

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

STANDARD VERTICAL TANKS SELECTION, DESIGN AND FABRICATION

PTS 34.51.01.31

FEBRUARY 2010



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For PTS Updates/Review

This revision of PTS **34.51.01.31 - Standard Vertical Tanks - Selection, Design and Fabrication (February 2010, Revision 1)** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards.

The previous version of this PTS **34.51.01.31 (September 1992)** will be removed from PTS binder/ e-repository from herein onwards.

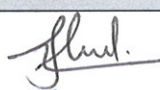
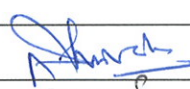
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PREFACE

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The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

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1. INTRODUCTION

1.1 SCOPE

This PTS is a revision of the earlier publication of the same number and title dated September 1992. It gives the minimum technical requirements for the selection, design and fabrication of standard vertical steel storage tanks and shall be used in conjunction with standard requisition sheets (see 1.3.2).

Vertical carbon steel tanks shall be selected and designed in accordance with EN 14015 and this PTS.

Erection and testing of vertical tanks, and any post-commissioning structural modifications undertaken within the operational window of such tanks, shall be in accordance with PTS 64.51.01.31.

NOTE: Due to their specific nature, all references in this PTS to EN 14015 shall mean the 2004 edition.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to PETRONAS companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, supply/marketing installations and in onshore exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regard to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that will carry out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that will manufacture or supply equipment or services as specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its engineering, procurement and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

requisition PTS 34.51.01.93., PTS 34.51.01.94., and PTS 34.51.01.95., as applicable to the tank in question.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (11).

1.5 CHANGES SINCE LAST REVISION

This PTS is a revision of the PTS with the same number dated September 1992. The main change is that BS 2654 has been withdrawn and replaced by EN 14015. This revision has involved a substantial restructuring of the PTS and so it is impractical to summarise the changes herein.

1.6 OTHER REQUIREMENTS FOR SPECIFICATION

1.6.1 Standard drawings

Contractor's drawings and calculations shall be based on EN 14015 and this PTS. PETRONAS Standard Drawings, group S 51, as listed in (11) are available as a reference and guide for details on standard tank fittings and features. However, it remains the Contractor's responsibility to satisfy the requirements outlined in this PTS.

1.6.2 Documentations

The Contractor should submit the following documents to the Principal for review and approval prior to the start of fabrication:

- a. Data sheet.
- b. Static design calculations for shell plate thicknesses.
- c. Static design calculations checking for resistance to wind loading (wind girders, stiffening rings).
- d. Design details and calculations of roof supporting structure.
 - ◆ For fixed roof tanks: frangibility check to be included.
 - ◆ For floating roof tanks: The design of floating roofs is not covered by this PTS since floating roofs are generally Contractor's standard designs. However all design details, including required buoyancy and strength calculations, shall be submitted.
- e. Static design calculations for preventing overturning by wind loading and for resistance to uplift (tank anchorage).
- f. Design details and calculations of seismic provisions (if applicable).
- g. If required by Principal, the design calculations shall include minimum allowed thicknesses of main tank components according to the theory of EEMUA 159.
- h. Tank venting calculations.
- i. All design and fabrication drawings. Drawings shall include the following data (where applicable):
 - 1) Material and welding consumable specification.
 - 2) Welding details and procedures.
 - 3) Location and details of welded seams.
 - 4) Parts that require post-weld heat treatment.
 - 5) Testing procedure.
 - 6) Extent of any NDT and visual inspection.
- j. A general arrangement drawing of each tank. This drawing shall be to scale and shall show the position of all mountings and accessories required, with reference to the relevant detail drawings.
- k. All static calculations and drawings required by local authorities.
- l. A marking diagram.

- m. Engineering, procurement and construction documents list (including fabrication and construction drawings).
- n. Corrosion allowances to be applied: maximum thickness increase to incorporate corrosion allowances is 3 mm.

Fabrication shall not begin until the Principal has agreed that there are no outstanding review comments and only after the Contractor has released the required documents as "Issued for Construction".

The Contractor shall submit the list of agreed documents to the Principal, at the following stages:

- 1. Review and comment prior to release as approved Issued for Construction.
- 2. All approved Issued for Construction documents.
- 3. All revised documents after initial approval and Issued for Construction
- 4. "As built" documents (including one digital set) on the completion of fabrication and construction.

1.6.3 Material certificates

Materials used in the fabrication of tanks designed in accordance with this PTS shall be supplied with material certificates in accordance with EN 10204, type 3.1.B. Material certificates shall be submitted to the Principal prior to commencement of fabrication.

2. TYPE AND SELECTION OF VERTICAL TANKS

2.1 DEFINITIONS

The various types of standard tanks used within the Group, are designated by a reference code, which consists of a three-letter prefix indicating the tank type, followed by a numerical group indicating the dimensions of the tank (diameter and height).

The following letter prefixes are used to identify the standard tanks described in this specification. The initial letter B of the prefix indicates that the shell is butt-welded.

BHC	=	High-pressure Cone roof tank
BLC	=	Low-pressure Cone roof tank
BNC	=	Non-pressure Cone roof tank (atmospheric tank)
BHD	=	High-pressure Dome roof tank
BLD	=	Low-pressure Dome roof tank
BND	=	Non-pressure Dome roof tank (atmospheric tank)
BOT	=	Open Top tank
BOF	=	Open top tank with Floating roof

Examples of the use of the code are as follows:

BHC 15/12 means High-pressure cone roof tank, 15 m diameter and 12 m high.

BND 36/18 means Non-pressure dome roof tank, 36 m diameter and 18 m high.

The abbreviations in Table 1 are used in this PTS to identify a specific type of tank.

Table 1 Abbreviations applicable for different types of tank

International abbreviation	Description	Standard tank
FRT	Fixed Roof Tank	BNC / BND BLC / BLD BHC / BHD
IFRT	Fixed Roof Tank with Internal Floating Cover (IFC)	BNC / BND + IFC BLC / BLD + IFC BHC / BHD + IFC
EFRT	External Floating Roof Tank	BOF
CFRT	Covered Floating Roof Tank	BOF + Geodesic dome roof

2.2 OPEN-TOP TANKS

This type of tank has no roof. They shall not be selected for the storage of petroleum products but may be used for fire water/cooling water.

2.3 FIXED ROOF TANKS (FRT)

These tanks can be divided into cone roof and dome roof types and each type can be further subdivided into non-pressure, low-pressure, high-pressure and very high-pressure fixed roof tanks. The range of applicable design pressures and design vacuum are in accordance with EN 14015 Clause 5 Table 3. These tanks shall be checked in accordance with EN 14015 Clause 12 and Annex G.5 to determine whether anchorage is required to prevent uplift and overturning at the lower shell tank bottom.

Non-pressure fixed roof tanks are suitable for storage at atmospheric pressure and are therefore provided with open vents. The design pressure/vacuum is 10.0/–5.0 mbar (ga).

Low-pressure fixed roof tanks are designed to work at a low internal pressure or vacuum. The design pressure/vacuum is 25.0/-8.5 mbar (ga). They are provided with pressure/vacuum breather valves set to be fully open at the design pressures.

High-pressure fixed roof tanks are designed to work at higher internal pressure or vacuum and are also fitted with pressure/vacuum breather valves set to be fully open at the design pressures. The design pressure/vacuum is 60.0/-8.5 mbar (ga).

Although EN 14015 also gives design rules for very high-pressure tanks [design pressure/vacuum +500/-20mbar (ga)], this PTS is not intended to cover design rules for them. IFRT, EFRT or CFRT tanks shall be selected in preference to very high-pressure tanks.

2.4 FIXED ROOF TANKS WITH INTERNAL FLOATING COVER (IFRT)

In a fixed roof tank an internal floating cover (IFC) can be installed to give a further reduction of vapour losses. These tanks can be designed as non-, low- and high-pressure tanks.

For safety and environmental reasons, internal floating covers shall be of the full-contact type.

2.5 FLOATING ROOF TANKS (EFRT)

2.5.1 General

This type of tank is designed to work at atmospheric pressure.

Although normally recommended only for diameters of 15 m and greater, this does not exclude its use in smaller diameters in special circumstances. The diameter of a floating roof tank shall at least be equal to its height to enable the use of a normal rolling ladder for access to the roof.

Types of floating roofs can vary but the most common used types are either pontoon single deck or double deck floating roofs.

2.5.2 Pontoon single deck floating roof

A pontoon single deck type roof consists of an outer pontoon ring divided by bulkheads into liquid tight compartments with an inner section of ordinary steel plates acting as a single deck membrane. This type of roof is recommended for tank diameters up to 48 m.

2.5.3 Double deck floating roof

A double deck floating type roof consists of an upper and a lower deck extending over the entire area of the liquid surface. The lower deck is separated from the upper deck by circumferential rim plates and radial bulkhead plates to form liquid tight compartments.

2.6 COVERED FLOATING ROOF TANKS (CFRT)

This type of tank has an aluminium geodesic self-supporting dome roof. The geodesic dome roof shall be designed with an integrated tension ring to contain the primary horizontal force. In this regard the roof attachment points shall be designed to assure the transfer of all roof loads to the tank shell, keeping local stresses within allowable limits, and shall incorporate slide bearing with low-friction bearing pads to minimise the horizontal radial forces from transfer into the tank shell. The design criteria in API 650 Appendix G shall be applied. Special attention shall be given to cold or very cold climates with respect to snow and ice load conditions.

This type of tank is classified as a BOF tank and all design features, are equivalent to those of a BOF type of tank. The tank can, in addition to the aluminium dome roof, be provided with an internal floating cover (IFC).

2.7 SELECTION OF VERTICAL TANKS

2.7.1 General input parameters

The selection of the most suitable type of storage tank(s) is a complex process and involves a series of decisions that relate specifically to the product or products to be stored. As shown in Figure 1, the selection process starts with the type of product to be stored and its physical properties, especially volatility. Volatility is a function of the True Vapour Pressure (TVP) of the liquid at storage temperature. All hydrocarbon (HC) products have the characteristic that the TVP increases with an increase in temperature. At the boiling point the TVP is equal to atmospheric pressure. The vapour pressure is usually determined by the Reid method. This is a standard test (ASTM D 323) whereby the vapour pressure is determined at 37.8 °C.

NOTE: All TVP values stated in this PTS are absolute pressures.

Environmental regulations have strict guidelines on vapour release to atmosphere. Local regulations shall be checked as these may limit the selection and use of a floating roof design and require that an alternative vapour control/recovery system be considered.

The TVP of hydrocarbons in fixed roof tanks (not equipped with an IFC or connected to a vapour treatment unit) shall be limited to 100 mbar and in external floating roof tanks this shall be limited to 625 mbar for single deck floating roofs or 765 mbar for double deck floating roofs. Products with a TVP value between 765 mbar and 860 mbar shall be stored in a double-deck floating roof, for which special measures and risk assessments shall be taken into account. These measures shall include, but are not limited to, fire ignition prevention measures and restricted roof access.

If the TVP is lower than 860 mbar the product can be stored in tanks that are designed and built in accordance with this PTS. Products with a TVP greater than 860 mbar shall be stored in low-pressure refrigerated storage tanks, or in pressurised storage vessels.

Depending on the product composition and prevailing local environmental conditions the use of cooling devices may be required in order to maintain the TVP below the allowable limit for conventional storage and shipping (rundown temperature control).

For groups of tanks containing the same product type (e.g gasolines), the vapour space of these tanks can be connected to create a vapour balancing system. The surplus of such a balancing system can be collected in a vapour buffer and sent to a vapour recovery unit.

Although they are not dealt with further in this PTS, factors such as evaporation losses, pumping losses, climatic conditions, air pollution, soil conditions and local regulations are all important factors and shall also be taken into consideration when selecting the most suitable type(s) and size(s) of storage required. Establishing the most appropriate storage arrangement requires the selection/decision process to be based on a study of the prevailing circumstances and thorough review/assessment of all factors involved.

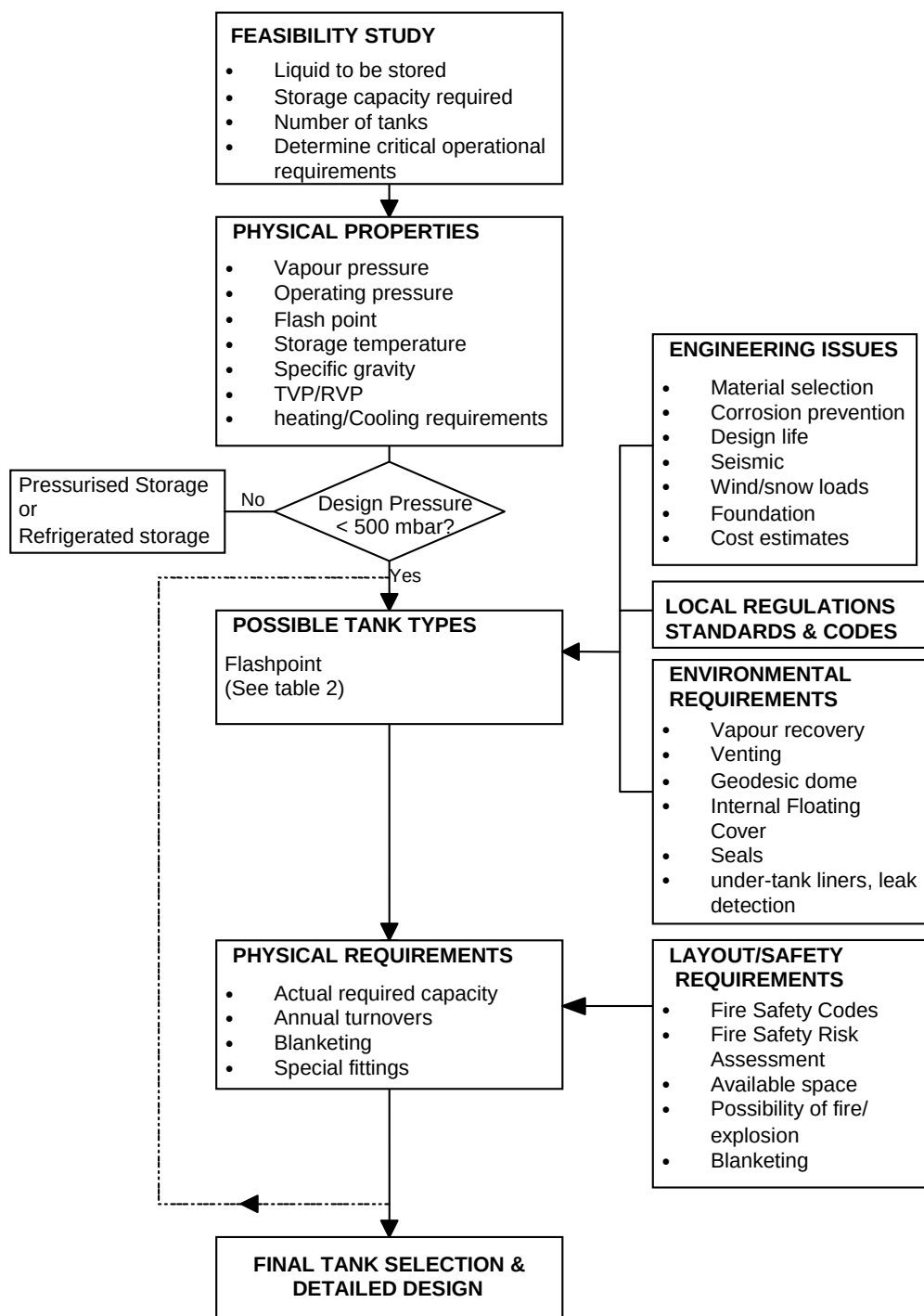


Figure 1 Overview of tank selection criteria

Final selection will be significantly influenced not only by the known properties of the products to be stored and the associated engineering issues, but also by criteria established through a detailed review of local regulations standards codes, environmental requirements, cost considerations and space availability. The engineering designer should evaluate in close cooperation with process engineering all the appropriate factors in establishing the criteria for final selection and detail design of the storage facility.

2.7.2 Best practice selection

Assessment of the number, size and type of tank(s) required depends on numerous and varied factors, as shown in (2.7.1). No hard and fast rules can be given. Each individual case shall be considered on its own unique set of needs, criteria and prevailing local conditions. However after the number, size and type of tank(s) required have been initially defined, the solution should be further reviewed, taking into consideration the following scale of economy and longer-term operational flexibility factors.

1. Strict application of the tank selection criteria as shown in (2.7.1) would, given the varied products likely to be stored, result in a different tank design for each product according to its properties. However in practice it is convenient to use a common design, depending on the number and type of tanks defined, the products to be stored and the plant's future operational needs,.

For example: BNC/BND tanks may be initially defined, but after the plants future storage and operational needs have been assessed, the better and more flexible solution may be to select BLC/BLD tanks. BLC/BLD tanks are easily converted to BNC/BND tanks, and with minor modifications they can operate as BHC/BHD tanks - by reinforcing the top-curb angle, providing holding down anchors at the junction of the shell and bottom plates if required and adjusting the setting pressure of the pressure/vacuum-relief valves.

2. Standard tank type and range by product flash point

An important physical property when rationalising the size and type of tank(s) required is the flash point classification of the products to be stored, particularly when the storage of different products over time is considered. Table 2 indicates the standard type and diameter range of tanks recommended for the storage of different classes of petroleum products according to their flashpoints.

3. Volatile products (high vapour pressure) such as crude oil, gasoline and naphtha should be stored in EFRTs, CFRTs or IFRTs to eliminate virtually all breathing and filling losses. Generally, for tanks containing products with a TVP below 100 mbar, vents shall be installed in compliance with EN 14015 and/or API 2000. See also section (8) of this PTS.

Table 2 **Types of tank for various products**

	TANK DIAMETER IN METRES (NOTE 3)																							
Class of product	3	4	6	8	10	12.5	15	17.5	20	22.5	25	27.5	30	33	36	39	42	45	48	54	60	66	72	78+
Class I, flash point less than 21°C and Class II(1), flash point between 21°C and 55°C handled below flash point	FRT(L,H) IFRT(N,L,H)						FRT(L,H) EFRT IFRT(N,L,H) CFRT			FRT(L) Preferably EFRT, IFRT(N) or CFRT							EFRT CFRT							
Class II(2), flash point 21°C and higher but less than 55°C handled above flash point and Class III(1) flash point above 55°C but handled below flash point	FRT(L) IFRT(N)						FRT(L) IFRT(N) EFRT CFRT			FRT(L) Preferably EFRT, IFRT(N) or CFRT							EFRT CFRT							
Class III(2) flash point 55°C and higher handled above flash point and unclassified	FRT(N)						FRT(N)			FRT(N)							EFRT CFRT							

NOTES

1. Classification of product is taken from the IP Code Part 19.
2. Fixed roof tanks (FRT) up to a diameter of 39 m incl., storing certain class I and II products, may be connected to a vapour recovery system, or a fixed roof with internal floating roof (IFRT) may be used (especially as an alternative to the BOF type) where rain water penetrating between shell and seal may have an adverse effect on the quality of the product stored.
3. The above selections are recommended, but other selections may be made if approved by the Principal.
4. (N)=Non Pressure, (L)= Low Pressure, (H)= High Pressure fixed roof tanks with either a cone or dome roof (see 2.1).

2.8 CAPACITIES

Appendix 3 lists the nominal gross capacities of all tanks that are considered to be within the standard range.

NOTE: The actual dead stock depends on the location of the **highest** nozzle in the lowest shell course, the present of a floating roof/cover and whether side entry mixers are installed. The figures as given in Appendix 3 are only indicative and may only be used for estimation purposes. Final net capacity shall be calculated during the detailed engineering design. For reducing dead stock in large tanks, the Principal may decide to specify smaller, but multiple, inlet/outlet nozzles (e.g. change from a single DN 900 inlet/outlet pipe to two DN 600 pipes connected to the DN 900 pipe outside the tank). This can considerably reduce the dead stock.

3. MATERIALS

3.1 SPECIFICATIONS FOR CARBON AND CARBON MANGANESE STEEL PLATES AND SECTIONS

All carbon and carbon manganese steel plate used in the manufacture of tanks designed and fabricated in accordance with this PTS shall comply with EN 14015 Clause 6.1.

If steel grades other than those complying with the above are proposed in conformity with accepted standards of the country in which the tanks are to be fabricated or the steel is to be rolled, these steel grades shall comply with EN 14015 Annex F.

3.2 SPECIFICATIONS FOR PIPE/FLANGES USED FOR NOZZLE BODIES AND INTERNAL PIPING

Pipe/flanges used for nozzle bodies and internal piping for tanks that are designed and fabricated in accordance with this PTS shall comply with EN 14015 Clauses 6.1.4 and 6.1.7.

3.3 SPECIFICATIONS MOUNTINGS

Unless otherwise agreed between the Principal and the Contractor, all mountings (reinforcement plates, insert plates, attachment plates, etc.) shall be of the same material type as the plate to which they are welded.

3.4 DESIGN TEMPERATURE

EN 14015 Clause 5.2 is applicable to the definition of the Design Metal Temperature and the requirements for selecting the Design Metal Temperature.

3.5 NOTCH DUCTILITY

EN 14015 Clause 6 Table 9 and Figure 1 shall apply.

3.6 MECHANICAL TESTING

Mechanical testing is required for all tank structural materials, including roof and bottom plates, with the exception of those structural materials for which the thickness is determined for practical reasons and not by stress considerations.

3.7 STRUCTURAL BOLTS

Structural bolts shall have metric threads to ISO 898, grade 8.8 and shall be hot dip galvanized. The allowable design stress shall not exceed the lower of one-half of the yield strength or one-third of the tensile strength.

3.8 ELEVATED OPERATING TEMPERATURE

For tanks designed for operating at elevated temperature above 100 °C the material properties shall comply with EN 14015 Clause 5.4.

NOTE: For tanks designed for operating at 100 °C or below, loads resulting from temperature effect may be ignored.