



CAN/ULC-S601-14 (Including Erratum 1)

STANDARD FOR SHOP FABRICATED STEEL ABOVEGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS



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STANDARD FOR SHOP FABRICATED STEEL ABOVEGROUND TANKS
FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

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ERRATUM NOTICE

ULC STANDARDS

STANDARD FOR SHOP FABRICATED STEEL ABOVEGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS	CAN/ULC-S601-14
ERRATUM 1	DECEMBER 2017

The following amendments are being incorporated into CAN/ULC-S601-14:

1. Revised item E in Clause 11.2.1.

NOTICE

PLEASE NOTE THAT THIS STANDARD INCLUDES ERRATUM(S). THE CURRENT EDITION OF THIS STANDARD IS NOT VALID UNLESS USED TOGETHER WITH THE ERRATUM(S).

IT IS POSSIBLE, HOWEVER, THAT CERTAIN CODES WILL REFER TO THE SUPERSEDED EDITION OF THIS STANDARD, WITHOUT THE ERRATUM(S). IN THOSE INSTANCES, THE COMPILATION OF THIS DOCUMENT ALLOWS FOR REFERENCE TO BE MADE TO THE STANDARD PRIOR TO THE INCLUSION OF THE ERRATUM(S).

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11.2.1 In addition to the markings required by Section 11.1, Marking – All Tanks, each rectangular tank shall be clearly marked with materials that are resistant to the environment to which the tank is intended to be exposed, with the following information, in letters at least 10 mm in height, located as indicated:

E For *generator-base tanks*:

“WARNING: THIS TANK MAY CONTAIN FLAMMABLE LIQUID. KEEP SOURCES OF IGNITION AWAY FROM THE TANK FILL AND VENT.” and

«AVERTISSEMENT : CE RÉSERVOIR PEUT CONTENIR DU LIQUIDE INFLAMMABLE. TENIR LES SOURCES D’INFLAMMATION ÉLOIGNÉES DU CONTENU DU RÉSERVOIR ET DE L’ÉVENT. »

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STANDARD FOR SHOP FABRICATED STEEL ABOVEGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

PREFACE

This is the Fifth Edition of the Standard for Shop Fabricated Steel Aboveground Tanks for Flammable and Combustible Liquids, CAN/ULC-S601-14.

This Edition of the Standard was developed by the ULC Task Group on Steel Aboveground Tanks (S601) and was formally approved by the ULC Committee on Stationary Steel Storage Containers for Flammable and Combustible Liquids.

Only metric SI units of measurement are used in this Standard. If a value for measurement is followed by a value in other units in parentheses, the second value may be approximate. The first stated value is the requirement.

Appendices A to D, identified as informative, are for guidance and informational purposes only.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the fact that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages, except as may be stated elsewhere in this Standard.

This Fifth Edition National Standard of Canada is based on, and now supersedes, the Fourth Edition.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patent rights. ULC Standards shall not be held responsible for identifying any or all such patent rights.

Requests for interpretation of this Standard should be sent to ULC Standards. The requests should be worded in such a manner as to permit a “yes” or “no” answer based on the literal text of the requirement concerned.

The initiation of the review of this Standard will commence within 5 years of the date of publication, unless the Standard is identified as fitting within a stabilized category, whereby the review will commence within the appropriate time frame set out by ULC Standards.

This Standard is intended to be used for conformity assessment.

1 SCOPE

1.1 This Standard sets forth minimum requirements for steel, *non pressure tanks* that are used for the aboveground storage of *flammable* and *combustible liquids* compatible with the material of construction and with a specific gravity not greater than 1.0.

NOTE: These tanks may also be used for the storage of *used oil*. For tanks intended solely for the collection of *used oil*, refer to CAN/ULC-S652, Standard for Tank Assemblies for the Collection, Storage and Removal of Used Oil.

1.2 This Standard covers tanks, which are fabricated, inspected and tested for leakage before shipment from the factory.

1.3 This Standard covers the construction of tanks for use in stationary installations. Tanks fabricated in accordance with this Standard are not intended for the transportation of *flammable* and *combustible liquids* nor are they intended to be transported while containing such liquids.

NOTE: Relocation of tanks other than *utility tanks* is subject to the requirements of the *authority having jurisdiction*.

1.4 The installation of such tanks shall be in accordance with, but not limited to, the following documents:

- A National Fire Code of Canada, Part 4;
- B CSA B139, Installation Code for Oil Burning Equipment;
- C CCME Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products; and
- D Regulations of the appropriate *authority having jurisdiction*.

1.5 Section 5 of this Standard covers the construction of single wall tanks. Section 6 covers the construction of tanks with *secondary containment*.

1.6 This Standard also covers aboveground steel, rectangular, *non-pressure workbench tanks* for the combined use as a working surface and storage of lubricating oils having capacities up to and including 2500 L.

1.7 This Standard also covers aboveground steel, rectangular, *non-pressure, generator-base tanks*.

1.8 This Standard also covers *utility tanks* and *double bottom utility tanks* designed to allow for relocation as required by their intended service. These tanks are for installation at locations such as farms, construction sites, demolition sites, exploration sites, forestry operations and similar locations.

1.9 This Standard does not cover wind loading or seismic loading of tanks. However, Guidelines for the Maximum Structural Limitations for Vertical Tanks (A2) are included in Appendix A (Informative), Explanatory Materials.

2 REFERENCE PUBLICATIONS

2.1 The documents shown below are referenced in the text of this Standard. Unless otherwise stated elsewhere in this Standard such reference shall be considered to indicate the edition and/or revisions of the document available at the date on which the Committee approved this ULC Standard. All undated references shall be interpreted as referring to the latest edition of that document.

Documents Published by the American Petroleum Institute (API)

1220 L Street NW, Washington, D.C. 20005-4070, U.S.A.
www.api.org

- API Standard 650-2007, Welded Steel Tanks for Oil Storage

Documents Published by the American Society of Mechanical Engineers (ASME)
3 Park Avenue, M/S 10 E, New York, NY 10016-5990, U.S.A.
Telephone: (212) 705-8562
www.asme.org

- ASME Boiler and Pressure Vessel Code, 2007

Documents Published by the American Society for Testing and Materials (ASTM)
100 Barr Harbour Drive, PO Box C700, West Conshohocken, PA 19428-2959 U.S.A.
Telephone: (610) 832-9585
www.astm.org

- ASTM A36/A36M-12, Standard Specification for Carbon Structural Steel
- ASTM 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 and Ultra-High Strength
- ASTM A1018/A1018M-10, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

Book Published by Van Nostrand Reinhold, Denver, CO, U.S.A.

- Bednar, Henry H., Pressure Vessel Design Handbook, 1981

Documents Published by the Canadian Council of the Ministers of the Environment
National Task Force on Storage Tanks
326 Broadway, Suite 400, Winnipeg, MB R3C 0S5
Telephone: (204) 948-2090; Fax (204) 948-2125
www.ccme.ca

- CCME PN 1326-2003, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Product

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Telephone: 1-800-463-6727, Fax: (416) 747-2473
www.csa.ca

- CSA 22.2 No. 0.15-01, Adhesive Labels
- CSA B139-09, Installation Code for Oil Burning Equipment

- CAN/CSA G40.20/G40.21-13, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
-

Code Published by the National Fire Protection Association (NFPA)
1 Batterymarch Park, Quincy, MA, 02269-9101 U.S.A.
Telephone: (617) 770-0700
www.nfpa.org

- NFPA 30-2012, Flammable and Combustible Liquids Code
-

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- National Building Code of Canada, 2010
 - National Fire Code of Canada, 2010
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- CAN/ULC-S602, Standard for Aboveground Steel Tanks for Fuel Oil and Lubricating Oil
 - CAN/ULC-S652, Standard for Tank Assemblies for the Collection, Storage and Removal of Used Oil
 - CAN/ULC-S663, Standard for Spill Containment Devices for Aboveground Flammable and Combustible Liquid Storage Tanks
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- UL 969-1995 (R 2008), Standard for Marking and Labelling Systems
-

Paper Originally Published in The Welding Journal Research Supplement
www.codeware.com

- Zick, L.P., "Stresses in Large Horizontal Cylindrical Pressure Vessels on Two Saddle Supports", September, 1951
-

3 GLOSSARY

NOTE: Terms used in this Standard that are in *italic* print are defined as follows:

3.1 **AUTHORITY HAVING JURISDICTION** – The governmental body responsible for the enforcement of any part of this Standard or the official or agency designated by that body to exercise such a function

3.2 **COMBUSTIBLE LIQUID** – Any liquid having a flash point at or above 37.8 °C and below 93.3 °C and as defined in the National Fire Code of Canada.

3.3 **DOUBLE BOTTOM UTILITY TANK(S)** – A *primary tank* with an additional bottom capable of being pressurized and with means for monitoring for leaks in the *interstitial space*. The *double bottom utility tank* is not considered as a *secondary containment*.

3.4 **DOUBLE WALL TANK(S)** – A *primary tank* with an *integral secondary containment* where the inner and outer walls are in intimate contact and the *interstice* is vacuum monitored.

3.5 **FLAMMABLE LIQUID** – Any liquid having a flash point below 37.8 °C and a vapour pressure not exceeding 276 kPa (absolute) at 37.8 °C and as defined in the National Fire Code of Canada.

3.6 **GENERATOR-BASE TANK(S)** – A tank, which has incorporated into its construction a support structure for a diesel generator and is used to store the fuel supply for this generator.

3.7 **INTEGRAL CONTAINED TANK(S) / INTEGRAL** – A structure where the *secondary containment* is built-in or attached to the *primary tank* structure in a manner that eliminates all precipitation from entering the *secondary containment*. The *secondary containment* is capable of being pressure tested.

3.8 **INTERSTICE / INTERSTITIAL SPACE** – The space between the *primary tank* and the *secondary containment* of a *double wall* or *integral contained tank* or the space between the *primary tank* and the additional bottom of a *double bottom utility tank* that is capable of being monitored for leakage.

3.9 **MANWAY** – An opening on a tank designed to provide personnel access to the interior of the tank.

3.10 **NON PRESSURE TANK(S) / NON-PRESSURE** – A tank that is normally vented to atmosphere and is not intended to accommodate internal pressures at the top of the tank greater than 7 kPa (gauge) nor internal vacuum greater than 300 Pa (gauge).

3.11 **PRIMARY TANK(S)** – The product storage tank.

3.12 **SECONDARY CONTAINMENT / CONTAINMENT** – Either double-walled or *integral contained* construction that is external to the *primary tank* and designed to prevent the contents of the *primary tank* from leaking outside the *containment*.

3.13 **USED OIL** – Previously used petroleum based oil and includes but is not restricted to, lubricating oil, crankcase oil, gear oil, transmission fluid and hydraulic fluid. It differs from waste oil in that it does not include hazardous waste.

NOTE: Waste oil contaminants include significant quantities of gasoline, solvents, antifreeze and fresh or salt water.

3.14 **UTILITY TANK(S)** – A tank which is designed to allow for relocation and intended for installation at farms, construction sites, demolition sites, exploration sites, forestry operations and similar locations. *Utility tanks* are not intended to be transported while containing fuel.

3.15 *WORKBENCH TANK(S)* – A rectangular tank used for the storage of lubricating oils which has its top surface intended for use as a working surface.

4 CONSTRUCTION – GENERAL

4.1 CAPACITIES AND DIMENSIONS

4.1.1 The actual tank capacity shall be not less than the nominal capacity but not greater than the nominal capacity plus 2.5%.

4.1.2 The inside diameter of any cylindrical tank shall not exceed 4000 mm.

4.1.3 The overall nominal inside shell length of any cylindrical tank shall be not greater than four times its diameter.

4.1.4 The overall nominal shell length of any horizontal cylindrical multi-compartment tank shall be not greater than six times the diameter provided the nominal shell length of the largest compartment is in compliance with Clause 4.1.3.

4.2 MATERIAL

4.2.1 The steel used in the fabrication of all tanks shall be welding quality carbon or low alloy steel. The following grades described in Subclause A to D, or their recognized equivalent, as described in Sub-clause F are acceptable. In general, these steels exhibit minimum yield strength of 200 MPa.

- A ASTM A1011/1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled Carbon, Structural High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability;
- B ASTM A1018/A1018M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength;
- C ASTM A36/A36M, Standard Specification for Carbon Structural Steel;
- D CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel;
- E Stainless Steel Type 304/304L or 316/316L; or
- F Carbon steel with a carbon content of 0.3 percent or less, or a carbon equivalency (CE) of 0.53 percent or less as determined by the formula below, and mechanical strength and welding characteristics at least equivalent to one of the steels specified in Subclauses A through D.

$$CE = C + (Mn + Si)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/1$$

in which: (C = Carbon, Mn = Manganese, Si = Silicon, Cr = Chromium, Mo = Molybdenum, V = Vanadium, Ni = Nickel and Cu = Copper).

4.2.2 All structural stiffening members shall be fabricated from steel in accordance with CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel, ASTM A36/A36M, Standard Specification for Carbon Structural Steel, or equivalent.

4.2.3 Where nominal thicknesses are required under this Standard, they shall be considered minimum except those required for rectangular tanks. The thickness tolerances for sheet and plate shall be as specified in Table 1, Minimum Permissible Thickness for Sheet and Plate Steel.

4.2.4 The acceptability of a particular lot of flat rolled steel shall be determined in the following manner:

- A The thickness of each of five pieces of stock shall be determined by five readings spaced equally along an edge of the full piece as rolled. Measurements shall be taken at least 25 mm from the edge of the sheet or plate. The instrument used shall be calibrated to a minimum of ± 0.013 mm.
- B If all thickness readings of the five pieces of stock are equal to or more than the minimum thickness limit specified from Table 1, the particular lot of material shall be considered acceptable.
- C If any of the thickness readings of any of the five pieces of stock are less than the minimum thickness limit specified, fifteen extra pieces shall be selected at random from the lot and their thickness determined.
- D If the thickness readings of all fifteen extra pieces are equal to or more than the minimum thickness specified from Table 1, the particular lot of material shall be considered acceptable, except that the individual pieces among the five which had thickness measurements less than the minimum thickness limit specified shall be rejected.
- E If any of the thickness readings of any of the fifteen extra pieces is less than the minimum thickness limit specified, the lot is not acceptable.
- F In lieu of steps A – E each plate used in the construction of each tank may be measured during the tank manufacturing process by one reading taken at least 25 mm from the edge of each sheet or plate in the as rolled condition before any additional forming is completed. If the thickness measured is equal or more than the minimum thickness limit specified, that sheet is acceptable. The instrument used shall be calibrated to a minimum of ± 0.013 mm.

4.3 WELDING

4.3.1 Each manufacturing facility shall have a written welding procedure as required by Subsection 4.4, Tank Joints, recognized by a third-party certifier and shall ensure that each operator doing the work shall be duly trained and qualified.

NOTE: In Canada, a third-party certifier may be, but is not limited to, the Canadian Welding Bureau or the *authority having jurisdiction*.

4.3.2 Each manufacturer shall have and maintain records of trained and qualified welders with respect to the manufacturer's written welding procedure.

4.3.3 Welding slag shall be removed from all internal and external welds prior to performing production testing.

4.4 TANK JOINTS

4.4.1 Joints shall be of the types shown in Figure 1 for tank shells, Figure 2 for tank heads, Figure 3 for tank roofs, Figure 4 for tank bottoms and Figure 5 for corner joints.

4.4.2 Tank joints shall be arranged so as not to occur at locations of openings or structural attachments.

4.4.3 Cylindrical heads, bulkheads, bottoms and roofs shall be fabricated of not more than four pieces, except for *utility tanks*, where these elements shall be fabricated of one piece. When two or more pieces are used, joints shall be of the full penetration butt type. (Refer to Joints S1.1, S1.2 and S1.3 of Figure 1).

4.4.4 Where a full penetration joint is specified, it shall be considered as a weld joint in which the total thickness of weld metal is a minimum of 100% of the thinner of the parent metal thicknesses. Radiography of this joint is not required.

4.5 TANK CONNECTIONS

4.5.1 Tank connections shall be provided for each opening by welding to the tank:

- A Steel threaded flanges or steel pipe couplings as illustrated in Figure 6; or
- B ANSI Class 150 Steel Pipe Flanges, as illustrated in Figure 6.

4.5.2 Threaded connections as specified in Designs 6.1 through 6.5 of Figure 6 shall be attached to the tank with full fillet welds. The threads shall not be warped or damaged as a result of welding. The size of threaded connections used below the highest liquid level shall be a maximum NPS 3 pipe with minimum rating equal to a 1 035 kPa (Class 150) coupling and a minimum wall thickness equal to or greater than the wall thickness of the tank.

4.5.3 The minimum length of threads, corresponding to the pipe size for Designs 6.1 through 6.4 shall be as specified in Figure 6.

4.5.4 Flanged connections shall be in accordance with Design 6.6 of Figure 6 and do not require a reinforcing plate.

4.5.5 Flanged connections located on the tank head shall be in accordance with Design 6.7 of Figure 6 and shall require a reinforcing plate.

4.5.6 The minimum distance between the centre line of two adjacent connections shall not be less than the sum of their diameters and the maximum size of any connection shall not be greater than half the radius of the tank.

NOTE: A *manway* is not considered a connection.

4.5.7 All threaded openings below the liquid level shall be provided with leak tight threaded closures by the tank manufacturer. The closures shall be made of metal equivalent to that used in the tank, and shall remain leak tight at the time of shipment.

4.5.8 All temporary closures shall be resistant to atmospheric degradation. At least one closure shall provide venting for the tank equivalent to a minimum open area of 4 mm internal diameter. All vented closures, which are visually indistinguishable from a permanent closure, shall be painted red.

4.6 VENTING

4.6.1 Each *primary tank* and each *primary tank* compartment of a multi-compartment tank shall be equipped with vent openings. Minimum venting requirements are shown in Table 2.

4.6.2 Both normal and emergency venting may be provided by a single vent opening having free internal areas provided that minimum total venting capacity and area shall be the sum of the normal and emergency venting requirements, as shown in Table 2, Column 6.

4.6.3 For tanks 5000 L or less, the normal vent opening and/or the emergency vent opening may be combined with the fill opening. When vents are combined with the fill opening, the following provisions shall be made:

- A The available vacuum venting area when the fill cap is closed shall be at least equal to the cross section of the product delivery line from the tank; and
- B The fill cap shall be provided by the manufacturer.

4.6.4 The tank shall be marked in accordance with Subclause 11.1.4 Item D.

4.6.5 The fittings for vent devices shall be identified in accordance with Clause 11.1.4, Items B and C.

4.6.6 Vents shall be designed in a manner that shall not result in flame impingement onto the surface of the tank in the event of vapour ignition and shall terminate in a vertical position above the highest liquid level.

4.6.7 Acceptable methods and design criteria for emergency venting are specified in Appendix B, Acceptable Method and Design Criteria for Vents. Vents with configurations other than those shown in Appendix B may be used provided they are rated by the vent manufacturer. (Refer to Column 5 of Table 2)

4.7 MANWAY DESIGN

4.7.1 *Manways*, when provided, shall have a minimum inside diameter of 600 mm and shall be of a bolted cover type. Material used for a *manway* shall be equivalent to that used in the tank.

4.7.2 A 600 mm inside diameter circular *manway* shall be fabricated in accordance with Figure 7. *Manway* Design 7.2, where installed on tanks or compartments greater than 50 000 L capacity or when installed on a tank head with a diameter greater than 3000 mm, shall have a reinforcing plate.

4.7.3 Any *manway* other than as described in Clause 4.7.2 shall be designed by a professional engineer and shall require a reinforcing plate.

4.7.4 Each *manway* shall be provided with a gasket not less than 3 mm in thickness which shall be of a material compatible with the stored product, as determined by the buyer.

4.7.5 All *manways* below the liquid level shall be made leak tight and shall remain leak tight at the time of shipment.

4.8 LIFTING

4.8.1 All tanks shall be equipped with a clearly identified lifting method, as described in Section 10, Installation Instructions. Where lift lugs are used as lifting method, it shall be in accordance with the requirements of Subsection 7.1, Lifting Lugs.

4.9 PRODUCTION TESTS

4.9.1 Each tank shall be production tested in accordance with Subsection 9.1, Production Leak Test.

5 SINGLE WALL TANKS

5.1 GENERAL

5.1.1 Single wall horizontal cylindrical tanks shall comply with the applicable requirements of Section 4, Construction – General, Subsections 5.2.1, Capacities through 5.2.2, Construction, and 5.3, Multi-Compartment Tanks.

5.1.2 Vertical cylindrical tanks shall comply with the applicable requirements of Section 4, Construction – General, and shall also meet all the requirements of Subsections 5.4.1, Capacities, through 5.4.3, Tailing Lugs and Anchors.

5.1.3 Rectangular tanks shall comply with the applicable requirements of Section 4, Construction – General, and shall also meet all the requirements for rectangular tanks of Subsections 5.5.1, Capacities and Construction and 5.5.2, Performance Tests.

5.1.4 *Generator-base tanks* shall comply with the applicable requirements of Section 4, Construction – General, shall incorporate into its construction a support structure for a generator, and shall be subject to the requirements of Subsection 8.7, Static Load Test.

5.1.5 *Utility tanks* shall comply with the applicable requirements of Section 4, Construction – General, and shall also meet all the requirements of Subsections 5.6.1, General through 5.6.3, Performance Tests.

5.2 HORIZONTAL CYLINDRICAL TANKS

5.2.1 CAPACITIES

5.2.1.1 Horizontal cylindrical tanks shall have capacities not greater than 200 000 L.

5.2.2 CONSTRUCTION

5.2.2.1 Horizontal tanks shall be constructed with shell and head joints as shown in Figures 1 and 2.

5.2.2.2 When the longitudinal shell seam is a continuous lap joint over the full length of the tank as shown in joint type S1.5 in Figure 1, the seam shall be located within 90° of the top centre line of the tank and shall be placed with the internal lap down so that water cannot gather and be retained in the crevice.

5.2.2.3 An unflanged flat cylindrical tank head shall be braced in accordance with Figure 8. The reinforcing members may be attached to either the inside or the outside of the head.

5.2.2.4 The nominal head and shell and compartment bulkhead thickness shall be the greater of 2.0 mm or the tank diameter divided by 500.

5.2.2.5 The flange depth on cylindrical tank heads shall be equal to $6\ t_h$ or 25 mm whichever is the greater, where t_h is equal to the head thickness in millimetres. The straight flange for tanks up to 1300 mm diameter shall be not less than 10 mm.

5.3 MULTI-COMPARTMENT TANKS

5.3.1 Multi-compartment tanks shall be fabricated using double bulkheads only. (Refer to Figure 9.)

5.3.2 Fittings located along the top or bottom centre line, as appropriate, shall be provided between compartments. For opening sizes and location refer to Figure 9.

5.3.3 All attachment joints from bulkheads to shell for compartment tanks shall be constructed with full fillet welds.

5.4 VERTICAL CYLINDRICAL TANKS

5.4.1 CAPACITIES

5.4.1.1 Vertical cylindrical tanks shall have capacities not greater than 175 000 L.

5.4.2 CONSTRUCTION

5.4.2.1 The nominal shell thickness shall be the greater of 2.0 mm or the tank diameter divided by 600. The nominal bottom thickness shall be the greater of 3.0 mm or the tank diameter divided by 500. The nominal roof thickness shall be in accordance with Table 3.

5.4.2.2 Roof to shell joints shall be as shown in Figure 3.

5.4.2.3 Shell joints shall be as shown in Figure 1, and vertical seams shall be arranged in a staggered pattern with a minimum offset of 100 mm. Where shell-to-shell joints are lap or offset joints, the internal lap shall be pointed down to prevent water from collecting in the crevice.

5.4.2.4 Bottoms of tanks shall be fabricated of not more than four pieces. When two or more pieces are used, joints shall be of the double welded full penetration butt type. (Refer to Joint S1.2 of Figure 1).

5.4.2.5 Typical bottom to shell joints are shown in Figure 4.

5.4.2.6 If the tank bottom is flanged, the minimum flange depth on tank bottoms shall be equal to $6 't_b'$ or 25 mm whichever is the greater, where $'t_b'$ is equal to the bottom thickness in millimetres.

5.4.2.7 When a roof angle is employed to attach the tops of vertical tanks, it shall be 35 mm by 35 mm by 6 mm for tanks up to and including 1500 mm in diameter, and 55 mm by 55 mm by 6 mm for tanks greater than 1500 mm in diameter.

5.4.2.8 The roofs of vertical tanks may be conical, flanged and dished, semi-elliptical, or hemispherical. The minimum cone height shall be equal to the tank diameter divided by 10. The minimum flange depth on tank roofs shall be equal to $6 't_r'$ or 50 mm whichever is greater, where $'t_r'$ is equal to the roof thickness in millimetres. When dished, the dish radius shall be 1.2 times the diameter for tank diameters up to and including 2500 mm.

5.4.2.9 The roofs of vertical tanks may be flat provided the design is verified by a professional engineer or,

- A The nominal thickness of the roof is in accordance with Table 3;
- B The flat roof to shell weld joints are in accordance with Figure 3, Joints R3.1 and R3.2;
- C The flat roof is not exposed to any additional loads with the exception of maintenance and installation personnel, and the tank is installed in an enclosure, which protects the tank from outdoor exposure.

5.4.3 TAILING LUGS AND ANCHORS

5.4.3.1 When required, tailing lugs shall be added. Refer to Figures 14 and 15 for typical tailing and lifting lug designs and locations.

5.4.3.2 When required, anchors shall be designed in accordance with good engineering practice.

5.5 RECTANGULAR TANKS

5.5.1 CAPACITIES AND CONSTRUCTION

5.5.1.1 Rectangular tanks shall have capacities not greater than 100 000 L. *Workbench tanks* shall have a maximum capacity of 2500 L.

5.5.1.2 The nominal shell (walls, top and bottom) thickness shall be determined in accordance with Table 4.

5.5.1.3 Typical rectangular tank corner joints are shown in Figure 5. Typical shell joints are shown in Figure 1.

5.5.1.4 Venting requirements for *workbench tanks* shall be in accordance with CAN/ULC-S602, Aboveground Steel Tanks for Fuel Oil and Lubricating Oil.

5.5.1.5 The wetted surface area of a rectangular tank shall be calculated as 75% of the exposed surface area. Column 2 of Table 2 shall be used to determine the required normal and emergency vent opening size. The bottom of a tank intended to rest directly on grade need not be included in the exposed surface area.

5.5.1.6 Multi-compartment rectangular tanks shall also meet the requirements of Subsection 5.3, Multi-Compartment Tanks.

5.5.2 PERFORMANCE TESTS

5.5.2.1 Proof of Design

5.5.2.1.1 The tank shall be tested to demonstrate that the strength of the assembly and the welded joints are in accordance with these requirements.

5.5.2.1.2 The tank shall not rupture or leak when subject to the proof of design test as described in Subsection 8.1, Proof of Design Test.

5.5.2.2 Static Load

5.5.2.2.1 *Workbench tanks* and *generator-base tanks* shall be subject to the requirements of Subsection 8.7, Static Load Test.

5.5.2.2.2 After being subjected to the static load test, the tank shall not leak when subjected to the requirements of Subsection 8.4, Pressure Leak Test.

5.5.2.3 Tank Support

5.5.2.3.1 A tank provided with integral supports shall show no evidence of permanent deformation or damage to the tank or supports when subjected to the requirements of Subsection 8.8, Tank Support Load Test.

5.5.2.3.2 Tank support, if provided, shall be adequate to support twice the weight of the filled tank without deformation.