NATIONAL
STANDARD
OF CANADA

CAN/ULC-S677-14

STANDARD FOR FIRE TESTED ABOVEGROUND TANK ASSEMBLIES FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

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NATIONAL STANDARD OF CANADA

CAN/ULC-S677-14

STANDARD FOR FIRE TESTED ABOVEGROUND TANK ASSEMBLIES FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

ICS 23.020.10, 75.200

Prepared and Published by

ULC Standards
Normes ULC

Approved by

Standards Council of Canada
Conseil canadien des normes

FIRST EDITION . . . . . .OCTOBER 2014

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STANDARD FOR FIRE TESTED ABOVEGROUND TANK ASSEMBLIES FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

PREFACE

This is the First Edition of the Standard for Fire Tested Aboveground Tank Assemblies for Flammable and Combustible Liquids, CAN/ULC-S677.

This Edition of the Standard was developed by the ULC Standards Task Group on CAN/ULC-S677 and was formally approved by the ULC Standards 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.

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

This First Edition National Standard of Canada is based on, and now supersedes, the First Edition, ULC/ORD-C142.5, Concrete Encased Steel Aboveground Tank Assemblies for Flammable and Combustible Liquids.

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 covers minimum requirements for shop fabricated, aboveground fire tested *tank assemblies* intended for storage of *flammable and combustible liquids* that have a specific gravity not greater than 1.0 and that are compatible with the material of the tank.

1.2 *Tank assemblies* constructed to meet this standard are intended to withstand exposure to a 1 h hydrocarbon pool fire.

1.3 These *tank assemblies* are intended for stationary installation and use in accordance with the following:

A National Fire Code of Canada, Part 4;

B CSA B139, Installation Code for Oil Burning Equipment;

C PN1326, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products;

D The Requirements of the Authority Having Jurisdiction.

1.4 *Tank assemblies* covered by these requirements are fabricated, inspected, and tested for leakage before shipment from the factory as completely assembled units.

1.5 These requirements do not address methods of anchoring which may be required to prevent uplift from flooding or movement due to wind or seismic forces.

1.6 These requirements do not address either the construction, or attachment means of ladders, stairs, runways, guardrails, platforms, or equipment supports.

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.

Document 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

• ANSI/ASME B36.10M-2004 (R2010), Standard for Welded and Seamless Wrought Steel Pipe

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Documents Published by the American Society for Testing and Materials (ASTM)
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• ASTM A36/A36M-12, Standard Specification for Carbon Structural Steel

• ASTM B117-11, Standard Practice for Operating Salt Spray (Fog) Apparatus

• ASTM E96/E96M-13, Standard Test Methods for Water Vapor Transmission of Materials

• ASTM G153-13, Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Non-metallic Materials

• ASTM G155-13, Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-metallic Materials

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Document Published by the Canadian Council of Ministers of the Environment
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• PN1326-2003, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products - 2003

Documents Published by the Canadian General Standards Board (CGSB)
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www.pwgsc.gc.ca

• CAN/CGSB-3.2-2013, Heating Fuel Oil

Standards Published by the CSA Group
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www.csagroup.ca

• CAN/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

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Codes Published by National Research Council of Canada (NRC)
1200 Montreal Rd, Bldg. M-58, Ottawa, ON K1A 0R6
Telephone: (800) 672 7990
www.nrc-cnrc.gc.ca

• National Fire Code of Canada, 2010

Documents Published by Underwriters Laboratories of Canada (ULC)
7 Underwriters Road, Toronto, ON M1R 3A9 Canada
Telephone: (416) 757-3611
www.ulc.ca

• CAN/ULC-S602-07, Aboveground Steel Tanks for Fuel Oil and Lubricating Oil

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• CAN/ULC-S601-14, Standard for Shop Fabricated Steel Aboveground Tanks for Flammable and Combustible Liquids

• CAN/ULC-S603.1-11, Standard for External Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids

3 GLOSSARY

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

3.1 *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.

3.2 *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.

3.3 *INTERSTICE / INTERSTITIAL SPACE* — The space between the *primary tank* and the *secondary containment* of a tank assembly that is capable of being monitored for leakage.

3.4 *NON-PRESSURE TANK* — 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).

3.5 *PRIMARY TANK(S)* — The product storage tank.

3.6 *SECONDARY CONTAINMENT / CONTAINMENT* — Construction, external to the *primary tank* designed to contain leakage.

3.7 *TANK ASSEMBLY — Non-pressure tank* consisting of a *primary tank*, a *secondary containment* and an *interstice* which meets the requirements of this standard. Insulation may be utilized in the *tank assembly*.

4 CONSTRUCTION

4.1 GENERAL

4.1.1 A *tank assembly* shall consist of a *primary tank,* a *secondary containment,* and an *interstice* which is capable of being monitored and which will meet the performance requirements of this Standard.

4.1.2 All structural stiffening members for *tank assemblies* shall be fabricated from Steel in accordance with CAN/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 THE PRIMARY TANK

4.2.1 The *primary tank* shall meet the requirements of the:

A CAN/ULC-S601, Standard for Shop Fabricated Steel Aboveground Tanks for Flammable and Combustible Liquids; or

B CAN/ULC-S602, Standard for Aboveground Steel Tanks For Fuel Oil and Lubricating Oil.

NOTE: In certain combinations of design life and environment, the application of a corrosion protection system (notably an industrial coating) to the exterior of the primary steel tank would be considered essential. Such coating would have to be applied during the construction of the *tank assembly.* The selection and specification of a suitable system falls outside the scope of this standard.

4.3 SECONDARY CONTAINMENT

4.3.1 *Secondary containment* shall be constructed to catch a leak from any location of the *primary tank* and contain the entire contents in the event that a leak occurs.

4.3.2 *Secondary containment* materials shall have a permeability of not more than 1.0×10^{-7} cm/s with the stored fluids as determined using the ASTM E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

4.3.3 *Secondary containment* shall be compatible with the stored product. Compatibility of the *secondary containment* shall be determined by the resistance to the internal fluids test in Section 7 of CAN/ULC-S603.1, Standard for External Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids.

4.3.4 *Secondary containment* shall be constructed to prevent rain or debris from entering the *interstitial space.*

4.3.5 *Secondary containment* shall be constructed so that it provides for the emergency venting of the *interstitial space*

4.3.6 *Secondary containment* shall either be provided with an emergency vent device or a form of construction that relieves excessive *interstitial space* pressure.

4.3.7 All fittings that penetrate the *secondary containment* structure shall be permanent and terminate above the maximum liquid level.

4.4 INTERSTITIAL MONITORING

4.4.1 The *secondary containment* shall be provided with a means for monitoring leakage into the *interstice.* The *interstice* shall be designed so that liquid can flow freely to the point of monitoring.

4.4.2 All enclosed spaces that could contain leakage from the *primary tank* shall be evaluated as *interstitial spaces* for *secondary containment.*

4.4.3 The *interstitial space* shall have provisions for monitoring leaks from the *primary tank* and for detecting *secondary containment* loss of integrity.

4.4.4 The continuity of, and the freedom of communication through, the *interstitial space* shall be verified as described in Subsection 5.9, Interstitial Communication Test.

4.5 WELDING

4.5.1 Each manufacturing facility shall have a written welding procedure 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.

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

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

4.6 NORMAL AND EMERGENCY VENTING

4.6.1 Venting devices for normal and emergency venting of the *primary tank* and emergency venting of the *secondary containment* shall be provided. If the *primary tank* has two or more compartments, each compartment shall be provided with a normal and emergency vent device.

4.6.2 Normal and emergency vents shall be sized in accordance with the standard to which the tank has been constructed.

4.6.3 A long-bolt manway shall not be used for emergency venting in lieu of an emergency vent device.

4.6.4 A weak shell to roof seam shall not be used for emergency venting of the *primary tank.*

4.6.5 *Tank assemblies* which employ venting by form of construction for the *secondary containment* shall be tested in accordance with Subsection 5.11, Pressure Surge Test.

5 PERFORMANCE

5.1 GENERAL

5.1.1 Except as described in Clause 5.1.2, each *tank assembly* shall be tested for compliance with the requirements of:

A Subsection 5.5, Ball Impact Test, and

B Subsection 5.8, Environmental Exposure.

5.1.2 The tests described in Clause 5.1.1 are not required for *tank assemblies* that use a minimum of 150 mm of concrete as the insulation or an external steel wall that provides protection for the insulation.

5.2 PIPE-FITTING, TORQUE STRENGTH TEST

5.2.1 Where fittings and their method of attachment differ from those described in the applicable standard specified in Clause 4.2.1, each fitting construction shall be subjected to this test. The fitting shall not crack or split, the threads shall not strip, and the *tank assembly* shall show no signs of damage.

5.2.2 A length of Schedule 40 pipe is to be threaded into a fitting for the pipe connection and tightened to the torque specified in Table 1.

5.3 PIPE-FITTING, BENDING-MOMENT STRENGTH TEST

5.3.1 Where fittings and their method of attachment differ from those described in the applicable standard specified in Clause 4.2.1, each fitting construction shall be subjected to this test. The fitting shall not crack or split, and the *tank assembly* shall show no signs of damage.

5.3.2 A 1.2 m length of Schedule 40 steel pipe is to be threaded into the fitting. A force is then to be applied to the top of the pipe. The force is to be first applied parallel to the longitudinal axis of the *tank assembly* and then transverse to the longitudinal axis of the *tank assembly*. The applied force is to be

increased so that the bending moment is increased from zero to 2712 N•m in 339 N•m increments. Whenever the Schedule 40 pipe bends before the required bending moment is reached, the test is to be stopped and the fitting, and *tank assembly* examined for compliance with the requirements in Clause 5.3.1.

5.4 LIFT-FITTING STRENGTH TEST

5.4.1 Each fitting or device intended to be used to lift and move a *tank assembly* shall be subjected to this test. The fitting or device shall withstand a load equal to twice that imposed by lifting the empty *tank assembly* for 1 min. When more than one fitting is provided on a *tank assembly*, the load is to be divided between the fittings in proportion to the load to which they are subjected by lifting the *tank assembly* as intended. Neither the fitting nor the *tank assembly* shall be damaged.

5.5 BALL IMPACT TEST

5.5.1 The *tank assembly* is to be subjected to six impacts from a 102 mm diameter steel ball having an impact energy of 98 N•m. The top, sides, corners, and fittings of the *tank assembly* are to be tested with no two impacts on the same point. The *tank assembly* shall show no visible signs of cracking or damage.

5.6 LOAD TEST

5.6.1 For flat-top *tank assembly* constructions, a 454 kg load is to be applied over a 305 x 305 mm surface at various places on the top surface of the *tank assembly* near the center of the longest unsupported span to determine the worst case condition. The load is to be sustained for 1 min at each location. The *tank assembly* surface shall not show signs of permanent deformation as a result of this test.

5.7 TANK SUPPORT LOAD TEST

5.7.1 Where the mass of the *tank assembly* is greater than those described in the applicable standard specified in Clause 4.2.1, a *tank assembly* provided with integral supports shall show no evidence of permanent deformation to the *tank assembly* or damage to the supports when tested as described in Clause 5.7.2.

5.7.2 The *tank assembly* is to be completely filled with water. An evenly distributed load equal to the mass of the filled *tank assembly* is to be placed across the top of the filled tank assembly on a line parallel to the longitudinal axis of the *tank assembly*. The *tank assembly* and supports shall withstand this load for 2 min.

5.8 ENVIRONMENTAL EXPOSURE

5.8.1 PERFORMANCE CRITERIA

5.8.1.1 Test samples are to consist of 610 by 152 by 152 mm structural steel tubes with 4.8 mm wall thickness. The steel tubes are to be provided with steel caps and covered with the insulation material in the minimum thickness being investigated.

5.8.1.2 A separate set of three samples shall be subjected to each of the exposures described in Clauses 5.8.2.1- 5.8.2.7. Each shall be provided with the insulation thickness established in Clause 5.8.1.1.

5.8.1.3 Samples shall show no visible signs of cracking or damage of the insulation.

5.8.2 SIMULATED ENVIRONMENTAL EXPOSURES

5.8.2.1 Cold Exposure - Samples are to be conditioned for a minimum of 16 h in a cold box maintained at – 40 ± 2°C. Immediately upon removal from the cold chamber, these samples and three additional unconditioned samples are to be subjected to a 9.6 N•m impact from a 50.8 mm diameter steel ball on the surface of the sample.

5.8.2.2 UV Light and Water - Three test samples shall be subjected to simulated UV light types and exposure times listed below:

A 360 h (Indoor rating) or 720 h (Outdoor rating) according to the requirements of ASTM G153, Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Non-metallic Materials; or

B 500 h (Indoor rating) or 1000 h (Outdoor rating) according to the requirements of ASTM G155, Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-metallic Materials.

The cycle rate shall be light for 17 min and light and water for 3 min.

5.8.2.3 Aging - Accelerated aging of the protective material is to be simulated by placing samples in a circulating air-oven at 66 ± 3°C for 270 days.

5.8.2.4 High Humidity - A high humidity condition is to be simulated by placing samples in a controlled humidity of 97 - 100 percent at 35 ± 2°C for 180 days.

5.8.2.5 Industrial Atmosphere - The sulfur dioxide (SO_2) content and carbon dioxide (CO_2) content of an industrial atmosphere is to be simulated by exposing the samples for 30 days to an amount of SO_2 equivalent to 1 percent of the volume of the test chamber, and an equal volume of CO_2. The test chamber is to be maintained at 35 ± 2°C and a small amount of water is to be maintained at the bottom of the chamber.

5.8.2.6 Salt Spray - A corrosive atmosphere is to be simulated by exposing samples to a salt spray for 90 days as described in ASTM B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.

5.8.2.7 Combination Wet, Freeze, and Dry Cycling- The freeze-thaw action is to be simulated by exposing samples to a cycle consisting of the equivalent of rainfall at the rate of 0.005 mm/s of water for 72 h, followed by a temperature of – 40 ± 3°C for 24 h, and then a dry atmosphere of 60 ± 3°C for 72 h. This cycle is to be repeated twelve times.

5.9 INTERSTITIAL COMMUNICATION TEST

5.9.1 The continuity of and the freedom of communication through the interstitial space shall be verified as described in Clauses 5.9.2 through 5.9.6.

5.9.2 At the furthest point from the interstitial monitoring location, a tank fitting shall be installed, if necessary, from the exterior of the tank to facilitate an interstitial leak simulation.

5.9.3 The *primary tank* shall be filled to capacity with water.

5.9.4 A monitoring system shall be installed.

5.9.5 At the furthest point from the interstitial monitoring location, water, rated air pressure or rated vacuum shall be applied to the *interstitial space*.

5.9.6 The time taken to indicate the presence of water, air pressure or vacuum at the monitoring location shall not exceed 24 h.

5.10 HYDROSTATIC STRENGTH TEST OF TANK ASSEMBLY

5.10.1 A *tank assembly* shall be subjected to this test when the *secondary containment* does not comply with the applicable standard specified in Clause 4.2.1. Both the *primary tank* and the *secondary containment* shall remain leak tight following the test.

Exception: In cases where the secondary containment provides venting by a form of construction, the Pressure Surge Test (Venting by Form of Construction) Subsection 5.11 shall be conducted.

5.10.2 The source of water pressure shall be capable of maintaining a pressure of at least 207 kPa for a period of not less than 2 min. The pressure gauges are to be calibrated and have a dial range of 0 - 345 kPa or 0 - 415 kPa, a face size of at least 89 mm in diameter, graduations of 10 kPa maximum, and an accuracy of ±1 percent of the full scale reading.

5.10.3 The *primary tank* and the *interstitial space* are to be filled with water. The *primary tank* is to be manifolded to the *interstitial space*. The pressure is to be applied gradually to the combined space in increments of 35 kPa at a rate not exceeding 14 kPa per minute. The pressure is to be held for 2 min after each increment of 35 kPa until the test pressure of 172 kPa is attained. Once the pressure is attained, it is to be held for a minimum of 20 min and the overall structure examined for visible signs of leakage or damage.

Exception: A test pressure of 100 kPa is to be used for tanks with a specified maximum production leakage test pressure of 20 kPa.

5.11 PRESSURE SURGE TEST (VENTING BY FORM OF CONSTRUCTION)

5.11.1 *Secondary containment* structures that provide emergency venting by a form-of construction, such as a frangible joint where the top is designed to be weaker than the walls, shall be subjected to this test.

5.11.2 The test shall be conducted on the manufacturer's tank configuration with the largest length to width ratio.

5.11.3 The vent openings are to be provided with the intended venting devices. The interstitial space is to be completely filled with water. The *interstitial space* is to be subjected to surge pressure of not more than 14 kPa.

5.11.4 Venting shall be such that only the seams of the *secondary containment* above the maximum normal liquid level fail. The internal pressure shall be directed upward at the moment of release, and there shall be no resulting projectiles. In addition, the *primary tank* shall be pressure tested for leakage in accordance with Clause 5.11.5 and examined for buckling. No leakage nor buckling shall be permitted.

5.11.5 A representative *tank assembly* shall be subjected to an air pressure of 35 kPa. The *primary tank* shall not show any deformation nor leakage.

5.12 FIRE TEST

5.12.1 A representative *tank assembly* shall be empty and exposed to a hydrocarbon pool fire for 1 h.

5.12.2 The test is to be conducted outdoors under conditions of essentially still air (5 km/h or less) and no precipitation. The ambient temperature shall be above 0°C.

5.12.3 Where the structural supports are 305 mm or more above grade, the temperature recorded on the supports shall not exceed a temperature of 540°C. Supports of any height shall not collapse.

5.12.4 The emergency venting shall not be impaired as a result of the fire exposure. This shall be determined by visual examination after the test.

5.12.5 The *tank assembly* shall be placed centrally in a pan measuring 300 mm in depth and 1200 mm greater in length and breadth than the outside dimensions of the *tank assembly*. Sufficient No. 2 fuel oil in accordance with CAN/CGSB-3.2, Heating Fuel Oil to provide a continuous burn for 1 h shall be placed in or continuously fed to the pan.

5.12.6 The fuel shall be ignited and allowed to burn freely for 1 h.

5.12.7 At the conclusion of the fire test, a leakage test is to conducted on the *primary tank*. The *primary tank* shall be completely filled with water and subjected to a 35 kPa hydrostatic pressure for 1 h. The *tank assembly* is to be tested in the position in which it will be installed. The pressure is not to decrease during the 1 h period. The *primary tank* shall not leak.

6 MARKING

6.1 The following information shall be permanently attached to the tank assembly and located so as to be readily visible when installed:

A Name of manufacturer;

B Year of manufacture;

C Capacity, L;

D Maximum Pressure 7 kPa;

E Maximum Vacuum 300 Pa;

F Resistant to a fire exposure of 1 h; and

G All additional marking information required by the Standard to which the *primary tank* has been constructed.

NOTE: Manufacturers should be aware that the authority having jurisdiction may also require that the mark of certifying agency be included on each tank.

7 INSTALLATION INSTRUCTIONS

7.1 Each tank shall be provided with a full set of installation instructions including at least the following:

A Instruction that the tank installer shall consult with the authority having jurisdiction to ensure that the requirements of this Standard and all Federal, Provincial, and Local Codes are met prior to installation;

B Location;

C Base Preparation;

D Lifting and handling instructions;

E Instructions for the piping of the vent to a remote location when required; and

F A description of vehicle barrier when the assemblies are accessible by, or adjacent to traffic.

TABLES

TABLE 1
Torques on Pipe Fittings

(Reference: Subsection 5.2.2)

Nominal pipe size, NPS[a]	Torque, N.m
3/4	226
1	271
1–1/4	328
1–1/2	350
2	373
2–1/2	395
3	407
3–1/2	418
4	429
6	475
8	520

[a] Nominal pipe size specifications are in accordance with the ANSI/ASME B36.10M, Standard for Welded and Seamless Wrought Steel Pipe.