause B.2.2.3 provides section headings that shall be used in the manual and a brief description of what each should contain.

(e) The quality control manual referred to in Item (d) shall be either a separate document from or an appendix to any manual prepared for a provincial pressure vessel jurisdiction or the ASME *Code* or, alternatively, include a cross-referencing document clearly indicating where all the B620 quality control manual requirements can be found in the ASME quality control manual.

(f) For facilities that operate mobile units, the quality control manual referred to in Item (d) shall specifically cover the activities of mobile units in the field, and in particular, verification of tests and inspections.

8.1.2 Mobile unit limitation

Mobile units shall not manufacture, modify, or assemble tanks.

8.1.3 Specific requirements

8.1.3.1

Facilities manufacturing the following tanks shall hold a current Certificate of Authorization from either a provincial pressure vessel jurisdiction for manufacture or from ASME (for the use of the ASME "U" stamp):

(a) TC 407 tanks with a MAWP greater than 240 kPa (35 psi) or designed to be loaded by vacuum, except those made of FRP;

(b) TC 412 with a MAWP greater than 103 kPa (15 psi) or designed to be loaded by vacuum, except those made of FRP;

(c) TC 331, TC 338, or TC 341 tanks; and

(d) TC 11, TC 51, or TC 60 portable tanks.

8.1.3.2

Facilities modifying the following tanks, or the applicable equivalent or substitute tanks referred to in CSA B621 or CSA B622, shall hold a current Certificate of Authorization from a provincial pressure vessel jurisdiction for manufacture or modification, from ASME for use of the ASME "U" stamp, or from the National Board of Boiler and Pressure Vessel Inspectors for the use of the "R" stamp as it applies to modifying, provided that function is covered in the scope of the quality control program required for the "R" stamp:

(a) TC 407 tanks with a MAWP greater than 240 kPa (35 psi) or designed to be loaded by vacuum, except those made of FRP;

(b) TC 412 with a MAWP greater than 103 kPa (15 psi) or designed to be loaded by vacuum, except those made of FRP;

(c) TC 331, TC 338, or TC 341 tanks;

(d) TC 11, TC 51, or TC 60 portable tanks;

(e) TC 307 with a MAWP greater than 240 kPa (50 psi) or designed to be loaded by vacuum, except those made of FRP;

(f) TC 312 with a MAWP greater than 103 kPa (15 psi), except those made of FRP; and

(g) TC 350 with a MAWP greater than 103 kPa (15 psi).

8.1.3.3

Facilities repairing the tanks listed in Clause 8.1.3.2, or the applicable equivalent or substitute tanks referred to in CSA B621 or CSA B622, shall hold a current Certificate of Authorization from

(a) a provincial pressure vessel jurisdiction for repair; or

(b) the National Board of Boiler and Pressure Vessel Inspectors for the use of the "R" stamp.

8.1.3.4
Facilities manufacturing, modifying, or repairing piping on tanks listed in Clause 8.1.3.2, or the applicable equivalent or substitute tanks referred to in CSA B621 or CSA B622, shall hold a current Certificate of Authorization from

(a) a provincial pressure vessel jurisdiction for the manufacture, modification, or repair of piping, as applicable, in accordance with CSA B51 or ASME B31.3; or
(b) the National Board of Boiler and Pressure Vessel Inspectors for the use of the "R" stamp as it applies to modifying or repairing piping, provided that such functions are covered in the scope of the quality control program required for the "R" stamp.

8.1.3.5
The manufacture, assembly, modification, repair, and inspection and test of FRP tanks shall be carried out by a registered facility specifically authorized to do so on its Certificate of Registration.

8.1.4 Application for registration

8.1.4.1
Applications for registration shall be submitted to the Director. Figure B.1 provides a sample of a form that can be used in applying for registration.

8.1.4.2
Applications shall include the following information:

(a) name, street address, and mailing address of the company or individual applying for registration;
(b) name, title, address, and telephone number of the corporate officer or other person responsible for compliance with this Standard;
(c) name, title, address, and telephone number of the local contact person responsible for compliance with this Standard, if different from Item (b);
(d) tank specifications and functions for which application for registration is being made;
(e) facility details, as follows:
    (i) workshop: a brief description of the facility, including approximate square footage, number of bays, and maximum tank size accommodation; and
    (ii) equipment: a brief description of the equipment used for
        (1) manufacture or repair;
        (2) testing and inspection (for tanks, accessories, and safety devices); and
        (3) tank cleaning and decontamination;
(f) a statement certifying that all design engineers, tank inspectors, testers, and welders used by the facility are qualified and experienced in accordance with Clauses 8.1.5.1, 8.1.6, 8.1.7, and 4.4, respectively;
(g) a statement certifying that the quality control program described in the quality control manual required by Clause 8.1.1(d) is in place and operating; and
(h) the signature of the corporate officer or other person responsible for compliance with this Standard as identified in Item (b).

8.1.4.3
Copies of the following documents shall be submitted with the application:

(a) if the applicant is not an individual, letters patent, certificates of incorporation, or other documents evidencing the legal existence of the applicant;
(b) only on specific request from the Director, an uncontrolled copy of the quality control manual or manuals required by Clause 8.1.1(d); and
(c) for manufacture, modification, or repair registration, a copy of the Certificate or Certificates of Authorization as required by Clause 8.1.3.

8.1.4.4
The application for registration of a facility that operates mobile units shall include the following additional information:
(a) the address from which the mobile units are controlled and where all documentation is kept, and the number of mobile units controlled from that location;
(b) a complete description of the mobile units;
(c) a description of all equipment carried in each mobile unit; and
(d) a description of customer equipment and services in the field necessary for the mobile unit to function.

8.1.4.5
The Director shall issue a Certificate of Registration where the Director is satisfied that the applicant has demonstrated familiarity with the requirements of this Standard and the capability to consistently meet the requirements of this Standard. The Certificate of Registration will remain valid until the expiry date shown on the certificate provided the information submitted pursuant to Clauses 8.1.4.2, 8.1.4.3, and 8.1.4.4 has not changed or unless the certificate is revoked or replaced by the Director

8.1.4.6
A Certificate of Registration shall remain valid beyond the expiry date if
(a) an application for renewal of registration is made in accordance with Clause 8.1.4 by registered mail at least 90 calendar days prior to the expiry date;
(b) a new certificate is not issued;
(c) the application for renewal has not been rejected by the Director; and
(d) the certificate due to expire is not revoked by the Director.

8.1.4.7
The Director may revoke the Certificate of Registration of the facility if the Director determines that the facility is not capable of or is not complying with the applicable requirements of this Standard.

8.1.5 Design Engineer

8.1.5.1 Design Engineer qualification
Every Design Engineer shall
(a) be an engineer and shall hold a current licence by the appropriate authorities of his or her residence in Canada or the United States to practise engineering; and
(b) have at least one year of experience in the design of highway tanks in accordance with CSA B620 or 49 CFR.

8.1.5.2 Design Engineer registration
The following requirements for Design Engineer registration shall apply:
(a) Applications for registration shall be submitted to the Director.
(b) A Design Engineer is registered on the Director's issuance of a Certificate of Registration and a registration number.
(c) Applications for registration shall include the following information:
  (i) name, street address, mailing address, and telephone number of the applicant;
  (ii) evidence of the professional status of the applicant under Clause 8.1.5.1(a);
  (iii) evidence of the experience of the applicant under Clause 8.1.5.1(b); and
  (iv) a statement signed by the applicant that he or she possesses the qualifications required by Clause 8.1.5.1.
(d) The Director shall issue a Certificate of Registration where the Director is satisfied that the applicant has demonstrated familiarity with the requirements of this Standard and the capability to consistently meet the requirements of this Standard. The Certificate of Registration will remain valid until the

expiry date shown on the certificate provided the information submitted pursuant to Item (c) above has not changed or unless the certificate is revoked or replaced by the Director.

(e) A Certificate of Registration shall remain valid beyond the expiry date if
  (i) an application for renewal of registration is made in accordance with Clause 8.1.5.2(c) by registered mail at least 90 calendar days prior to the expiry date;
  (ii) a new certificate is not issued;
  (iii) the application for renewal has not been rejected by the Director; and
  (iv) the certificate due to expire is not revoked by the Director.

(f) The Director may revoke the Certificate of Registration of the Design Engineer if the Director determines that the Design Engineer is not complying with the applicable requirements of this Standard.

8.1.6 Tank Inspector qualification

A Tank Inspector shall have

(a) the knowledge and ability to determine if a tank conforms to a particular specification; and

(b) education and experience in the construction, inspection, testing, or retesting of tanks of that specification, as follows:
  (i) an engineering degree or professional engineer status in a province of Canada, and one year of experience;
  (ii) a technical diploma and two years of experience;
  (iii) a high-school diploma and three years of experience; or
  (iv) five years of experience or more.

8.1.7 Tester qualification

A tester shall

(a) be familiar with the specification tank on which the test is performed;

(b) be familiar with the test procedure and pass/fail criteria;

(c) have at least one year of experience performing the test; and

(d) be trained and experienced in the use of the testing equipment.

8.2 Documentation

8.2.1 Certificate of Compliance

(a) A Certificate of Compliance shall contain
  (i) the title “Certificate of Compliance”;
  (ii) a statement that the tank, fittings, valves, piping, and protective devices comply with the applicable specifications of this Standard to the extent of the work performed by the manufacturer or assembler;
  (iii) the number and ratings of all vents required for compliance;
  (iv) all information required to be marked on the metal identification plate(s);
  (v) the name, address, and registration number of the registered facility; and
  (vi) the signature, name, and business address of the person at the facility responsible for compliance.

(b) A Modification Certificate of Compliance shall contain
  (i) the title “Modification Certificate of Compliance”;
  (ii) a statement that the tank, fittings, valves, piping, and protective devices comply with the applicable specifications of this Standard to the extent of the work performed by the modifier;
  (iii) the number and ratings of all vents required for compliance;
  (iv) all information required to be marked on the Modification Plate;
  (v) the name, address, and registration number of the registered facility;
  (vi) the original manufacturer’s TCRN or MDIN, as applicable, referred to in Clause 8.3.2;
  (vii) the signature, name, and business address of the person at the facility responsible for compliance;

(viii) a detailed description of the modification;
(ix) the original dates of vehicle manufacture and certification; and
(x) a statement that all modifications have been performed in compliance with the requirements of this Standard.

(c) A copy of the Certificate shall be retained by the manufacturer, assembler, or modifier for a minimum of 20 years from the date of delivery.

(d) The Certificate shall be retained by the owner or the owner's designate throughout the ownership of the tank, and a copy shall be retained for at least one year thereafter, as required by Clauses 5.1.7 and 6.1.8.

(e) The provisions of Clauses 5.1.7 and 6.1.8 with respect to change of ownership shall apply to the Certificate of Compliance.

(f) Where the Certificate of Compliance has been lost or destroyed and a copy cannot be obtained, then a Replacement Certificate of Compliance can be generated if
(i) a valid B620 metal identification plate is present on the tank;
(ii) upon review of all available manufacturing, sales, and owner history documents, the Design Engineer and owner certify that the tank was designed and constructed and certified to a TC specification;
(iii) a Design Engineer inspects the tank and the Design Engineer and owner certify that the tank continues to conform to the TC specification;
(iv) an internal inspection, external inspection, pressure test, and leakage test are successfully performed in accordance with B620 by a registered facility;
(v) a replacement Certificate of Compliance is prepared in accordance with the requirements set out in the TC specification to which the tank was originally certified;
(vi) the replacement certificate is clearly marked "Replacement Certificate of Compliance" and includes
(1) the certification statements referred to in Items (ii) and (iii);
(2) the date of recertification;
(3) the name, registration number, and signature of the Design Engineer;
(4) the name, address, phone number and signature of the owner;
(vii) for tanks requiring pressure vessel certification, a copy of the manufacturer's data report pursuant to ASME or CSA B51 is obtained;
(viii) copies of the relevant supporting documentation referred to in Items (ii), (iii), and (vii) are attached to the replacement certificate; and
(ix) copies of the Replacement Certificate of Compliance and supporting documents are retained by the Design Engineer for a minimum of 20 years from the date of issue, and by the owner throughout the ownership of the tank and for at least one year thereafter.

8.2.2 Reports of inspections and tests during manufacture, assembly, or modification

The following requirements shall apply:

(a) Reports shall be completed in accordance with Clause 7.3.1 for those inspections and tests performed during manufacture or modification of a tank.

(b) On delivery of the tank, a copy of the reports shall be provided to the owner or owner's designate, who shall retain them throughout the ownership of the tank and for at least one year thereafter.

(c) The provisions of Clause 5.1.7 with respect to change of ownership shall apply to the copy of the reports.

(d) In addition to Clause 7.3.3, the registered facility performing the inspection or test shall retain a copy of the reports for a minimum of 20 years from the date of delivery.

8.3 Design review

8.3.1 General

The following requirements for design reviews shall apply:

(a) Every design of a pressure tank referred to in Clause 5.1.1.2 or Clause 6, except Specification TC 44 tanks, shall be reviewed in accordance with Clause 8.3.3 and shall also meet the following requirements:
  (i) the review shall verify that the design is in conformity with the specification;
  (ii) the calculations and drawings illustrating the design shall be signed by a professional engineer to indicate that the design has been reviewed prior to the submission to the designated design review agency;
  (iii) one of the following shall apply:
    (1) the calculations and drawings shall also be marked with the printed name of the professional engineer, his or her stamp, and the approval stamp of the Designated Agency that reviewed the design in accordance with Clause 8.3.3.1; or
    (2) a record shall be maintained listing all calculations, applicable drawings, and revision numbers used in a design. This record shall include the printed name of the professional engineer, his or her stamp and signature, and the approval stamp of the Designated Agency that reviewed the design in accordance with Clause 8.3.3.1.

(b) For specification tanks other than those pressure tanks referred to in Clause 5.1.1.2 or Clause 6, but including Specification TC 44 tanks
  (i) every design shall be reviewed and approved by a Design Engineer;
  (ii) the review shall verify that the design is in conformity with the specification;
  (iii) the calculations and drawings illustrating the design shall be signed by the Design Engineer to indicate that the design has been reviewed and approved; and
  (iv) one of the following shall apply:
    (1) the calculations and drawings shall also be marked with the printed name of the Design Engineer, his or her registration number, and the MDIN; or
    (2) a record shall be maintained listing all calculations, applicable drawings, and revision numbers used in a design. This record shall include the printed name of the Design Engineer, his or her signature, his or her registration number, and the MDIN.

(c) For all specification tanks, the manufacturer, assembler, or modifier shall retain the calculations and drawings for not less than 20 years after the date of manufacture, assembly, or modification of the last tank of that design.

8.3.2 Manufacturer's Design Identification Number (MDIN)

The MDIN shall be

(a) for the design of a pressure tank referred to in Clause 5.1.1.2 or Clause 6, except Specification TC 44 tanks, the TCRN in accordance with Clause 8.3.3; and

(b) for all other specification tanks, a unique number for the design assigned by the registered facility.

The MDIN shall be clearly shown on the metal identification plate of each completed tank. The MDIN shall remain valid for new construction provided the design is in compliance with the specification and edition of the B620 Standard adopted by reference in the *TDG Regulations*.

8.3.3 Transport Canada Registration Number (TCRN)

8.3.3.1 Application for design review

The applicant shall prepare a complete design for a pressure tank referred to in Clause 5.1.1.2 or Clause 6, except Specification TC 44 tanks, and submit it to a designated agency for review. The submission shall be approved by a professional engineer licensed by the appropriate authorities of his or her residence in Canada or the United States. The submission shall include all drawings, calculations, and accessory specifications for the tank vehicle or portable tank.

The Designated Agency shall issue a written report with respect to compliance with this Standard.

8.3.3.2 Application for a TCRN

8.3.3.2.1
The applicant shall be responsible for applying to the Director for a TCRN. The application shall include
(a) the name, address, and telephone number of the applicant;
(b) a summary description of the design and its intended application; and
(c) the written report from the designated agency referred to in Clause 8.3.3.1.

8.3.3.2.2
The Director shall issue a TCRN if he or she is satisfied that the design conforms to the applicable specification in this Standard. The TCRN will remain valid for new construction until the expiry date shown on the certificate, provided
(a) The facility registration is valid for the applicable specification and registration functions.
(b) The facility registration has not expired or been revoked or replaced by the Director.
(c) The design is in compliance with the specification and edition of the B620 Standard adopted by reference in the *TDG Regulations*.

8.3.3.2.3
On request from the Director, a copy of the approved design review package shall be sent by the Designated Agency to Transport Canada for the purpose of compliance monitoring.

8.3.3.3 Designated Agency for design review

8.3.3.3.1
Application for designation shall be made to the Director and include
(a) the name, address, and telephone number of the applicant;
(b) the tank specifications for which the applicant wishes to perform design reviews; and
(c) the capabilities, qualifications, and experience of the technical staff performing the design reviews.

8.3.3.3.2
The Director shall designate an agency and issue a Certificate of Registration when he or she is satisfied with the agency's capability, competence, and experience in reviewing tank designs for conformity to the ASME *Code* and this Standard. The Certificate of Registration will remain valid until the expiry date shown on the certificate provided the information submitted pursuant to Clause 8.3.3.3.1 has not changed or unless the certificate is revoked or replaced by the Director.

8.3.3.3.3
A Certificate of Registration shall remain valid beyond the expiry date if
(a) An application for renewal of registration is made in accordance with Clause 8.3.3.3.1 by registered mail at least 90 calendar days prior to the expiry date.
(b) A new certificate is not issued.
(c) The application for renewal has not been rejected by the Director.
(d) The certificate due to expire is not revoked by the Director.

8.3.3.3.4
To be designated, an agency shall not be in a conflict of interest because of activities related to
(a) design of means of containment;
(b) manufacture, modification, or assembly of means of containment included in the scope of this Standard; or
(c) any other activity that could represent a conflict of interest.

8.3.3.3.5

The Director may revoke the Certificate of Registration of the Designated Agency if the Director determines that the Designated Agency is not, or is not capable of, complying with the applicable requirements of this Standard.

8.3.4 Changes in design and tank modification

The following requirements shall apply:

(a) For pressure tanks referred to in Clause 5.1.1.2 or Clause 6 except Specification TC 44 tanks
   (i) a change in design shall require further review of the relevant parts of the design in accordance with Clause 8.3.3; and
   (ii) the modification of existing tanks shall be performed in accordance with Clause 7.6 and Parts RC and RD of NBBI ANSI-NB-23.

   Note: *Where changes are already covered by a TCRN, application for a new TCRN is not required.*

(b) For specification tanks other than those pressure tanks referred to in Item (a)
   (i) the design change shall be approved by the Design Engineer; and
   (ii) the modification of existing tanks shall be performed in accordance with Clause 7.6.

8.3.5 Renewal of a TCRN

An application for renewal of a TCRN shall be made in accordance with Clause 8.3.3.

8.4 Marking

8.4.1

During the manufacture, modification, or assembly of a tank, the marking of the metal identification plate(s) required by the specification shall be completed only where

(a) the manufacture, modification, or assembly of the tank has been performed according to the specification by a registered facility; and
(b) the registered facility has certified that the tank meets the specification(s) marked on the plate(s).

8.4.2

A tank shall not be marked in accordance with Clause 7.4 unless

(a) the tank has been inspected or tested by a registered facility; and
(b) the tank test or inspection was successfully performed according to the applicable requirements of Clause 7.

8.4.3

Test and inspection markings shall not be altered, removed, or added to unless the marking is done in accordance with Clause 7.4 by a facility registered for manufacture, assembly, modification, repair, test, or inspection of highway or portable tanks in accordance with this Standard or by an agent designated in writing by the registered facility.

Annex A (normative)
Transition and retrofitting

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

A.1 Scope

This Annex describes the discontinuation of the certification of tanks to the requirements in CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09. In some cases, the specifications in CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09 have been superseded, and in other cases the requirements for certain specifications have been revised. This Annex also covers the transition from the facility registration and the periodic inspection and testing requirements in CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09 to those in CSA B620-14. The requirements for permissive and mandatory retrofitting of specific components on certain existing tanks are also provided.

A.2 Expiry of CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09

No person shall construct or certify a tank according to the requirements of CSA B620-1987 after 15 August 2002.

No person shall construct or certify a tank according to the requirements of CAN/CSA-B620-98 after 21 September 2005.

No person shall construct or certify a tank according to the requirements of CSA B620-03 after the date when CSA B620-09 came into force under the *TDG Regulations*.

No person shall construct or certify a tank according to the requirements of CSA B620-09 after the date when this 2014 edition comes into force under the *TDG Regulations*.

Notes:

(1) *These requirements apply to all tanks, including newly manufactured specification tanks, tanks manufactured prior to 15 August 2002 with specification shortages complying with Clause 5.5 §178.340-10 of CSA B620-1987, tanks with incomplete or partial construction complying with Clause 5.1.7.2 of CAN/CSA-B620-98, tanks with incomplete or partial construction complying with Clause 5.1.7.2 of CSA-B620-03, and non-specification tanks being brought up to specification.*

(2) *Tanks certified to CSA B620-1987 requirements prior to 15 August 2002, to CAN/CSA-B620-98 requirements prior to 21 September 2005, to CSA B620-03 requirements prior to the date when CSA B620-09 came into force under the* TDG Regulations *and to CSA B620-09 requirements prior to the date when the 2014 edition of this Standard comes into force under the* TDG Regulations *may continue in dangerous goods use as specified in CSA B621-14 and CSA B622-14.*

(3) *Missing nameplates may be replaced if documentation can be provided proving that the tank was originally certified to CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, or CSA B620-09 requirements (see Clause 7.7 of this Standard).*

(4) *Where permitted by the* TDG Regulations*, non-specification tanks and tanks with specification shortages may continue in dangerous goods use but may not be brought up to specification and certified to CSA B620-1987 requirements after August 2002; may not be brought up to specification or certified to CAN/CSA-B620-98 requirements after 21 September 2005; may not be brought up to specification or certified to CSA B620-03 requirements after the date when CSA B620-09 came into force under the* TDG Regulations*; and may not be brought up to specification or certified to CSA B620-09 requirements after the date when this Standard comes into force under the* TDG Regulations*.*

A.3 Facility registration — Transition from CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09 to CSA B620-14

The following requirements shall apply to facility registration during the transition from CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09 to CSA B620-14:

(a) Registration of a facility in accordance with CSA B620-1987 or CAN/CSA-B620-98 or CSA B620-03 is no longer valid after the date that this Standard comes into force under the *TDG Regulations*, regardless of the date of expiry on the Certificate of Registration.

(b) Registration of a facility in accordance with CSA B620-09 shall be deemed to be registration in accordance with Clause 8 of this Standard only for those functions and tank specifications designated on the Certificate of Registration of the facility.

(c) Deemed registration under Item (b) shall expire on the date of expiry marked on the Certificate of Registration, unless that certificate is superseded, cancelled, or revoked.

(d) A facility deemed to be registered in accordance with Item (b)
   (i) if authorized to manufacture, modify, or assemble, shall manufacture, modify, or assemble in accordance with the requirements of this Standard;
   (ii) if authorized to repair, shall repair tanks in accordance with the requirements of this Standard; or
   (iii) if authorized to inspect or test, shall perform those inspections or tests specified in Clause 7 of this Standard that are equivalent to those designated on the Certificate of Registration of the facility.

A.4 Periodic inspection and testing requirements — Transition from CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09 to CSA B620-14

The following requirements shall apply to periodic inspection and testing during the transition from CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, and CSA B620-09 to CSA B620-14:

(a) For the purposes of periodic inspection and testing required by Clause 7 of this Standard, a particular test conducted in accordance with CSA B620-1987 before 15 August 2002; CAN/CSA-B620-98 before 21 September 2005; CSA B620-03 before the coming into force of CSA B620-09 under the *TDG Regulations* or CSA B620-09 before the coming into force of this 2014 edition of this Standard under the *TDG Regulations* shall be deemed to be the equivalent test under Clause 7 of this Standard.

(b) Where an inspection or test required by Clause 7 of this Standard was not previously required under CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, or CSA B620-09 that test shall be completed within one year following the coming into force of this Standard under the *TDG Regulations* unless the retest or inspection period specified in Clause 7, when measured from the certification date marked on the tank, has not yet expired. Where the tank has been in dangerous goods service as a non-spec or spec short tank, the retest or inspection period shall be measured from the date of manufacture of the tank.

(c) If the time period in Clause 7 of this Standard for any particular test or inspection is shorter than that required by CSA B620-1987, CAN/CSA-B620-98, CSA B620-03, or CSA B620-09 the time period in Clause 7 of this Standard shall apply.

A.5 Manhole assemblies on TC 306, TC 306 Crude, and low-pressure TC 312 tanks

No later than 15 August 2005, TC 306 tanks, TC 306 Crude tanks, and TC 312 tanks with a test pressure of 241 kPa (35 psi) or less shall be equipped with a manhole assembly that

(a) complies with Clause 5.6.6 of this Standard, Clause 5.6.5 of CAN/CSA-B620-98, §178.345-5 of 49 CFR, or TTMA RP No. 61;

(b) has been certified by the manhole assembly manufacturer in writing as conforming to Clause 5.6.6 of this Standard, Clause 5.6.5 of CAN/CSA-B620-98, §178.345-5 of 49 CFR, or TTMA RP No. 61, except for the hydrostatic testing or marking required by Clause 5.6.6 of this Standard, Clause 5.6.5 of CAN/CSA-B620-98, §178.345-5 of 49 CFR, or TTMA RP No. 61; or
(c) has been individually tested and marked in accordance with TTMA RP No. 61 by a registered test and inspection facility.

A.6 Thermal and remotely activated self-closing stop valves for TC 350 tanks

The following requirements shall apply to thermal and remotely activated self-closing stop valves for TC 350 tanks:

(a) TC 350 tanks shall be equipped with thermal and remotely activated self-closing stop valves that comply with the requirements of Clause 5.6.11 of CAN/CSA-B620-98 or Clause 5.6.12 of CSA B620-03, CSA B620-09, or of this Standard.
(b) The requirements of Item (a) shall not apply to a TC 350 tank if
  (i) it is used exclusively to transport petroleum crude oil, UN1267; and
  (ii) the tank's metal identification plate is marked by a registered manufacturer, assembler, or modifier to show "TC 350 Crude" in place of "TC 350".

A.7 Alternative pressure-relief systems for TC 306, TC 307, TC 312, and TC 350 tanks

A.7.1

As an alternative to the requirements of the original specification, TC 306 tanks shall be equipped with pressure-relief systems that comply with Clauses 5.6.10 and 5.7.4 of CAN/CSA-B620-98, Clauses 5.6.11 and 5.7.4 of CSA B620-03, Clauses 5.6.11 and 5.7.4 of CSA B620-09, or Clauses 5.6.11 and 5.7.4 of this Standard. Venting capacities shall not be less than those required by the original specification, and all venting on the tank or compartment shall comply with the applicable edition of CSA B620.

A.7.2

As an alternative to the requirements of the original specification, TC 307, TC 312, and TC 350 tanks shall be equipped with pressure-relief systems that comply with Clause 5.6.10 of CAN/CSA-B620-98, Clause 5.6.11 of CSA B620-03, Clause 5.6.11 of CSA B620-09, or Clause 5.6.11 of this Standard. Venting capacities shall not be less than those required by the original specification, and all venting on the tank or compartment shall comply with the applicable edition of CSA B620.

A.7.3

Any pressure-relief device that is replaced shall comply with Clause 5.6.11.3 of this Standard or with §178.345-10(b)(3) of CFR 49

A.8 TCRNs and MDINs — Transition from CSA B620-03 and CSA B620-09 to CSA B620-14

The following requirements shall apply:

(a) An existing TCRN issued in accordance with CSA B620-98, CSA B620-03, or CSA B620-09 shall be reviewed by an engineer in accordance with Clause 8.3.1 for changes in design that may be required as a result of revisions to the requirements in this Standard. The following shall apply:
   (i) If changes to the design are required, the applicant shall submit a design package including a list of items verified and the changed design information to a Designated Agency for verification of compliance with this Standard in accordance with Clauses 8.3.3 and 8.3.4. The Designated Agency shall review the submission for compliance and then issue a report to Transport Canada as to the compliance of the submission. Transport Canada will issue a new TCRN upon receipt of a positive report.
   (ii) If no changes to the design are required, the applicant shall submit a list of items verified to a Designated Agency for verification of compliance with this Standard in accordance with Clause 8.3.3. The Designated Agency shall review the submission for compliance and then issue a report to Transport Canada as to the compliance of the submission. Transport Canada will renew the TCRN upon receipt of a positive report.

(b) An existing MDIN issued in accordance with CAN/CSA-B620-98, CSA B620-03, or CSA B620-09 shall be reviewed by a Design Engineer for compliance with this Standard in accordance with Clause 8.3.1 prior to construction of a tank other than a pressure tank identified in Clause 5.1.1.2 or Clause 6 and including Specification TC 44 tanks. The following shall apply:
   (i) If changes to the design are required, the changes shall be reviewed and approved in accordance with Clauses 8.3.1 and 8.3.4.
   (ii) If no changes to the design are required, the Design Engineer shall document the items verified for compliance with this Standard.

A.9 TC 306 Crude tanks

A tank of specification TC 306 or MC 306 may be marked "TC 306 Crude" on the nameplate if

(a) it was constructed before 15 August 2002 in compliance with the TC 306 or MC 306 specification except as follows:
   (i) the tank's MAWP may be between
      (1) 18 kPa (2.65 psi) and 34.5 kPa (5 psi); or
      (2) 69 kPa (10 psi) and 101 kPa (14.7 psi), provided that the vents comply with Clause 5.7 §178.342-4 of CSA B620-1987;
   (ii) thermal and remote actuation of closures in accordance with Clause 5.6 §178.341-5 of CSA B620-1987 is not required; and
   (iii) product discharge openings may be equipped with external shut-off valves if they are designed, installed, and protected in accordance with Clause 5.5 §178.340-8(d) of CSA B620-1987; and

(b) the Certificate of Compliance and nameplate are amended by a registered manufacturer, assembler, or modifier to show "TC 306 Crude" in place of "TC 306" or "MC 306".

Annex B (informative)
Sample registration documents

Note: *This Annex is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.*

B.1 Application for facility registration

Application for Registration as a Facility for the Manufacture, Modification, Assembly, Repair, Testing, or Inspection of Tanks Built in Accordance with the Specifications Included in CSA B620

Section A: *Application information* (Please indicate whether this is a new or renewal application or a change of scope. For a renewal application or a change of scope, please indicate your facility registration number with Transport Canada.)

☐ New ☐ Renewal ☐ Scope Change Facility Registration Number: 25- _____

Section B: *Contact and Facility Information*

1) Facility Information

Company Name	Company Telephone	Company Fax
Company Street Address	Company Mailing Address	

2) Local Contact

Local Contact	Title
Business Mailing Address	Telephone
	Fax

3) Corporate Contact

Corporate Officer	Title
Business Mailing Address	Telephone
	Fax

(Continued)

Figure B.1
Sample application for facility registration
(See Clause 8.1.4.1.)

Section B: *Contact and Facility Information (continued)*

4) Tank Specifications (Please check those functions for which you are applying, indicating with an "M" those functions that are mobile.)

		Inspection				Test/retest								
		External	Internal	Lining	Upper coupler	Hydrostatic	Pneumatic	Leak test	Fluorescent test	Thickness test	Repair	Manufacture	Assembly	Modification
Highway tanks	TC 406													
	TC 406 Crude													
	TC 406 FRP													
	TC 407													
	TC 407 FRP													
	TC 412													
	TC 412 FRP													
	TC 423													
	TC 306													
	TC 306 Crude													
	TC 307													
	TC 312													
	TC 350													
	TC 350 Crude													
	TC 331													
	TC 338													
	TC 341													
	Other (specify)													
Portable tanks	TC 11													
	TC 44													
	TC 51													
	TC 60													
	Other (specify)													

(Continued)

Figure B.1 (Continued)

Indicate the material submitted with this application by checking "Yes" or "N/A" (Not Applicable):

Section C: *Required Certificates/Legal Information*

Yes	N/A	
☐	☐	**1)** Letter of Incorporation, Letters Patent, evidence of registration as a company
☐	☐	**2)** Certificate of Authorization for the ASME "U" stamp
☐	☐	**3)** Certificate of Authorization from a provincial pressure vessel jurisdiction for manufacture or repair
☐	☐	**4)** National Board of Boiler and Pressure Vessel Inspectors Certificate of Authorization for the "R" stamp
☐	☐	**5)** Certificate of Authorization from a provincial pressure vessel jurisdiction for the manufacture, modification, or repair of piping in accordance with CSA B51 or ASME B31.3

Section D: *Facility Details*

Yes	N/A	
☐	☐	**1)** Workshop area description: approximate area (square metres/feet), number of bays, maximum tank size accommodation, address if different from company address
☐	☐	**2)** Mobile unit information: a) address of control location, location of documentation, and number of units; b) complete description of units; c) description of equipment carried in each unit; and d) description of customer equipment and services in the field necessary for the mobile unit to function.

Section E: *Statements*

a) The quality control manual required by Clause 8.1.1(d) of CSA B620, including the inspection and testing procedures, reports, and certificates of compliance, is in compliance with the version of CSA B620 and its revisions that are in force under the TDG Regulations.

b) All design engineers, tank inspectors, testers, and welders are qualified and experienced in accordance with Clauses 8.1.5.1, 8.1.6, 8.1.7, and 4.4, respectively, of CSA B620. Evidence of this qualification is on file as described in the quality control manual.

c) The quality control program described in the quality control manual is in place and operating as required by CSA B620.

Signed: _____ (Corporate Officer named in Part 3 of Section A)

Date: _____

Figure B.1 (Concluded)

B.2 Sample quality control manual

B.2.1 Cover page for quality control manual

Quality Control Manual

for

☐ Manufacture [M]
☐ Modification [Mod]
☐ Repair [R]
☐ Assembly [A]
☐ Inspection, Test, and Reset [IT]

of

Highway Tanks and Portable Tanks

for the

Transportation of Dangerous Goods by Road

in accordance with CSA B620

Control Number _____

Revision Number _____

Approved by _____

Date _____

Figure B.2
Sample cover page for quality control manual
(See Clause 8.1.1.)

B.2.2 Sections to be included in the quality control manual

B.2.2.1
Each page in the manual shall show a revision number and the date of issue.

B.2.2.2
The original quality control manual shall be signed by the person responsible for the issue and maintenance of the manual.

B.2.2.3
A table of contents or index page shall be provided showing each of the sections identified below. Where the section heading addresses an operation not included in the registered activities of the facility, e.g., material control in the case of retest or inspection, the words "Not Applicable" or "N/A" should be entered instead of a page number.

Section	Heading	Required for				
1	**Scope**	**M**	**MOD**	**R**	**A**	**IT**
	Describe the range of activities covered by CSA B620 that will be performed at the facility, the specifications on which each of these activities will be performed, and where these activities will be performed (e.g., manufacture and repair of TC 406, inspection and retest of TC 406, 407, 412, and 331, and mobile inspection and retesting of TC 406 tanks).					
2	**Glossary of abbreviations**	**M**	**MOD**	**R**	**A**	**IT**
	List any abbreviations to be used in the document and provide the full term (e.g., TC refers to Transport Canada and SRV refers to safety relief valve).					
3	**Statement of authority**	**M**	**MOD**	**R**	**A**	**IT**
	Include the title and quality control duties of the person(s) responsible for administering the quality control program and the various standards to be used for the activities. There shall be a statement that this person has the responsibility and authority to control production.					
4	**Organization chart**	**M**	**MOD**	**R**	**A**	**IT**
	Provide an organization chart showing flow of responsibility for quality control from the most senior manager to those involved directly in the operations.					
5	**Manual control**	**M**	**MOD**	**R**	**A**	**IT**
	Identify the person responsible for the issue and maintenance of the manual, including its periodic update and revision, its distribution, and the removal of superseded versions from circulation.					
6	**Drawing and design control**	**M**	**MOD**	**R**	**A**	
	Describe the system for control of drawings and designs to ensure that they are performed by the appropriate personnel and are in line with the requirements of CSA B620. *This section shall identify* – *the person(s) responsible for the approval of designs and design changes;* – *the process that is used to ensure that all designs, changes, and revisions are authorized and that only the currently authorized drawings or designs are used; and* – *the design review and approval process that describes who is responsible for reviewing the design of a new tank or a modification to a tank, the issuance of an MDIN and/or TCRN, and the application process for a TCRN, if applicable.*					

Section	Heading	Required for
7	**Manufacture**	**M**

This section shall describe the requirements and processes for manufacture of tanks, including scope of work, authorizations, design reviews, inspection and testing requirements, marking, and certification.

7.1 *Scope of work and authorizations:*
Describe the scope of manufacture and indicate that the manufacture of tanks is done in accordance with the version of CSA B620 that is in force under the TDG Regulations *and with the version of the ASME* Code *that is referenced in CSA B620. Where applicable, this section shall also indicate which Certificates of Authorization are held by the facility (ASME, provincial pressure vessel jurisdiction, National Board of Boiler and Pressure Vessel Inspectors).*

7.2 *Design review:*
Refer to Section 6.

7.3 *Inspection and testing:*
This section shall specify
- *who is responsible for the inspection and testing required on completion;*
- *what type of inspections and tests shall be performed prior to certification and delivery of a highway or portable tank; and*
- *where the inspection and testing will be carried out.*

7.4 *ID plate and other required markings:*
This section shall specify
- *who applies the ID plate and how it is affixed to the tank;*
- *that the final assembler shall mark the TC specification and completion and certification date on the plate;*
- *the information to be indicated on the ID plate (provide a sample).*
- *other tank markings and decals, if required in CSA B620; and*
- *who ensures that marking has been done in accordance with CSA B620.*

7.5 *Tank certification:*
This section shall specify
- *the items that shall be listed on the Certificate of Compliance (provide a sample); and*
- *that the final assembler is responsible for ensuring that all certification is completed in accordance with CSA B620.*

8	**Assembly**	**A**

This section shall describe the requirements and processes for assembly of tanks, including scope of work, authorizations, design reviews, inspection and testing requirements, marking, and certification.

8.1 *Scope of work:*
Of the following functions, specify those that are performed:
- *assembly of tanks in accordance with an approved design provided by a TC registered manufacturer; and*
- *the design of a portion of the assembly of a highway or portable tank.*

In addition, describe the scope of assembly (mounting tanks, installing fittings, etc.) and indicate that the assembly is done in accordance with the version of CSA B620 that is in force under the TDG Regulations *and with the version of the ASME* Code *that is referenced in CSA B620.*

8.2 *Design review*
Refer to Section 6.

Section	Heading	Required for
8.3	*Inspection and testing:* *This section shall specify* *– who is responsible for the inspection and testing required on completion;* *– what type of inspections and tests shall be performed prior to certification and delivery of a highway or portable tank; and* *– where the inspection and testing will be carried out.*	
8.4	*ID plate and other required markings:* *This section shall specify* *– who applies the ID plate and how it is affixed to the tank;* *– that the final assembler shall mark the TC specification and completion and certification date on the plate;* *– the information to be indicated on the ID plate (provide a sample);* *– other tank markings and decals, if required in CSA B620; and* *– who ensures that marking has been done in accordance with CSA B620.*	
8.5	*Tank certification:* *This section shall specify* *– the items that shall be listed on the Certificate of Compliance (provide a sample);and* *– that the final assembler is responsible for ensuring that all certification is completed in accordance with CSA B620.*	
9	**Modification**	**MOD**
	This section shall describe the requirements and processes for modification of tanks, including scope of work, authorizations, design reviews, inspection and testing requirements, marking, and certification.	
9.1	*Scope of work and authorizations:* *Describe the scope of work (specify the types of modifications performed) and indicate that modifications must be performed in accordance with the version of CSA B620 that is in force under the* TDG Regulations *and with the version of the ASME* Code *that is referenced in CSA B620. Where applicable, this section shall also indicate which Certificates of Authorization are held by the facility (ASME, provincial pressure vessel jurisdiction, National Board of Boiler and Pressure Vessel Inspectors).*	
9.2	*Design review:* *Refer to Section 6.*	
9.3	*Inspection and testing:* *This section shall specify* *– who is responsible for the inspection and testing required on completion;* *– what type of inspections and tests shall be performed prior to certification and delivery of a highway or portable tank; and* *– where the inspection and testing will be carried out.*	
9.4	*Plate markings:* *Describe the marking requirements for a modification plate (provide a sample).*	
9.5	*Tank certification:* *This section shall specify* *– the items that shall be listed on the Modification Certificate of Compliance (provide a sample); and* *– who is responsible for ensuring that all certification is done in accordance with CSA B620.*	

Section	Heading	Required for				
10	**Repairs**			**R**		
10.1	*Scope of work and authorizations:* *Describe the scope of work related to repairs, indicate that repairs must be performed in accordance with the version of CSA B620 that is in force under the TDG Regulations, and that any repairs shall be made in compliance with the original design. Where applicable, this section shall also indicate which Certificates of Authorization are held by the facility (provincial pressure vessel jurisdiction, National Board of Boiler and Pressure Vessel Inspectors).*					
10.2	*Inspection and testing:* *This section shall specify* *– what type of inspection/test is required after repairs; and* *– where the inspection and testing will be conducted.*					
11	**Material control**	**M**	**MOD**	**R**	**A**	
	Where the activities involve provision of materials to be used in manufacture, modification, or repair, describe the processes undertaken for the purchase, receipt, identification, storage, and use of appropriate materials for any design. These processes should ensure, for example, that only the materials specified in the design are used and that any changes or substitutions are approved by the design engineer.					
12	**Inspection and testing — Examination**	**M**	**MOD**	**R**	**A**	**IT**
	Step-by-step written procedures, reports, and criteria to be used when inspecting, testing, and retesting new or in-service tanks shall be described. These procedures and reporting requirements shall be applicable to all activities and tank types identified in the scope and shall be included in the manual or in separate identifiable documents referenced in the manual.					
13	**Test and inspection marking**	**M**	**MOD**	**R**	**A**	**IT**
	Describe the markings to be used by the facility when it is satisfied that the registered activities have been completed in compliance with CSA B620. List the test and inspection markings and indicate who applies them, and how and when they are applied.					
14	**Nonconformities — Corrective action**	**M**	**MOD**	**R**	**A**	**IT**
	Describe the action to be taken in the event that a quality control problem is discovered during production or during an audit. This description should include an account of the process used to determine the appropriate course of action for the current problem (e.g., scrap or rework parts, change the design) and the changes that will be made to prevent recurrences of the problem (e.g., changes to quality control procedures).					
15	**Welding control**	**M**	**MOD**	**R**		
	Describe the control procedures in place to ensure that all welding procedures and personnel meet the requirements of the standards and codes for the work performed. These procedures shall ensure that all weld procedures are qualified, all welders are qualified to the appropriate weld procedures, the weld procedures are specified on the drawings, repair procedure, or job sheet, and the welders have access to the correct procedure.					
16	**Calibration**	**M**	**MOD**	**R**	**A**	**IT**
	Describe the quality control procedures for ensuring that instruments used to check the requirements of CSA B620 are maintained and calibrated, and that they operate within suitable parameters. For each instrument, a record shall be kept, identifying each instrument, the method of calibration, its calibration frequency, and the date of its last calibration. The action to be taken if an instrument is found to be out of calibration during use shall be described.					

Section	Heading	Required for				
17	**Quality audits**	**M**	**MOD**	**R**	**A**	**IT**

Describe the internal procedures in place to check that the quality control program is performing as intended. These can include internal audits and periodic reviews of the manual to ensure that it is consistent with procedures followed.

18	**Registration — Facilities and personnel**	**M**	**MOD**	**R**	**A**	**IT**

Provide details of the registered facility and the qualifications and experience of authorized personnel (e.g., design engineers, tank inspectors, testers, and welders), as required in CSA B620, and describe the policy for keeping these records up to date.
Records providing evidence of the qualifications of all design engineers, tank inspectors, testers, and welders working to any of the requirements of CSA B620 shall be kept on file while the workers are so employed, and for at least five years after the end of employment. That date shall be clearly indicated in the file.

19	**Mobile units**					**IT**

Provide a description of the mobile units, including the number of units and list of equipment carried, the address from which the mobile units are controlled, where all documentation and reports are stored and retained, and a description of customer equipment and services in the field necessary for the mobile unit to function.

20	**Records retention**	**M**	**MOD**	**R**	**A**	**IT**

Describe the procedures in place and the person(s) responsible for ensuring that documents required by CSA B620 and applicable codes, and those used to assure quality control, are properly circulated and retained for the required periods. These documents should be listed, their flow described, and storage locations indicated.

21	**Exhibits**	**M**	**MOD**	**R**	**A**	**IT**

Attach samples of actual completed documents used for quality control. Include samples of inspection and test reports and decals, nameplates, Certificates of Compliance, material data reports, etc.

22	**Revision control sheet**	**M**	**MOD**	**R**	**A**	**IT**

Provide a list showing the latest issue date and number for each page in the manual (page revision numbers for the original document should consist of the page in question and a revision number starting with 0 (e.g., page 2, revision 0). The original of this list shall be signed by the person responsible for the manual.

B.3 Certificate of registration

Certificate of Registration as a Facility for the Manufacture, Modification, Assembly, Repair, Test, Retest, or Inspection of Highway Tanks and Portable Tanks in Accordance with CSA B620

Facility Name: _____ Registration Number: _____

Head Office Address: _____

Corporate officer or other person responsible for compliance:

Name: _____ Title: _____

The facility located at

_____

_____

is hereby registered for the functions indicated below:

Specification tanks	Leak test	Thickness test	Fluorescent test	Lining inspection	Visual inspection		Retest		Repair	Assembly	Modification	Manufacturer
					External	Internal	Hydrostatic	Pneumatic				
TC 406												
TC 406 FRP												
TC 407												
TC 407 FRP												
TC 412												
TC 412 FRP												
TC 423												
TC 331												
TC 338												
TC 341												
TC 11												
TC 51												
TC 60												
Other (specify)												

For periodic inspection and tests, this registration is applicable only to the above facility and for the functions indicated above when they are carried out on the indicated specification tanks and their Canadian and US specification equivalents according to CSA B621 and B622.

Expiry Date of Registration
This certificate is valid until the expiry date indicated below. A new application shall be submitted where there is any substantial change in the information given on the application form filed with Transport Canada. Application for renewal of this certificate shall be made at least three months before expiry.

Date of Issue: _____

Date of Expiry: _____ _____
For Director, Regulatory Requirements, Transport Dangerous Goods Directorate

Figure B.3
Sample Certificate of Registration
(See Clause 8.1.1.)

Annex C (informative)
Alternatives to internal inspection of vacuum-insulated TC 341 highway tanks

Note: *This Annex is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.*

C.1 General

The following regime may be used as an alternative to the 10-year internal inspection and retest requirements specified in Table 7.1 for a vacuum-insulated TC 341 tank. This alternative regime shall begin with the successful completion of the cold vacuum retention test (CVRT) or the helium detection test (HDT) within five years of the last internal inspection or date of manufacture. An owner may revert to the required internal inspection test regime by completing the requirements of Table 7.1 not more than five years after the completion of the last alternative inspection and test.

C.2 Quarterly vacuum reporting

Quarterly vacuum reporting shall be performed as follows:

(a) A reading of the vacuum level in the annular space between the inner and outer vessels shall be taken at three-month intervals.

(b) The vacuum readings shall be taken with an instrument
   (i) where the reading is within the linear range;
   (ii) that when in the 0 to 50 µm Hg range, the accuracy is warranted by the manufacturer to be within 3% of that range;
   (iii) that when in the 51 µm Hg and higher range, the accuracy is warranted by the manufacturer to be within 10% of that range; and
   (iv) with which the repeatability is within 2%.

   Dial markings or readouts at the required readings shall be in units equivalent to 20 µm Hg or less at the level of the reading.

(c) In the event that a 500 µm Hg increase in the annular space vacuum is recorded in a quarterly period, appropriate investigation and remediation shall be carried out to ensure the integrity of the inner vessel and safe operation in transportation before the highway tank is returned to service.

(d) Where the quarterly vacuum reading exceeds 1000 µm Hg (cold), appropriate investigation and repair shall be carried out to ensure the integrity of the inner vessel and safe operation in transportation before the highway tank is returned to service.

(e) Subsequent to any minor repairs (defined as replacement of the vacuum gauge, repair or replacement of the vacuum valve, or repair of the vacuum space relief device), the vacuum shall be restored and a settled cold vacuum reading taken within 48 h of the first fill. Confirmation of the integrity of the vacuum and the vessel shall be provided by a subsequent reading to be taken between 24 and 72 h later; this reading shall not register a change of more than 20 µm Hg.

(f) The facility taking these readings and completing the report is not required to be registered with Transport Canada. When the annual external inspection required by Table 7.1 is performed, the report for the prior three quarters shall be sent to the registered facility performing the inspection, for verification and for inclusion as part of the report on the annual inspection. The registered facility shall take and report the fourth quarterly reading.

(g) Where a unit has been taken out of service for more than a year and quarterly vacuum readings have not been taken, a CVRT shall be performed before the unit is returned to service.

(h) A quarterly report shall be recorded on the form provided in Figure C.2 and retained in accordance with Clause 7.3. Required repairs shall be traceable to the report.

C.3 Cold vacuum retention test (CVRT)

A CVRT shall be performed at 5-year intervals. The owner may elect to go directly to an HDT. The CVRT is used to determine whether or not there is a loss of vacuum from the annular space of a vacuum-insulated highway tank. Should a loss of vacuum be identified, other tests shall be required to verify the integrity of the tank. The CVRT shall be performed as follows:

(a) The vacuum readings shall be taken with an instrument
   (i) where the reading is within the linear range;
   (ii) that when in the 0 to 50 µm Hg range, the accuracy is warranted by the manufacturer to be within 3% of that range;
   (iii) that when in the 51 µm Hg and higher range, the accuracy is warranted by the manufacturer to be within 10% of that range; and
   (iv) with which the repeatability is within 2%.

   Dial markings or readouts at the required readings shall be in units equivalent to 20 µm Hg or less at the level of the reading.
(b) The tank should be parked in a shaded area, out of the sun (preferably in a location where the ambient temperature will remain relatively constant).
(c) The tank shall be filled to at least 70% volumetric capacity with a normal lading to ensure that the annular space is thoroughly cold and any trace moisture content is frozen out.
(d) The unit shall be allowed to cool thoroughly until the vacuum gauge reading in the annular space remains constant for a period of 4 h.
(e) If this reading is at 1000 µm Hg or lower, the test may proceed. If the settled vacuum gauge reading is higher than 1000 µm Hg, the vacuum shall be evacuated and allowed 4 h to stabilize to less than 900 µm Hg. After that time, the test may proceed.
(f) If the vacuum does not stabilize, the tank shall have failed the CVRT, and an HDT shall be required.
(g) The start time of the test and the vacuum gauge reading at that time shall be recorded.
(h) The vessel shall be left for a period of 72 h, during which time further vacuum gauge readings shall be taken and recorded at least every 24 h. If the reading at the end of the test has not risen more than 20 µm Hg during that period, the tank shall have passed the test.
(i) If the reading has increased more than 20 µm Hg, the tank shall be subjected to an HDT.
(j) The report for this test shall be recorded on the form provided in Figure and retained in accordance with Clause 7.3.

C.4 Helium detection test (HDT)

This test may be used to determine whether or not there is a loss of vacuum due to migration of product into the annular space. It provides a basis on which a determination can be made of the integrity of the tank. The HDT shall be performed as follows:

(a) The vacuum readings shall be taken with an instrument
   (i) where the reading is within the linear range;
   (ii) that when in the 0 to 50 µm Hg range, the accuracy is warranted by the manufacturer to be within 3% of that range;
   (iii) that when in the 51 µm Hg and higher range, the accuracy is warranted by the manufacturer to be within 10% of that range; and
   (iv) with which the repeatability is within 2%.

   Dial markings or readouts at the required readings shall be in units equivalent to 20 µm Hg or less at the level of the reading.
(b) All liquid product shall be removed from the tank and the internal pressure reduced to atmosphere.
(c) The tank shall be warmed by allowing it to stand or by purging it with a clean, dry, inert gas.
(d) When all liquid has been evaporated, a vacuum pump shall be connected to the appropriate connection on the jacket and a vacuum shall be established in the annular space at approximately 100 µm Hg. A helium mass spectrometer (analyzer) shall be connected to the suction side of the vacuum pump before connection to the annular space.

(e) The tank shall be pressurized to 150 kPa (22 psi), using a clean, dry, inert gas and sufficient helium (between 2 and 5%) to detect a leak, while the annular space continues to be evacuated.
(f) The valve shall be slowly opened to the helium analyzer.
(g) The readings on the helium analyzer shall be observed to determine if there is any helium leaking through the shell, head, or internal piping of the tank.
(h) A minimum of 1 h shall be allowed for any trace helium to migrate from a leak at a distance from the vacuum pump suction to the point of pickup. Pumping shall be continued until the instrument reading reaches equilibrium. This reading shall be recorded.
(i) If the leak rate exceeds 2.5×10^{-6} mL/s (1.5256×10^{-5} in^3/s) with no less than 5% helium in the mixture, the highway tank shall be removed from service until the source of the leak has been identified and repaired.

A written report shall be completed in accordance with Clause 7.3. This report shall be recorded on the form provided in Figure C.3.

C.5 Pressure test

Tests shall be performed at five-year intervals in accordance with the applicable requirements in Clause 7.2.7.

C.6 External visual and upper coupler area inspections

Annual external visual inspections and five-year upper coupler area inspections shall also be required in accordance with Tables 7.1 and 7.2.

C.7 Instrumentation calibration

All vacuum gauges and mass spectrometers shall be calibrated at least annually and in accordance with the manufacturer's instructions.

C.8 Marking

On satisfactory completion of the required CVRT specified in this Annex, a TC 341 highway tank shall be marked with the letter "C", instead of the letter "I", in accordance with Clauses 7.4.1 and 7.4.2. The letter "I" shall not be used. TC 341 highway tanks tested and marked in accordance with this Annex shall be retested in accordance with this Standard after five years. Marking for the pneumatic test and external visual inspection shall be in accordance with Clause 7.4.

Cold Vacuum Report Log

Company: _____ Unit Number: _____ Specification: _____

Address: _____ Vehicle Manufacturer: _____

_____ Serial Number: _____

_____ Capacity: _____

_____ Insulation: _____

Telephone: _____ Wrapped* ☐ Powder† ☐

Date	Vacuum reading, µm Hg‡	Liquid level	Reporter's signature	Reporter's name (print)	Comment/action§

**Verified by Registered Facility Performing Annual External Inspection*

Name: _____ Inspector's Name (print): _____

Address: _____ Signature: _____

Facility Registration Number: _____ Date: _____

*"Wrapped" includes fibreglass and laminated.
†"Powder" includes perlite.
‡Readings shall be taken at least once every three months.
§Comment/action section shall list all actions preserving vacuum system integrity (i.e., vacuum pump down, thermocouple replacement, CVRT testing, etc.).

Figure C.1
Cold vacuum report log
(See Clause C.2.)

Cold Vacuum Retention Test Report

Test Facility Reg. # _____

Company: _____

Address: _____

_____

Insulation: _____

Vacuum reading on receipt: _____ µm Hg

Pumped down: Yes ☐ No ☐

Vehicle Manufacturer: _____

Serial Number: _____

Specification: _____ Capacity: _____

Wrapped* ☐ Powder† ☐

*"*Wrapped*" includes fibreglass and laminated.*
†"*Powder*" includes perlite.

Date	Time	Vacuum reading, µm Hg‡

Start test:

Liquid content level _____ cm/in

Tank pressure _____ kPa/psig

Finish test:

Liquid content level _____ cm/in

Tank pressure _____ kPa/psig

‡*Readings shall be taken at least once every* 24 h.

Change of vacuum over 72 h: Reading increase ☐ Reading decrease ☐

To pass test, vacuum shall not increase more than 20 µm Hg.

Pass ☐ **Fail** ☐

Tester's name: _____ (print)

Tester's signature: _____

Date: _____

Figure C.2
Cold vacuum retention test report
(See Clause C.3.)

Helium Detection Test Report

Date of Test: _____ Vehicle Manufacturer: _____

Test Facility Reg. # _____ Serial Number: _____

Company: _____ Specification: _____

Address: _____

_____

Capacity: _____

Insulation: Wrapped* ☐ Powder† ☐

**"Wrapped" includes fibreglass and laminated.*
†"Powder" includes perlite.

The above highway tank was subjected to a helium detection test in accordance with the procedure specified in CSA B620, Appendix C.

The unit met the criteria described in that test: Yes ☐ No ☐

Tester's name: _____ Tester's signature: _____
(print)

Date: _____

Figure C.3
Helium detection test report
(See Clause C.4.)

Annex D (informative)
Tests for off-truck emergency shutdown systems

Note: *This Annex is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.*

D.1 Meter-equipped tanks

An operator of a highway or portable tank equipped with a calibrated meter may check the internal self-closing (ISC) valve for leakage through the valve seat using the meter as a flow measurement indicator. Each emergency discharge control actuator (on-truck and off-truck) shall be operated and the meter monitored for meter creep.

The test shall be performed as follows:

(a) Lading shall be delivered from the tank or returned to the tank through the delivery system.
Note: *This may be performed while the truck engine is at idle.*

(b) After the flow through the meter is established, the operator shall close the ISC valve and monitor the indication of the meter.

(c) The flow through the meter shall stop within 30 s, and the meter creep shall cease within 5 s after the flow through the meter stops.

D.2 Non-meter-equipped tanks

For highway or portable tanks that are not equipped with a meter, the following is one acceptable method that may be used to check the ISC valve for closure:

(a) All ISC valves shall be opened.

(b) Each emergency discharge control remote actuator (on-truck and off-truck) shall be operated to ensure that each ISC valve indicator has moved to the closed position.

(c) The ISC valves shall be in the closed position.

(d) All of the material in the downstream piping shall be evacuated, and the piping shall be returned to atmospheric temperature and pressure.

(e) The outlet shall be monitored for 30 s for detectable leakage.

(f) There shall be no detectable leakage.

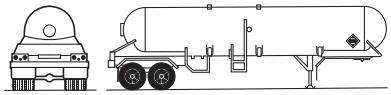
Annex E (informative)
Highway and portable tank specifications

Note: *This Annex is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.*

E.1
This Annex describes some general features for each tank specification and the products for which they are commonly used. See Clause E.2 for highway tank specifications and Clause E.2 for portable tank specifications. For complete design and use details, refer to this Standard, CSA B621, and CSA B622.

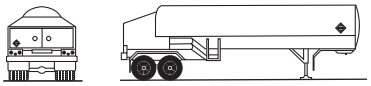
E.2 Highway tank specifications

TC 331



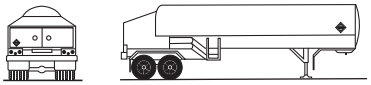
- Highway tank for liquefied compressed gases (e.g., LPG, NH3)
- Seamless or welded, or a combination of the two
- Steel or aluminum
- Design pressure shall be at least 690 kPa (100 psi) and not more than 3450 kPa (500 psi)

TC 338



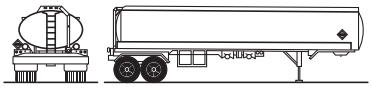
- Insulated highway tank for refrigerated liquefied gases
- Supported welded inner vessel enclosed within a jacket
- Insulation between the inner vessel and jacket
- Insulation may be by vacuum
- Design pressure shall be at least 180 kPa (26 psi) and not more than 3450 kPa (500 psi)

TC 341



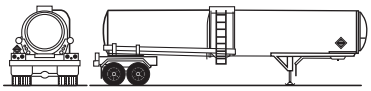
- Insulated highway tank for nonflammable refrigerated liquefied gases
- Pressure control valve set at or below 174.4 kPa (25.3 psi)
- Supported inner vessel enclosed within a jacket
- Insulation between the inner vessel and jacket
- Insulation may be by vacuum
- MAWP shall be at least 174.4 kPa (25.3 psi) and no more than 1034.2 kPa (150 psi)

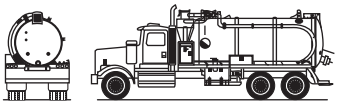
TC 406



- Highway tank for flammable liquids and low hazard chemicals (e.g., gasoline, diesel)
- Steel or aluminum shell or fibre-reinforced plastic (FRP)
- MAWP between 18 and 28 kPa (2.65 and 4 psi)
- If transporting crude, MAWP between 18 and 100 kPa (2.65 and 14.7 psi)

TC 407

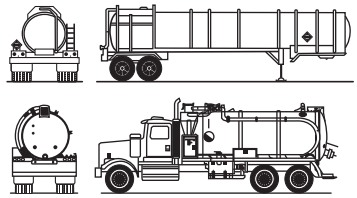




- Highway tank for toxic, corrosive, and flammable liquids
- Circular cross-section
- MAWP of at least 172 kPa (25 psi)
- Over 235 kPa (35 psi or vacuum loaded), shall be ASME-certified
- May be vacuum loaded if external design pressure is at least 103 kPa (15 psi) and internal design pressure is at least 173 kPa (25 psi)
- Steel, aluminum, or fibre-reinforced plastic (FRP)

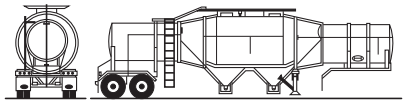
(Continued)

TC 412



- Highway tank for corrosive and some flammable liquids
- MAWP of at least 35 kPa (5 psi)
- MAWP greater than 104 kPa (15 psi) shall be circular cross-section and ASME certified
- Steel, aluminum, or fibre-reinforced plastic (FRP)
- May be vacuum loaded if external design pressure is at least 103 kPa (15 psi) and internal design pressure is at least 173 kPa (25 psi)

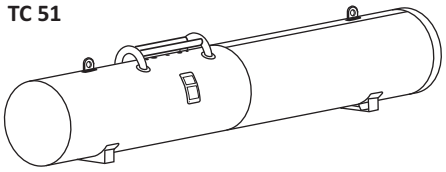
TC 423



- Highway tank for emulsion and water-gel explosives
- MAWP of at least 35 kPa (5 psi) but not more than 103 kPa (15 psi)
- Steel or aluminum
- Hopper style configuration accommodated
- Insulated

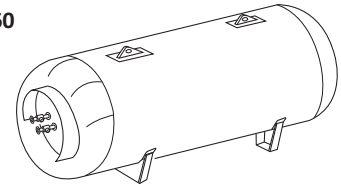
E.3 Portable tank specifications

TC 51



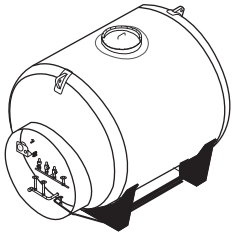
- Portable tank for liquefied compressed gases (e.g., LPG, NH3)
- Steel
- Seamless or welded, or a combination of the two
- Water capacity greater than or equal to 450 L (119 US gal)
- Design pressure of at least 690 kPa (100 psi) and no more than 3450 kPa (500 psi)

TC 60



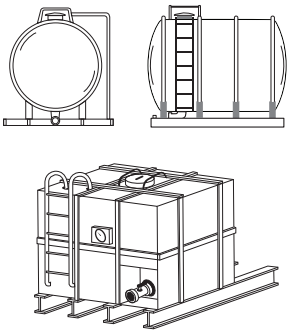
- Portable tank for corrosive and some other liquids
- Fusion welded
- Cylindrical shape
- MAWP not less than 276 kPa (40 psi)

TC 11



- Portable tank for nonflammable refrigerated liquefied gases
- Design pressure of 174.3 kPa (25.3 psi) or greater
- Minimum water capacity of 450 L (119 US gal)
- Inner vessel shall be seamless or welded
- Circular cross-section
- Insulated (often by vacuum)

TC 44



- Portable tank for diesel fuel only
- Steel or aluminum
- Slab-sided or other configurations accommodated
- MAWP between 18 and 28 kPa (2.65 and 4 psig)
- Minimum water capacity 3000 L (660 Imp gal)

Figure E.1
Portable tank specifications

CSA Group prints its publications on Rolland Enviro100, which contains 100% recycled post-consumer fibre, is EcoLogo and Processed Chlorine Free certified, and was manufactured using biogas energy.

ISBN 978-1-77139-339-3