NATIONAL
STANDARD
OF CANADA

CAN/ULC-S603-14

# STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

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**NATIONAL STANDARD OF CANADA**

**CAN/ULC-S603-14**

# STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

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# STANDARD FOR STEEL UNDERGROUND TANKS FOR FLAMMABLE AND COMBUSTIBLE LIQUIDS

## PREFACE

This is the Fourth Edition of the Standard for Steel Underground Tanks for Flammable and Combustible Liquids, CAN/ULC-S603.

This Edition of the Standard has been 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.

Appendices A to 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 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 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.

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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

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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

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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

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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

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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

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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

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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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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

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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

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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

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## 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/m$^3$ 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/m$^3$ 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·'$t_h$' 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

tank due to temperature change, precludes their removal by environmental forces and prevents water from getting into the tank during yard storage. When malleable iron or cast iron plugs are used they shall be made hand tight only after testing of the tank.

4.5.13 For shipping purposes only, all flanged openings shall be fitted with a plywood cover of 18.5 mm minimum thickness, or a metal cover of 2 mm minimum thickness, or a special purpose plastic flange protector.

4.5.14 When equipped with a *manway*, fittings for the *primary tank* may be welded into the *manway* cover. (Refer to Figure 9). The fittings shall be either threaded or flanged.

## 4.6 VENT OPENINGS

4.6.1 Each compartment of a tank shall have provision for the attachment of a vent pipe of a size not less than that specified in Table 2.

## 4.7 MANWAY DESIGN

4.7.1 Except as provided in Clause 4.7.2, *manways* shall be fabricated in accordance with Figure 10. *Manway* designs 10.2 and 10.3 shall incorporate reinforcing plates when installed on tanks or compartments greater than 50 000 L capacity.

4.7.2 Any *manway* other than that described in Clause 4.7.1 shall be designed by a professional engineer.

4.7.3 A *manway*, when provided, shall be of a bolted cover type and shall be located above the point of highest liquid level.

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 with reference to the gasket manufacturer's documentation.

## 4.8 LIFTING

4.8.1 All tanks shall be equipped with a clearly identified lifting method, as described in the manufacturer's installation instructions.

4.8.2 Where lifting lugs are used, they shall be fabricated in accordance with Figure 11 and shall be installed in accordance with Figure 12. Tanks with a capacity of 5 000 L or less may be equipped with one lifting lug. Lifting lugs for tanks with a capacity of 50 000 L or less do not require reinforcing plates.

4.8.3 The lugs, as installed in accordance with Figure 12, shall be located to avoid shell seams, fittings and/or *manways*.

4.8.4 Lifting methods which do not conform to Figure 11, shall be tested in accordance with the requirements in Subsection 8.1, Lifting Test.

4.8.5 In lieu of testing in accordance with Subsection 8.1, Lifting Test, calculations stamped by a professional engineer may be used to determine compliance.

## 4.9 INTERNAL PROTECTION

4.9.1 Steel wear plates shall be installed in all tanks as described in Clauses 4.9.2 through 4.9.4.

4.9.2 All wear plates shall be curved to fit the inside radius of the tank.

4.9.3 Tanks of diameter 1 300 mm and less shall have 6 mm thick steel wear plates continuously welded to the inside bottom of the tank beneath each fitting. The wear plates shall be minimum 250 mm wide and 250 mm long for single fittings. For multiple fittings placed in a row, the minimum dimensions for the wear plates shall be 250 mm wide by the distance between the extreme fitting centres plus 250 mm.

4.9.4 Tanks of diameter greater than 1 300 mm shall have a minimum 6 mm thick steel wear plate continuously welded to the inside bottom at each end of the tank as illustrated in Figure 13.

## 4.10 MULTI-COMPARTMENT TANKS

4.10.1 Multi-compartment tanks shall be fabricated using double bulkheads only (Refer to Figure 14).

4.10.2 Double bulkheads shall be fabricated of not more than 3 pieces. When 2 or more pieces are used, joints shall be double welded butt joints.

4.10.3 Fittings of minimum 48.3 mm diameter located along the top centre line shall be provided between compartments in order to provide a means for monitoring product leakage between compartments.

4.10.4 All compartment bulkhead head to shell attachment joints shall be full fillet welds. Where *manways* are not provided, access openings in accordance with Appendix A, Access Openings, shall be provided to permit welding and testing of compartment heads.

4.10.5 Compartment bulkhead thicknesses shall be the same as tank head thicknesses as determined by tank diameter from Table 1.

4.10.6 Designs that do not conform to the requirements of Clause 4.10.5 may be used in the construction of the tank, when the tank conforms to the requirements of Subsection 8.3, Alternative Compliance Path, except that the minimum bulkhead thickness shall be 3.12 mm.

# 5 SINGLE WALL TANKS

## 5.1 GENERAL

5.1.1 The minimum shell thickness of a tank shall be in accordance with the requirements of Subsection 5.2, Table of Fixed Thickness Values, or Subsection 5.3, Roark Formula, or the tank shall comply with the requirements of Subsection 8.3, Alternative Compliance Path.

5.1.2 All tanks shall have a minimum head thickness in accordance with the requirements of Table 1.

5.1.3 Designs that do not conform to the requirements of Clause 5.1.2 may be used in the construction of the tank, when the tank conforms to the requirements of Subsection 8.3, Alternative Compliance Path.

## 5.2 TABLE OF FIXED THICKNESS VALUES

5.2.1 Table 1 shows the minimum shell thickness for a range of tank diameters and lengths covered by the requirements of this Standard, for burial depths up to 1 m.

5.2.2 Designs that do not conform to the requirements of Clause 5.2.1 may be used in the construction of the tank, when the tank conforms to the requirements of Subsection 8.3, Alternative Compliance Path.

## 5.3 ROARK FORMULA

### 5.3.1 Shell Thickness Calculations

5.3.1.1 The calculated pressure from the Roark equation shall be equal to or greater than the external pressure at the bottom of the tank surrounded by only water and submerged 1.5 m or at a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The buckling pressure shall be calculated using the following equation:

$$P= [\ 0.807E_st_s^2 / (Lr)\ ]\cdot[\ (1-u^2)^{-3}(t_s/r)^2\ ]^{.25}$$

where:

- $P$ is buckling pressure, kPa;
- $E_s$ is modulus of elasticity of steel (203.4 x $10^6$ kPa for structural grade A36 carbon steel);
- $t_s$ 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).

NOTE: Reference: Roark's Formulas for Stress and Strain, 6th Edition, Warren Young, Table 35, Case 19b, Page 690

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

$$t_{s\ min} = [(P_1L^{3/2}(1-u^2)^{3/4})/(0.807E_s)]^{0.4}$$

$$L_{max} = [0.807E_st_s^2/P_1r][(1-u^2)^{-3}(t_s/r)^2]^{0.25}$$

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 x $10^6$ 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).

5.3.1.3 Values for "$E_s$" and "u" for other than A36 structural grade carbon steel shall be from recognized technical reference books or established by an engineering evaluation of the material.

5.3.1.4 Where a tank meets the requirement of Subsection 8.2, External Pressure Test, the minimum shell thickness may be reduced by 25 % from the value calculated using the Roark equation for a tank of the same length and diameter.

5.3.1.5 Single wall tank shall have a minimum shell thickness of 3.12 mm.

### 5.3.2 Stiffener Thickness Calculations

5.3.2.1 Where there is one stiffener added to the midpoint of a tank, the tank length may be increased by 25 %. Where two stiffeners are added and placed at the 1/3 and 2/3 positions of a tank, the tank length may be increased by 40 %. In accordance with Clause 4.1.2, the overall length of a tank shall not be greater than 6 times its diameter. Other arrangements of stiffeners shall require an engineering evaluation.

5.3.2.2 Stiffeners shall be intermittently welded at spots located at a minimum of 25 mm but not over 300 mm apart, and extend 360° around the tank. The stiffeners shall have an opening at the top and bottom so that liquid and vapour can move past the stiffeners.

5.3.2.3 The required moment of inertia (Ireq) of the stiffener is described below:

$$I_{req} = 0.11PL_{rs}D^3/E_s$$

where:

- $P$ 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 ($203.4 \times 10^6$ kPa for structural grade A36 carbon steel);
- $L_{rs}$ is rib spacing, mm; and
- $D$ is outer diameter of tank, mm.

5.3.2.4 The moment of inertia of the stiffener shall be verified from tables or calculations from recognized technical reference books, or the tank with stiffeners shall meet the requirements of Subsection 8.2, External Pressure Test.

NOTE: The Canadian Institute of Steel Construction (CISC) Handbook on Steel Construction, 9th Edition is an acceptable reference.

5.3.2.5 Where a bulkhead is intended to be used as a stiffener, it shall also meet the requirements of this Subsection.

# 6 DOUBLE WALL TANKS

## 6.1 PRIMARY TANKS

6.1.1 The *primary tank* shall be constructed in accordance with the applicable requirements in Section 4, Construction - General, of this Standard.

6.1.2 When equipped with a *manway*, fittings for the *primary tank* may be welded into the *manway* cover. (Refer to Figure 9). The fittings shall be either threaded or flanged.

6.1.3 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.

## 6.2 SECONDARY CONTAINMENT

### 6.2.1 General

6.2.1.1 The configuration of the *secondary containment* shall be in accordance with Figure 15.

6.2.1.2 *Double wall tanks* shall have the *secondary containment* cover a minimum of 300° of the circumferential surface area of the *primary tank*, or a surface area corresponding to 95 % of the internal volume of the *primary tank*, whichever is greater, including 100 % coverage of the *primary tank* heads.

6.2.1.3 The *secondary containment* shall be constructed with materials in accordance with Subsection 4.2, Materials.

6.2.1.4 The material thickness of the *secondary containment* heads shall be not less than the thickness of the *primary tank* heads.

6.2.1.5 The material thickness of the *secondary containment* shell shall be in accordance with Table 3, or a minimum of 2.3 mm when calculated in accordance with the Roark equation described in Subsection 5.3, Roark Formula.

6.2.1.6 The equivalent steel thickness of the secondary shell for *double wall tanks* is:

$$t_{eq} = (t_{primary}^{2.5} + t_{secondary}^{2.5})^{0.4}$$

The equivalent thickness value is substituted into the Roark equation described in Subsection 5.3, Roark Formula.

6.2.1.7 Conformance to the requirements of Clauses 6.2.1.3 to 6.2.1.6 need not be demonstrated when the tank conforms to the requirements of Subsection 8.3, Alternative Compliance Path.

### 6.2.2 Configuration

#### 6.2.2.1 General

6.2.2.1.1 Construction of the *secondary containment* shall be separate from, but may include, attachment to the *primary tank* by stitch welding, provided that the stitch welded joint is within the monitored *interstice*. The *secondary containment* may also be in intimate contact with the outer surface of the *primary tank*. Typical *secondary containment* head and shell configurations are shown in Figures 6, 7 and 16.

6.2.2.1.2 The *secondary containment* shall provide a continuous *interstice* in that area of the final assembly that is considered to be double wall.

6.2.2.1.3 In 360° *double wall tanks*, the welded connection of the fittings to the *primary tank* shall be within the *interstice*. (Refer to Figure 17.)

#### 6.2.2.2 Provision for Connection Rings/Collars and Leak Detection

6.2.2.2.1 The *secondary containment* may be equipped with an integral connection ring/collar for field attachment of a *spill containment sump* or *manway* riser.

6.2.2.2.2 Where provided, the *spill containment sump* or *manway* riser shall be attached to the collar by seal welding or bolting of a liquid tight design with gaskets in accordance with the requirements of Clause 4.7.4.

6.2.2.2.3 When a continuous interstitial monitoring system is required, the tank design shall provide a means for the connection of the system to be accessible from ground level.

### 6.3 WELD JOINTS

6.3.1 Weld joints of the type shown in Figures 3, 4 and 5 of the *primary tank* weld joint procedure, and in accordance with Figures 1, 6, 7, 9 and 15 through 17, shall be used for the construction of the *secondary containment* head and shell joints.

*Exception: Weld joint S3.5 in Figure 3 also applies to all tank sizes, diameters and all steel thicknesses.*

### 6.4 FACTORY TESTING

6.4.1 The *primary tank* shall be leak tested in accordance with Subsection 9.1, Production Leak Test, prior to the attachment of the *secondary containment*.

6.4.2 Pressure testing of the *interstice* shall be in accordance with Subsection 9.1, Production Leak Test, with the *primary tank* pressurized and maintaining an internal pressure as required in Table 4.

NOTE: The air supply for use in testing the *interstice* must be taken from the *primary tank* and regulated to prevent over pressurizing.

## 7 ACCESSORIES

### 7.1 HEATING COILS AND HOT WELLS

7.1.1 A heating coil or hot well that is provided as part of a tank assembly and that handles a fluid other than that stored in the tank, such as steam or hot water, shall have no threaded joints in that portion located within the tank. The coil or hot well connection shall exit from the tank above the liquid level, unless made of steel having a wall thickness not less than that specified for that portion of the tank shell through which the connection exits. A continuous full fillet weld shall be made where a connection pierces the tank or a *manway* cover.

### 7.2 SUPPLEMENTARY EQUIPMENT

7.2.1 The following supplementary equipment shall be supplied with each tank by the manufacturer:

A A gauge chart; and

B A gauge stick of minimum 11 mm by 19 mm with a length 800 mm greater than the tank diameter plus the maximum burial depth, graduated in centimetres.

## 8 PERFORMANCE TESTS

### 8.1 LIFTING TEST

8.1.1 Lifting methods, as specified by the tank manufacturer, shall be capable of lifting a mass equivalent to twice the mass of an empty tank without deformation of the tank or leakage, when tested in accordance with Clause 8.1.2.

8.1.2 While containing water equal to the mass of an empty tank, a representative tank shall be suspended by the lifting device for at least 1 min. After unloading, the tank shall be examined for deformation and shall not leak when subjected to a leakage test as described in Subsection 9.1, Production Leak Test.

## 8.2 EXTERNAL PRESSURE TEST

8.2.1 A tank shall not leak, collapse or implode or buckle (defined as deflection of 5 % of the tank diameter) when subjected to the conditions described in Clause 8.2.2. The tank selection shall represent the worst case for the range of tank sizes under evaluation. Diameter deflections shall be measured according to the procedure of Clause 8.3.6.3.

8.2.2 An empty tank shall be installed in a test fixture that will facilitate the tank to be submerged in water. The support structure for the test tank shall not add additional tensile or compressive stresses to the bottom of the test tank. Water is then added to the test fixture until the tank is submerged 1.5 m or to a depth equal to the manufacturer's specified maximum burial depth, whichever is greater. The tank is to remain submerged for 1 h.

8.2.3 Conformance to the requirements of Clauses 8.2.1 and 8.2.2 need not be demonstrated when the tank conforms to the requirements of Subsection 8.3, Alternative Compliance Path.

## 8.3 ALTERNATIVE COMPLIANCE PATH

NOTE: The requirements and exceptions described in this Standard require tank assemblies demonstrating compliance via the alternative compliance path to meet the applicable requirements of Subsections 4.1, Capacities and Dimensions, through 4.3, Welding; Subsection 4.5, Tank Connections through Clause 4.10.4; Subsection 6.1, Primary Tanks; Subsections 6.2.2, Configuration, through 8.1, Lifting Test; and Sections 9, Production Test, through 12, Shipping and Installation. Tank assemblies demonstrating compliance via the alternative compliance path need not meet the following requirements: Subsection 4.4, Tank Joints; Clause 4.10.5; Clause 5.1.2; Subsections 5.2, Table of Fixed Thickness Values and 5.3, Roark Formula; Subsection 6.2.1, Secondary Containment - General; and Subsection 8.2, External Pressure Test.

### 8.3.1 General

8.3.1.1 The largest length of each given tank diameter shall be tested in accordance with the requirements of Subsections 8.3.3, Leakage Test, through 8.3.7, Flood Loading. However, the same tank sample is not required to be subjected to all tests. For spherical tanks that differ only in diameter, only the largest diameter tank is required to be tested.

8.3.1.2 All references to values of pressure and vacuum, unless otherwise indicated, shall be considered as ″gauge″.

8.3.1.3 Measurements of tank diameter shall be recorded at the approximate centre point of the tank, for comparison purposes, before and after the backfilling process and 18 h after the installation has been completed. The deflection shall not exceed ± 5 % of the original diameter.

### 8.3.2 Manways

8.3.2.1 Where *manway* assemblies are provided, the largest size *manway*, shall be assessed by including it in a performance tested tank design as provided for in this Standard.

### 8.3.3 Leakage Test

8.3.3.1 Single wall tanks shall be tested and proved tight against leakage by applying a minimum internal air pressure of 35 kPa (21 kPa for tanks larger than 3050 mm (10 ft) diameter). The test pressure shall be held for not less than 30 min. When the required pressure is achieved, the source of pressure shall be removed and the tank, including all joints and plugs, shall be tested for leakage with a soap solution or other acceptable liquid.

8.3.3.2 *Double wall tanks*, and multi-compartment tanks shall be checked for leakage by applying 35 kPa pressure or vacuum (21 kPa for tanks larger than 3050 mm (10 ft) diameter) to the *interstitial space* and/or *monitorable bulkheads* while all compartments of the *primary tank* are vented to atmosphere. When the required pressure is achieved, the source of pressure shall be removed and the test pressure or vacuum shall be held for 30 min without loss or gain of 1.0 kPa.

8.3.3.3 As an alternative to Clause 8.3.3.2, and where pressure is used to check for leakage of the tank, the compartments of the *primary tank* and the exterior wall of the tank may be checked for leakage by application of a soap solution to both the interior surface of each compartment of the *primary tank* and the exterior surface of the tank and checking for bubbles. Any wall not capable of soap testing will require the pressure or vacuum test in accordance with Clause 8.3.3.2.

NOTE: Vacuum or pressure readings may require compensation in accordance with the Ideal Gas Law (PV = nRT) for changes in temperature or atmospheric pressure that occur during the test period.

### 8.3.4 Tank Integrity Testing

8.3.4.1 The empty sample of a *primary tank* or each compartment of a multi-compartment tank and simultaneously the *interstitial space* of a *double wall tank* or multiple wall tank, if applicable, shall be subjected to a continuous internal pressure or vacuum of not less than 35 kPa (21 kPa for tanks larger than 3050 mm (10 ft) diameter) for a period not less than 30 min. The tank shall not collapse and the *interstitial space* and/or space between *monitorable bulkheads* and the tank shall not leak when tested in accordance with the requirements of Subsection 8.3.3, LeakageTest, as applicable.

8.3.4.2 Each *interstice* of a double wall or multiple wall tank shall be tested by connecting a vacuum or pressure source to the *interstice*, depending on the intended method of monitoring, at a vacuum or pressure not be less than 1.5 times the manufacturer's recommended monitoring vacuum or pressure. The developed vacuum or pressure shall be maintained for not less than 30 min. The tank shall not collapse and the *interstitial space* and/or space between *monitorable bulkheads* and the tank shall not leak when tested in accordance with the requirements of Subsection 8.3.3, Leakage Test.

8.3.4.3 Each *interstice* of a double wall or multiple wall tank intended for liquid filled monitoring shall be tested for integrity at a pressure equal to 1.5 times the static pressure developed when filled in accordance with the manufacturer's printed instructions and maintained for a minimum of 30 min. The tank shall not leak when tested in accordance with the requirements of Subsection 8.3.3, Leakage Test, or as indicated by loss of liquid in the monitoring system if the *interstice* is tested by filling with liquid.

### 8.3.5 Hydrostatic Pressure

8.3.5.1 The tank shall be designed to withstand hydrostatic testing at a pressure of 175 kPa (103 kPa for tanks larger than 3050 mm (10 ft) in diameter) with no evidence of rupture or leakage when conducted in accordance with the requirements of Clauses 8.3.5.2 and 8.3.5.3, as applicable.

8.3.5.2 A sample tank complete with fittings and of the capacity and design for which acceptance is required, shall be placed on a 300 mm *crushed stone* or *pea gravel* bed. At the manufacturer's option, placement of the tank with backfill to a maximum of 25 % of the vertical height of the tank shall be permitted to prevent bending of the tank due to static water load. The *primary tank* shall be filled with water and subjected to an internal hydrostatic pressure of 175 kPa (103 kPa for tanks larger than 3050 mm (10 ft) diameter), measured at the top of the tank, which should be gradually applied in increments of 35 kPa and held for 5 min at each pressure level. This pressure shall be maintained for 60 min.

8.3.5.3 For multi-compartment tank bulkheads, a hydrostatic pressure of 175 kPa (103 kPa for tanks larger than 3050 mm (10 ft) diameter) shall first be applied to one compartment, while the adjacent compartment is full of water and vented, as described in Clause 8.3.5.2. Then, after release of the pressure on one compartment, the same pressure shall be applied, in the same manner, to each other compartment. As an alternative, the tank may be buried for this test according to the requirements of Clause 8.3.6.2.

8.3.5.4 The sample tank shall then be emptied and then tested as described in Subsection 8.3.3, Leakage Test, as applicable.

### 8.3.6 Concentrated Loading

8.3.6.1 The tank shall be designed to withstand a concentrated load of 10 600 kg on the top centre line of the tank applied in the manner described in Clause 8.3.6.2 with no evidence of buckling or failure.

8.3.6.2 A sample tank in an empty condition shall be installed in a pit and anchored in accordance with the manufacturer's printed instructions. The tank shall then be backfilled with *crushed stone* or *pea gravel* to a level of 900 mm above the top centre line of the tank.

NOTE: Backfill materials other than *pea gravel* or *crushed stone* may be used according to the specification of the manufacturer when the purpose of the test is to qualify the tank for installation in such alternate backfill materials.

8.3.6.3 Measurements of tank diameter shall be recorded at the approximate centre point of the tank, for comparison purposes, before and after the backfilling process and 18 h after the installation has been completed. The change in diameter shall not exceed ± 5 % of the original diameter.

8.3.6.4 While installed, the sample tank shall be subjected to a concentrated load of 10 600 kg at grade level applied through 480 by 480 mm contact area above the centre of the tank at the midpoint of its length for a minimum of 120 min.

8.3.6.5 After the test period, the load, and then the backfill, shall be removed and the tank examined for structural damage. As an alternative, this may be done at the completion of the flood loading test, as described in Subsection 8.3.7, Flood Loading.

8.3.6.6 The tank shall then be subjected to a leakage test in accordance with Subsection 8.3.3, Leakage Test, as applicable. There shall be no evidence of leakage during the test.

### 8.3.7 Flood Loading

8.3.7.1 The tank shall be designed to withstand the unusual loading conditions resulting from flooding at the site and shall be tested as described in Clauses 8.3.7.2 through 8.3.7.7 with no evidence of buckling or failure. For *double wall tanks* and multiple wall tanks the *interstice* and the *primary tank* shall be manifolded during the test.

8.3.7.2 The sample tank, in an empty condition, shall be installed in accordance with Clause 8.3.6.2. The test pit shall be filled with water, level with the top of the backfill, and maintained in this condition for a period of 18 h.

8.3.7.3 Measurement of vertical diameter (or height) at the approximate centre point of the tank shall be recorded before and after flooding.

8.3.7.4 Following the 18 h test, the change in diameter shall not exceed ± 5 % of the original diameter before flooding.

8.3.7.5 Following the above test period, the sample tank shall be subjected to an internal vacuum of 35 kPa for a period of not less than 5 min while maintaining the conditions described in Clause 8.3.7.2.

8.3.7.6 The backfill shall be removed and the tank shall then be tested in accordance with the requirements of Subsection 8.3.3, Leakage Test, as applicable. There shall be no evidence of leakage.

8.3.7.7 The tank shall be examined for structural damage.

### 8.3.8 Tank Connections

8.3.8.1 Each connection shall be capable of withstanding a torque applied in accordance with the test method described in Clauses 8.3.8.2 and 8.3.8.3 with no evidence of damage or leakage as a result of these tests.

8.3.8.2 Torque shall be applied to representative threaded connections attached to the shell of the sample tank, to the minimum values shown in Table 5.

8.3.8.3 The torque specified in Table 5 shall be applied in approximately 5 equal increments over a 10 min interval.

8.3.8.4 The tank and connections shall be examined for evidence of cracking, splitting or stripping of threads, or failure of the weld between the tank and a connection.

8.3.8.5 The tank shall then be subjected to an aerostatic leakage test in accordance with Subsection 8.3.3, Leakage Test, as applicable. There shall be no evidence of leakage.

8.3.8.6 Each connection shall be capable of withstanding a bending moment of 2700 N·m applied in accordance with the test method described in Clauses 8.3.8.7 and 8.3.8.8. There shall be no evidence of leakage or damage.

8.3.8.7 A total bending moment of 2700 N·m acting in a vertical plane coincident with, or parallel to, the longitudinal axis of the tank, shall be applied to representative tank connections in approximately 5 equal increments over a 10 min interval.

8.3.8.8 A total bending moment of 2700 N.m acting in a vertical plane at right angles to the longitudinal axis of the tank, shall be applied to representative tank connections in approximately 5 equal increments over a 10 min interval.

8.3.8.9 The tank and connections shall be examined for evidence of cracking or splitting or failure of the weld between the tank and a connection.

8.3.8.10 The tank shall then be subjected to an aerostatic leakage test in accordance with Subsection 8.3.3, Leakage Test, as applicable. There shall be no evidence of leakage.

# 9 PRODUCTION TEST

## 9.1 PRODUCTION LEAK TEST

9.1.1 Each tank shall be tested by the manufacturer after all welding slags have been removed and all fittings and appurtenances such as nylon bushings[1] and anode plate connector assemblies, etc., which are appropriate to its use, have been fitted. Each tank shall be proven tight against leakage at all points

[1]For recommended practice for the installation of nylon bushings, refer to CAN/ULC-S603.1, Standard for External Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids.

including welds, threaded joints, fittings and *manways* by applying pressure in accordance with Table 4. While the pressure is maintained, a soap solution, or equivalent, shall be brushed or poured over all seams, threaded connections, flanged connections, bolts, etc. A complete inspection of the entire tank surface for flaws in the welds or parent metal shall then be made.

NOTE: The air supply for use in testing tanks shall be regulated to prevent over pressurizing. Use of a plug designed to relieve pressure at 40 kPa is recommended.

9.1.2 If leaks are noted during the test, the pressure shall be removed, the tank reworked and then retested. Defects in welds shall be repaired by grinding, chipping or gouging the defective weld from one or both sides of the joint, as required, and re-welding. For steel 3 mm or less in thickness, repairs to leaks may be made by welding over the defects.

NOTE: The exterior of the tank may be primed to prevent atmospheric weathering during storage.

9.1.3 After testing, the plugs in all openings shall be backed off to a hand tight position.

### 9.2 VACUUM HOLD TEST

9.2.1 A vacuum test shall be performed only on a *double wall tank*.

9.2.2 A minimum vacuum of 63 kPa gauge shall be drawn on the *interstice*. The vacuum reading shall be recorded daily over a 5-day period. If a continuous decrease in gauge reading occurs, remedial action in accordance with Clause 9.2.3 shall be taken.

NOTE: A vacuum decrease less than 9 kPa would not require remedial action.

9.2.3 The tank shall be re-tested in accordance with Subsection 9.1, Production Leak Test. All detected leaks shall be repaired and the tank re-tested in accordance with Clause 9.2.2.

9.2.4 The tank shall be stored and shipped with the vacuum on the *interstice* applied. The vacuum at time of shipment shall be recorded on the daily vacuum record as described in Clause 9.2.2 and the record shall be kept for a minimum period of 1 year. Where, at time of shipment, a vacuum reading more positive than 51 kPa exists on the *interstice*, the tank shall not be shipped and immediate remedial action shall be taken.

## 10 INSTALLATION INSTRUCTIONS

10.1 The manufacturer’s installation instructions, maintenance recommendation and a record of the vacuum at the time of shipping shall accompany each tank. The instructions should include but not be limited to the following information:

A Base preparation and backfill requirements;

B Lifting and handling instructions;

C Venting;

D The maximum test pressure for single wall tanks;

E The maximum burial depth;

F Instructions for installation and operation of alternative compatible leak detection and/or monitoring devices, if applicable

G Requirement that the stored product is compatible with the material of construction, including gaskets; and

H Requirement that the installer consult with the *authority having jurisdiction* to ensure that the applicable Federal, Provincial and Local Codes are met prior to installation.

NOTE: Refer to Appendix B, Monitoring After Burial, for information pertaining to monitoring the tank for leakage after burial.

## 11 MARKING

11.1 The following information shall be engraved or stamped on a corrosion-resistant nameplate permanently attached to the tank:

A Name of tank manufacturer;

B Serial Number of tank;

C ″Single Wall Storage Tank” or ″Double Wall Storage Tank″;

D For *double wall tanks* “Secondary Containment Wrap is x°”, where x identifies the angular value;

E For single wall tanks “Refer to manufacturer’s instructions for maximum test pressure” and « Reportez-vous aux instructions du fabricant pour une pression maximale de l’essai »;

F *Primary tank* capacity, L;

G Year of manufacture;

H “Maximum operating pressure, 7 kPa”;

I “Maximum operating vacuum, 300 Pa”;

J “Compartment Tank - Cap: Comp 1 * L; Comp 2 * L”, (where applicable); and

*Specify Capacity

K Grade(s) of steel used for construction of the *primary tank*.

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

11.2 Where a metal nameplate is used, it shall be clamped onto the mounting plate as shown in Figure 18 and shall be seal welded continuously to the tank shell. The nameplate shall be located on or within 150 mm of the top longitudinal centre line of the tank. Where the tank manufacturer supplies a *spill containment sump*, the nameplate shall be installed in the *spill containment sump*.

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.

11.4 In addition, each tank shall be clearly marked in the location shown in Figure 19 in letters 25 mm high in a contrasting colour with the following information:

A ″REMOVE TEMPORARY PLUGS″;

B ″UNUSED OPENINGS SHALL BE MADE LEAK TIGHT″;

C Located at the lifting device(s) of the tank:

″MAXIMUM TANK WEIGHT _ kg (_ lb)″;

D “MAXIMUM BURIAL DEPTH: _____m

NOTE: The burial depth is measured from the top of the tank shell to grade”;

E Located at the negative pressure (vacuum) gauge:

″DOUBLE WALL TANK - VACUUM IS DRAWN BETWEEN WALLS - IF GAUGE READING IS LESS THAN 42 kPa VACUUM - DO NOT INSTALL TANK - CONTACT MANUFACTURER″;

F Located at factory attached monitor, when applicable:

″THIS TANK IS EQUIPPED WITH A FACTORY ATTACHED PERMANENT VACUUM MONITOR - FOLLOW MANUFACTURER’S INSTRUCTIONS″;

G Located at monitor standpipe, when applicable:

″MONITOR WELL PIPE SHALL TERMINATE IN A SURFACE BOX AND HAVE A WEATHER TIGHT COVER”; and

H “ENSURE THAT THE STORED PRODUCT IS COMPATIBLE WITH THE CONSTRUCTION MATERIAL, INCLUDING GASKETS”.

## 12 SHIPPING AND INSTALLATION

12.1 All *double wall tanks* constructed to this Standard shall be shipped to the installation site with a minimum vacuum of 51 kPa gauge drawn on the *interstice*.

12.2 Each *double wall tank* shall be equipped with a visible vacuum gauge, connected to the *secondary containment* in a manner that will register the vacuum drawn on the *interstice*.

12.3 Positive pressure monitoring of the *interstice* shall not be permitted.

# TABLES

## TABLE 1
## CAPACITIES AND DIMENSIONS

(Reference: Clauses 4.2.3, 4.10.5, 5.1.2 and 5.2.1)

| MINIMUM CAPACITY RANGE, L | MINIMUM TANK INSIDE DIAMETER, mm | LITRES PER MILLIMETRE LENGTH | MINIMUM HEAD / BULKHEAD THICKNESS '$t_h$', mm | MAXIMUM LENGTH (mm) FOR CORRESPONDING MINIMUM SHELL THICKNESS, mm | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 790 to 3 920 | up to 1 000 | 0.785 | 1.80 | (2 000) 1.8 | (3 750) 2.30 | (5 000) 2.80 | - | - | - |
| 1 530 to 7 670 | 1 001 to 1 250 | 1.227 | 2.30 | (2 500) 2.30 | (4 250) 2.80 | (6 250) 3.30 | - | - | - |
| 1 730 to 8 630 | 1 251 to 1 300 | 1.327 | 2.30 | (2 500) 2.30 | (4 000) 2.80 | (6 250) 3.30 | (6 500) 3.80 | - | - |
| 2 650 to 13 250 | 1 301 to 1 500 | 1.767 | 2.80 | (3 250) 2.80 | (4 750) 3.30 | (7 000) 3.80 | (7 500) 4.30 | - | - |
| 4 200 to 21 000 | 1 501 to 1 750 | 2.405 | 3.30 | (3 750) 3.30 | (5 250) 3.80 | (7 000) 4.30 | (8 750) 4.70 | - | - |
| 6 280 to 31 410 | 1 751 to 2 000 | 3.142 | 3.80 | (4 250) 3.80 | (6 000) 4.30 | (7 500) 4.70 | (10 000) 5.20 | - | - |
| 8 950 to 44 730 | 2 001 to 2 250 | 3.976 | 4.30 | (4 750) 4.30 | (6 500) 4.70 | (8 000) 5.20 | (10 250) 5.62 | (11 250) 6.12 | - |
| 12 270 to 61 360 | 2 251 to 2 500 | 4.909 | 4.70 | (4 250) 4.30 | (5 500) 4.70 | (7 250) 5.20 | (8 500) 5.62 | (10 500) 6.12 | (12 500) 6.62 |
| 21 210 to 106 000 | 2 501 to 3 000 | 7.069 | 5.62 | (6 500) 5.62 | (8 250) 6.12 | (9 500) 6.62 | (11 250) 7.12 | (13 750) 7.60 | (15 000) 8.60 |
| 28 225 to 141 125 | 3 001 to 3 300 | 8.553 | 6.62 | (6 000) 5.62 | (6 750) 6.12 | (8 500) 6.62 | (9 750) 7.12 | (11 500) 7.60 | (16 500) 8.60 |
| 33 670 to 168 370 | 3 301 to 3 500 | 9.621 | 6.62 | (6 250) 6.12 | (7 000) 6.62 | (9 250) 7.12 | (10 750) 7.60 | (14 500) 8.60 | (17 500) 9.54 |
| 36 640 to 183 200 | 3 501 to 3 600 | 10.179 | 7.12 | (6 250) 6.12 | (7 000) 6.62 | (8 750) 7.12 | (10 500) 7.60 | (13 500) 8.60 | (18 000) 9.54 |
| 50 270 to 250 000 | 3 601 to 4 000 | 12.566 | 7.6 | (8 750) 7.60 | (12 000) 8.60 | (15 000) 9.54 | (20 000) 10.54 | - | - |

## TABLE 2
## VENT PIPE SIZE

(Reference: Clause 4.6.1)

| MAXIMUM NOMINAL CAPACITY OF TANK, L | MINIMUM VENT FITTING PIPE SIZE, mm |
|---|---|
| 2 500 | 42.2 |
| 10 000 | 48.3 |
| 35 000 | 60.3 |
| 75 000 | 73.0 |
| 250 000 | 88.9 |
| NOTE: For guidance in sizing the vent piping in order to prevent pressures in the tank from exceeding 17 kPa (gauge) with various flow rates and pipe lengths, refer to Appendix C, Guidelines for minimum vent line diameters (versus flow rate and pipe length). | |

## TABLE 3
## MINIMUM THICKNESS FOR THE SECONDARY CONTAINMENT SHELL

(Reference: Clause 6.2.1.5)

| PRIMARY TANK INSIDE DIAMETER, mm | SECONDARY CONTAINMENT SHELL MINIMUM THICKNESS, mm |
|---|---|
| Up to 1 600 | 2.30 |
| 1 601 to 3 000 | 2.80 |
| 3 001 to 4 000 | 4.30 |

## TABLE 4
## LEAK TEST PRESSURES

(Reference: Clauses 6.4.2 and 9.1.1)

| | TANK DIAMETER, mm | | |
|---|---|---|---|
| | Up to 1 750 | 1 751 to 3 000 | 3 001 to 4 000 |
| **MINIMUM TEST PRESSURE, kPa (gauge)** | 30 | 20 | 10 |
| **MAXIMUM TEST PRESSURE, kPa (gauge)** | 35 | 30 | 20 |

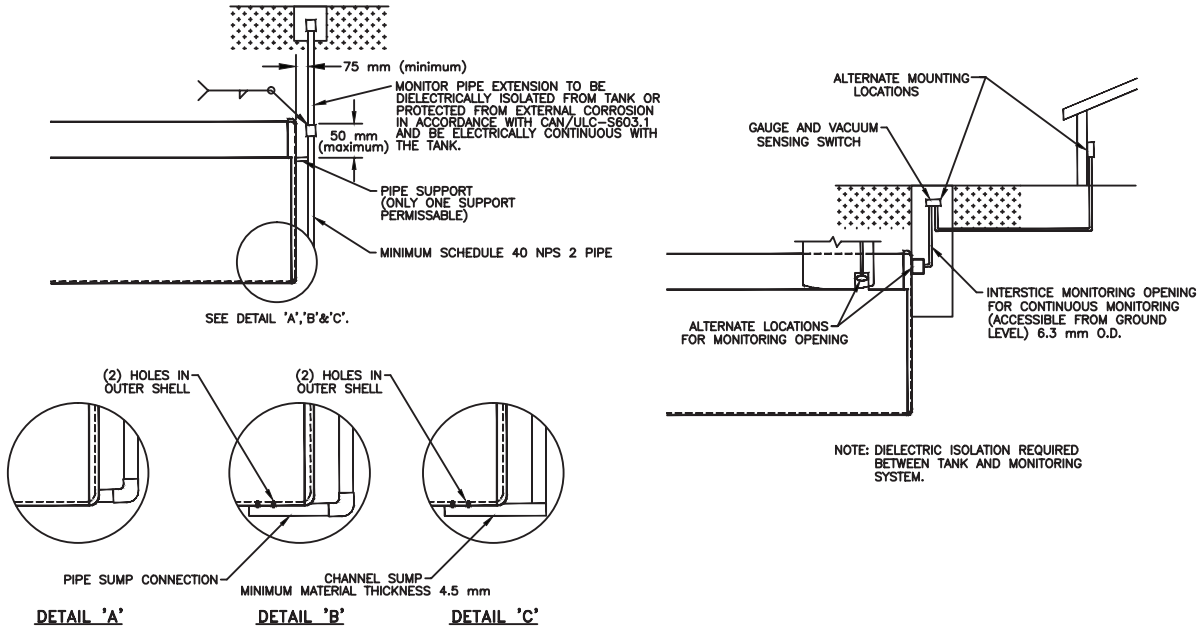
## TABLE 5
## MINIMUM TORQUE STRENGTH OF FITTINGS

(Reference: Clauses 8.3.8.2 and 8.3.8.3)

| Pipe Size, NPS Sch. 40 | Torque, N·m |
|---|---|
| 2 | 1 500 |
| 2-1/2 | 1 600 |
| 3 | 1 650 |
| 3-1/2 | 1 700 |
| 4 | 1 750 |
| 6 | 1 900 |

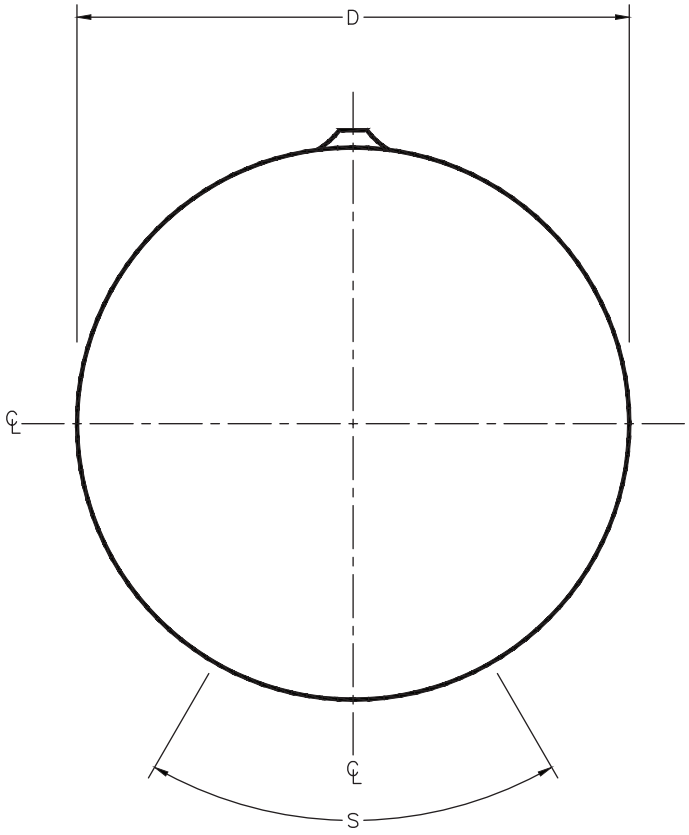
# FIGURES
## FIGURE 1
### TYPICAL LEAK/VACUUM MONITORING

(Reference: Clauses 1.2 and 6.3.1)



## FIGURE 2
### INSIDE SEAL WELDING

(Reference: Clause 4.3.4, Figures 3 and 4)



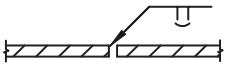
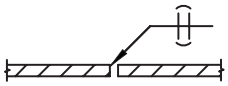
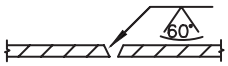
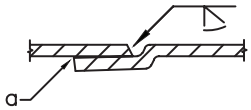
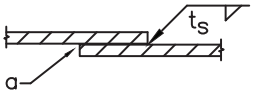
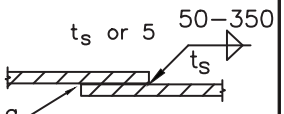

NOTES:

1. D – TANK DIAMETER.
2. S – LENGTH OF SEAL WELD.

| TANK DIAMETER (D), mm | SEAL WELD LENGTH (S), mm |
|---|---|
| Up to 2 000 | 1 000 |
| 2 001 to 2 500 | 1 250 |
| 2 501 to 3 000 | 1 500 |
| 3 001 to 3 600 | 1 750 |
| 3 601 to 4 000 | 2 000 |

## FIGURE 3
### SHELL JOINTS

(Reference: Clauses 4.4.1.1 and 6.3.1, Figures 16, A1)

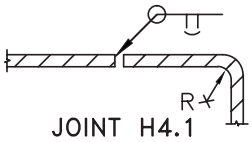
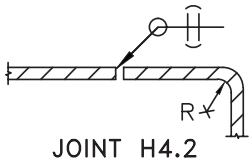
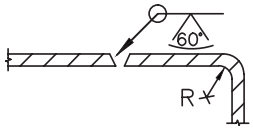
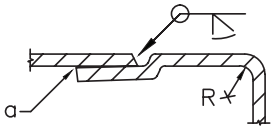
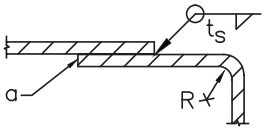
| ILLUSTRATION | TYPE | APPLICATION |
|---|---|---|
|  JOINT S3.1 | Single Welded Square Butt Joint Full Penetration | Limited for use up to and including 1 500 mm diameter and maximum shell thickness of 4.5 mm. |
|  JOINT S3.2 | Double Welded Square Butt Joint Full Penetration | For all diameters and metal thicknesses. |
|   JOINT S3.3 | Bevel Prepared 'V' Groove Butt Joint Full Penetration | For all diameters and metal thicknesses. |
|   JOINT S3.4 | Butt Joint with One Plate Edge Offset Full Penetration | For all diameters and metal thicknesses[a]. |
|   JOINT S3.5 | Single Welded Full Fillet Lap Joint | Limited for use up to and including 2 500 mm diameter and maximum shell thickness of 7 mm minimum overlap 12 mm. This joint must be located within 45° of top centre line on longitudinal joints [a]. See also Clause 4.4.1.4. |
|   JOINT S3.6 | Welded Full Fillet Lap Joint with Intermittant Welding on Inside | For all diameters and metal thicknesses, minimum overlap 12 mm[a]. |

a Tanks 10 000 L and larger shall have seal welding on the inside bottom circumferential and longitudinal joints. See Figure 2.

$t_s$ Shell thickness.

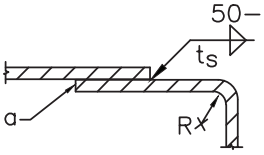
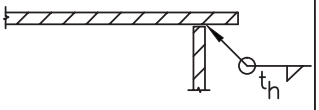
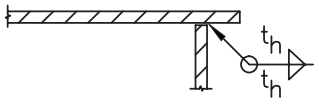
## FIGURE 4
### HEAD JOINTS

(Reference: Clauses 4.4.2.2 and 6.3.1, Figure 16)

| ILLUSTRATION | TYPE | APPLICATION |
|---|---|---|
|  JOINT H4.1 | Single Welded Square Butt Joint Full Penetration | Limited for use up to and including 1 500 mm diameter and maximum shell thickness of 4.5 mm. |
|  JOINT H4.2 | Double Welded Square Butt Joint Full Penetration | For all diameters and metal thicknesses. |
|  JOINT H4.3 | Bevel Prepared 'V' Groove Butt Joint Full Penetration | For all diameters and metal thicknesses. |
|  JOINT H4.4 | Butt Joint with One Plate Edge Offset Full Penetration | For all diameters and metal thicknesses[a]. |
|  JOINT H4.5 | Single Welded Full Fillet Lap Joint | Limited for use up to and including 2 500 mm diameter and maximum shell thickness of 7 mm, minimum overlap of 12 mm[a]. |

## FIGURE 4 (Cont'd)
### HEAD JOINTS

(Reference: Clauses 4.4.2.2 and 6.3.1, Figure 16)

| ILLUSTRATION | TYPE | APPLICATION |
|---|---|---|
| SMALLER OF $t_S$ or 5<br>50–350<br>  <br><br>JOINT H4.6 | Single Welded Full Fillet Lap Joint With Intermittant Welding on Inside | For use on all diameters and metal thicknesses, minimum overlap 12 mm[a]. |
|  <br><br>JOINT H4.7 | Single Welded Full Fillet Tee Joint | Limited for use up to and including 1 500 mm diameter and maximum shell thickness of 4.5 mm. (See Figure 5, Bracing For Unflanged Flat Heads.) |
|  <br><br>JOINT H4.8 | Double Welded Full Fillet Tee Joint | For use on all diameters and metal thicknesses. (See Figure 5, Bracing For Unflanged Flat Heads.) |

a Tanks 10 000 L and larger shall have seal welding on the inside bottom circumferential joints. See Figure 2 and Appendix A.

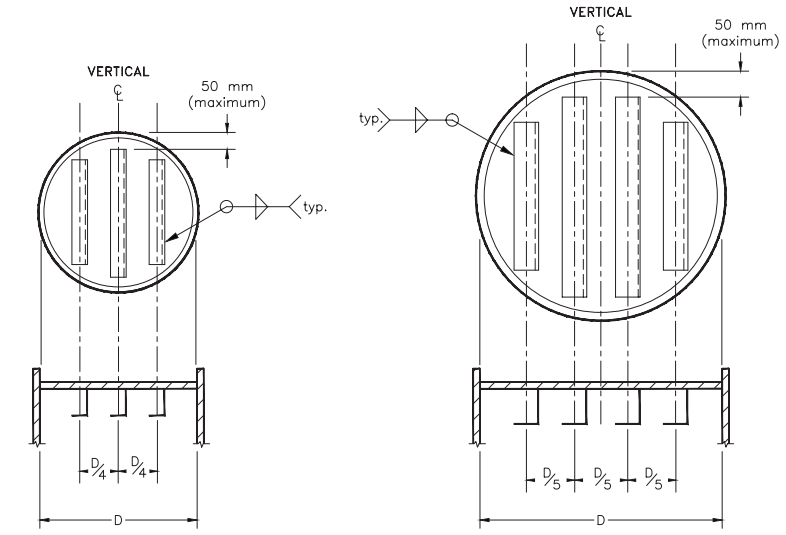
$t_h$ Head Thickness

$t_S$ Shell Thickness

R Minimum Inside Radius $2t_h$

## FIGURE 5
### BRACING FOR UNFLANGED FLAT HEADS

(Reference: Clause 4.4.2.4 and 6.3.1, Figure 4)




DESIGN No. 5.1 (Typical)
FOR TANK DIAMETERS
2 500 OR LESS

DESIGN No. 5.2 (Typical)
FOR TANK DIAMETERS
2 501 TO 4 000 mm

CONTINUOUS WELD SIZE: $(t_h)/2$ but not less than 3 mm.
INTERMITTENT WELD SIZE: $t_h$ but not less than 3 mm.

| NOMINAL HEAD DIAMETER 'D', mm | NO. OF REINFORCEMENTS[b] | CHANNEL SIZE, mm | ANGLE SIZE[a], mm |
|---|---|---|---|
| Up to 1 500 | 3 | C75 x 6 | 55 x 55 x 8 or 65 x 65 x 6 |
| 1 501 - 1 750 | 3 | C75 x 6 | 75 x 75 x 10 or 90 x 90 x 8 |
| 1 751 - 2 000 | 3 | C100 x 8 | 90 x 90 x 13 or 100 x 100 x 10 |
| 2 001 - 2 500 | 3 | C130 x 10 | 100 x 100 x 13 or 125 x 90 x 10 |
| 2 501 - 3 000 | 4 | C150 x 12 | 125 x 125 x 16 or 150 x 100 x 13 |
| 3 001 - 3 600 | 4 | C180 x 15 | 150 x 150 x 13 or 150 x 100 x 16 |
| 3 601 - 4 000 | 4 | C180 x 18 | 150 x 150 x 16 or 200 x 100 x 16 |

[a]Longer leg of angle welded perpendicular to head.
[b]Either angles or channels may be used.
[c]The bottom ends of reinforcing members shall be continuously welded on all sides for the distance that is 150 mm above the bottom of the tank.
$t_h$ — Head thickness.

**FIGURE 6**
**FLANGED HEADS WITH TURNING LUGS**
(Reference: Clauses 4.4.2.5, 6.1.3, 6.2.2.1.1 and 6.3.1)

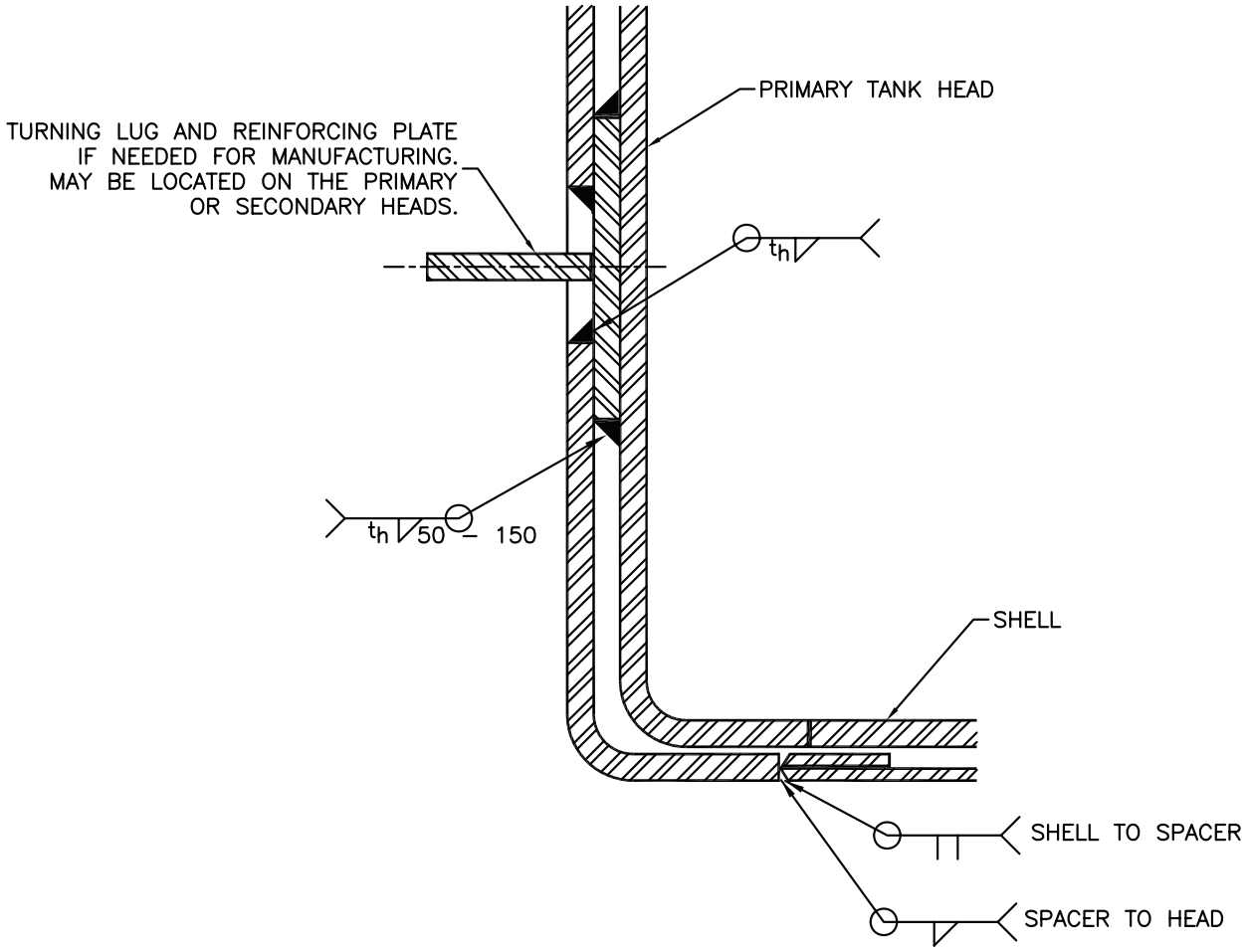
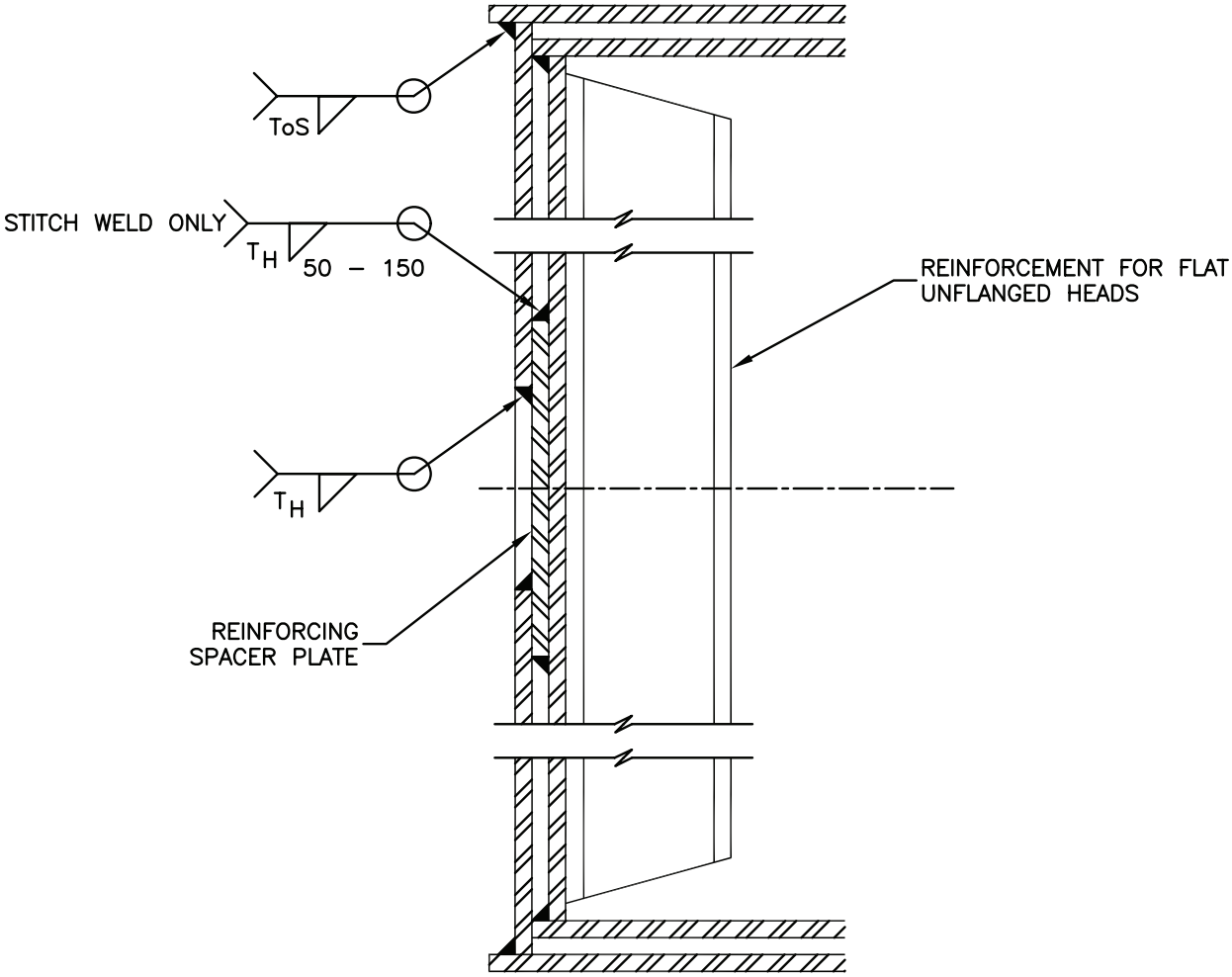


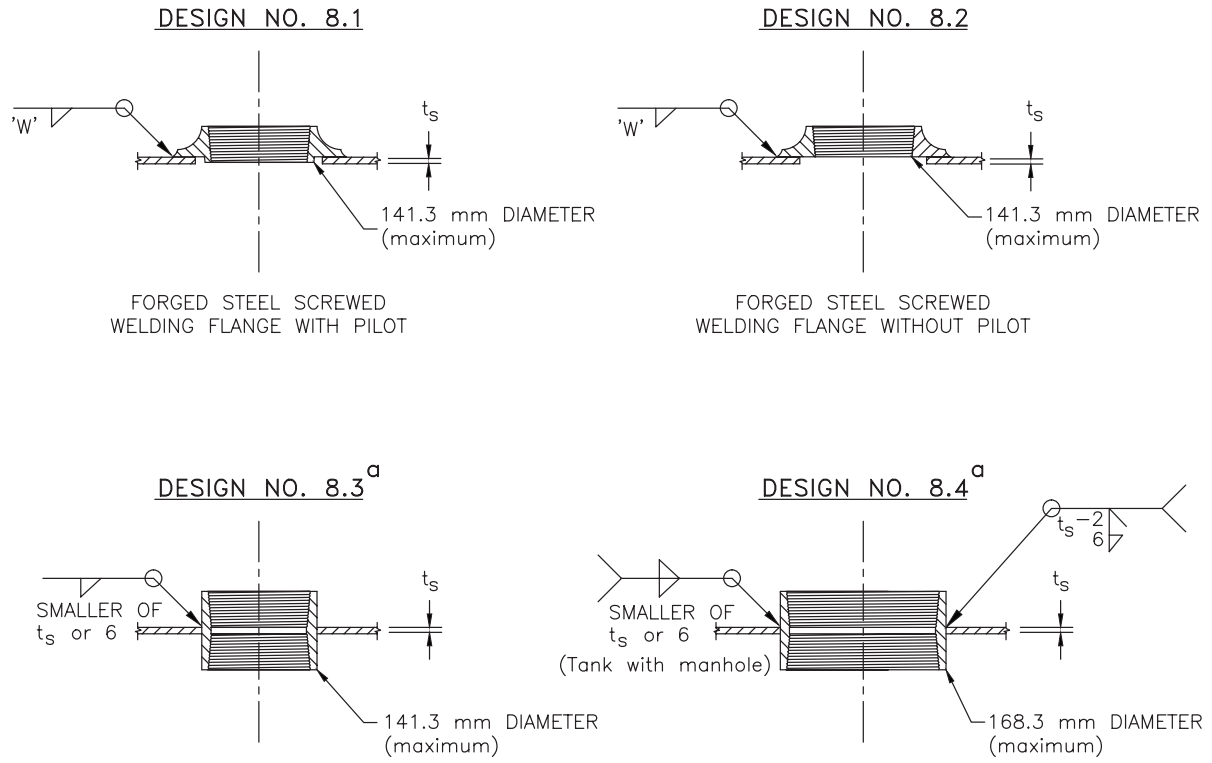
**FIGURE 7**
**FLAT UNFLANGED HEADS WITH INTERIOR REINFORCEMENT**

(Reference: Clauses 4.4.2.5, 6.1.3, 6.2.2.1.1 and 6.3.1)



## FIGURE 8
### TANK CONNECTIONS

(Reference: Clauses 4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5 and 4.5.9.2)




NOTES:

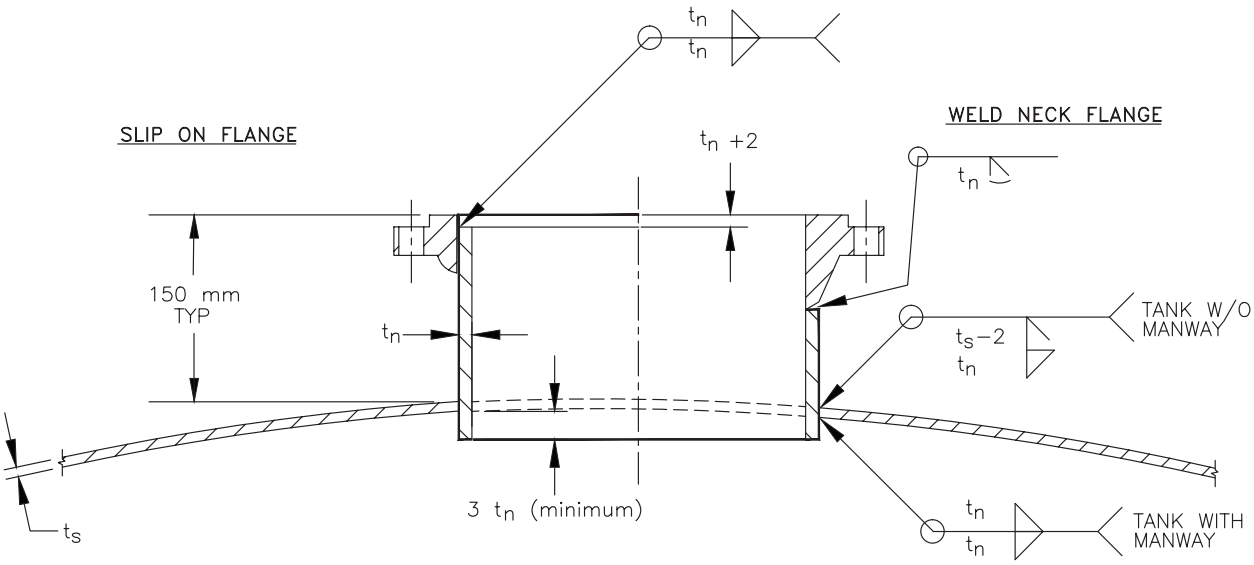
1. a – FULL OR HALF PIPE CONNECTIONS.
2. $t_s$ – SHELL THICKNESS.

| PIPE SIZE OUTSIDE DIAMETER, mm (Nominal Pipe Size, NPS) | MINIMUM LENGTH OF THREAD, mm | ATTACHMENT WELD 'W', mm (UNLESS NOTED) |
|---|---|---|
| 26.7 (3/4) | 11 | 3 |
| 33.4 (1) | 16 | 3 |
| 42.2 (1–1/4) | 16 | 3 |
| 48.3 (1–1/2) | 16 | 3 |
| 60.3 (2) | 18 | 4 |
| 73.0 (2–1/2) | 25 | 4 |
| 88.9 (3) | 25 | 4 |
| 101.6 (3–1/2) | 25 | 4 |
| 114.3 (4) | 28 | 6 |
| 141.3 (5) | 28 | 6 |
| 168.3 (6) | 28 | 6 |

**FIGURE 8 (Cont'd)**
**TANK CONNECTIONS**

(Reference: Clauses 4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5 and 4.5.9.2)

DESIGN No. 8.5




NOTES:

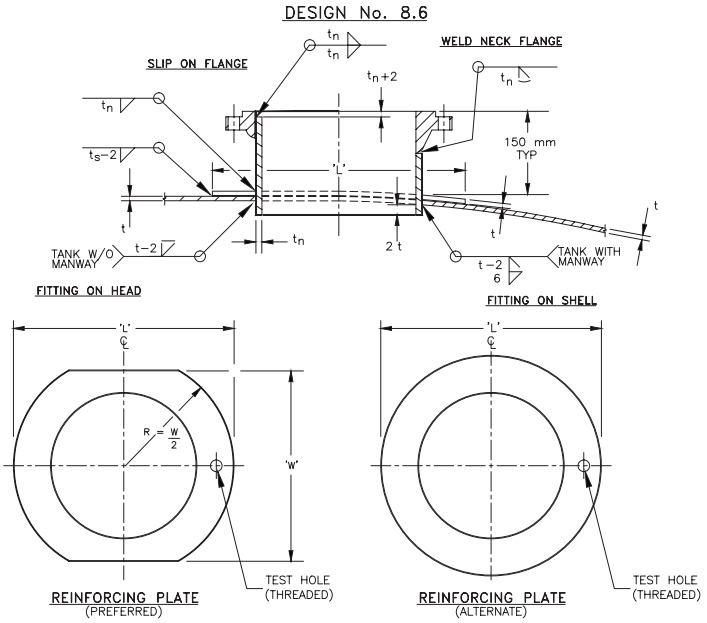
1. $t_n$ – NECK THICKNESS.
2. $t_s$ – SHELL THICKNESS.

| Pipe Size<br>Outer Diameter, mm<br>(Nominal Pipe Size, NPS) | Neck Thickness<br>'$t_n$', mm |
|---|---|
| 26.7 (3/4) | 3.91 (XS) |
| 33.4 (1) | 4.55 (XS) |
| 42.2 (1–1/4) | 4.85 (XS) |
| 48.3 (1–1/2) | 5.08 (XS) |
| 60.3 (2) | 5.54 (XS) |
| 73.0 (2–1/2) | 7.01 (XS) |
| 88.9 (3) | 7.62 (XS) |
| 101.6 (3–1/2) | 8.08 (XS) |
| 114.3[b] (4) | 8.56 (XS) |
| 141.3[b] (5) | 9.53 (XS) |
| 168.3[b] (6) | 10.97 (XS) |
| 219.1[b] (8) | 12.70 (XS) |
| 273.0[b] (10) | 12.70 (XS) |

[b]The heavier neck thickness of Design 9.5 may not allow sufficient clearance for submersible pumps. Use Design 8.6 for this purpose.

## FIGURE 8 (Cont'd)
## TANK CONNECTIONS

(Reference: Clauses 4.5.1, 4.5.2, 4.5.3, 4.5.4, 4.5.5 and 4.5.9.2)



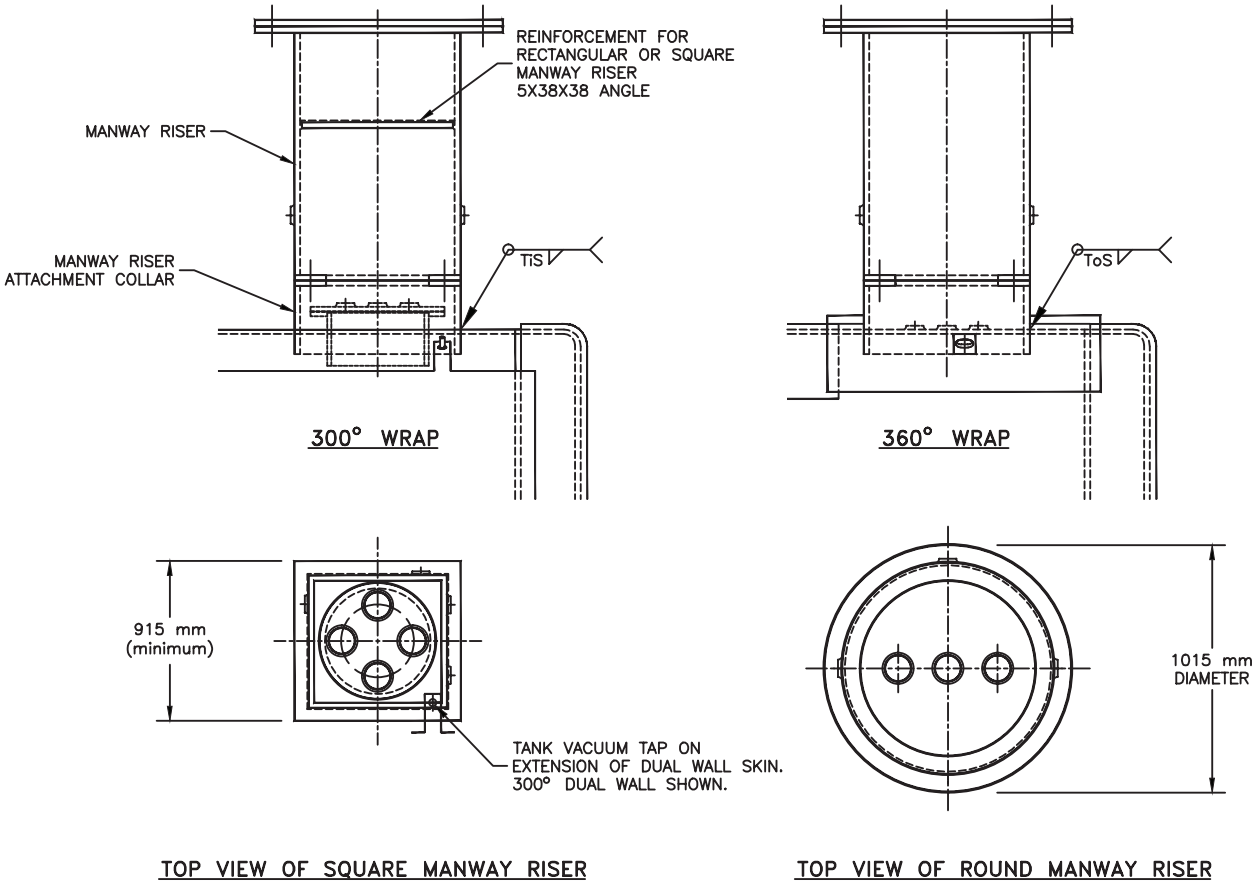

NOTES:

1. TEST HOLE THREADED WITH 13.7 mm PIPE TAP. (THIS HOLE SHALL BE PLUGGED AFTER LEAK TESTING THE TANK.)
2. WHERE A SPLIT PLATE IS USED, A TEST HOLE IS REQUIRED IN EACH HALF PLATE.
3. $t_n$ – NECK THICKNESS.
4. $t_s$ – SHELL THICKNESS.

| PIPE SIZE OUTSIDE DIAMETER, mm (Nominal Pipe Size, NPS) | NECK THICKNESS '$t_n$', mm | REINFORCING PLATE DIMENSIONS[c] | |
|---|---|---|---|
| | | 'L', mm | 'W', mm |
| 114.3 (4) | 6.02 (STD) | 200 | - |
| 141.3 (5) | 6.55 (STD) | 220 | - |
| 168.3 (6) | 7.11 (STD) | 260 | - |
| 219.1 (8) | 8.18 (STD) | 330 | - |
| 273.0 (10) | 9.27 (STD) | 410 | - |
| 323.9 (12) | 9.53 (STD) | 510 | 490 |
| 355.6 (14) | 9.53 (STD) | 570 | 550 |
| 406.4 (16) | 9.53 (STD) | 630 | 610 |
| 457.0 (18) | 9.53 (STD) | 720 | 690 |
| 508.0 (20) | 9.53 (STD) | 800 | 770 |
| 559.0 (22) | 9.53 (STD) | 880 | 840 |
| 610.0 (24) | 9.53 (STD) | 960 | 915 |
| [c]Thickness is equal to '$t_s$' or 4.5 mm minimum. | | | |

## FIGURE 9
### MANWAY RISER ATTACHMENT RING/COLLAR

(Reference: Clauses 4.5.14 and, 6.1.2)




NOTES:

1 Provision for venting of the manway riser to atmosphere is subject to the Authority Having Jurisdiction.

2 TiS – Thickness of Inner Shell

3 ToS – Thickness of Outer Shell

4 Manway risers that facilitate access to the Manway from grade are not the same as spill containment sumps. Spill containment sumps are intended to provide containment of spilled/leaked liquids from piping, to prevent external water from entering the tank, and as an enclosure for fueling system equipment, such as pumps.

5 Only two cross-section shapes are shown in the figure, other shapes may be applied in riser designs.

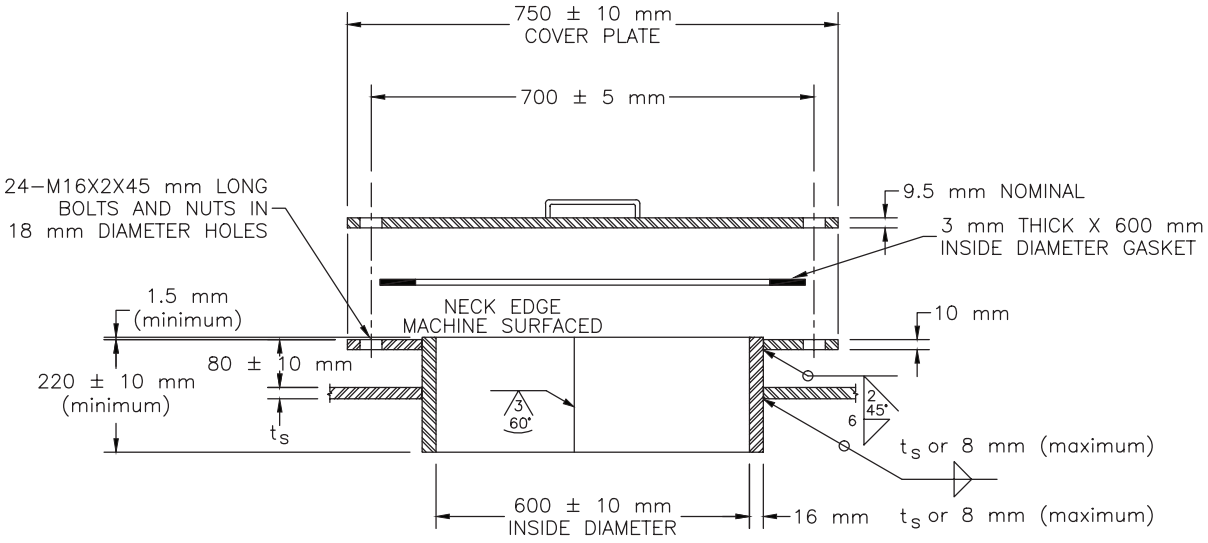
6 The requirements of this Standard apply to the attachment ring/collar. The manway riser is shown for illustration purposes only.

## FIGURE 10
### MANWAY DESIGNS

(Reference: Clause 4.7.1)

DESIGN No. 10.1

(WITH INTEGRAL REINFORCING WITHIN NECK)



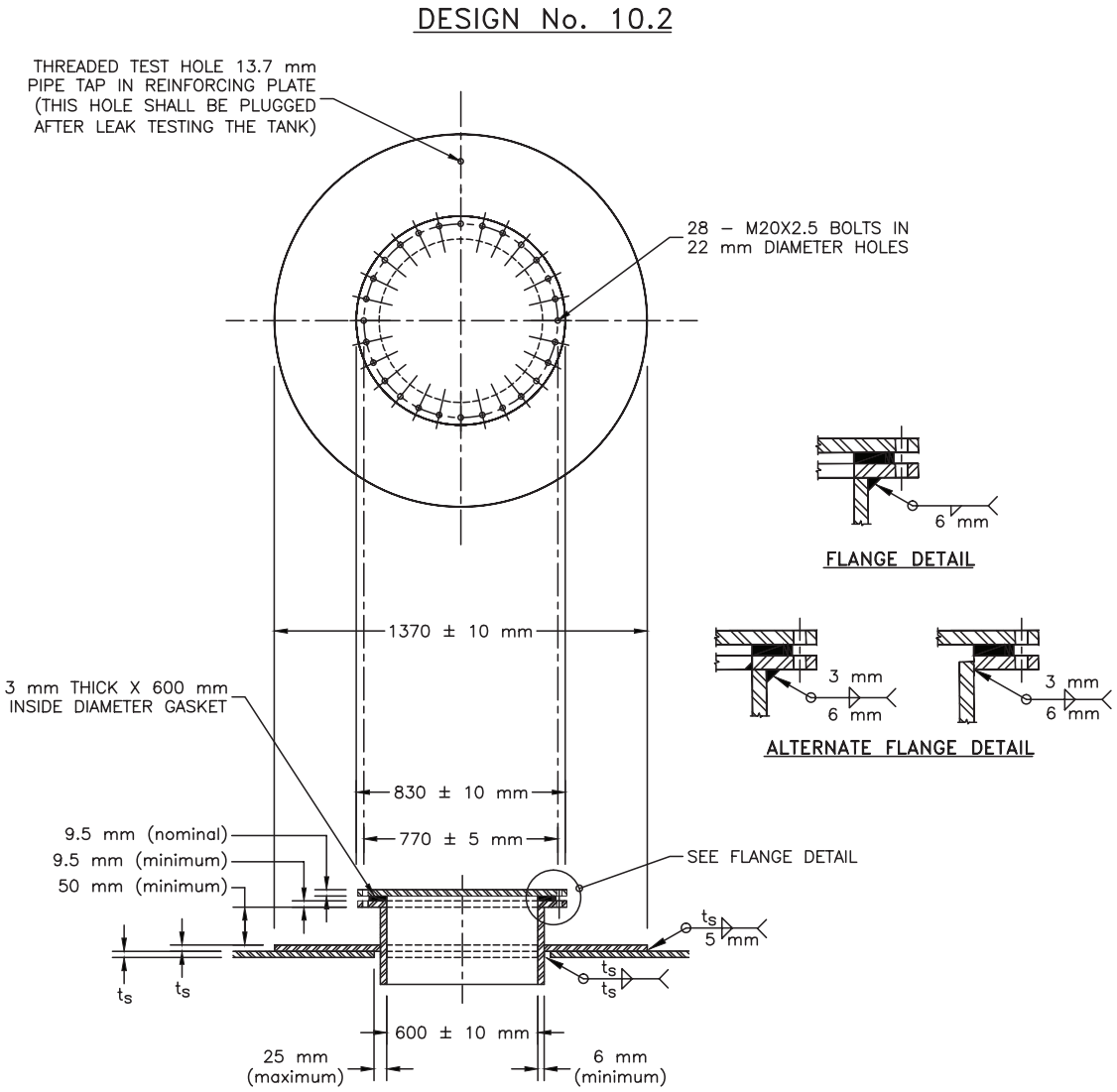

NOTES:

1 THE SEALING SURFACE OF THE COVER SHALL BE FREE OF HOT ROLL MILL SCALE.

2 $t_s$ – SHELL THICKNESS.

**FIGURE 10 (Cont'd)**
**MANWAY DESIGNS**

(Reference: Clause 4.7.1)




NOTES:

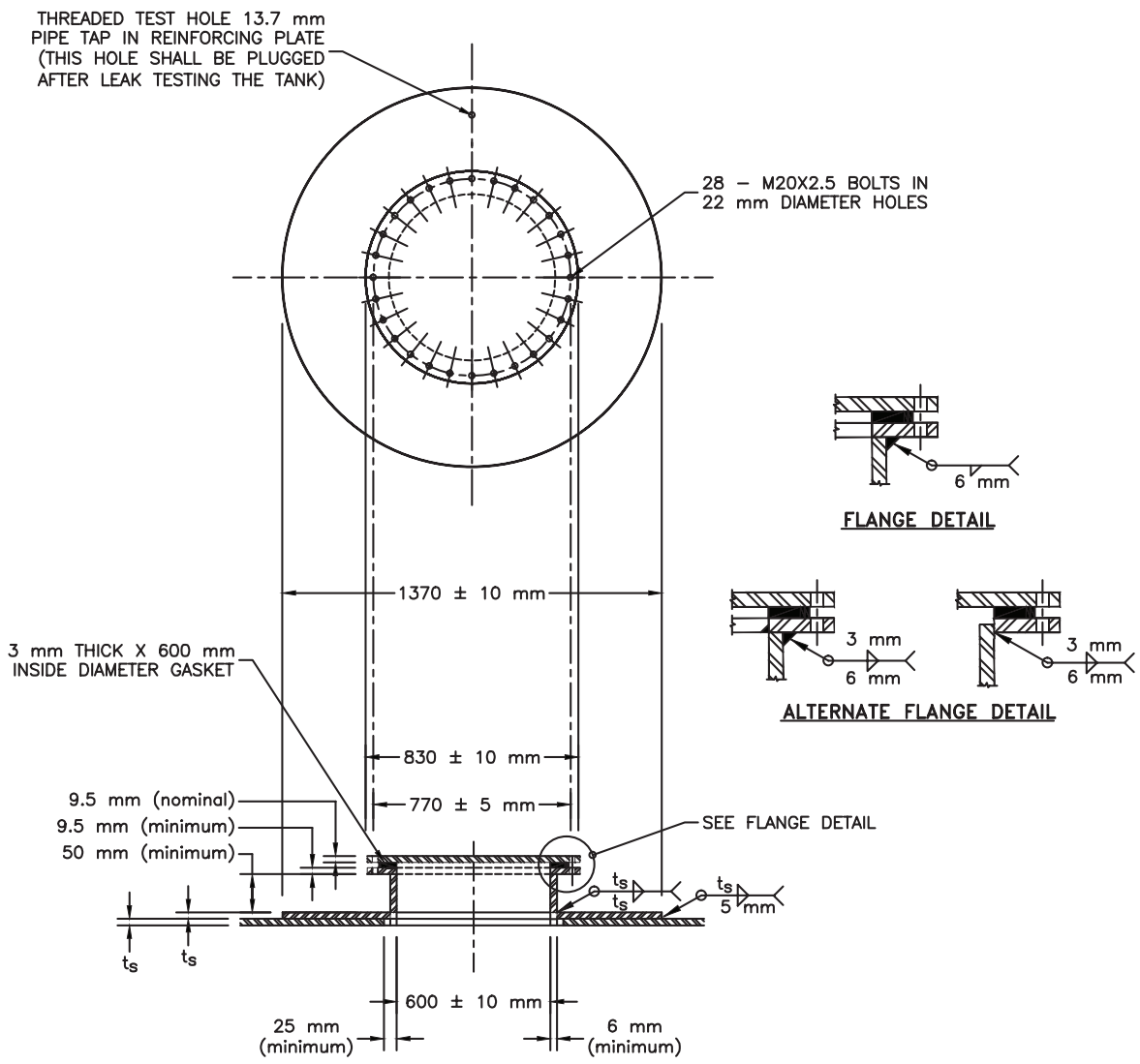
1 THE SEALING SURFACE OF THE COVER SHALL BE FREE OF HOT ROLL MILL SCALE.

2 REINFORCING PLATES ARE REQUIRED ON TANKS GREATER THAN 50 000 LITRE CAPACITY.

3 $t_s$ – SHELL THICKNESS.

**FIGURE 10 (Cont'd)**
**MANWAY DESIGNS**
(Reference: Clause 4.7.1)

DESIGN No. 10.3




NOTES:

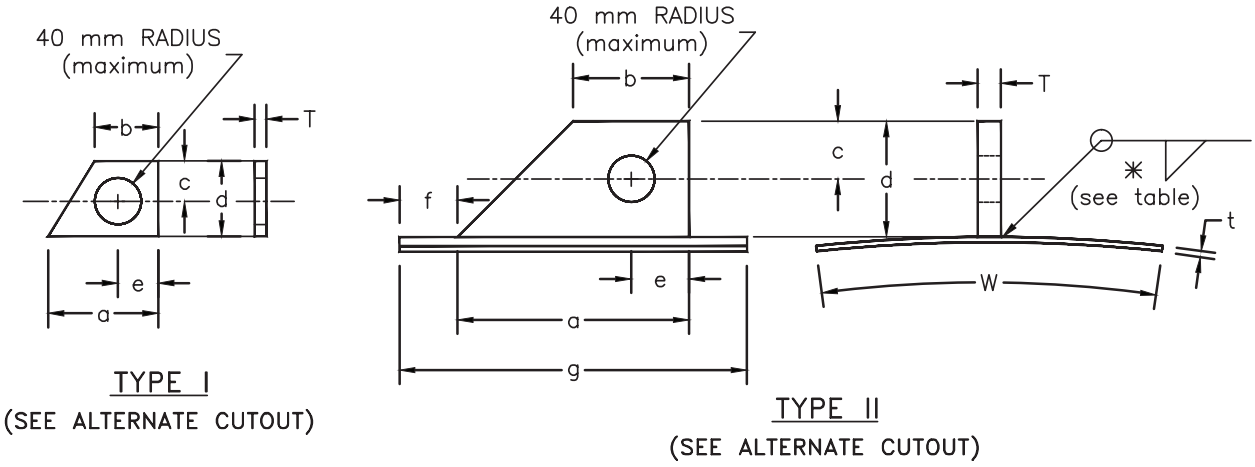
1 THE SEALING SURFACE OF THE COVER SHALL BE FREE OF HOT ROLL MILL SCALE.

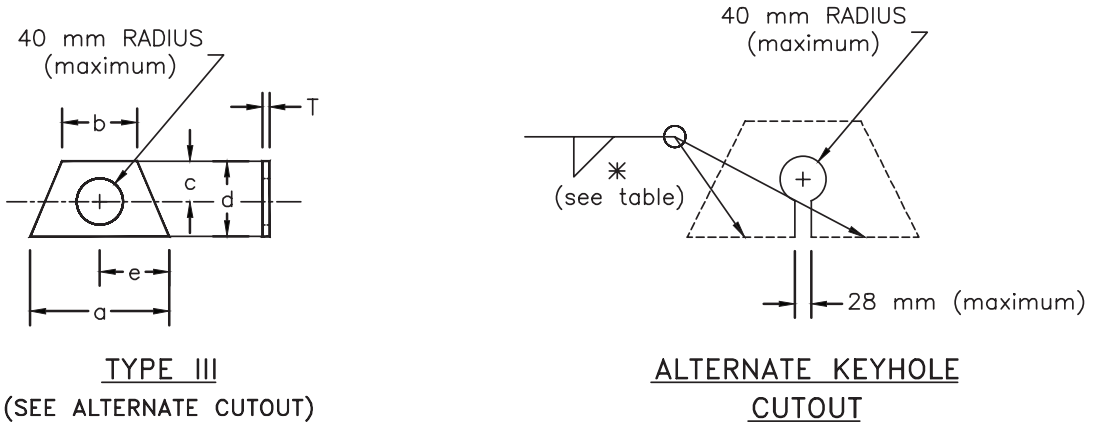
2 REINFORCING PLATES ARE REQUIRED ON TANKS GREATER THAN 50 000 LITRE CAPACITY.

3 $t_s$ – SHELL THICKNESS.

## FIGURE 11
### LIFTING LUG DESIGNS

(Reference: Clauses 4.8.2 and 4.8.4, Figures 12 and 14)



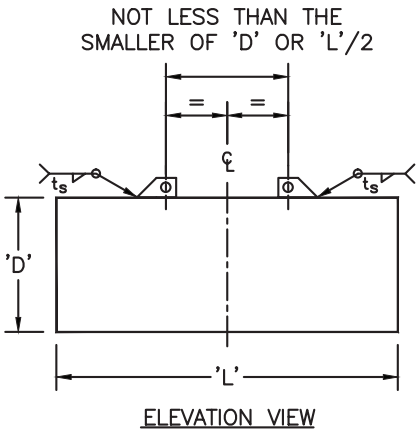



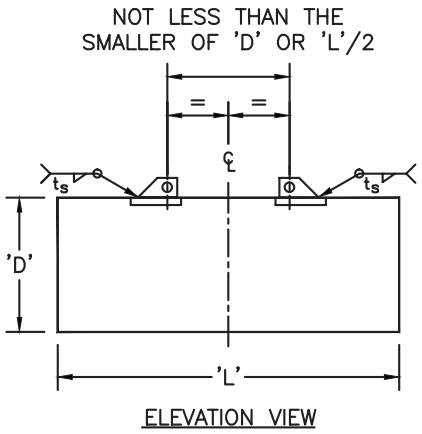

| MAXIMUM NOMINAL CAPACITY OF TANK, L | DIMENSIONS, mm | | | | | | | | | | FILLET WELD SIZE, mm | TYPE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 'a' | 'b' | 'c' | 'd' | 'e' | 'f' | 'g' | 'T' | 't' | 'W' | | |
| | | | | | | | | | | | | |
| 5 000 | 240 | 130 | 70 | 130 | 120 | - | - | 6 | - | - | - | III |
| 25 000 | 190 | 110 | 70 | 130 | 70 | - | - | 6 | - | - | - | I |
| 50 000 | 190 | 110 | 70 | 130 | 70 | - | - | 10 | - | - | - | I |
| 75 000 | 200 | 120 | 80 | 150 | 80 | 60 | 300 | 16 | 8 | 300 | 8 | II |
| 100 000 | 200 | 120 | 80 | 150 | 80 | 60 | 300 | 20 | 8 | 300 | 8 | II |
| 125 000 | 250 | 140 | 90 | 180 | 90 | 75 | 380 | 25 | 10 | 300 | 9 | II |
| 175 000 | 300 | 150 | 90 | 200 | 100 | 100 | 500 | 25 | 12 | 450 | 9 | II |
| 250 000 | 400 | 200 | 90 | 200 | 100 | 100 | 600 | 40 | 12 | 450 | 9 | II |

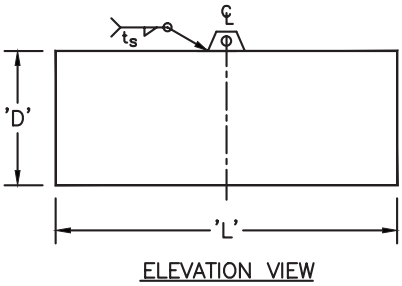
## FIGURE 12
### LIFTING LUG LOCATIONS

(Reference: Clauses 4.8.2 and 4.8.3)

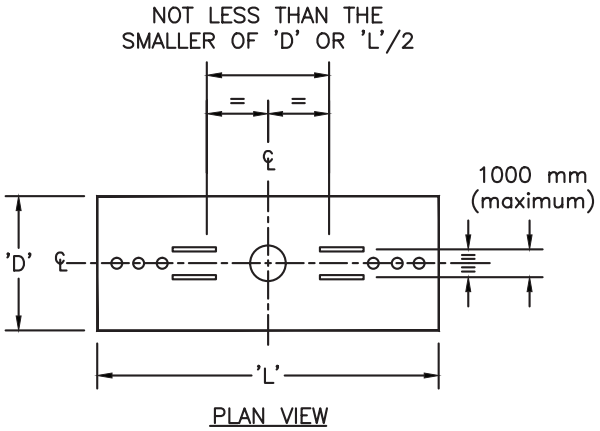
NOTE: Refer also to Figure 11




ONE LIFTING LUG PERMITTED ON TANKS
UP TO 5 000 L MAXIMUM

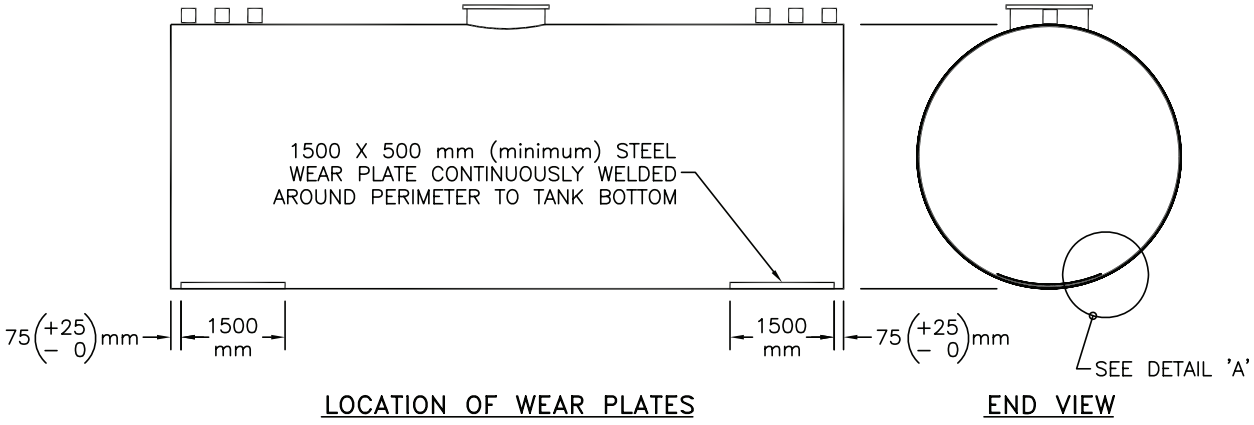


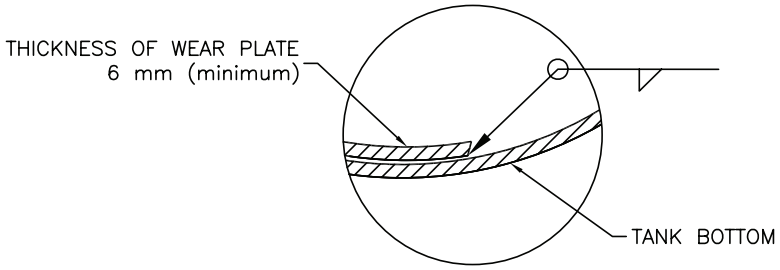

APPLIES ONLY TO DOUBLE WALL TANKS
OF 175 000 L CAPACITY OR GREATER

NOTE: $t_s$ - SHELL THICKNESS.

**FIGURE 13**
**WEAR PLATE DETAIL**
**(TANK LARGER THAN 1300 mm DIAMETER)**

(Reference: Clause 4.9.4)



## FIGURE 14
### BULKHEAD CONSTRUCTION FOR MULTI-COMPARTMENT TANKS

NOTE: Refer also to Figure 11

(Reference: Clause 4.10.1)

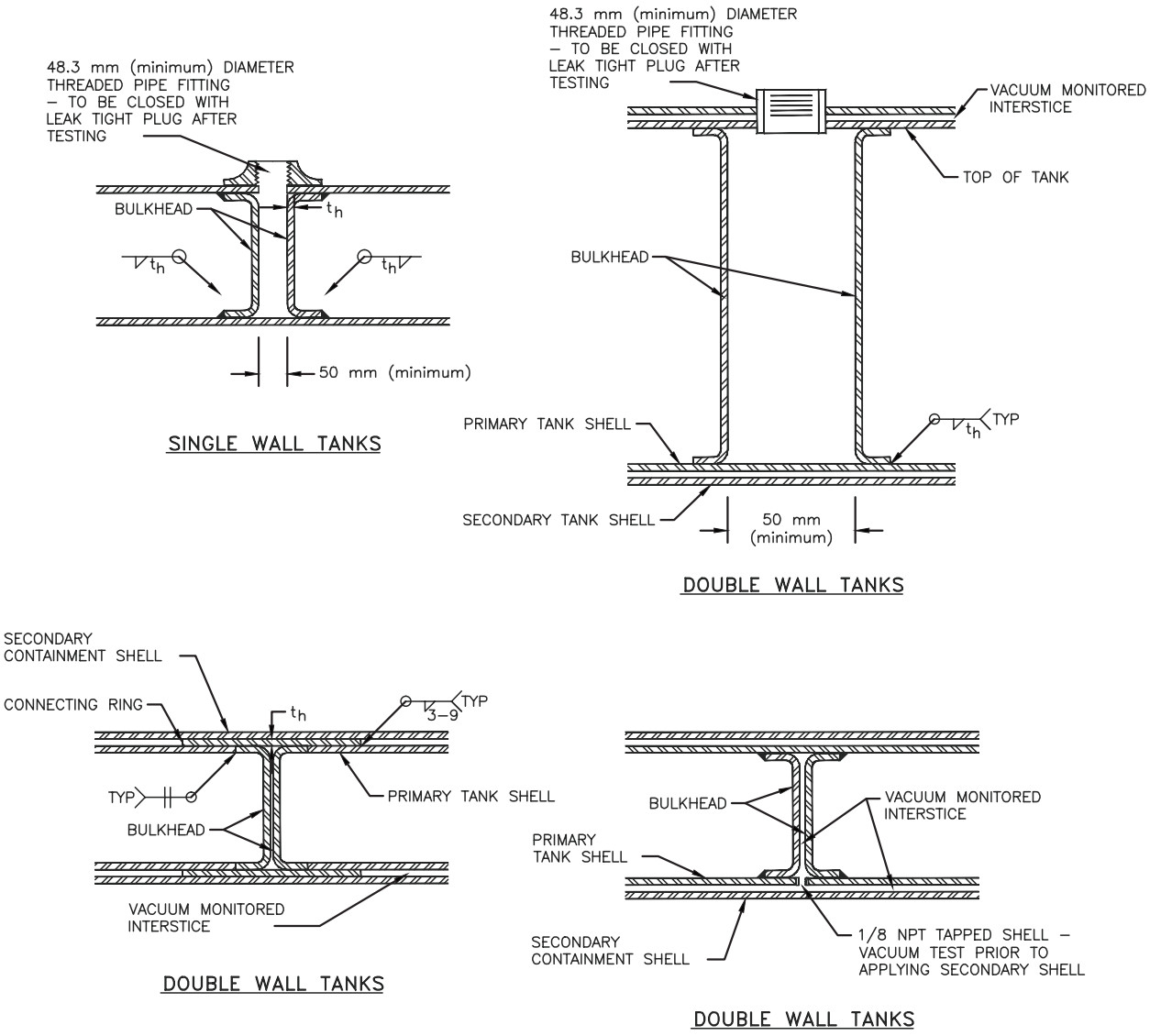
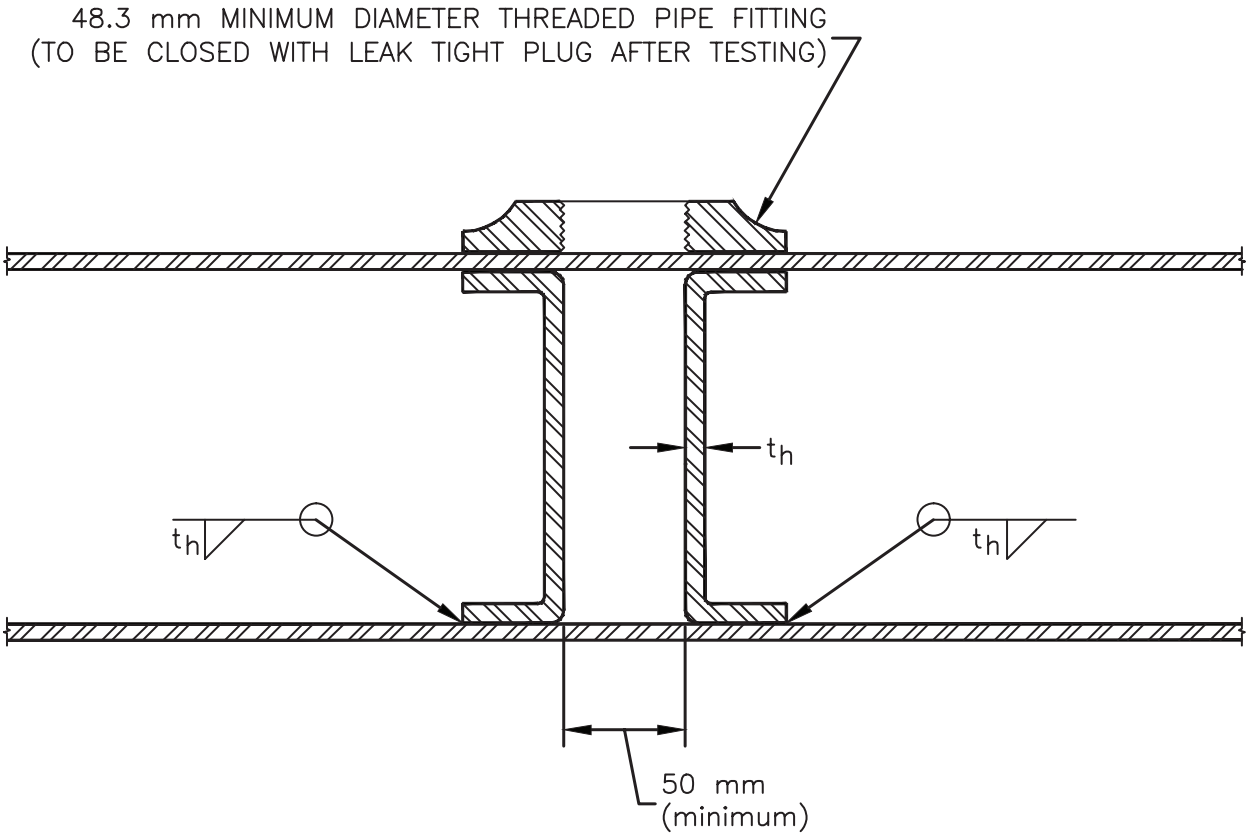


**FIGURE 14 (Cont'd)**
**BULKHEAD CONSTRUCTION FOR MULTI-COMPARTMENT TANKS**

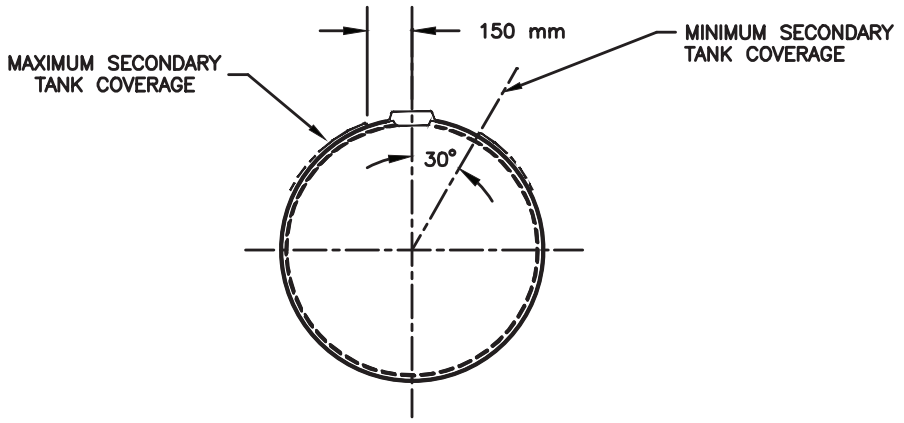
NOTE: Refer also to Figure 11

(Reference: Clause 4.10.1)

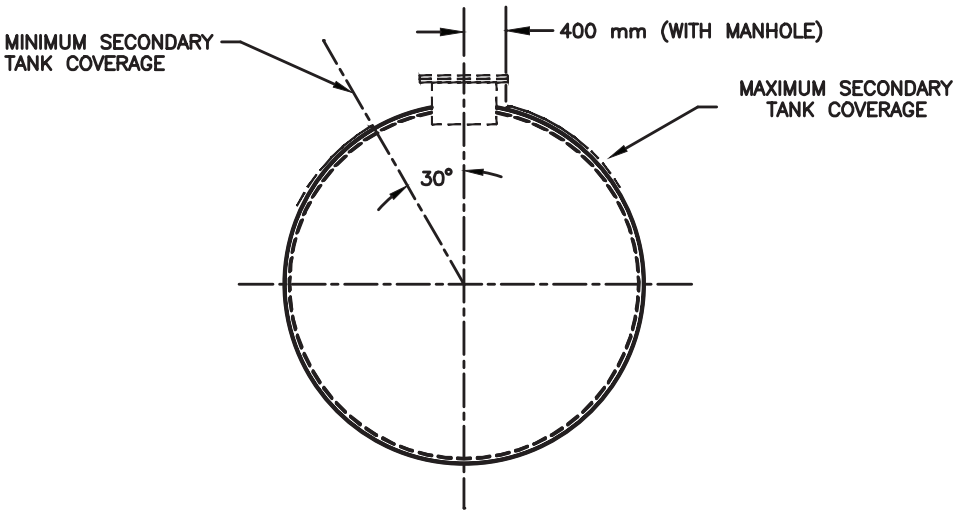



NOTE: $t_h$ – HEAD THICKNESS

**FIGURE 15**
**DOUBLE WALL TANK CONFIGURATION**
(Reference: Clauses 6.2.1.1 and 6.3.1)



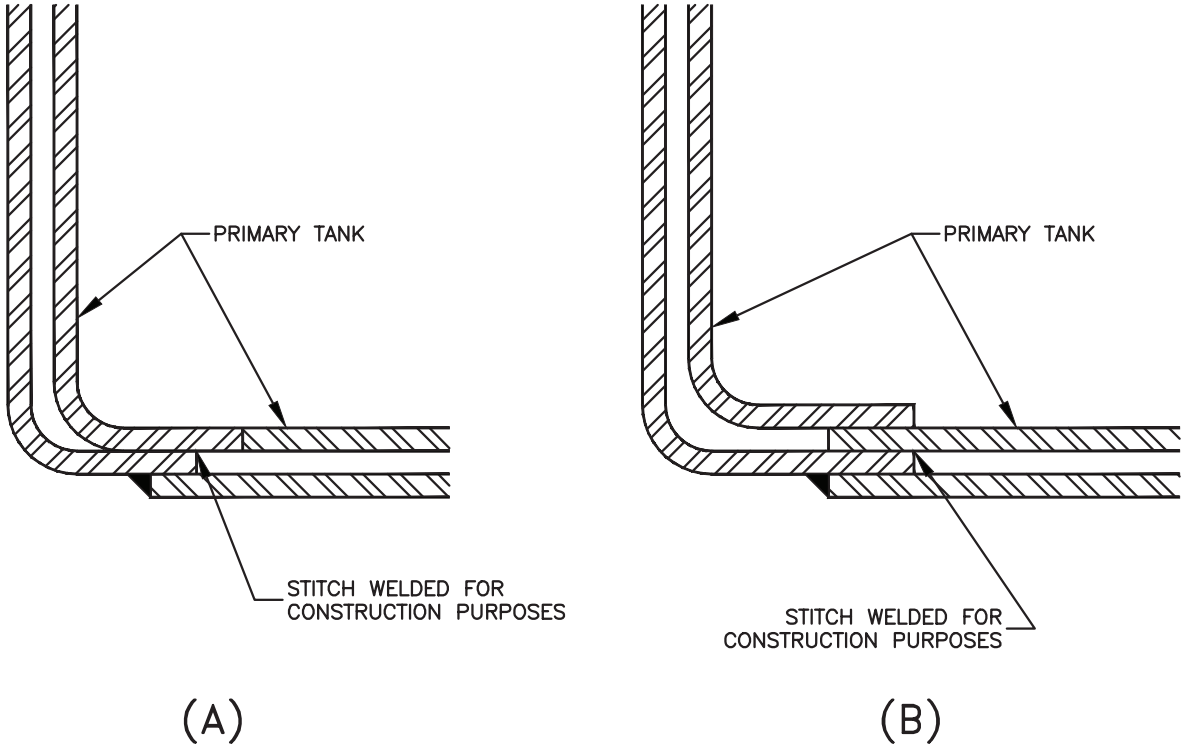

TANKS LESS THAN
10 000 L CAPACITY




TANKS 10 000 L CAPACITY
AND LARGER

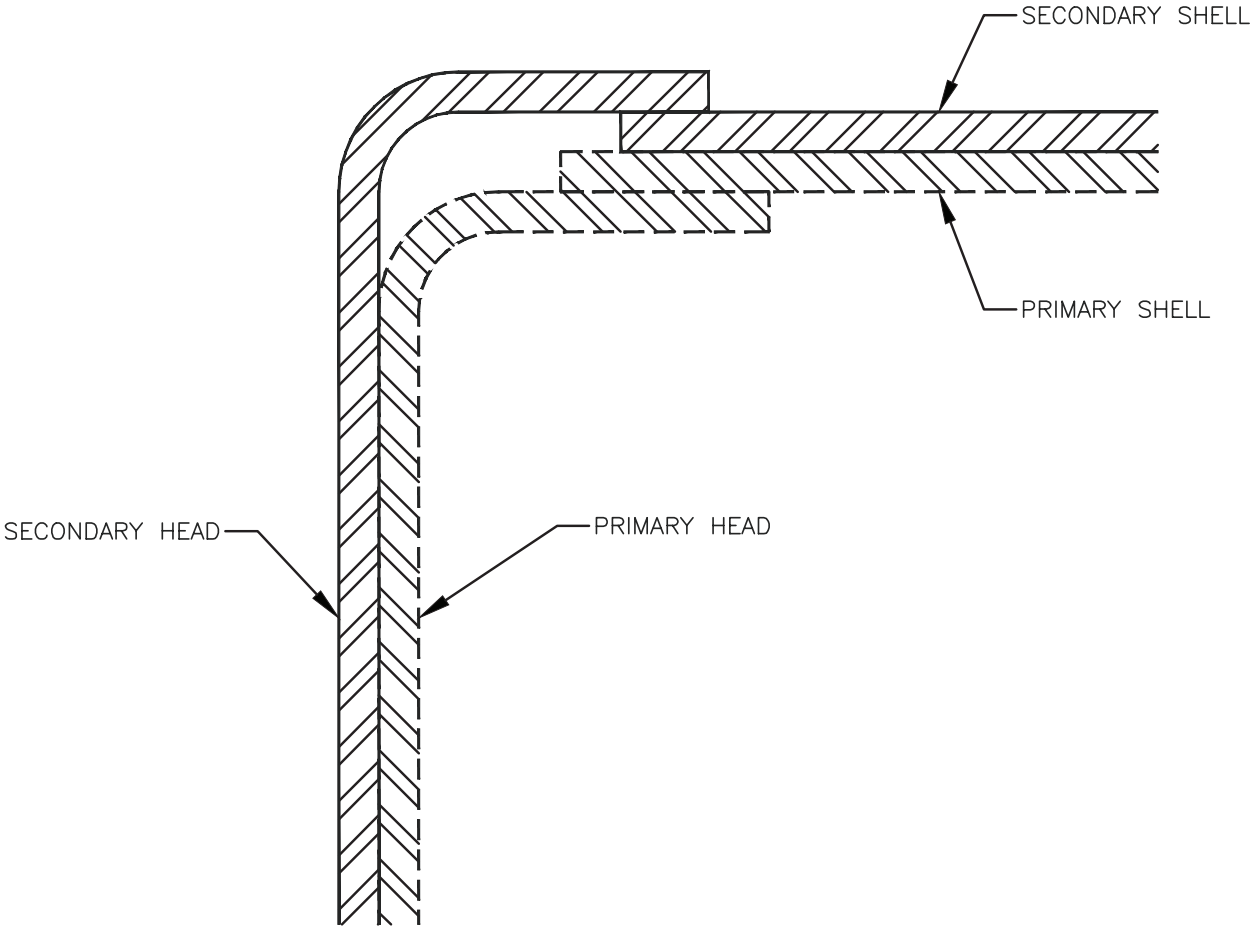
## FIGURE 16
### TYPICAL HEAD/SHELL CONNECTIONS

(Reference: Clauses 6.2.2.1.3 and 6.3.1)




NOTE: REFER TO FIGURE 3 AND 4 FOR WELDING DETAILS

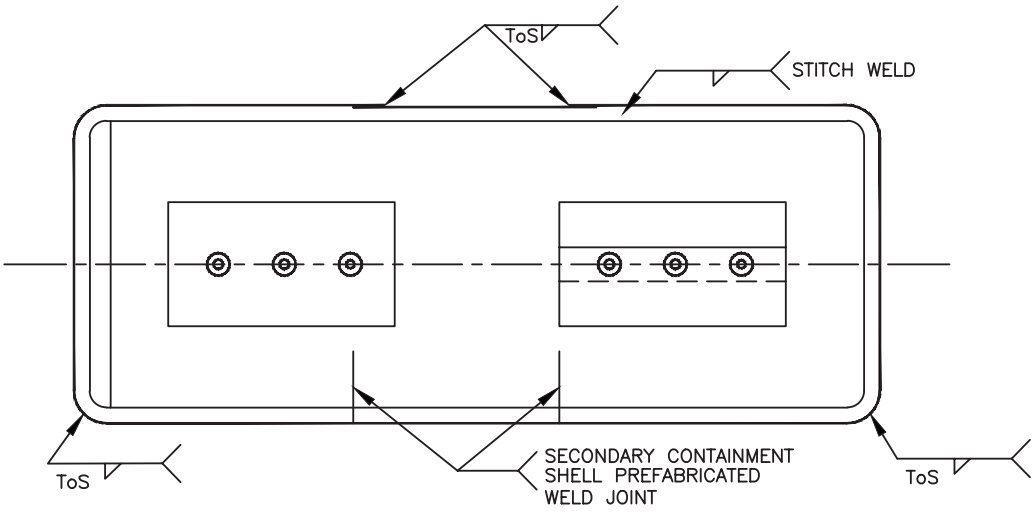
**FIGURE 16 (Cont'd)**
**TYPICAL HEAD/SHELL CONNECTIONS**
(Reference: Clauses 6.2.2.1.3 and 6.3.1)



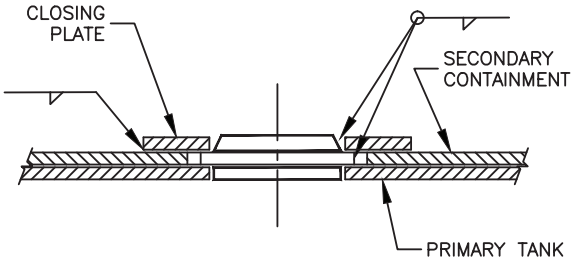

(C)

## FIGURE 17
**TYPICAL SECONDARY CONTAINMENT WALL CONNECTIONS TO GROUPED & INDIVIDUAL TANK FITTINGS**

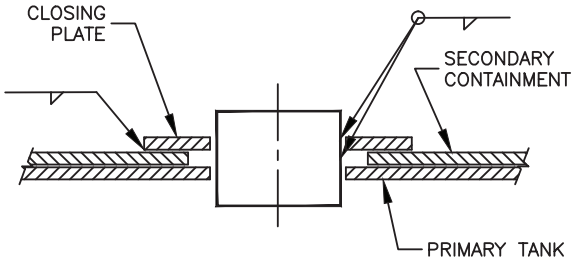
(Reference: Clauses 6.2.2.1.3 and 6.3.1)



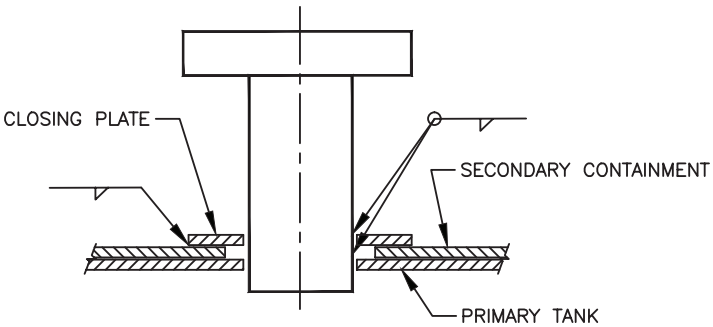

PLAN VIEW – PREFABRICATED SECONDARY CONTAINMENT SHELL
TYPICAL APPLICATION




WELD–IN FLANGE




HALF AND FULL COUPLINGS




FLANGED FITTING

## FIGURE 18
### NAMEPLATE MOUNTING DETAIL

(Reference: Clauses 11.2)

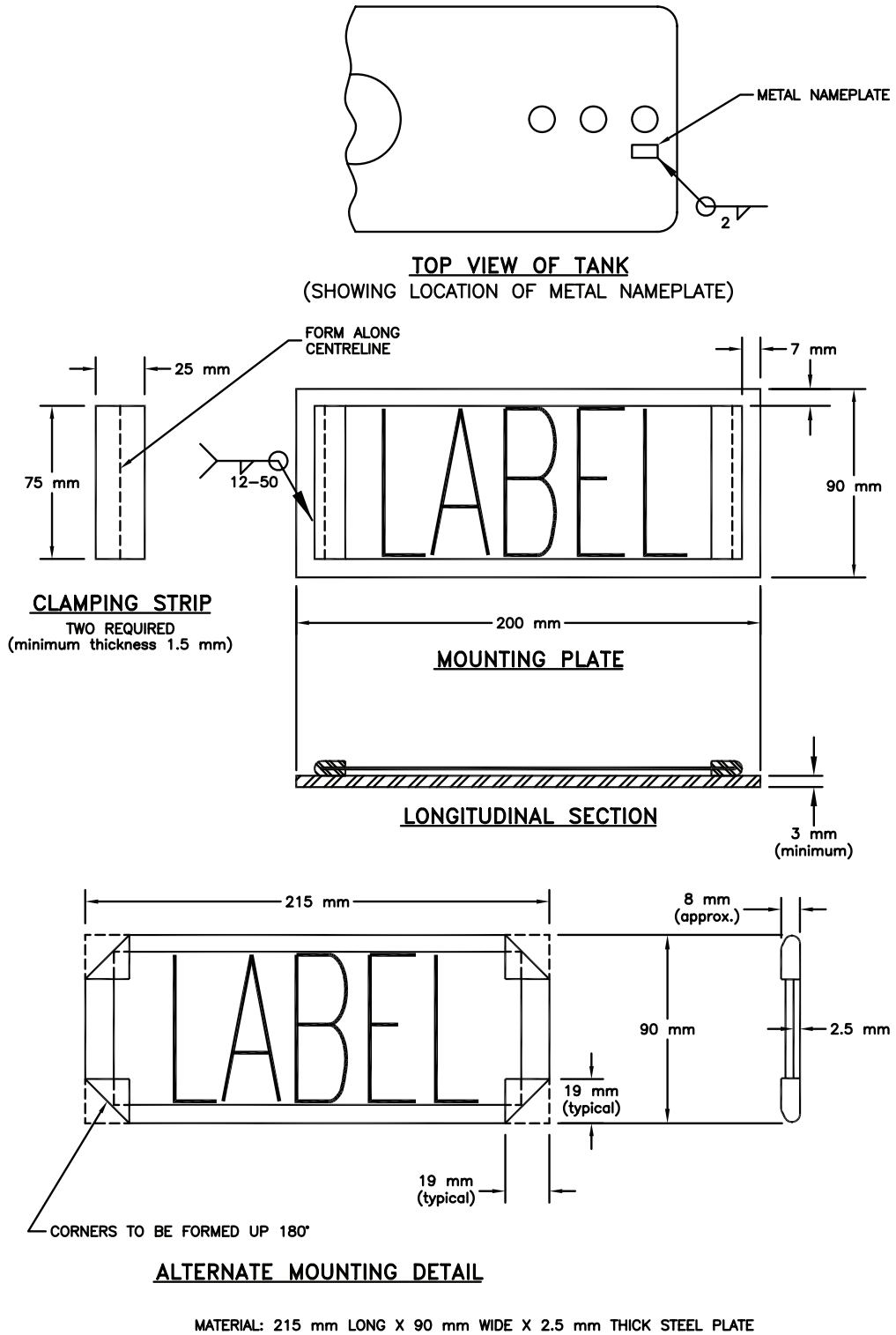
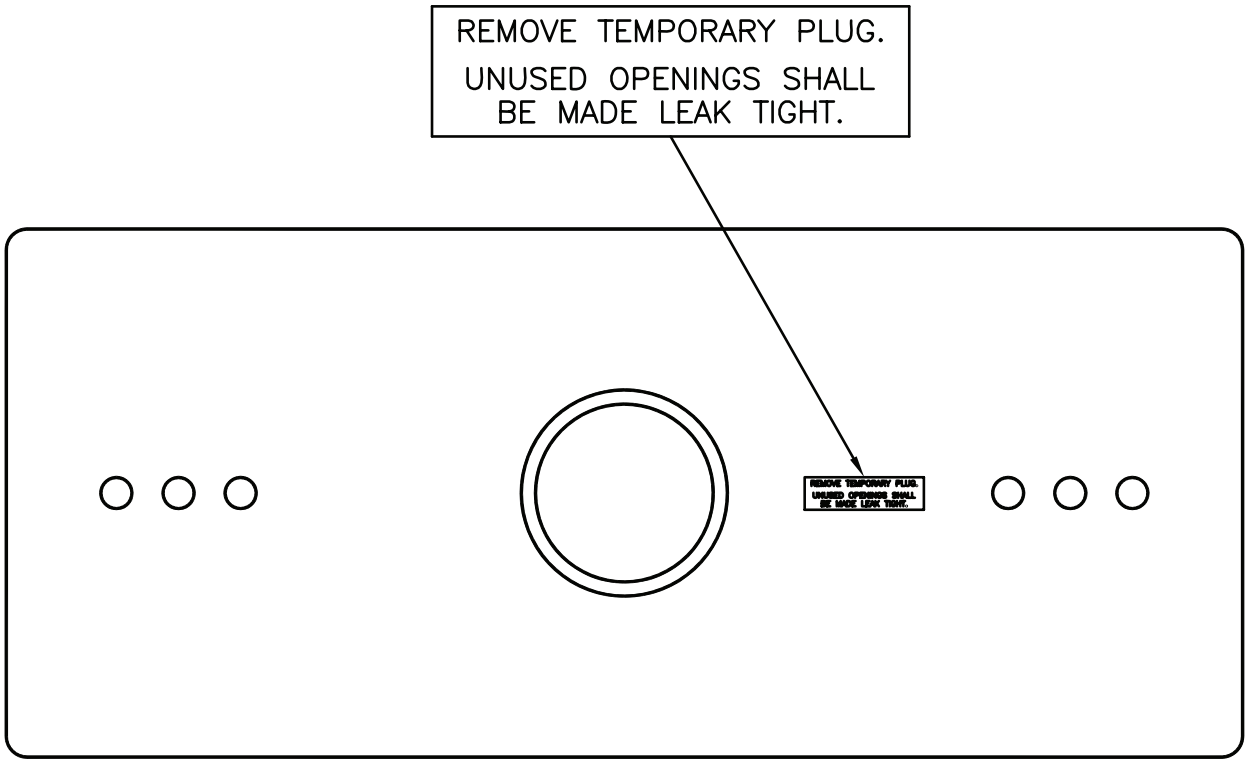


**FIGURE 19**
**LOCATION OF WARNING NOTICE**
(Reference: Clauses 11.4)




PLAN VIEW

# APPENDIX A – ACCESS OPENINGS (INFORMATIVE)

(Reference: Clauses 4.3.4 and 4.10.4, Figure 4)

## A1 GENERAL

A1.1 Where there is a *manway* in a horizontal 10 000 L tank or larger, access can be gained through the *manway*.

A1.2 Where there is no *manway*, an access opening shall be provided. Alternatively, use joint H4.3 for one head. (Refer to Clause A1.6.)

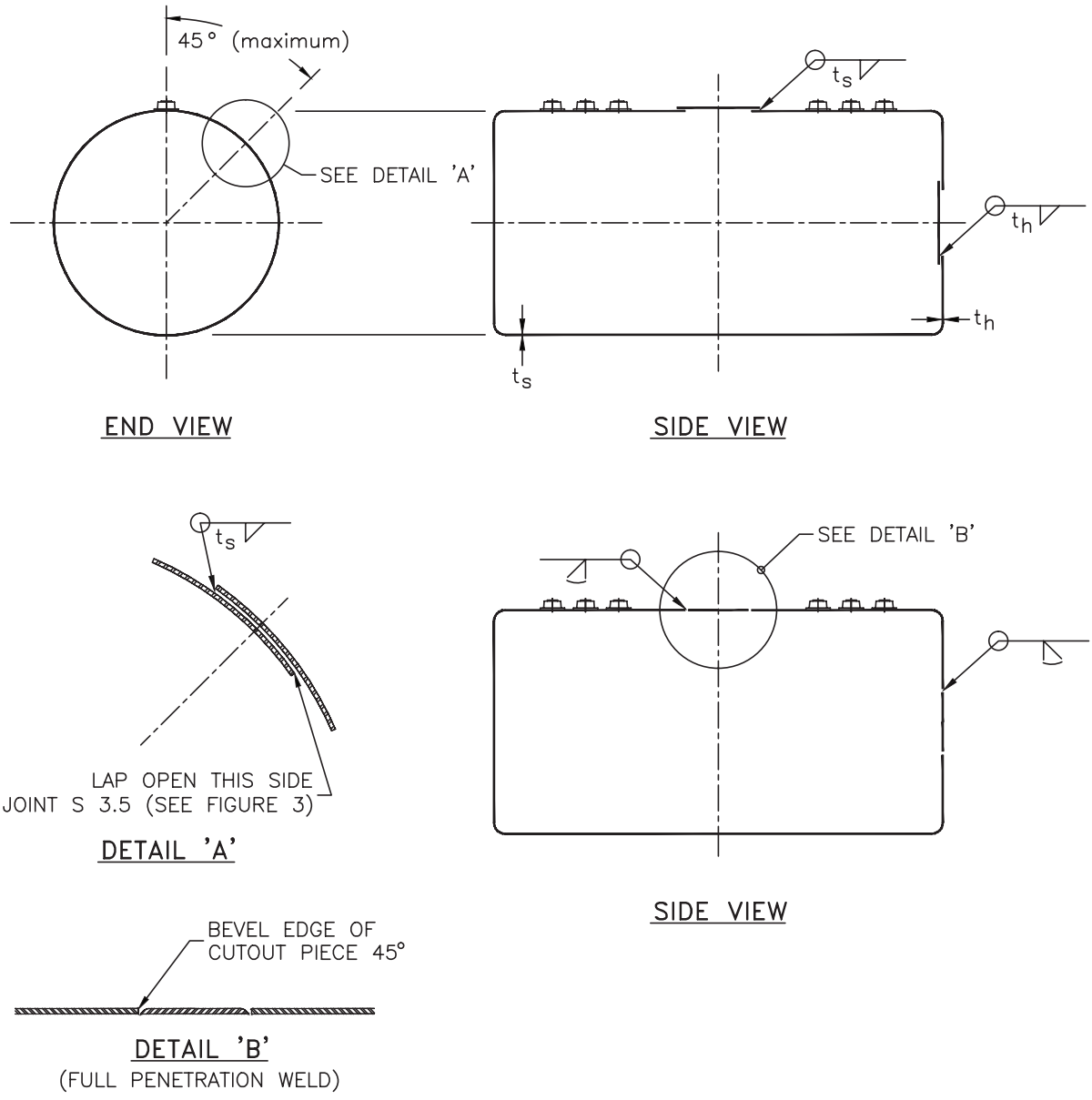
A1.3 The access opening shall be 550 mm in diameter (minimum) and may be located on the top longitudinal axis with a minimum clearance of 200 mm from any fittings or lifting lugs. An alternative location for the opening may be in the centre of one head.

A1.4 The cover plate may be circular or octagonal in shape with a thickness equal to the tank shell for the top access opening cover or a thickness equal to the tank head for the head opening cover. Alternatively, the piece cut out from the opening may be used provided the plate edge is bevelled to achieve full penetration welds.

A1.5 When the larger cover plates are used, the cover on the top centre line shall be on the outside of the tank and the cover used on the head shall be on the inside of the tank. (Refer to Figure A1.)

A1.6 When using a butt joint with bevelled prepared edges, (Joint H4.3) the last tank head may be welded on after all inside seal welding has been completed. An access opening is not necessary.

**FIGURE A1**
**ACCESS OPENINGS**
(Reference: Clause A1.5)




NOTES:

1 $t_s$ – SHELL THICKNESS.

2 $t_h$ – HEAD THICKNESS.

# APPENDIX B – MONITORING AFTER BURIAL (INFORMATIVE)

(Reference: Clause 10.1)

## B1 GENERAL

B1.1 When vacuum monitoring is used, the minimum vacuum permitted on the *interstice* should be 34 kPa gauge. A vacuum reading of less than 34 kPa gauge may be indicative of the need for immediate remedial action. The tank manufacturer should be contacted for the test methods necessary for checking the vacuum monitor connection system and/or the tank for leak detection.

# APPENDIX C – GUIDELINES FOR MINIMUM VENT LINE DIAMETERS (VERSUS FLOW RATE AND PIPE LENGTH) (INFORMATIVE)

(Reference: Table 2)

## C1 GUIDELINES

| MAXIMUM FLOW RATE, L/min | PIPE LENGTH (PLUS 7 ELBOWS) | | |
|---|---|---|---|
| | 15 m | 30 m | 60 m |
| 750 | 42.2 | 42.2 | 42.2 |
| 1 000 | 42.2 | 42.2 | 60.3 |
| 1 500 | 42.2 | 48.3 | 60.3 |
| 2 000 | 48.3 | 60.3 | 60.3 |
| 2 300 | 48.3 | 60.3 | 60.3 |
| 2 700 | 60.3 | 60.3 | 73.0 |
| 3 800 | 60.3 | 73.0 | 88.9 |

# APPENDIX D – DESIGN CRITERIA (INFORMATIVE)

(Reference: N/A)

## D1 GENERAL

D1.1 The tanks covered by this Standard have been theoretically designed to withstand an external pressure of 14 kPa (gauge) in free air in accordance with the procedures described in ASME BPVC, Boiler & Pressure Vessel Code, Section VIII, Division 1, Design & Fabrication of Pressure Vessels. This Standard procedure provides a factor of safety of at least 3:1. An additional factor of safety is introduced by consideration of the support provided when tanks are buried

D1.2 The design is based upon an assumed cover of 1 m of earth. The backfill is assumed to be compacted in 300 to 500 mm layers to approximately 90 % proctor density or better. The surface loadings are those applicable to underground tanks in normal use.

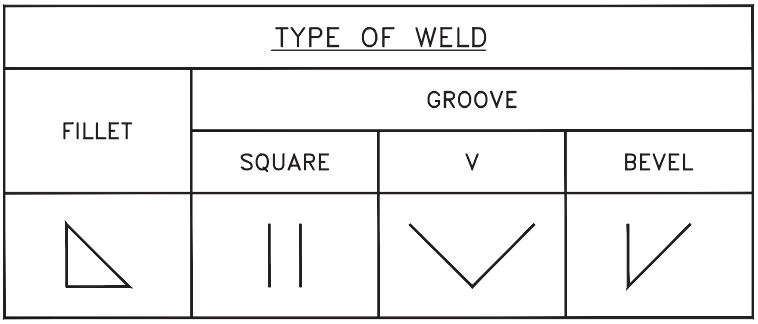
D1.3 The beam strengths of the tank configurations covered by these specifications have also been considered but have not been found to be a limiting design consideration.

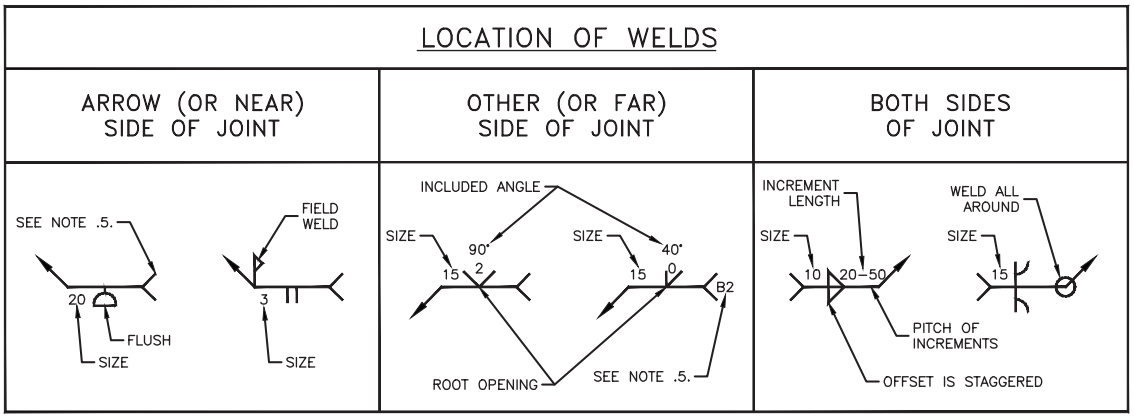
D1.4 In applying the above design considerations to the various tank configurations covered by this specification, the computed steel thicknesses have been rounded out to the nearest 0.5 mm for thicknesses up to 8 mm and to the nearest millimetre for larger thicknesses. The head thickness in each case is required to be at least equal to the tank diameter divided by 500.

# APPENDIX E – WELDING SYMBOLS (INFORMATIVE)

(Reference: N/A)

## E1 GENERAL




NOTES:

1. The side of the joint to which the arrow points is the arrow side, and the opposite side of the joint is the other side.
2. Arrow side and other side welds are the same size, unless otherwise shown.
3. Symbols apply between abrupt changes in the direction of welding or to the extent of hatching or dimension lines, except where the all round symbol is used.
4. All welds are continuous and of the user's standard proportions unless otherwise shown.
5. Tail of arrow is used for specification process or other reference. (Tail of arrow may be omitted when reference is not used.)
6. When a bevel groove or J groove weld symbol is used, the arrow shall point with a definite break toward the member, which is to be chamfered. (In cases where the member to be chamfered is obvious, the break in the arrow may be omitted.)
7. Dimensions of weld sizes, increment lengths, and spacing are in millimetres.
8. For more detailed instruction in the use of these symbols refer to AWS A2.4, Standard Symbols for Welding, Brazing and Non-Destructive Examination