

**CAN/ULC-S603-14
(Including Erratum 1)**

**STANDARD FOR STEEL UNDERGROUND TANKS FOR
FLAMMABLE AND COMBUSTIBLE LIQUIDS**

Prepared and Published by:



Approved by:



**Standards Council of Canada
Conseil canadien des normes**

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CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE
AND COMBUSTIBLE LIQUIDS

ICS 23.020.10

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ERRATUM NOTICE

ULC STANDARDS

STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS	CAN/ULC-S603-14
ERRATUM 1	DATE OF ERRATUM: JUNE 2017

The following erratum are being incorporated into (CAN/ULC-S603-14):

1. Revised Section 2.
2. Revised Clause 4.1.2.
3. Revised Clause 5.3.1.2.
4. Revised Clause 11.3.

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IT IS POSSIBLE, HOWEVER, THAT CERTAIN CODES WILL REFER TO THE SUPERSEDED EDITION OF THIS STANDARD, WITHOUT THE ERRATUM(S).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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2 REFERENCE PUBLICATIONS

2.1 Standard Published by the American Society of Mechanical Engineers (ASME)

Available through Global Engineering Documents, an IHS Company

15 Inverness Way East, Englewood, CO 80112 U.S.A.

Telephone: (800) 854-7179

www.asme.org

- ASME B36.10M-2004, Welded and Seamless Wrought Steel Pipe
 - ASME BPVC-2011, Boiler & Pressure Vessel Code, Section VIII, Division 1, Design and Fabrication of Pressure Vessels
-

4 CONSTRUCTION - GENERAL

4.1.2 The overall nominal shell length of a tank shall be not greater than six (6) times its diameter.

NOTE: The 6:1 ratio limit may be exceeded if a tank is designed according to Table 1.

5.3 ROARK FORMULA

5.3.1 Shell Thickness Calculations

5.3.1.2 Using the Roark formula, the minimum steel shell thickness ($t_{s \text{ min}}$) or the maximum tank length (L_{max}) may be calculated using the following equations, respectively:

$$t_{s \text{ min}} = [(P_1 L r^{3/2} (1-u^2)^{3/4}) / (0.807 E_s)]^{0.4}$$

$$L_{\text{max}} = [0.807 E_s t_s^2 / P_1 r] [(1-u^2)^{-3} (t_s / r)^2]^{0.25}$$

where:

- P_1 is calculated external pressure at the bottom of a submerged tank in water, kPa. The water depth equals 1.5 m or the maximum burial depth for the tank, whichever is greater, plus the tank diameter;
- E_s is modulus of elasticity of steel (203.4×10^6 kPa for structural grade A36 carbon steel);
- $t_{s \min}$ is thickness of steel tank shell, mm;
- L is length of tank, mm;
- r is inner radius of tank, mm; and
- u is Poisson's Ratio (0.287 for structural grade A36 carbon steel).
-

11 MARKING

11.3 Alternate methods of attachment are permissible provided that the nameplate is affixed to the tank in a manner that will destroy the nameplate if removed from the tank. If a pressure-sensitive label, ink, paint-stencilling or other method is used, it shall comply with the requirements of CSA 22.2 No. 0.15, Adhesive Labels, or UL 969, Standard for Marking and Labelling Systems, be suitable for outdoor use and exposure to fuel and have a surface temperature rating within -35°C to 60°C .

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STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

PREFACE

This is the Fourth Edition of the Standard Test Method for Steel Underground Tanks for Flammable and Combustible Liquids

This Edition of the Standard has been formally approved by the ULC Standards Committee on Stationary Steel Storage Containers for Flammable and Combustible Liquids

This Standard has been developed in compliance with the requirements of SCC for accreditation of a Standards Development Organization.

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.

Annexes A, B, C, D and E, identified as Informative, are for information 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 possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

This Fourth Edition National Standard of Canada is based on, and now supersedes, the Third Edition of ULC-S603.

Attention is drawn to the possibility that some of the elements of this Canadian standard may be the subject of patents rights. ULC Standards shall not be held responsible for identifying any or all such patents 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 and action to revise or reaffirm this Standard will not exceed 5 years from 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.

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1 SCOPE

1.1 Except as described in Clause 1.7, these minimum requirements cover single and double wall cylindrical steel, *non-pressure tanks* of the horizontal type that are used for the underground storage of *flammable liquids* and *combustible liquids*, that are compatible with the material of construction.

1.2 These minimum requirements cover *double wall tanks* with provision for leak detection monitoring of the *interstice* between the walls.

NOTE: The designs identified in this Standard are satisfactory for vacuum and/or electronic monitoring devices. (Refer to Figure 1.)

1.3 This Standard also provides design criteria for integral connections (connection rings/collars) for *spill containment sumps* or *manway* risers.

1.4 These minimum requirements cover tanks, which are fabricated, inspected and tested for leakage before shipment from the factory as completely assembled vessels.

NOTE: For the requirements for tanks provided with corrosion protection systems at the factory, refer to the Standard CAN/ULC-S603.1, Standard for External Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids.

1.5 These minimum requirements cover tanks up to a maximum capacity of 250 000 L.

1.6 The requirements in this Standard are for the construction of stationary tanks and do not cover their installation, maintenance and operation. The installation, maintenance and operation of these tanks may be covered by any of, 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 API RP 1615, Installation of Underground Petroleum Storage Systems;
- D CCME PN 1326, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products;
- E NFPA 30, Flammable and Combustible Liquids Code; and
- F Regulations of the appropriate *authority having jurisdiction*.

1.7 Where described elsewhere in the Standard, an alternative means of demonstrating compliance is provided in Subsection 8.3, Alternative Compliance Path. Tank designs subjected to the alternative compliance path need not be cylindrical. It is intended that proponents will use one of the design-based approaches identified in the rest of the Standard, or that described in Subsection 8.3, Alternative Compliance Path, as an equivalent means of obtaining certifications for their products.

1.8 The requirements in this Standard cover products that are integral or built-in to the tank.

NOTE: These requirements do not cover products not integral to the tank, such as *spill containment sumps*.

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.

Guide Published by the American Petroleum Institute (API)
1220 L Street, Northwest, Washington, DC 20005-4070 U.S.A.
Telephone: (202) 682-8000
www.api.org

- API RP 1615-2011, Installation of Underground Petroleum Storage Systems

Standard Published by the American Society of Mechanical Engineers (ASME)
Available through Global Engineering Documents, an IHS Company
15 Inverness Way East, Englewood, CO 80112 U.S.A.
Telephone: (800) 854-7179
www.asme.org

- BPVC-2011, Boiler & Pressure Vessel Code, Section VIII, Division 1, Design and Fabrication of Pressure Vessels

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-13, Standard Specification for Carbon Structural Steel
- ASTM A283/A283M-12, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
- ASTM A635/A635M-13, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-rolled, Alloy, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for
- ASTM A1011/A1011M-14, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, 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
- ASTM C33/C33M-13, Standard Specification for Concrete Aggregates

Standard Published by the American Welding Society (AWS)
550 NW LeJeune Road, Miami, FL 330126 U.S.A.
Telephone: (305) 443-9353

www.aws.org

- AWS A2.4-12, Standard Symbols for Welding, Brazing and Non-Destructive Examination

Document published by the Canadian Council of Ministers of the Environment (CCME)
123 Main, Suite 360, Winnipeg, MB R3C 1A3
Telephone: (204) 945-4664
www.ccme.ca

- CCME PN 1326 UPD 2013, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products

Standards Published by CSA Group
5060 Spectrum Way, Suite 100, Mississauga, Ontario L4W 5N6 Canada
Telephone: 1-800-463-6727
www.csa.ca

- CSA B139-09 (UPD1, 2010), Installation Code for Oil Burning Equipment
- CSA C22.2 No. 0.15-01, Adhesive Labels
- CSA G40.20/40.21-13, 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

Code published by the National Research Council of Canada (NRC)
Publication Sales M20, National Council of Canada, Institute for Research in Construction
Ottawa, ON K1A 0R6
Telephone: (613) 993-2463 or (800) 672-7990
www.nrc-cnrc.gc.ca

- National Fire Code of Canada, 2010

Documents Published by ULC Standards
171 Nepean Street, Suite 400, Ottawa, ON K2P 0B4 Canada
Telephone: (416) 757-3611, ext. 61744; Fax (613) 231-5977, "ATTN: Publications"
E-mail: publications@ulc.ca
www.ulc.ca

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

- CAN/ULC-S656-14, Standard for Oil-Water Separators

Document Published by Underwriters Laboratories, Inc.
333 Pfingsten Road, Northbrook, IL 60062-2096 U.S.A.
Telephone: +1-847-272-8800
www.ul.com

- UL 969-95 (R2008), Standard for Marking and Labelling Systems
-

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 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 **CRUSHED STONE** — Washed, crushed aggregate or crushed gravel with an angular particle size not more than 13 mm diameter that is clean and free flowing and with no more than 5 % passing a No. 8 sieve (2.38 mm screen size opening). The material has a minimum dry gravel density of 1520 kg/m³ and meets the requirements of ASTM C33/C33M, Standard Specification for Concrete Aggregates, for quality and soundness.

3.4 **DOUBLE WALL TANK** — A *primary tank* with an integral *secondary containment* where the *interstice* is capable of being vacuum monitored.

NOTE: Refer to Section 12, Shipping and Installation, which requires that *double wall tanks* are shipped with vacuum monitoring in place.

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

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

3.8 **MONITORABLE BULKHEAD** — An impermeable partitioning structure within a *primary tank* separating the *primary tank* into independent liquid *containment* compartments, and consisting of two layers of material with a space between them that is capable of being monitored for leaks.

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

3.10 **PEA GRAVEL** — A naturally rounded aggregate, actual size no greater than 19 mm, free-flowing and with no more than 5 % passing a No. 8 sieve (2.38 mm screen size opening). The material has a minimum dry gravel density of 1520 kg/m³ and meets the requirements of ASTM C33/C33M, Standard Specification for Concrete Aggregates, for quality and soundness. Local names vary and include “*pea gravel*”, “*pea stone*”, “*roofing gravel*”, etc.

3.11 **PRIMARY TANK** — The product storage tank.

3.12 **SECONDARY CONTAINMENT / CONTAINMENT** — Construction, external to a *primary tank*, intended to capture leakage due to failure of the *primary tank*.

3.13 **SPILL CONTAINMENT SUMP** — A liquid tight *containment* attached to the tank to provide a ground level enclosure, which may be monitored for spill *containment* and adaptation to double wall product piping. The *spill containment sump* may contain the product piping connections to the tank, the product fill line, product pressure or suction pumping devices, and leak detection sensors for double wall piping.

4 CONSTRUCTION - GENERAL

4.1 CAPACITIES AND DIMENSIONS

4.1.1 Where tank diameters and lengths are described in this Standard, these shall be interpreted as the internal diameter and internal length of the *primary tank*, unless otherwise stated. The inside diameter of any tank shall not exceed 4000 mm.

4.1.2 The overall nominal shell length of a tank shall be not greater than six (6) times its diameter.

4.1.3 The nominal capacity of tanks fabricated to these requirements shall not exceed 250 000 L.

4.1.4 Heads may be flat flanged, flat braced, flanged and dished, semi elliptical or hemispherical. When other than flat flanged or flat braced heads are used, a special chart of tank capacity shall be supplied by the tank manufacturer.

4.1.5 When a nominal capacity of a tank manufactured in accordance with this Subsection is specified, the actual capacity shall be not less than the nominal capacity but not more than the nominal capacity plus 2.5 %.

4.2 MATERIALS

4.2.1 The steel used in the fabrication of these tanks shall be welding quality carbon or low alloy steel with a minimum yield strength of 200 MPa. The following grades or their recognized equivalents are acceptable:

- A ASTM A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates, Grade 'C';
- B ASTM A1011/1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength;
- C 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;
- D ASTM A36/A36M, Standard Specification for Carbon Structural Steel;
- E ASTM A635/A635M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, and High-Strength Low-Alloy with Improved Formability, General Requirements for;

- F CSA G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel;
- G Stainless Steel Type 304/304L or 316/316L; or
- H Carbon steel with a carbon content of 0.3 % or less, or a carbon equivalency (CE) of 0.53 % or less as determined by the formula below, and mechanical strength and welding characteristics at least equivalent to one of the steels specified in Sub-clauses A through G.

$$CE = C + (Mn + Si)/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

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/Structural Quality Steel; or ASTM A36/A36 M, Standard Specification for Carbon Structural Steel, or equivalent.

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

- A The thickness of each of 5 pieces of stock shall be determined by 5 micrometer 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 5 pieces of stock are equal to or more than the minimum thickness limit specified in Table 1, the particular lot of material shall be considered acceptable;
- C If any of the thickness readings of any of the 5 pieces of stock are less than the minimum thickness limit specified, 15 extra pieces shall be selected at random from the lot and their thicknesses determined;
- D If the thickness readings of all 15 extra pieces are equal to or more than the minimum thickness specified in Table 1, the particular lot of material shall be considered acceptable, except that the individual pieces among the 5 which had thickness measurements less than the minimum thickness limit specified shall be rejected; and
- E If any of the thickness readings of any of the 15 extra pieces is less than the minimum thickness limit specified, the lot is not acceptable; or
- F In lieu of steps A to 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 Subsections 4.4.1, Shell Joints and 4.4.2, Heads and Head 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, a professional engineer, 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.

4.3.4 Tanks with a capacity of 10 000 L and more shall have seal welded joints along the inside tank bottom of shell to shell and head to shell lap joints and butt joints with one plate edge offset for the length specified in Figure 2. Radiography of this joint is not required. Refer to Appendix A, Access Openings, for access into the tank to make the seal welds.

4.4 TANK JOINTS

4.4.1 Shell Joints

4.4.1.1 Shell joints shall be of the types shown in Figure 3. When the longitudinal shell seam is a continuous lap joint over the full length of the tank, as shown in joint type S3.5 the seam shall be located within 45° of the top centre line of the tank.

4.4.1.2 Longitudinal shell joints shall be arranged so as not to occur at locations of openings or structural attachments.

4.4.1.3 When more than one plate is required to fabricate the tank shell on tanks 10 000 L or larger, the longitudinal shell joints shall be staggered by 100 mm except in the case where a longitudinal lap joint is used in combination with a circumferential butt joint.

4.4.1.4 Joint S3.5 may be used on longitudinal seams without internal seal welding on tanks up to and including 2500 mm diameter, providing that the inside lap is positioned down in order to permit liquid to run out of the joint and located within 45° of the top centre line.

4.4.2 Heads and Head Joints

4.4.2.1 Heads shall be fabricated of not more than three pieces. When two or more pieces are used, double welded butt joints shall be used.

4.4.2.2 Heads shall be attached to the shell by one of the joints illustrated in Figure 4.

4.4.2.3 The flange depth shall be equal to $6 \cdot t_h$ or 25 mm whichever is the greater, where t_h is equal to the head thickness in millimetres.

4.4.2.4 An unflanged flat head shall be braced in accordance with Figure 5. The reinforcing members may be attached to either the inside or the outside of the head.

4.4.2.5 A *primary tank* incorporating turning lugs or using flat, unflanged heads shall require the attachment of a reinforcing plate to the centre of each head in accordance with Figures 6 and 7. The reinforcing plate shall be of a minimum diameter of 600 mm and a minimum thickness equal to that of the *primary tank* heads.

4.4.3 Alternative Compliance Path for Heads, Head Joints and Shell Joints

4.4.3.1 Conformance to the requirements of Subsection 4.4.1, Shell Joints and 4.4.2, Heads and Head Joints, need not be demonstrated when the tank conforms to the requirements of Subsection 8.3, Alternative Compliance Path.

4.5 TANK CONNECTIONS

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

- A Forged steel threaded flanges or steel pipe couplings as illustrated in Figure 8; or
- B ANSI Class 150 Steel Pipe Flanges, as illustrated in Figure 8.

4.5.2 Threaded connections as specified in Designs 8.1 through 8.4 of Figure 8 shall be attached to the shell with full fillet welds. Precautions shall be taken to ensure that as a result of welding, the threads are not warped or damaged.

4.5.3 The minimum length of threads, corresponding to the pipe size for Designs 8.1 through 8.4 shall be as specified in Figure 8.

4.5.4 Flanged connections shall be as shown in Design 8.5. Pipe wall thickness corresponding to the pipe size is shown in Figure 8 with flanges of minimum ANSI Class 150, limited to 273.0 mm maximum outside diameter pipe.

4.5.5 Flanged connections shown in Design 8.6 for pipe sizes 114.3 mm to 610.0 mm outside diameter shall have pipe wall thicknesses of the size specified in Figure 8. ANSI Class 150 flanges and reinforcing plates shall be used.

4.5.6 Flanged fittings shall be installed such that bolt holes straddle the longitudinal centre line.

4.5.7 Except as indicated in Clauses 4.5.8, 4.5.9.1 and 4.5.9.2, all openings shall be located in the top of the tank parallel with its longitudinal axis.

NOTE: Where the requirements of this Standard are applied by reference from Standard CAN/ULC-S656, Standard for Oil-Water Separators, the locations of the connections may vary from the limits imposed by Clauses 4.5.7 to 4.5.10.

4.5.8 If the application of a tank is such that tank connections are required to be grouped, the openings may be located in the *manway* cover or off the centre of the longitudinal axis under the conditions specified in Clauses 4.5.9.1 and 4.5.9.2.

4.5.9.1 For fuel storage tanks, no fitting shall be located more than 300 mm off the longitudinal centre line of the top as measured along the tank circumference, unless located in a *manway* cover. The top face of the tank connection fitting welded to the tank shall terminate above the top of the shell.

4.5.9.2 For oil-water separators, no head fitting shall be mounted below the 90 % volume liquid level, and head fittings shall conform to the requirements of Figure 8, Design 8.6.

4.5.10 The minimum distance between the centre line of two adjacent connections shall not be less than the sum of their nominal diameters.

4.5.11 The maximum internal diameter of any one connection shall not be greater than the *primary tank* internal diameter divided by four ($D/4$)

4.5.12 The threaded openings shall be provided with closures of malleable iron plugs, cast iron plugs, plastic plugs, or plastic venting closures at the point of manufacture. Metal plugs shall have non-hardening sealing compound applied. Three of the openings in each tank or each compartment of a tank may have plastic plugs or plastic venting closures as temporary closures to permit venting of the tank. The venting closures shall be designed in a manner that prevents accidental pressurization or depressurization of the