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COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS

Sub-Committee of Experts on the Transport of Dangerous Goods

REPORT OF THE SUB-COMMITTEE OF EXPERTS ON ITS TWELFTH SESSION (Geneva, 1-12 July 1996)

Addendum 1

Annexes 1 and 2

Annex 1 - **Report of the Working Group on Portable Tanks (see also ST/SG/AC.10/C.3/24 paras. 18 to 47)**

Annex 2 - **Report of the drafting group on guidelines for assigning portable tank requirements to substances in Classes 3 to 9 (see also ST/SG/AC.10/C.3/24, paras. 19 to 21)**

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ANNEX 1

REPORT OF THE WORKING GROUP ON PORTABLE TANKS

1. The Working Group on Portable Tanks reconvened from 1-12 July 1996 during the twelfth session of the Sub-Committee. Dr. Schulz-Forberg (Germany) presided as Chairman. Experts from France, Germany, Norway, Netherlands, Sweden, United Kingdom and the United States of America, observers from South Africa, Spain and Switzerland and representatives from OCTI, EIGA and TCA/EPTA attended the working group meeting. The group agreed to the following agenda:

(a) Review of decisions by the Sub-Committee (see paragraphs 18 to 40 of the Report of the Sub-Committee on its twelfth session, ST/SG/AC.10/C.3/24)
(b) Discussion of Portable Tank Tables in Chapters 12 and 17;
(c) Final reading of Chapter 12;
(d) Report (Part I) to be presented to the Sub-Committee;
(e) Final reading of Chapter 17;
(f) Future work programme and timetable;
(g) Report (Part II) to be presented to the Sub-Committee;
(h) Any other business.

2. The Chairman reminded the working group of previous decisions and the terms of reference handed down by the Committee and Sub-Committee. He reaffirmed that the goal of the portable tank harmonization effort is to establish a complete and harmonized set of truly multimodal requirements to be used for transport anywhere in the world. He stressed that the new requirements should be established in the RID/ADR, 49 CFR and other regulations not as amendments to existing requirements, but as alternative requirements for tank manufacturers and users involved in international multimodal transport. The chairman indicated that in the RID/ADR for instance, he envisioned that a new appendix would be added to cover the new international multimodal portable tank requirements while the existing Appendix B.1.b/X would be maintained for portable tanks used exclusively for regional land transport within RID/ADR member states. The expert from the United States indicated that amendments to 49 CFR would be undertaken in a similar manner. On this basis, existing national and regional requirements would remain in the regulations and the new requirements would be introduced as an alternate means of compliance for portable tanks transported internationally. The new requirements would establish a new generation of portable tanks. He confirmed the need to establish grandfathering provisions for existing portable tanks since the new requirements should only apply to portable tanks built after January 1, 1999 or 2000 (depending on decisions taken by national and international regulatory bodies). The Chairman confirmed the group’s goal for completing the harmonization work by December 1996. The group noted the guidance provided by the Sub-Committee relevant to developing a text in accordance with the restructuring of the UN Recommendations. It was agreed that the expert from the United States of America would develop the reformatted text for the tenth revised edition of the UN Recommendations based strictly on the harmonized text developed by the working group following the twelfth session of the Sub-Committee meeting.

Agenda Item (a)

3. The working group considered INF. 43 (EIGA) concerning the transport of non-refrigerated liquefied gases in portable tanks. The representative from EIGA asked the group to delete the paragraph "The design reference temperature should be less than the critical temperature of the gas to be transported to ensure that the gas at all times is liquefied." in paragraph 12.26.13 of ST/SG/AC.10/C.3/R.741 (paragraph 12.26.14 in this report). The expert from the United Kingdom

reminded the group that Chapter 12 of the UN Recommendations currently only allows liquefied gases to be transported in portable tanks. He suggested that a new section would need to be developed to cover transport of liquefied gases with critical temperatures above the design reference temperatures specified in paragraph 12.26.13 of ST/SG/AC.10/C.3/R.741 (paragraph 12.26.14 in this report). The expert from the United States indicated that some of the gases proposed in the EIGA proposal have extremely high absolute vapour pressures, some are highly toxic and some are not allowed for transport in existing regulations. The representative from OCTI indicated that the RID/ADR allows these gases to be transported in multiple element portable tanks (see marginals 212 235 and 212 251 from TRANS/WP.15/139). The representative from EIGA agreed to take the discussions into account and to develop a comprehensive proposal for gases with critical temperatures below the design temperature specified in paragraph 12.26.13 of ST/SG/AC.10/C.3/R.741 (paragraph 12.26.14 in this report) for the 19th session of the Committee of Experts.

4. The group then discussed ST/SG/AC.10/C.3/R.776 (Germany) concerning tank strings. The chairman summarized the decision of the Sub-Committee that tank strings should be considered more or less as a means for marking portable tanks while the T notes described in ST/SG/AC.10/C.3/R.618/Rev.1 (United States) should be considered as a means more or less of identifying tank requirements in the new dangerous goods list. The expert from Sweden indicated that neither the German or United States proposals identify a means for identifying requirements or markings for liquefied gas tanks. The group agreed that since there was no clear consensus on establishing tank types and there was not much time left in the current biennium that all references to tank types in Chapters 12 and 17 should be deleted pending a comprehensive proposal. The group decided to replace the words "tank type" in paragraph 12.19.1 with the words "and the substances or group of substances allowed for transport". The chairman noted that this could be reversed in the next biennium pending the outcome of discussions concerning the incorporation of tank types and the rationalized approach.

5. The group next discussed the Sub-Committee’s decision to maintain a factor of 1.3 versus 1.5 for determining test pressure based on design pressure for portable tanks intended for the transport of liquefied gases. Some group members expressed concern that the multiplying factor was different for tanks intended for liquids and liquefied gases. Most members agreed that the minimum thicknesses specified for liquids override the results of design calculations based on test pressure. The expert from the United States explained that the pressure vessel code used in his country requires the hydrostatic test pressure to be 1.5 times design pressure while applying lower design reference temperatures. The group considered that since the test pressure was required to be **at least** 1.3 times design pressure there was no real conflict in requirements. The expert from Sweden suggested that the group consider amending 12.28.3 to begin "At a pressure equal to 1.3 times the design pressure, the...............". This would mean a possibility to increase the test pressure referred to in 12.28.2 up to 1.65 times the design pressure without changing the actual design. He also pointed out that increasing the stress during the pressure test above the presently allowed 0.75 Re would from a technical point of view be beneficial to safety. However, although the group generally supported his proposal it was not adopted since it would require an extensive change to the design requirements of Chapters 12 and 17.

6. The group discussed the Sub-Committee’s decision to allow two external closures for bottom openings on portable tanks intended for the transport of solids, highly viscous and crystallisable substances. The group agreed to adopt the figure of 2,680 mm^2/s for defining highly viscous substances. The group did not agree to delete the word crystallisable since they were not convinced that all crystallisable substances are highly viscous. Group members were asked to consider this further with their colleagues back home and to consider whether the word crystallisable could be deleted. The group asked the expert from Germany to add a list of solid substances currently assigned 12.7.2 in

Table 12.2 to his list of 12 highly viscous substances developed based on current tank table assignments. The expert from Germany was also asked to develop a definition for crystallisable.

7.   The group considered the proposals related to use of the terms flame trap or flame arrester in INF. 8, INF 20 and ST/SG/AC.10/C.3/R.777. The group decided not to incorporate either term but instead to include the following text based on performance criteria in lieu of the words flame trap "with a device which will prevent immediate passage of a flame into the tank" in paragraph 12.3.9 of ST/SG/AC.10/C.3/R.741. The group asked the expert from Germany to provide a definition for explosion pressure proof. The group developed the following text "capable of withstanding an internal explosion resulting from an immediate passage of a flame into the tank without leakage" to replace the words explosion pressure proof. The group agreed to this text.

8.   The group considered paragraphs 1.2, 1.3 and 1.4 in ST/SG/AC.10/C.3/R.723 (Argentina) based on the direction provided by the Sub-Committee. The group maintained the words "as a general rule" in paragraph 12.20.3 on the basis that the text allows the competent authority or its authorized body discretion in allowing test mediums other than water (e.g. another liquid or in extreme cases a gas). This was considered necessary for tanks intended for the transport of water reactive substances. The portable tank working group did not adopt the proposal in paragraph 1.3 of ST/SG/AC.10/C.3/R.723 since the group considered that the competent authority should be authorized to waive internal examinations for tanks in dedicated service or where alternate test methods are used. The group accepted the proposal in paragraph 1.4 of ST/SG/AC.10/C.3/R.723 in part by adding the word "gauge" between the words "effective" and "pressure" in paragraph 12.2.6(a) of ST/SG/AC.10/C.3/R.741.

9.   In conjunction with the Sub-Committee’s decision, the group incorporated a reference to France’s rail impact test procedure (see INF.23 (France) and this report).

10.   Based on a discussion of ST/SG/AC.10/C.3/R.783 (IMO) the group concluded that there is no intention to subject freight containers to a 4g impact test.

11.   Based on ST/SG/AC.10/C.3/R.772 (Belgium) the group agreed to amend paragraphs 12.16.1, 12.36.1 and 17.11.1 in ST/SG/AC.10/C.3/R.741 by adding the words "under maximum filling conditions" after the word "should" and before the words "be situated". The working group rejected the proposal not to allow the authorized body to waive the internal examination.

Agenda Item (b)

12.   Based on a proposal in ST/SG/AC.10/C.3/R.773 (Belgium) the group agreed to add a new note 15 for Table 12.2 as follows:

> "The portable tank should be fitted with a device located under maximum filling conditions in the vapour space of the shell to prevent the build up of excess pressure due to the slow decomposition of the substance transported. This device should also prevent leakage of liquid or entry of foreign matter into the tank. This device should be approved by the competent authority or its authorized body."

The group agreed that this note should be assigned to the following UN numbers: 1791, 1908, 2014, 2015, 2984 and 3149.

13.   The group agreed in principle to adopt a note in Table 12.2 taking into account note T 37 in 49 CFR. The group asked the expert from the United States to develop a proposal for the 19th

session of the Committee of Experts.

14. The group did not consider whether Tables 12.1, 12.2 and 17.1 should be maintained or how to incorporate tank provisions into the new dangerous goods list since this matter was to be discussed by the rationalized approach working group and the Sub-Committee.

Agenda Item (c)

15. The group considered the TCA/EPTA proposals ST/SG/AC.10/C.3/R.728 and ST/SG/AC.10/C.3/R.729. The group adopted these proposals with minor amendments (see Chapter 12 in this report).

16. The group did not adopt the proposal in ST/SG/AC.10/C.3/R.762 (United States) concerning paragraph 12.10.2 because they felt that the test pressure was well defined for liquid tanks and that relief device set pressures should be defined on the basis of test pressure. The proposal relevant to paragraph 12.33.1 was adopted in principle by changing the figure of 1.1 to 1.2. The proposals relevant to refrigerated liquefied gases were deferred to discussion under agenda item (e).

17. The group did not delete the design requirements for aluminum portable tanks even though none are authorized in Table 12.2. The group acknowledged the fact that aluminium is allowed for portable tanks intended for the transport of hydrogen peroxides and pure nitric acid in RID/ADR. The group agreed to include the existing text requiring aluminum tanks to be insulated and fitted with a jacket from paragraph 12.3.1 of the Recommendations in paragraph 12.3.1 of ST/SG/AC.10/C.3/R.741.

18. The group agreed to adopt an amendment to paragraphs 12.3.1, 12.27.1 and 17.3.1 consistent with an informal proposal submitted by the experts from Germany and Spain. Several experts indicated that they believed that actual values of Rm and Re for fine grain steel should be used as opposed to guaranteed values provided in the material standards.

19. Based on INF.15 (United States) the group agreed in principle to replace the formula for determining the size of test specimens in Chapters 12 and 17 with a reference to ISO:6892-1984 and the requirement that the specimen gauge length should be 50 mm.

20. Based on INF.39 (Argentina) the group agreed to add the words "need to" after the words "the shipper may" in paragraph 12.22.1 in ST/SG/AC.10/C.3/R.741.

21. The group discussed the information required on the marking plate in 12.43.1 for the non-refrigerated liquefied gases. Specifically the group was concerned with the terms: "total mass", "maximum permissible gross mass" and "maximum permissible load mass for each gas permitted". The representative from OCTI reminded the group that maximum permissible load mass is used to prevent the tank from being over filled whereas maximum permissible gross mass is used for preventing overloading. The group agreed with this concept. The term "total mass" was replaced by the term "maximum permissible gross mass" in paragraphs 12.2.10, 12.3.10, 12.26.10 and 12.27.9.

22. The group discussed the reference to the Compressed Gas Association CGA S-1.2 in paragraph 12.33.1.1 based on a proposal by the expert from the United States based on a proposal made during the Atlanta intercessional meeting. The expert from the United Kingdom informed the group that the Compressed Gas Association standard includes a disclaimer which indicates that the Compressed Gas Association does not accept responsibility for the information contained within the standard. The expert from the United States told the group that the Compressed Gas Association

standard is used widely by industry and is incorporated by reference in the 49 CFR. He explained that it was his understanding that the information contained in the CGA standard represented the best available information. He indicated that other group members should identify alternative sources of information if they existed. The group agreed to include the reference to CGA S-1.2 in the footnote to the relief capacity formula in 12.33.1.1 only for the purpose of calculating pressure relief device delivery capacities on the basis of thermodynamic properties of specific liquefied gases. The words "see for instance CGA S-1.2" were added at the end of the footnote. The expert from the United Kingdom objected to the group’s decision.

23. During the course of the final reading of the requirements for non-refrigerated liquefied gases the representative from Tank Container Association agreed to provide a proposal for relaxation of some requirements applicable to portable tanks of capacities less than 1000 litres. TCA also agreed to provide a proposal addressing tank requirements for chlorine and a proposal concerning markings for pressure relief devices.

24. The group concluded the final reading of Chapter 12. A number of additional minor and editorial amendments were adopted to the Chapter 12 text. Annex 1 includes the text agreed to by the working group. This text will be reviewed by a small editorial correspondence group and provided to the Working Group on Portable Tanks for a final review via correspondence. The approved text will be used by the expert from the United States to develop the reformatted text which will be submitted as an official paper for the Committee meeting.

Agenda Item (d)

25. The chairman of the working group presented a draft report including a summary of the issues discussed under agenda items (a) through (c) of the agenda.

Agenda Item (e)

26. The group began the final reading of Chapter 17. The expert from the United States provided the group with copies of several informal proposals which he requested be considered based on comments received from industry representatives in his country. The working group used ST/SG/AC.10/C.3/R.741 as a basis for considering paragraphs 17.1 through 17.12.2 and the updated French INF 11 document (now dated January 1996) from the eleventh session of the Sub-Committee as a basis for considering paragraphs 17.13 through 17.19.4.

27. In paragraph 17.2.2 the group revised the definition of portable tank consistent with 12.26.2. The group felt that clear definitions for the terms "gas cylinders" and "receptacles" should be introduced within the recommendations including a maximum volume of 1000 litres for these types of packagings.

28. In paragraph 17.2.9 the group agreed to delete the words "equal to at least 1.3 times the MAWP" in the definition of test pressure. The expert from the United States recommended deleting the factor of 1.3 in paragraph 12.26.8 to make the liquefied gas sections consistent. This was agreed. The expert from the United States also requested that the definition not be limited to allowing only a hydraulic pressure test. The expert from the United Kingdom proposed to replace "hydraulic pressure test" with "proof pressure test". The group agreed to adopt "pressure test"in lieu of "hydraulic pressure test".

29. The expert from the United States suggested that the group delete the square brackets around the text "at least 90% of the MAWP" for the refrigerated liquefied gases. He felt that there was

justification for differentiating between non-refrigerated and refrigerated liquefied gases. The group adopted the text "at least 90% of the MAWP" in paragraph 17.2.10.

30. In paragraph 17.2.11 the group decided to adopt a definition for "Maximum permissible gross mass" in lieu of a definition for total mass consistent with previous decisions relevant to the requirements in Chapter 12.

31. The group next began a discussion of the definition of holding time in paragraph 17.2.12. The group decided that more defined criteria for the determination of holding time should be incorporated in the Recommendations. It was decided to address this matter under the discussion of paragraph 17.3.8. The group agreed to the existing text in 17.2.12 with the exception that "heat leak" was changed to "heat influx".

32. The group then considered a proposal by the expert from the United Kingdom proposing incorporation of a design reference temperature of -40°C to 50°C for jackets. The majority of the group agreed that although the jacket forms an integral part of the portable tank it is not an integral part of the pressure retaining system. The group considered that the jacket is not within the pressure boundary for design and construction purposes. The expert from the United Kingdom indicated that it was his opinion that the jacket is designed according to the pressure vessel code. The proposal was not adopted. The working group agreed to incorporate general requirements for the construction of jackets in the text in paragraph 17.3.1.

33. The group discussed paragraph 17.3.8 and considered whether to leave the determination of holding time to the competent authority or to develop more comprehensive text based on the proposed text provided by the expert from the United States and the draft CEN standard provided by the expert from France. The group agreed that a simple reference to the CEN standard (prEN 12213) was not acceptable at this time because the standard is in draft form and because of the concerns (e.g. use of enthalpy formula vs. internal energy formula) raised by the observers from TCA. The group convened a drafting group which developed new text for determining holding time and holding time marking requirements. The group decided to adopt a reference ambient temperature of 30 °C vs. 50 °C based on the fact that a 30 °C factor more accurately characterizes the mean daily temperature (considering 24 hr heating and cooling). The group agreed to adopt text which outlines the determination of heat influx (efficiency of the insulation), the concept of a reference holding time and an actual holding time.

34. In relation to paragraph 17.3.9 the group discussed whether the Compressed Gas Association (CGA) standard, CGA-341:1995 should be incorporated as an acceptable means of calculating critical collapsing pressure for the jackets of vacuum insulated portable tanks. The proposal was not adopted.

35. The words "including the effects of fatigue" were adopted based information provided by the expert from Germany during the Atlanta meeting and on a proposal from the expert from the United States in paragraph 17.3.11. Working group members considered that it was necessary from a safety perspective to include considerations for fatigue in the design of portable tanks. The appropriate sections of Chapters 12 and 17 were amended in accordance with this decision.

36. The expert from the United States informed the group of comments by a representative of France during an ISO/TC 197/WG2 meeting in Tokyo concerning multimodal transportation of liquid hydrogen in portable tanks. The comments suggested that design loads should be specified instead of static loads in considering rail impacts. In addition, it was suggested at the Tokyo ISO meeting that the requirements for the design of portable tanks be readdressed; especially to accommodate rail transportation of these multimodal portable tanks where the accelerations can be very severe. The group

agreed that the 4g impact test satisfied the requirements.

37. When discussing 17.13.5, the expert from Sweden pointed out that the use of the words tank and shell in his opinion was not correct. In his view the text should clearly indicate that the protection against collision referred to in this paragraph was afforded by the jacket of a vacuum insulated portable tank. However this view was not supported by the majority and the text as it appeared in the French INF document was adopted. The expert from Sweden objected to the decision.

38. In considering the paragraphs under 17.15, Inspection and Testing, the group agreed to use the text from paragraph 12.40 and the French INF document as a basis for the inspection and test requirements applicable to portable tanks intended for the transport of refrigerated liquefied gases (cryogenic tanks). The group considered the text and took into account specific requirements necessary for the tanks subject to the requirements of Chapter 17. For instance, the group incorporated text to allow items of equipment to be tested separately from the shell. The group agreed to incorporate a reference to 17.4.2 to more precisely define the test pressure for the pressure test. The group agreed that pneumatic pressure tests should be allowed for some portable tanks since the tank supports in some cases (e.g. helium or hydrogen tanks) are not designed to support the weight of water which would be required for a hydrostatic pressure test. Since internal inspection would be extremely impracticable for cryogenic tanks without openings (see 17.6.4) the group agreed not to require internal inspections. The expert from Germany developed revised text taking into account the decisions of the group and it was adopted (see Chapter 17 in this report).

39. The expert from the United States proposed to allow an initial degree of filling of 98% for both flammable and non-flammable gases. The expert from the United Kingdom objected because he felt that the 2% ullage was not an acceptable safety margin. The majority of the group supported the proposal from the United States because cryogenic tanks will only reach maximum filling limits when the maximum holding time is reached. The experts from the United Kingdom and Norway and the observer from Spain objected to the decision. The group adopted the proposal.

40. In regard to 17.7.2 the group agreed to maintain the existing text relevant to the transport of helium.

41. The representative from EIGA and the experts from France and Sweden expressed concern that some of the decision taken relevant to Chapter 17 were taken hastily due to the minimal time available for discussions. They indicated that a disproportionate amount of time had been devoted to Chapter 12. The chairman agreed to express these concerns to the Sub-Committee and reminded group members that they could submit proposals for consideration by the Committee at its nineteenth session and that the deadline for submission is September 20, 1996.

CHAPTER 12

RECOMMENDATIONS ON MULTIMODAL PORTABLE TANK TRANSPORT

12.1 Preamble

12.1.1 The provisions of this Chapter apply to portable tanks (including tank-containers) intended for the transport of dangerous goods of all Classes except Class 1 and refrigerated liquefied gases of Class 2 by all modes of transport. Requirements for portable tanks intended for the transport of refrigerated liquefied gases are covered in Chapter 17. In addition to the provisions of this Chapter, and unless otherwise specified, the applicable requirements of the International Convention for Safe Containers (CSC) should be fulfilled by any portable tank which meets the definition of a "container" within the terms of the Convention. Additional requirements may apply to offshore portable tanks that are handled in open seas.

12.1.2 In recognition of scientific and technological advances, the technical provisions of this chapter may be varied by alternate arrangements. These alternate arrangements should offer a level of safety not less than that given by the provisions of this Chapter with respect to the compatibility with substances transported and resistance to impact, loading and fire. For international transport alternate arrangement portable tanks should be approved by the applicable competent authorities.

12.1.3 These provisions are presented in two parts. The first contains general requirements applicable to portable tanks intended for the transport of dangerous goods of Classes 2, 3, 4, 5, 6, 7, 8 and 9. The second comprises tables of dangerous goods showing the special requirements which modify or supplement the requirements for each particular substance. Tables 12.1 and 12.2 will be required to be brought up to date from time to time by the possible addition of new substances and in the light of technical progress.

12.1.4 If a substance is not listed in Tables 12.1 or 12.2 interim approval for transport may be issued by the competent authority of the country of origin. The approval should be included in the documentation of the consignment and contain as a minimum the information normally provided in the list of substances in Tables 12.1 and 12.2 and the conditions under which the substance should be transported. Appropriate measures should be initiated by the competent authority to include the substance in Tables 12.1 and 12.2.

PORTABLE TANK REQUIREMENTS FOR LIQUID AND SOLID SUBSTANCES OF CLASSES 3 THROUGH 9

12.2 Definitions

12.2.1 The following requirements apply to portable tanks intended for the transport of substances in Classes 3, 4, 5, 6, 7, 8 and 9:

12.2.2 *Portable tank* means a multimodal portable tank having a capacity of more than 450 litres used for the transport of dangerous substances of Classes 3 through 9. The portable tank includes a shell fitted with service equipment and structural equipment necessary for the transport of dangerous substances. The portable tank should be capable of being loaded and discharged without the removal of its structural equipment. It should possess stabilizing members external to the shell, and should be capable of being lifted when full. It should be designed primarily to be loaded onto a transport vehicle or ship and should be equipped with skids, mountings or accessories to facilitate mechanical handling.

Road tank-vehicles, rail tank-wagons, non-metallic tanks and intermediate bulk containers (IBCs) are not considered to fall within the definition for portable tanks;

12.2.3 *Shell* means the tank proper, including openings and their closures, but does not include service equipment or external structural equipment;

12.2.4 *Service equipment* means measuring instruments and filling, discharge, venting, safety, heating, cooling and insulating devices;

12.2.5 *Structural equipment* means the reinforcing, fastening, protective and stabilizing members external to the shell;

12.2.6 *Maximum allowable working pressure (MAWP)* means the pressure that should not be less than the greatest of the following two pressures measured at the top of the shell while in operating position:

12.2.6.1 the maximum effective gauge pressure allowed in the shell during filling or discharge; or

12.2.6.2 the maximum effective gauge pressure to which shells intended to transport liquids are designed, should be the sum of the following pressures:

12.2.6.2.1 the absolute vapour pressure (in bar) of the substance at 65 °C minus 1 bar;

12.2.6.2.2 the partial pressure (in bar) of air or other gases in the ullage space being determined by a maximum ullage temperature of 65 °C and a liquid expansion due to the increase of the mean bulk temperature of t_r-t_f (t_f = filling temperature usually 15 °C, t_r = 50 °C maximum bulk temperature);

12.2.7 *Design pressure* means the pressure to be used, according to a recognized pressure vessel code. The design pressure should not be less than the greatest of the following three pressures:

12.2.7.1 the pressure in 12.2.6.1; or

12.2.7.2 the pressure in 12.2.6.2 and the head pressure determined on the basis of the dynamic forces due to inertia specified in 12.3.10; such a head pressure should not be taken less than 0.35 bar; or

12.2.7.3 the minimum test pressure specified in Table 12.2, divided by 1.5;

12.2.8 *Test pressure* means the maximum gauge pressure at the top of the shell taken during the hydraulic pressure test equal to at least 1.5 times the design pressure. The minimum test pressure for portable tanks used for specific substances is given in column 5 in Table 12.2;

12.2.9 *Leakproofness test* means a test using air or an inert gas which consists of subjecting the shell and its service equipment to an effective internal pressure equivalent to not less than 25% of the MAWP;

12.2.10 *Maximum permissible gross mass (MPGM)* means the sum of the tare mass of the portable tank and the heaviest load authorized for transport;

12.2.11 *Reference steel* means a steel with a tensile strength of 370 N/mm^2 and an elongation at fracture of 27%;

12.2.12 *Mild steel* means a steel with a guaranteed minimum tensile strength of 360 N/mm^2 to 440 N/mm^2 and a guaranteed minimum elongation at fracture conforming to 12.4.3.2;

12.2.13 *Design temperature range* for the shell is considered to be -40 °C to 50 °C for substances transported under ambient conditions. For substances handled under elevated temperature conditions the design temperature should be at least equivalent to the maximum temperature of the substance during loading, discharge or transport. More severe design temperatures should be considered for portable tanks subjected to severe climatic conditions.

12.3 General requirements for the design and construction of portable tanks intended for the transport of substances of Classes 3 through 9

12.3.1 Shells should be designed and constructed in accordance with the provisions of a pressure vessel code recognized by the competent authority. Shells should be made of metallic materials suitable for forming. The materials should in principle conform to national or international material standards. For welded shells only a material whose weldability has been fully demonstrated should be used. Welds should be skilfully made and afford complete safety. In choosing the material, the design temperature range should be taken into account with respect to risk of brittle fracture, to stress corrosion cracking and to resistance to impact. If fine grain steel is used the value of the yield strength, Re should not exceed 460 N/mm^2 and the guaranteed value of the upper limit of the tensile strength Rm should not exceed 725 N/mm^2 in accordance with the material specifications. Aluminium may only be used as a construction material when indicated in Table 12.2 for the substance to be transported. In those cases where aluminium is authorized, it should be insulated to prevent significant loss of physical properties when it is subjected to a heat load of 110 kW/m^2 for a period of at least 30 minutes. The insulation should remain effective at all temperatures up to 649 °C and should be jacketed with a material with a melting point of not less than 700 °C. Portable tank materials should be suitable for the external environment in which they may be transported.

12.3.2 Portable tank shells, fittings, and pipework should be constructed of materials which are:

12.3.2.1 substantially immune to attack by the substance(s) intended to be transported; or

12.3.2.2 properly passivated or neutralized by chemical reaction; or

12.3.2.3 lined with corrosion-resistant material directly bonded to the shell or attached by equivalent means.

12.3.3 Gaskets should be made of materials not subject to attack by the substance(s) intended to be transported.

12.3.4 The lining of a portable tank should meet the following:

12.3.4.1 The material used to line the shell should be:

12.3.4.1.1 substantially immune to attack by the substance(s) intended to be transported;

12.3.4.1.2 homogeneous;

12.3.4.1.3 non porous;

12.3.4.1.4 free from perforations;

12.3.4.1.5 sufficiently elastic; and

12.3.4.1.6 compatible with the thermal expansion characteristics of the shell.

12.3.4.2 The lining of the shell, portable tank fittings and piping should be:

12.3.4.2.1 attached by bonding or other satisfactory means;

12.3.4.2.2 continuous; and

12.3.4.2.3 extended around the face of any flange.

12.3.4.3 Joints and seams in the lining should be made by fusing the material together or by other equally effective means.

12.3.5 Contact between dissimilar metals which could result in damage by galvanic reaction should be avoided.

12.3.6 The materials of the portable tank, including any devices, gaskets, linings and accessories, should not adversely affect the substances intended for transport in the portable tank.

12.3.7 Portable tanks should be designed and constructed with supports to provide a secure base during transport and with suitable lifting and tie-down attachments.

12.3.8 Shells, their attachments and their service and structural equipment should be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads including the effects of fatigue during normal conditions of handling and transport.

12.3.9 Shells without vacuum-relief valves should be designed to withstand without permanent deformation an external pressure at least 0.4 bar above the internal pressure. Shells equipped with vacuum-relief valves should be designed to withstand, without permanent deformation, an external over-pressure of 0.21 bar gauge or greater and should have their vacuum-relief valve set to relieve at minus (-) 0.21 bar gauge. A greater negative setting may be used provided the external design pressure is not exceeded. Portable tanks intended for the transport of liquids meeting the flashpoint criteria of Class 3, or elevated temperature materials transported above their flashpoint, should be either:

12.3.9.1 equipped with only vacuum-relief devices which will prevent immediate passage of flame into the shell; or

12.3.9.2 have a shell capable of withstanding without leakage an internal explosion resulting from an immediate passage of flame into the shell.

12.3.10 Portable tanks and their fastenings should, under the maximum permissible load, be capable of absorbing the following separately applied static forces:

12.3.10.1 in the direction of travel: twice the maximum permissible gross mass multiplied by acceleration (g) */;

12.3.10.2 horizontally at right angles to the direction of travel: the maximum permissible gross mass (where the direction of travel is not clearly determined, the forces should be equal to twice the maximum permissible gross mass) multiplied by acceleration (g)*/.

12.3.10.3 vertically upwards: the maximum permissible gross mass multiplied by acceleration(g)*/; and

12.3.10.4 vertically downwards: twice the maximum permissible gross mass (total loading including the effect of gravity) multiplied by acceleration (g)*/.

12.3.11 Under each of these forces, the safety factors to be observed should be as follows:

12.3.11.1 for metals having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; or

12.3.11.2 for metals with no clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed 0.2% proof strength and, for austenitic steels, the 1% proof strength.

12.3.12 The value of yield strength or proof strength should be the value according to national or international material standards. If no material standard exists for the metal in question, the value of yield strength or proof strength used should be approved by the competent authority. When austenitic steels are used, the specified minimum values of Re or Rm according to the material standards may be increased by up to 15% if these higher values are provided in the material inspection certificate.

12.3.13 Portable tanks should be capable of being electrically earthed when they are used for the transport of substances meeting the flashpoint criteria of Class 3 or elevated temperature materials are transported above their flashpoint. Measures should be taken to prevent a dangerous electrostatic discharge.

12.4 Design criteria

12.4.1 Shells should be of a design capable of being stress-analyzed mathematically or experimentally by resistance strain gauges, or by other methods approved by the competent authority.

12.4.2 Shells should be designed and constructed to withstand a hydraulic test pressure equal to at least 1.5 times the design pressure. Specific requirements are laid down for particular substances listed in Table 12.2. Attention is drawn to the minimum shell thickness requirements specified in 12.5.1 to 12.5.10.

12.4.3 At the test pressure, the primary membrane stress σ in the shell should conform to the material-dependent limitations prescribed below.

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*/ For calculation purposes $g=9.81$ m/s^2.

12.4.3.1 for metals and alloys exhibiting a clearly defined yield point or characterized by a guaranteed proof strength (0.2% proof strength generally or 1% proof strength for austenitic steels), the membrane stress σ at the test pressure should not exceed 0.75 Re or 0.50 Rm, whichever is lower, where:

Re = yield strength, or 0.2% proof strength or, for austenitic steels, 1% proof strength;

Rm = minimum tensile strength.

12.4.3.2 The values of Re and Rm to be used should be the specified minimum values according to national or international material standards. Where no material standard exists for the metal or alloy in question, the values of Re and Rm used should be approved by the competent authority or its authorized body. When austenitic steels are used, the specified minimum values for Re and Rm according to the material standards may be increased by up to 15% if these higher values are provided in the material inspection certificate. Ratios of Re/Rm exceeding 0.85 are not allowed for steels used in the construction of welded shells. In determining the ratio Re/Rm, the values specified in the material inspection certificate should be used. The values specified in the material inspection certificate should conform with the following provisions:

12.4.3.2.1 for steel, the elongation at fracture, in%, should not be less than 10,000/Rm where Rm is in N/mm^2, with an absolute minimum of 16% for fine grain steels and 20% for other steels;

12.4.3.2.2 for aluminium, the elongation at fracture, in% should not be less than 10,000/6 Rm where Rm is in N/mm^2, with an absolute minimum of 12%.

12.4.3.3 For the purpose of determining actual values for materials, it should be noted that for sheet metal, the axis of the tensile test specimen should be at right angles (transversely) to the direction of rolling. The permanent elongation at fracture should be measured on test specimens of rectangular cross sections in accordance with ISO 6892:1984 using a 50 mm gauge length.

12.5 Minimum shell thickness

12.5.1 The minimum thickness of the shell should be the greater thickness based on:

12.5.1.1 the minimum thickness determined in accordance with the provisions of 12.5.2 through 12.5.10;

12.5.1.2 the minimum thickness determined in accordance with the recognized pressure vessel code including the provisions in 12.4.3; and

12.5.1.3 the thickness specified in Table 12.2.

12.5.2 The thickness in reference steel, or equivalent in actual metal of the cylindrical portions of the shells, the ends (heads) and the manhole covers should be:

12.5.2.1 For powdery or granular solid substances of PG I and for liquid substances:

12.5.2.1.1 not less than 5 mm when the shell diameter is less than or equal to 1.8 m;

12.5.2.1.2 not less than 6 mm when the shell diameter is greater than 1.8 m.

12.5.2.2 For portable tanks intended for the transport of powdery or granular substances of PG II or III, the thickness should be not less than 5 mm irrespective of the shell diameter.

12.5.3 Where additional protection of the portable tank against damage is provided, the competent authority may authorize for a portable tank having a test pressure below 2.65 bar, a reduction in the minimum shell thickness in proportion to the protection provided. However, the cylindrical portion of the shells, the ends (heads) and the manhole covers of shells not more than 1.80 m in diameter should not be less than 3 mm thick in the reference steel or of equivalent thickness in the actual metal, and those of shells more than 1.80 m in diameter should not be less than 4 mm thick in the reference steel or of equivalent thickness in the actual metal.

12.5.4 The cylindrical portion, the ends (heads) and the manhole covers in 12.5.2 and 12.5.3 should not be less than 3 mm thick regardless of the material of construction.

12.5.5 The additional protection referred to in 12.5.3 may be provided by overall external structural protection, such as suitable "sandwich" construction with the outer shielding secured to the shell, double wall construction or by supporting the shell in a complete framework with longitudinal and transverse structural members.

12.5.6 The thickness of a metal other than the reference steel prescribed in 12.5.2 and 12.5.3 should be determined by using the following equation:

$$e_1 = \frac{21.4 e_o}{\sqrt[3]{Rm_1 \times A_1}}$$

where:

e_1	=	the required equivalent thickness of the metal to be used in mm
e_o	=	minimum thickness for the reference steel specified in Table 12.2
Rm_1	=	guaranteed minimum tensile strength of the metal to be used in N/mm^2 (see 12.4.3)
A_1	=	guaranteed minimum elongation at fracture (as a percentage) of the metal to be used.

12.5.7 Where in Table 12.2, a minimum thickness of 8 mm, 10 mm or 12 mm is required, it should be noted that the thickness provided is based on a shell diameter of 1.8 m and on the properties of the reference steel . For metals having other characteristics and for shells having diameters greater than 1.8 metres, these values should be changed using the following equation:

$$e_1 = \frac{21.4 e_o d_1}{1.8 \sqrt[3]{Rm_1 \times A_1}}$$

where:

e_1	=	the required equivalent thickness of the metal to be used in mm;
e_o	=	minimum thickness for the reference steel specified in table 12.2;
d_1	=	the actual diameter of the shell in metres but not less than 1.8 m;
Rm_1	=	guaranteed minimum tensile strength of the metal to be used in N/mm^2 (see 12.4.3);
A_1	=	guaranteed minimum elongation at fracture (as a percentage) of the metal to be used according to national or international standards.

12.5.8 In no case should the wall thickness be less than that prescribed in 12.5.2, 12.5.3 and 12.5.4. All parts of the shell should have a minimum thickness as determined by 12.5.2 to 12.5.5. This thickness should be exclusive of any corrosion allowance.

12.5.9 If mild steel conforming to the definition of 12.2.12 is used, calculation using the equation according to 12.5.6 is not required.

12.5.10 There should be no sudden change of plate thickness at the attachment of the ends (heads) to the cylindrical portion of the shell.

12.6 Service equipment

12.6.1 Service equipment should be so arranged as to be protected against the risk of being wrenched off or damaged during conditions of handling and transport. If the connection between the frame and the shell allows relative movement between the sub-assemblies, the equipment should be so fastened as to permit such movement without risk of damage to working parts. The external discharge fittings (pipe sockets, shut-off devices), the internal stop-valve and its seating should be protected against the danger of being wrenched off by external forces (for example using shear sections). The filling and discharge devices (including flanges or threaded plugs) and protective caps (if any) should be capable of being secured against any unintended opening.

12.6.2 All openings in the shell, intended for loading or discharging lading, should be fitted with a manually operated stop valve located as near as practicable to the shell. Other openings, except for openings leading to venting or pressure-relief devices, should be equipped with either a stop-valve or another suitable means of closure located as close as reasonably practicable to the shell.

12.6.3 Each portable tank should be fitted with a manhole or other inspection openings of a suitable size to allow for internal inspection and adequate access for maintenance and repair of the interior. Compartmented portable tanks should have a manhole or other inspection openings for each compartment.

12.6.4 As far as reasonably practicable, external fittings should be grouped together. For insulated portable tanks, top fittings should be surrounded by a spill collection reservoir with suitable drains.

12.6.5 All portable tank connections should be clearly marked to indicate the function of each.

12.6.6 Each stop-valve or other means of closure should be designed and constructed to a rated pressure not less than the maximum allowable working pressure of the shell taking into account the temperatures expected during transport. Each stop-valve with a screwed spindle should be closed by a clockwise motion of the handwheel. For other stop-valves the position and/or direction of closure should be clearly indicated. All stop-valves should be constructed to prevent unintentional opening.

12.6.7 No moving parts, such as covers, components of closures, etc., which are liable to come into frictional or percussive contact with aluminium portable tanks intended for the transport of flammable liquids meeting the flashpoint criteria of Class 3 or elevated temperature substances transported above their flashpoint should be made of unprotected corrodible steel.

12.6.8 All piping should be of suitable metallic material. Welded pipe joints should be used wherever possible. Where copper tubing is permitted, joints should be brazed or have an equally strong metal union. The melting point of brazing materials should be no lower than 525 °C. Joints should not decrease the strength of the tubing (e.g. as may be the case when cutting threads). Ductile metals should be used in the construction of valves or accessories. The bursting strength of all piping and pipe fittings should be the greater of at least four times the strength at the maximum allowable working pressure of the shell or at least four times the strength at the pressure to which it may be subjected in service by the action of a pump or other device (except pressure-relief devices). Suitable provisions should be made in every case to prevent damage to piping due to thermal expansion and contraction, mechanical shock and vibration.

12.7 Bottom openings

12.7.1 Certain substances listed in Table 12.2 should not be transported in portable tanks with bottom openings. When Table 12.2 prohibits bottom openings, the shell should not be pierced below the lading level. When existing openings are closed it should be accomplished by permanently welding suitable blank flanges internally and externally to the shell.

12.7.2 Bottom discharge outlets for portable tanks carrying certain solids, crystallisable or highly viscous substances should be equipped with not less than two serially mounted and mutually independent shut-off devices. The design should satisfy the competent authority, or its authorized body, and should include:

12.7.2.1 an external stop-valve fitted as close to the shell as practicable; and

12.7.2.2 a liquid tight closure at the end of the discharge pipe, which may be a bolted blank flange or a screw cap.

12.7.3 Every bottom discharge outlet, except as provided in 12.7.2, should be equipped with three serially fitted and mutually independent shut-off devices. The design of the equipment should satisfy the competent authority, or its authorized body and include the following:

12.7.3.1 a self-closing internal stop-valve, that is a stop-valve within the shell or within a welded flange or its companion flange, such that:

12.7.3.1.1 the control devices are so designed as to prevent any unintended opening through impact or other inadvertent act;

12.7.3.1.2 the valve may be operable from above or below;

12.7.3.1.3 if possible, the setting of the valve (open or closed) should be capable of being verified from the ground; and

12.7.3.1.4 it should be possible to close the valve from an accessible position of the portable tank that is remote from the valve itself.

12.7.3.2 an external stop-valve fitted as close to the shell as practicable; and

12.7.3.3 a liquid tight closure at the end of the discharge pipe, which may be a bolted blank flange or a screw cap.

12.7.4 The internal shut-off device required in 12.7.3.1 should continue to be effective in the event of damage to the external control device.

12.7.5 For a lined shell, the internal stop-valve required by 12.7.3.1 may be replaced by an external stop-valve. The manufacturer should satisfy the requirements of the competent authority or its authorized body.

12.8 Safety relief

12.8.1 All portable tanks should be fitted with at least one pressure-relief device. All relief devices should be designed, constructed and marked to the satisfaction of the competent authority or its authorized body.

12.9 Pressure-relief devices

12.9.1 Every portable tank of 1,900 litres or more, or every independent compartment of a portable tank of similar capacity, should be provided with one or more pressure-relief devices of the spring-loaded type and may in addition have a frangible disc or fusible element in parallel with the spring-loaded devices except when prohibited by reference to 12.9.3 in Table 12.2. The pressure-relief devices should be designed and have sufficient capacity to prevent rupture of the shell due to over pressurization or vacuum resulting from loading, unloading, or from heating of the lading.

12.9.2 Pressure-relief devices should be designed to prevent the entry of foreign matter, the leakage of liquid and the development of any dangerous excess pressure.

12.9.3 Portable tanks for the transport of certain substances listed in Table 12.2 should have a pressure-relief device approved by the competent authority. Unless a portable tank in dedicated service is fitted with an approved relief valve constructed of materials compatible with the load, such device should comprise a frangible disc preceding a spring-loaded valve. If a frangible disc is inserted in series with the required pressure-relief valve, the space between the frangible disc and the pressure-relief valve should be provided with a pressure gauge or suitable tell-tale indicator for detection of disc rupture, pin holing, or leakage which could cause a malfunction of the pressure-relief system. The frangible disc should rupture at a nominal pressure 10% above the start to discharge pressure of the relief valve.

12.9.4 Every portable tank with a capacity of less than 1,900 litres should be fitted with a pressure-relief device which may be a frangible disc if the latter complies with the requirements of 12.12.1. If no spring-loaded pressure-relief valve is used, the frangible disc should be set to rupture at a nominal pressure equal to the test pressure.

12.9.5 If the shell is fitted with arrangements for air-pressure or inert-gas pressure discharge, the inlet line should be provided with a suitable pressure-relief device set to operate at a pressure not higher than the maximum allowable working pressure of the shell. A stop-valve should be provided at the entry to the shell.

12.10 Setting of pressure-relief devices

12.10.1 It should be noted that the devices should operate only in conditions of excessive rise in temperature, as the shell will not during transport be subject to undue fluctuations of pressure due to operating procedures (see 12.13.2).

12.10.2 The required pressure-relief valve should be set to start-to-discharge at a nominal pressure of the five-sixths of the test pressure for shells having a test pressure up to and including 4.5 bar and 110% of two-thirds of the test pressure for shells having a test pressure of more than 4.5 bar. The valve should, after discharge, close at a pressure not lower than 10% below the pressure at which discharge starts, and should remain closed at all lower pressures provided that this requirement not be so construed as to prevent the use of vacuum-relief or combination pressure-relief and vacuum-relief devices.

12.11 Fusible elements

12.11.1 Fusible elements, if allowed in Table 12.2, should function at a temperature between 110 °C and 149 °C provided that the developed pressure in a shell at the fusing temperature of the element does not exceed the test pressure of the portable tank. They should be placed at the top of the shell in the vapour space and in no case should they be shielded from external heat. Fusible elements should not be utilized on portable tanks with a test pressure which exceeds 2.65 bar. Special considerations meeting the satisfaction of the competent authority or its authorized body should be given to fusible elements of portable tanks used for substances transported at elevated temperatures.

12.12 Frangible discs

12.12.1 Except as provided in 12.9.3, frangible discs, if used should be set to rupture at a nominal pressure equal to the test pressure throughout the design temperature range. Particular attention should be given to the requirements of 12.6.1 and 12.9.3 if frangible discs are used.

12.13 Capacity of pressure-relief devices

12.13.1 The spring-loaded pressure-relief device required by 12.9.1 should have a minimum diameter of 31.75 mm. Vacuum-relief devices, if used, should have a minimum cross sectional flow area of 284 mm^2.

12.13.2 The combined delivery capacity of the relief devices in condition of complete fire engulfment of the portable tank should be sufficient to limit the pressure in the shell to 20% above the start-to-discharge pressure of the relief device. Emergency pressure-relief devices may be used to achieve the full relief capacity prescribed. Emergency pressure-relief devices may be of the spring-loaded, frangible or fusible type. The total required capacity of the relief devices may be determined by using the formula in 12.13.2.1 or the table in 12.13.2.2.

12.13.2.1 To determine the total required capacity of the relief devices, which should be regarded as being the sum of the individual capacities of the several devices, the following formula should be used:

$$Q = 12.4\ \frac{FA^{0.82}}{LC}\sqrt{\frac{ZT}{M}}$$

where: **Q** = minimum required rate of discharge in cubic metres of air per hour at standard conditions: 1 bar and 0 °C (273 K);

F = is a coefficient with the following value:

for uninsulated shells **F** = 1

for insulated shells **F** = U(649 - t)/13.6 but in no case is less than 0.25 where:

U = thermal conductance of the insulation, in $kW \cdot m^{-2} K^{-1}$, at 38 °C

t = actual temperature of the substance at loading (°C); if this temperature is unknown, let t = 15 °C:

The value of **F** given above for insulated shells may be taken provided that the insulation is in conformity with 12.13.2.3;

A = total external surface area of shell in square metres
Z = the gas compressibility factor in the accumulating condition (if this factor is unknown, let Z equal 1.0);
T = absolute temperature in Kelvin (°C + 273) above the pressure-relief devices in the accumulating condition;
L = the latent heat of vaporization of the liquid, in kJ/kg, in the accumulating condition;
M = molecular mass of the discharged gas;
C = a constant which may be taken from the following Table which is derived from the following equation as a function of the ratio k of specific heats:

where:

$$k = \frac{C_p}{C_v}$$

C_p = the specific heat at constant pressure and
C_v = the specific heat at constant volume;

$$C = \sqrt{k \left(\frac{2}{k + 1}\right)^{\frac{k+1}{k-1}}}$$

when k > 1

$$C = 0.607$$

when k = 1 or is unknown

VALUES FOR THE CONSTANT C:

k	**C**	**k**	**C**	**k**	**C**
1.00	0.607	1.26	0.660	1.52	0.704
1.02	0.611	1.28	0.664	1.54	0.707
1.04	0.615	1.30	0.667	1.56	0.710
1.06	0.620	1.32	0.671	1.58	0.713
1.08	0.624	1.34	0.674	1.60	0.716
1.10	0.628	1.36	0.678	1.62	0.719
1.12	0.633	1.38	0.681	1.64	0.722
1.14	0.637	1.40	0.685	1.66	0.725
1.16	0.641	1.42	0.688	1.68	0.728
1.18	0.645	1.44	0.691	1.70	0.731
1.20	0.649	1.46	0.695	2.00	0.770
1.22	0.652	1.48	0.698	2.20	0.793
1.24	0.656	1.50	0.701		

12.13.2.2 As an alternative to the formula above, shells designed for the transport of liquids may have their relief devices sized in accordance with the following Table. This table assumes an insulation value of F = 1 and should be adjusted accordingly if the shell is insulated. Other values used in determining this table are:

M = 86.7 T = 394 K
L = 334.94 kJ/kg C = 0.607
Z = 1

MINIMUM EMERGENCY VENT CAPACITY, Q, IN CUBIC METRES PER AIR PER SECOND AT 1 BAR AND 0 °C (273 K)

A Exposed area (square metres)	**Q (Cubic metres of air per second)**	**A Exposed area (square metres)**	**Q (Cubic metres of air per second)**
2	0.230	37.5	2.539
3	0.320	40	2.677
4	0.405	42.5	2.814
5	0.487	45	2.949
6	0.565	47.5	3.082
7	0.641	50	3.215
8	0.715	52.5	3.346
9	0.788	55	3.476
10	0.859	57.5	3.605
12	0.998	60	3.733
14	1.132	62.5	3.860
16	1.263	65	3.987
18	1.391	67.5	4.112
20	1.517	70	4.236
22.5	1.670	75	4.483
25	1.821	80	4.726
27.5	1.969	85	4.967
30	2.115	90	5.206
32.5	2.258	95	5.442
35	2.400	100	5.676

12.13.2.3 Insulation systems, used for the purpose of reducing venting capacity, should be approved by the competent authority or its authorized body. In all cases, insulation systems approved for this purpose should:

12.13.2.3.1 remain effective at all temperatures up to 649 °C; and

12.13.2.3.2 be jacketed with a material having a melting point of 700 °C or greater.

12.14 Marking pressure-relief devices

12.14.1 Every pressure-relief device should be plainly and permanently marked with the pressure or temperature at which it is set to discharge, in bar or kPa, and the rated flow capacity of the device, in standard cubic metres per second. Where practicable the following information should be shown:

12.14.1.1 the manufacturer's name and the relevant catalogue number;

12.14.1.2 allowable tolerances at start-to-discharge pressure (frangible disc) and allowable temperature tolerances (fusible elements).

12.14.2 The rated flow capacity marked on the pressure-relief devices should be determined according to ISO 4126-1:1996.

12.15 Connections to pressure-relief devices

12.15.1 Connections to pressure-relief devices should be of sufficient size to enable the required discharge to pass unrestricted to the safety device. No stop-valve should be installed between the shell and the pressure-relief devices except where duplicate devices are provided for maintenance or other reasons and the stop-valves serving the devices actually in use are locked open or the stop-valves are interlocked so that at least one of the duplicate devices is always in use. There should be no obstruction in an opening leading to a vent or pressure-relief device which might restrict or cut-off the flow from the shell to that device. Vents from the pressure-relief devices, where used, should deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving device.

12.16 Siting pressure-relief devices

12.16.1 Each pressure-relief device inlet should be situated on top of the shell in a position as near the longitudinal and transverse centre of the shell as reasonably practicable. All pressure-relief device inlets should under maximum filling conditions be situated in the vapour space of the shell and the devices should be so arranged as to ensure the escaping vapour is discharged unrestrictedly.
For flammable substances, the escaping vapour should be directed away from the shell in such a manner that it cannot impinge upon the shell. Protective devices which deflect the flow of vapour are permissible provided the required relief-device capacity is not reduced.

12.16.2 Arrangements should be made to prevent access to the pressure-relief devices by unauthorized persons and to protect the devices from damage caused by the portable tank overturning.

12.17 Gauging devices

12.17.1 Glass level-gauges, or gauges made of other fragile material, which are in direct communication with the contents of the shell should not be used.

12.18 Portable tank support, frameworks, lifting and tie-down attachments

12.18.1 Portable tanks should be designed and fabricated with a support structure to provide a secure base during transport. The forces specified in 12.3.10 and the safety factors specified in 12.3.11 should be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.

12.18.2 The combined stresses caused by portable tank mountings (e.g. cradles, framework, etc.) and portable tank lifting and tie-down attachments should not cause excessive stress in any portion of the shell. Permanent lifting and tie-down attachments should be fitted to all portable tanks. Preferably they should be fitted to the portable tank supports but may be secured to reinforcing plates located on the shell at the points of support.

12.18.3 In the design of supports and frameworks the effects of environmental corrosion should be taken into account.

12.18.4 Forklift pockets should be capable of being closed off. The means of closing forklift pockets should be a permanent part of the framework or permanently attached to the framework. Single compartment portable tanks with a length less than 3.65 m need not have closed off forklift pockets provided that:

12.18.4.1 the shell including all the fittings are well protected from being hit by the forklift blades; and

12.18.4.2 the distance between the centres of the forklift pockets is at least half of the maximum length of the portable tank.

12.18.5 If portable tanks are not protected during transport, according to 12.24.1, the shells and service equipment should be protected against collision. Examples of protection against collision include:

12.18.5.1 protection against lateral impact may consist, for example, of longitudinal bars protecting the shell on both sides at the level of the median line;

12.18.5.2 protection of the portable tank against overturning may consist, for example, of reinforcement rings or bars fixed across the frame;

12.18.5.3 protection against rear impact may consist of a bumper or frame;

12.18.5.4 external fittings should be designed or protected so as to preclude the release of contents upon impact or overturning of the portable tank upon the fittings.

12.19 Design approval

12.19.1 The competent authority or its authorized body should issue a design approval certificate for any new design of a portable tank. This certificate should attest that a portable tank has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this chapter. If a series of portable tanks are manufactured without change in the design, the certificate should be valid for the entire series. The certificate should refer to the prototype test report, the substances or group of substances allowed to be transported, the materials of construction of the shell and of the lining, if applicable, and an approval number. The approval number should consist of the distinguishing sign or mark of the State in whose territory the approval was granted, i.e. the distinguishing sign for use in international traffic as prescribed by the Convention on Road Traffic, Vienna 1968, and a registration number. Alternative arrangements according to 12.1.2, if any, should be indicated on the certificate. A design approval may serve for the approval of smaller portable tanks made of materials of the same kind and thickness, by the same fabrication techniques and with identical supports, equivalent closures and other appurtenances.

12.19.2 The prototype test report for the design approval should include at least the following:

12.19.2.1 the results of the applicable frame-work test specified in ISO 1496-3:1995;

12.19.2.2 the results of the impact test in 12.19.3 when applicable; and

12.19.2.3 the results of the initial inspection and test in 12.20.2.

12.19.3 For portable tanks meeting the definition of container in the CSC, a prototype representing each design should be subjected to an impact test. The prototype portable tank should be shown to be capable of absorbing the forces resulting from an impact equivalent to at least 4 times (4 g) the maximum gross mass of the fully loaded portable tank at a duration typical of the mechanical shocks experienced in rail transport. The following is a listing of standards describing methods acceptable for performing the impact test:

12.19.3.1 Association of American Railroads,
Manual of Standards and Recommended Practices,
Specifications for Acceptability of Tank Containers (AAR.600), 1992

12.19.3.2 Canadian Standards Association (CSA),
Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods
(B620-1987).

12.19.3.3 Société Nationale des Chemins de Fer Français
C.N.E.S.T. 002-1966.
Tank containers, longitudinal external stresses and dynamic impact tests.

12.20 **Inspection and Testing**

12.20.1 The shell and items of equipment of each portable tank should be inspected and tested before being put into service for the first time (initial inspection and test) and thereafter at not more than five-year intervals (5 year periodic inspection and test) with an intermediate periodic inspection and test (2.5 year periodic inspection and test) midway between the 5 year periodic inspections and tests. An exceptional inspection and test should be performed regardless of the last periodic inspection and test when necessary according to 12.20.6.

12.20.2 The initial inspection and test of a portable tank should include a check of the design characteristics, an internal and external examination of the portable tank and its fittings with due regard to the substances to be transported, and a pressure test. Before the portable tank is placed into service, a leakproofness test and a test of the satisfactory operation of all service equipment should also be conducted. If the shell and its fittings have been pressure-tested separately, they should be subjected together after assembly to a leakproofness test.

12.20.3 The 5-year periodic inspection and test should include an internal and external examination and, as a general rule, a hydraulic pressure test. Sheathing, thermal insulation and the like should be removed only to the extent required for reliable appraisal of the condition of the portable tank. If the shell and equipment have been pressure-tested separately, they should be subjected together after assembly to a leakproofness test.

12.20.4 The intermediate 2.5 year periodic inspection and test should at least include:

12.20.4.1 an internal and external examination of the portable tank and its fittings with due regard to the substances intended to be transported;

12.20.4.2 a leakproofness test;

12.20.4.3 a test of the satisfactory operation of all service equipment.

12.20.4.4 For portable tanks dedicated to the transport of a single substance, the internal examination may be waived or substituted by other test methods or inspection procedures by the competent authority or its authorized body.

12.20.5 Portable tanks, empty and uncleaned, may be moved after the expiration of the 5 year periodic inspection and test. In addition, the 2.5 year inspection and test may be performed within 3 months before and after the specified date.

12.20.6 The exceptional inspection and test is necessary when the portable tank shows evidence of damaged or corroded areas, or leakage, or other conditions that indicate a deficiency that could affect the integrity of the portable tank. The extent of the exceptional inspection and test should depend on the amount of damage or deterioration of the portable tank. It should include at least the 2.5 year inspection and test according to 12.20.4.

12.20.7 The internal and external examination should ensure that:

12.20.7.1 the shell is inspected for pitting, corrosion, or abrasions, dents, distortions, defects in welds or any other conditions, including leakage, that might render the shell unsafe for transport;

12.20.7.2 the piping, valves, heating/cooling system, and gaskets are inspected for corroded areas, defects, and other conditions, including leakage, that might render the portable tank unsafe for loading, discharge or transport;

12.20.7.3 devices for tightening manhole covers are operative and there is no leakage at manhole covers or gaskets;

12.20.7.4 missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;

12.20.7.5 all emergency devices and valves are free from corrosion, distortion and any damage or defect that could prevent their normal operation. Remote closure devices and self-closing stop-valves should be operated to demonstrate proper operation;

12.20.7.6 linings are inspected in accordance with criteria outlined by the lining manufacturer;

12.20.7.7 required markings on the portable tank are legible and in accordance with the applicable requirements;

12.20.7.8 the framework, supports and arrangements for lifting the portable tank are in a satisfactory condition.

12.20.8 The inspections and tests in 12.20.2, 12.20.3, 12.20.4 and 12.20.6 should be performed or witnessed by an expert approved by the competent authority or its authorized body. If the pressure test is a part of the inspection and test, the test pressure should be the one indicated on the data plate of the portable tank. While under pressure, the shell should be inspected for any leaks in the shell, piping or equipment.

12.20.9 In all cases where cutting, burning or welding operations on the shell have been effected, that work should be to the approval of the competent authority or its authorized body taking into account the pressure vessel code used for the construction of the shell. A pressure test to the original test pressure should be performed.

12.20.10 If evidence of any unsafe condition is discovered, the portable tank should not be placed or returned to service until it has been corrected and the test is repeated and passed.

12.21 **Document Retention**

12.21.1 The design approval certificate, the test report and the certificate showing the results of the initial inspection and test for each portable tank issued by the competent authority or its authorized body should be retained by the authority or body and the owner. Owners should be able to provide this documentation upon the request of any competent authority.

12.22 Filling

12.22.1 Prior to filling, the shipper should ensure that the appropriate portable tank is used and that the portable tank is not loaded with substances which in contact with the materials of the shell, gaskets, service equipment and any protective linings, are likely to react dangerously with them to form dangerous products or appreciably weaken the material. The shipper may need to consult the manufacturer of the substance in conjunction with the competent authority for guidance on the compatibility of the substance with the portable tank materials.

12.22.1.1 Portable tanks should not be filled above the extent provided for by 12.22.3 to 12.22.6. The applicability of 12.22.3, 12.22.4 or 12.22.6 to individual substances is specified by the reference in Table 12.2.

12.22.2 The maximum degree of filling for general use is determined by the formula:

$$\text{Degree of filling} = \frac{97}{1 + \alpha\,(t_r - t_f)}$$

12.22.3 The maximum degree of filling for liquids of Division 6.1 and Class 8, in Packing Groups I and II, and liquids with an absolute vapour pressure of more than 1.75 bar at 65 ºC, is determined by the formula:

$$\text{Degree of filling} = \frac{95}{1 + \alpha\,(t_r - t_f)}$$

12.22.4 In these formulae α is the mean coefficient of cubical expansion of the liquid between the mean temperature of the liquid during filling (t_f) and the maximum mean bulk temperature during transport (t_r). For liquids transported under ambient conditions α could be calculated by the formula:

$$\alpha = \frac{d_{15} - d_{50}}{35 \times d_{50}}$$

in which d_{15} and d_{50} are the densities of the liquid at 15 °C and 50 °C, respectively.

12.22.4.1 The maximum mean bulk temperature (t_r) should be taken as 50 ºC except that, for journeys under temperate or extreme climatic conditions, the competent authorities concerned may agree to a lower or require a higher temperature, as appropriate.

12.22.5 The provisions of 12.22.3 to 12.22.4 should not apply to portable tanks the contents of which are maintained at a temperature above 50 ºC during transport for instance by means of a heating device. For portable tanks equipped with a heating device, a temperature regulator should be used to ensure the maximum degree of filling is not more than 95% full at any time during transport.

12.22.5.1 The maximum degree of filling for liquids transported under elevated temperature conditions is determined by the formula:

$$\text{Degree of filling} = 95 \,.\, \frac{d_r}{d_f}$$

in which d_f and d_r are the densities of the liquid at the mean temperature of the liquid during filling and the maximum mean bulk temperature during transport respectively.

12.22.6 Portable tanks should not be offered for transport:

12.22.6.1 with a degree of filling, for liquids having a viscosity of less than 2,680 mm^2/s at 20 °C, of more than 20% but less than 80% unless the shells of portable tanks are divided, by partitions or surge plates, into sections of not more than 7,500 litres capacity;

12.22.6.2 with residue of goods transported adhering to the outside of the shell or service equipment;

12.22.6.3 that are leaking or damaged to such an extent that the integrity of the portable tank or its lifting or securing arrangements may be affected; and

12.22.6.4 unless the service equipment has been examined and found to be in good working order.

12.23 Marking

12.23.1 Every portable tank should be fitted with a corrosion resistant metal plate permanently attached to the portable tank in a conspicuous place readily accessible for inspection. If for reasons of portable tank arrangements, the plate cannot be permanently attached to the shell, the shell should be marked with at least the information required by the pressure vessel code. As a minimum at least the following information should be marked on the plate by stamping or by any other similar method.

Country of manufacture:

U	Approval	Approval	For Alternate Arrangements
N	COUNTRY	NUMBER	"AA"

Manufacturer's name or mark . . . .

Manufacturer's serial number . . . .

Authorized body for the design approval . . . .

Owner's registration number . . . .

Year of manufacture . . . .

Pressure Vessel Code to which the shell is designed . . . .

Test pressure . . . . bars or kilopascals (kPa) gauge

MAWP . . . . bars gauge or kilopascals (kPa) gauge

Water capacity at 20 °C . . . . litres

Water capacity of each compartment at 20 °C . . . . litres

Initial pressure test date and witness identification . . . .

Design temperature range, ... °C to . . . . °C

Maximum allowable working pressure for heating/cooling system bars or kilopascals (kPa) gauge . . . .

Shell material(s) and material standard reference(s) . . . .

Equivalent thickness in reference steel . . . . mm

Lining material (if any) . . . .

Date and type of most recent periodic test(s)

Month . . . . Year . . . . Test Pressure . . . . bars or kilopascals(kPa) gauge

Stamp of expert who performed or witnessed the most recent test . . . .

12.23.2 The following information should be marked either on the portable tank itself or on a metal plate firmly secured to the portable tank:

Name of the operator . . . .

Name of substance(s) being transported (and maximum mean bulk temperature if greater than 50 °C) . .

Maximum permissible gross mass . . . . kg

Unladen (tare) mass . . . . kg

12.23.3 The substances being transported should be identified as specified in Chapter 13 of the Recommendations.

12.24 Transport requirements

12.24.1 During transport, portable tanks should be adequately protected against lateral and longitudinal impact and against overturning. This protection is not required if portable tanks are constructed to withstand impact or overturning examples of such protection are given in 12.18.5.

12.24.2 Certain substances are chemically unstable. They are accepted for transport only if the necessary steps have been taken to prevent their dangerous decomposition, transformation or polymerization during transport. To this end, care should in particular be taken to ensure that shells do not contain any substances liable to promote these reactions.

12.24.3 The temperature of the outer surface of the shell excluding openings and their closures or of the thermal insulation should not exceed 70 °C during transport. When dangerous goods are transported at elevated temperatures in either liquid or solid state, the shell must be thermally insulated to meet this condition.

12.24.4 Empty portable tanks not cleaned and not gas-free should comply with the same requirements as portable tanks filled with the previous substance.

12.25 Handling requirements

12.25.1 Fork-lift pockets of portable tanks should be closed off when the portable tank is filled.

12.25.2 Substances should not be transported in adjoining compartments of shells if they may react dangerously with each other and cause:

12.25.2.1 combustion and/or evolution of considerable heat;

12.25.2.2 evolution of flammable, toxic or asphyxiant gases;

12.25.2.3 the formation of corrosive substances;

12.25.2.4 the formation of unstable substances;

12.25.2.5 dangerous rise in pressure.

PORTABLE TANK REQUIREMENTS FOR NON-REFRIGERATED LIQUEFIED GASES OF CLASS 2

12.26 Definitions

12.26.1 The following requirements apply to portable tanks intended for the transport of non-refrigerated liquefied gases of Class 2. Additional requirements may apply to offshore portable tanks that are handled in open seas.

12.26.2 *Portable tank* means a multimodal portable tank having a capacity of more than 450 litres used for the transport of non-refrigerated liquefied gases of Class 2. The portable tank includes a shell fitted with service equipment and structural equipment necessary for the transport of gases. The portable tank should be capable of being loaded and discharged without the removal of its structural equipment. It should possess stabilizing members external to the shell, and should be capable of being lifted when full. It should be designed primarily to be loaded onto a transport vehicle or ship and should be equipped with skids, mountings or accessories to facilitate mechanical handling. Road tank-vehicles, rail tank-wagons, non-metallic tanks, intermediate bulk containers (IBCs), gas cylinders and large receptacles are not considered to fall within the definition for portable tanks.

12.26.3 *Shell* means the tank proper, including openings and their closures, but does not include service equipment or structural equipment;

12.26.4 *Service equipment* means measuring instruments and filling, discharge, venting, safety and insulating devices;

12.26.5 *Structural equipment* means the reinforcing, fastening, protective and stabilizing members external to the shell;

12.26.6 *Maximum allowable working pressure (MAWP)* means a pressure that should not be less than the greatest of the following two pressures measured at the top of the shell while in operating position but in no case less than 7 bar:

12.26.6.1 the maximum effective gauge pressure allowed in the shell during filling or discharge; or

12.26.6.2 the maximum effective gauge pressure to which shells are designed, should be:

12.26.6.2.1 for liquefied gases for which the MAWP (in bar) is given in column (5) in Table 12.1, the appropriate value;

12.26.6.2.2 for other liquefied gases, the sum of the following pressures:

12.26.6.2.2.1 the absolute vapour pressure (in bar) of the liquefied gas at the design reference temperature minus 1 bar;

12.26.6.2.2.2 the partial pressure (in bar) of air or other gases in the ullage space being determined by the design reference temperature and the liquid phase expansion due to the increase of the mean bulk temperature of t_r-t_f (t_f=filling temperature usually 15°C, t_r = 50°C maximum bulk temperature);

12.26.7 *Design pressure* means the pressure used, according to a recognized pressure vessel code. The design pressure should be not be less than the greatest of the following two pressures:

12.26.7.1 the pressure in 12.26.6.1; or

12.26.7.2 the pressure in 12.26.6.2 and the head pressure determined on the basis of the dynamic forces due to inertia specified in 12.27.9, such a head pressure should be not less than 0.35 bar.

12.26.8 *Test pressure* means the maximum gauge pressure at the top of the shell taken during the pressure test;

12.26.9 *Leakproofness test* means a test using gas which consists of subjecting the shell and its service equipment to an effective internal pressure equivalent to not less than 25% of the MAWP;

12.26.10 *Maximum permissible gross mass (MPGM)* means the sum of the tare mass of the portable tank and the heaviest load authorized for transport;

12.26.11 *Reference steel* means a steel with a tensile strength of 370 N/mm^2 and an elongation at fracture of 27%;

12.26.12 *Mild steel* means a steel with a guaranteed minimum tensile strength of 360 N/mm^2 to 440 N/mm^2 and a guaranteed minimum elongation at fracture conforming to 12.28.3.2.1;

12.26.13 *Design temperature range* for the shell is considered to be -40 °C to 50 °C for liquefied gases transported under ambient conditions. More severe design temperatures should be considered for portable tanks subjected to severe climatic conditions.

12.26.14 *Design reference temperature* means the temperature at which the vapour pressure of the contents is determined for the purpose of calculating the maximum allowable working pressure. The design reference temperature should be less than the critical temperature of the liquefied gas intended to be transported to ensure that the gas at all times is liquefied. This value for each portable tank type is as follows:

12.26.14.1 shell with a diameter of 1.5 metres or less: 65°C;

12.26.14.2 shell with a diameter of more than 1.5 metres:

12.26.14.2.1 without insulation or sun shield: 60°C

12.26.14.2.2 with sun shield (see 12.27.12): 55°C

12.26.14.2.3 with insulation (see 12.27.12): 50°C.

12.26.15 *Filling density* means the average mass of liquefied gas per litre of shell capacity (kg/l). The filling density is given in column (8) in Table 12.1.

12.27 General requirements for the design and construction of portable tanks for non-refrigerated liquefied gases of Class 2

12.27.1 Shells should be designed and constructed in accordance with the provisions of a pressure vessel code recognized by the competent authority. Shells should be made of steel suitable for forming. The materials should in principle conform to national or international material standards. For welded shells, only a material whose weldability has been fully demonstrated should be used. Welds should be

skilfully made and afford complete safety. If the manufacturing process or the materials make it necessary, the shells should be suitability heat-treated to guarantee adequate toughness in the weld and in the heat affected zones. In choosing the material the design temperature range should be taken into account with respect to risk of brittle fracture, to stress corrosion cracking and to resistance to impact. If fine grain steel is used, the guaranteed value of the yield strength, Re should not exceed 460 N/mm^2 and the guaranteed value of the upper limit of the tensile strength, Rm should not exceed 725 N/mm^2 in accordance with the material specifications. Portable tank materials should be suitable for the external environment in which they may be transported.

12.27.2 Portable tank shells, fittings and pipework should be constructed of materials which are:

12.27.2.1 substantially immune to attack by the liquefied gas(s) intended to be transported; or

12.27.2.2 properly passivated or neutralized by chemical reaction.

12.27.3 Gaskets should be made of materials not subject to attack by the liquefied gas(s) intended to be transported.

12.27.4 Contact between dissimilar metals which could result in damage by galvanic reaction should be avoided.

12.27.5 The materials of the portable tank, including any devices, gaskets, and accessories, should not adversely affect the liquefied gases intended for transport in the portable tank.

12.27.6 Portable tanks should be designed and constructed with supports to provide a secure base during transport and with suitable lifting and tie-down attachments.

12.27.7 Portable tanks should be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads including the effects of fatigue during normal conditions of handling and transport.

12.27.8 Shells should be designed to withstand an external pressure of at least 0.4 bar gauge above the internal pressure without permanent deformation. When the shell is to be subjected to a significant vacuum before loading or during discharge it should be designed to withstand an external pressure of at least 0.9 bar gauge above the internal pressure and should be proven to that pressure.

12.27.9 Portable tanks and their fastenings should, under the maximum permissible load, be capable of absorbing the following separately applied static forces:

12.27.9.1 in the direction of travel: twice the maximum permissible gross mass multiplied by acceleration (g)*/;

12.27.9.2 horizontally at right angles to the direction of travel: the maximum permissible gross mass (where the direction of travel is not clearly determined, the forces should be equal to twice the maximum permissible gross mass) multiplied by acceleration (g)*/;

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*/ For calculation purposes g = 9.81 m/s^2.

12.27.9.3 vertically upwards: the maximum permissible gross mass multiplied by acceleration (g)*/; and

12.27.9.4 vertically downwards: twice the maximum permissible gross mass (total loading including the effect of gravity) multiplied by acceleration (g)*/.

12.27.10 Under each of these forces, the safety factors to be observed should be as follows:

12.27.10.1 for steels having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; or

12.27.10.2 for steels with no clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed 0.2% proof strength and, for austenitic steels, the 1% proof strength.

12.27.11 The values of yield strength or proof strength should be the value according to national or international material standards. If no material standard exists for the steel in question, the value of yield strength or proof strength used should be approved by the competent authority. When austenitic steels are used, the specified minimum values of Re and Rm according to the material standards may be increased by up to 15% if this value is provided in the material inspection certificate.

12.27.12 If the shells intended for the transport of liquefied gases are equipped with thermal insulation, the thermal insulation systems should satisfy the following requirements:

12.27.12.1 consist of a shield covering not less than the upper third but not more than the upper half of the surface of the portable tank and separated from the shell by an air space about 40 mm across; or
12.27.12.2 consist of a complete cladding of adequate thickness of insulating materials protected so as to prevent the ingress of moisture and damage under normal transport conditions to provide a thermal conductance no greater than 0.67 $W/m^{-2} K^{-1}$;

12.27.12.3 if the protective covering is so closed as to be gas-tight, a device should be provided to prevent any dangerous pressure from developing in the insulating layer in the event of inadequate gas tightness of the shell or of its items of equipment;

12.27.12.4 the thermal insulation should not inhibit access to the fittings and discharge devices.

12.27.13 Portable tanks intended for the transport of flammable liquefied gases should be capable of being electrically earthed.

12.28 **Design criteria**

12.28.1 Shells should be of a circular cross-section.

12.28.2 Shells should be designed and constructed to withstand a pressure test equal to at least 1.3 times the design pressure. Specific requirements are laid down for particular liquefied gases in Table 12.1. Attention is drawn to the minimum shell thickness requirements for these shells specified in 12.29.1 to 12.29.5.

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*/ For calculation purposes $g = 9.81\ m/s^2$.

12.28.3 At the test pressure, the primary membrane stress σ in the shell should conform to the material-dependent limitations prescribed below.

12.28.3.1 for steels exhibiting a clearly defined yield point or characterized by a guaranteed proof strength (0.2% proof strength generally or 1% proof strength for austenitic steels), the membrane stress σ at the test pressure should not exceed 0.75 Re or 0.50 Rm, whichever is lower, where:

Re = yield strength, or 0.2% proof strength or, for austenitic steels, 1% proof strength;

Rm = minimum tensile strength.

12.28.3.2 The values of Re and Rm to be used should be specified minimum values according to national or international material standards. Where no material standard exists for the steel in question, the values of Re and Rm used should be approved by the competent authority or its authorized body. When austenitic steels are used, the specified minimum values of Re and Rm according to the material standards may be increased by up to 15% if these higher values are provided in the material inspection certificate. Ratios of Re/Rm exceeding 0.85 are not allowed for steels used in the construction of welded shells. In determining the ratio Re/Rm, the values specified in the material inspection certificate should be used. The values in the material inspection certificate should conform with the following provisions:

12.28.3.2.1 For steels the elongation at fracture, in %, should not be less than 10,000/Rm where Rm is in N/mm^2, with an absolute minimum of 16% for fine grained steels and 20% for other steels.

12.28.3.3 For the purpose of determining actual values for materials, it should be noted that for sheet metal, the axis of the tensile test specimen should be at right angles (transversely) to the direction of rolling. The permanent elongation at fracture should be measured on test specimens of rectangular cross sections in accordance with ISO 6892:1984 using a 50 mm gauge length.

12.29 **Minimum shell thickness**

12.29.1 The minimum thickness of the shell, should be the greater thickness based on:

12.29.1.1 the minimum thickness determined in accordance with the provisions of sections 12.29.2 to 12.29.5; and

12.29.1.2 the minimum thickness determined in accordance with the recognized pressure vessel code including the provisions in 12.28.3.

12.29.2 The cylindrical portion of the shells, the ends (heads) and the manhole covers of shells not more than 1.80 m in diameter should be not less than 5 mm thick in the reference steel or equivalent thickness in the actual steel. Shells of more than 1.80 m in diameter should not be less than 6 mm thick in the reference steel or of equivalent thickness in the actual steel. The cylindrical portion, the ends (heads) and the manhole covers of all shells should be at least 4 mm thick regardless of the materials of construction.

12.29.3 The thickness of a steel other than the reference steel prescribed in 12.29.2 should be determined by using the following equation:

$$e_1 = \frac{21.4 e_o}{\sqrt[3]{Rm_1 \times A_1}}$$

where: e_1 = the required equivalent thickness of the steel to be used in mm;
e_o = minimum thickness for the reference steel specified in 12.29.2;
Rm_1 = guaranteed minimum tensile strength of the steel to be used in N/mm^2 (see 12.28.3);
A_1 = guaranteed minimum elongation at fracture (as a percentage) of the steel to be used according to national or international standards.

12.29.4 If mild steel conforming to the definition of 12.26.12 is used, calculation using the equation according to 12.29.3 is not required.

12.29.5 There should be no sudden change of plate thickness at the attachment of the ends (heads) to the cylindrical portion of the shell.

12.30 **Service equipment**

12.30.1 Service equipment should be so arranged as to be protected against the risk of being wrenched off or damaged during of handling and transport. If the connection between the frame and the shell allows relative movement between the sub-assemblies, the equipment should be so fastened as to permit such movement without risk of damage to working parts. The external discharge fittings (pipe sockets, shut-off devices), the internal stop-valve and its seating should be protected against the danger of being wrenched off by external forces (for example using shear sections). The filling and discharge devices (including flanges or threaded plugs) and protective caps (if any) should be capable of being secured against any unintended opening.

12.30.2 All openings in the shell more than 1.5 mm in diameter except those for pressure-relief devices, inspection openings or closed bleed holes should be provided with three mutually independent shut-off devices in series, the first being an internal stop valve, excess flow valve or equivalent device, the second being an external stop-valve and the third being a blank flange or equivalent device.

12.30.2.1 Where a portable tank is fitted with an excess flow valve:

12.30.2.1.1 A excess flow valve should be so fitted that its seating is inside the shell or inside a welded flange or, if fitted externally, its mountings should be designed so that in the event of impact its effectiveness should be maintained.

12.30.2.1.2 Excess flow valves should be selected and fitted so as to close automatically when the rated flow specified by the manufacturer is reached. Connections and accessories leading to or from such a valve should have a capacity for a flow greater than the rated flow of the excess flow valve.

12.30.3 For filling and discharge openings the first shut-off device should be an internal stop-valve and the second should be a stop-valve placed in an accessible position on each discharge and/or filling pipe.

12.30.4 For filling and discharge openings of portable tanks intended for the transport of flammable and/or toxic gases the internal stop-valve should be a quick closing safety device, which closes automatically in the event of unintended movement of the portable tank or fire engulfment. It should also be possible to operate this device by remote control.

12.30.5 The shells may be equipped, in addition to filling, discharge and gas pressure equalizing orifices, with openings in which gauges, thermometers and manometers can be fitted. Connections for such instruments should be made by suitable welded nozzles or pockets and not be screwed connections through the shell.

12.30.6 Each portable tank should be fitted with a manhole or other inspection openings of a suitable size to allow for internal inspection and adequate access for maintenance and repair of the interior.

12.30.7 Service equipment, excluding inspection openings and pressure-relief devices, should be grouped together so far as reasonably practicable.

12.30.8 All portable tank connections should be clearly marked to indicate the function of each.

12.30.9 Each stop-valve or other means of closure should be designed and constructed to a rated pressure not less than the maximum allowable working pressure of the shell taking into account the temperatures expected in transport. Each stop-valve with a screwed spindle should be closed by a clockwise motion of the handwheel. For other stop-valves the position and/or direction of closure should be clearly indicated. All stop-valves should be constructed to prevent unintentional opening.

12.30.10 All piping should be of suitable metallic material. Welded pipe joints should be used wherever possible. Where copper tubing is permitted, joints should be brazed or have an equally strong metal union. The melting point of brazing materials should be no lower than 525 °C. Joints should not decrease the strength of tubing (e.g. as may be the case when cutting threads). Ductile metals should be used in the construction of valves or accessories. The bursting strength of all piping and pipe fittings should be the greater of at least four times the strength at the maximum allowable working pressure of the shell or at least four times the strength at the pressure to which it may be subjected in service by the action of a pump or other device (except pressure-relief devices). Suitable provisions should be made in every case to prevent damage to piping due to thermal expansion and contraction, mechanical shock and vibration.

12.31 **Bottom openings**

12.31.1 For certain gases indicated in Table 12.1 shell openings for any purpose below the liquid level are not allowed.

12.32 **Pressure-relief devices**

12.32.1 Portable tanks should be provided with one or more spring-loaded pressure-relief devices. Frangible discs not in series with a spring-loaded pressure-relief device are not permitted. The devices should open automatically at a pressure not less than the MAWP and be fully open at a pressure equal to 110% of the MAWP. These devices should, after discharge, close at a pressure not lower than 10% below the pressure at which discharge starts and should remain closed at all lower pressures. The pressure-relief devices should be of a type that will resist dynamic stresses including liquid surge.

12.32.2 Pressure-relief devices should be designed to prevent the entry of foreign matter, the leakage of gas and the development of any dangerous excess pressure.

12.32.3 Portable tanks intended for the transport of certain gases listed in Table 12.1 should have a pressure-relief device approved by the competent authority. Unless a portable tank in dedicated service is fitted with an approved relief valve constructed of materials compatible with the load, such device should comprise a frangible disc preceding a spring-loaded valve. The space between the frangible disc and the valve should be provided with a pressure gauge or a suitable tell-tale indicator. This arrangement permits the detection of disc rupture, pinholing or leakage which could cause a malfunction of the pressure-relief device. The frangible discs should rupture at a nominal pressure 10% above the start-to-discharge pressure of the relief valve.

12.33 **Capacity of pressure-relief devices**

12.33.1 The combined delivery capacity of the relief devices should be sufficient that, in the event of total fire engulfment, the pressure (including accumulation) inside the shell does not exceed 120% of the MAWP. Spring-loaded relief devices should be used to achieve the full relief capacity prescribed.

12.33.1.1 To determine the total required capacity of the relief devices, which should be regarded as being the sum of the individual capacities of the several devices, the following formula*/ should be used:

$$Q = 12.4 \frac{FA^{0.82}}{LC} \sqrt{\frac{ZT}{M}}$$

where:

Q = minimum required rate of discharge in cubic metres of air per hour at standard conditions: 1 bar and 0°C (273 K);

F = is a coefficient with the following value:
for uninsulated shells **F**=1
for insulated shells **F**=U(649-t)/13.6 but in no case is less than 0.25 where:
U = thermal conductance of the insulation, in kW m^{-2} K^{-1}, at 38°C,
t = actual temperature of the liquefied gas at loading (°C); if this temperature is unknown, let **t**=15°C.
The value of **F** given above for insulated shells may be taken provided that the insulation is in conformity with 12.33.1.2;

A = total external surface area of shell in square metres;

Z = the gas compressibility factor in the accumulating condition (if this factor is unknown, let **Z** equal 1.0);

T = absolute temperature in Kelvin (°C + 273) above the pressure-relief devices in the accumulating condition;

L = the latent heat of vaporization of the liquid, in kJ/kg, in the accumulating condition;

M = molecular mass of the discharged gas;

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*/ This formula applies only to liquefied gases which have critical temperatures well above the temperature at the accumulating condition. For gases which have critical temperatures near or below the temperature at the accumulating condition, the calculation of the pressure-relief device delivery capacity should consider further thermodynamic properties of the gas (see for example CGA S-1.2-1995).

C = a constant which may be taken from the following table which is derived from the following equation as a function of the ratio k of specific heats

where: $$k = \frac{C_p}{C_v}$$

C_p = the specific heat at constant pressure and
C_v = the specific heat at constant volume;

$$C = \sqrt{k \left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

when k > 1

$$C = 0.607$$

when k = 1 or is unknown

VALUES FOR THE CONSTANT C:

k	**C**	**k**	**C**	**k**	**C**
1.00	0.607	1.26	0.660	1.52	0.704
1.02	0.611	1.28	0.664	1.54	0.707
1.04	0.615	1.30	0.667	1.56	0.710
1.06	0.620	1.32	0.671	1.58	0.713
1.08	0.624	1.34	0.674	1.60	0.716
1.10	0.628	1.36	0.678	1.62	0.719
1.12	0.633	1.38	0.681	1.64	0.722
1.14	0.637	1.40	0.685	1.66	0.725
1.16	0.641	1.42	0.688	1.68	0.728
1.18	0.645	1.44	0.691	1.70	0.731
1.20	0.649	1.46	0.695	2.00	0.770
1.22	0.652	1.48	0.698	2.20	0.793
1.24	0.656	1.50	0.701		

12.33.1.2 Insulation systems, used for the purpose of reducing the venting capacity, should be approved by the competent authority or its designated approval agency. In all cases, insulation systems approved for this purpose should:

12.33.1.2.1 remain effective at all temperatures up to 649°C; and

12.33.1.2.2 be jacketed with a material having a melting point of 700°C or greater.

12.34 **Marking pressure-relief devices**

12.34.1 Every pressure-relief device should be plainly and permanently marked with the pressure at which it is set to discharge and the rated flow capacity of the device in standard cubic metres per second. Where practicable the following information should be shown:

12.34.1.1 the manufacturer’s name and the relevant catalogue number;

12.34.1.2 allowable tolerances at start-to-discharge pressure (frangible disc).

12.34.2 The rated flow capacity marked on the pressure-relief devices should be determined according to ISO 4126-1:1996.

12.35 **Connections to pressure-relief devices**

12.35.1 Connections to pressure-relief devices should be of sufficient size to enable the required discharge to pass unrestricted to the safety device. No stop-valve should be installed between the shell and the pressure-relief devices except where duplicate devices are provided for maintenance or other reasons and the stop-valves serving the devices actually in use are locked open or the stop-valves are interlocked so that at least one of the duplicate devices is always operable and cable of meeting the requirements of 12.33. There should be no obstruction in an opening leading to a vent or pressure relief device which might restrict or cut-off the flow from the shell to that device. Vents from the pressure-relief devices, where used, should deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving device.

12.36 **Siting pressure-relief devices**

12.36.1 Each pressure-relief device inlet should be situated on top of the shell in a position as near the longitudinal and transverse centre of the shell as reasonably practicable. All pressure relief device inlets should under maximum filling conditions be situated in the vapour space of the shell and the devices should be so arranged as to ensure that the escaping vapour is discharged unrestrictedly. For flammable liquefied gases, the escaping vapour should be directed away from the shell and in such a manner that it cannot impinge upon the shell. Protective devices which deflect the flow of vapour are permissible provided the required relief-device capacity is not reduced.

12.36.2 Arrangements should be made to prevent access to the pressure relief devices by unauthorized persons and to protect the devices from damage caused by the portable tank overturning.

12.37 **Gauging devices**

12.37.1 Unless a portable tank is intended to be filled by weight it should be equipped with one or more gauging devices. Glass level-gauges, or gauges made of other fragile material, which are in direct communication with the contents of the shell should not be used.

12.38 **Portable tank supports, frameworks, lifting and tie-down attachments**

12.38.1 Portable tanks should be designed and fabricated with a support structure to provide a secure base during transport. The forces specified in 12.27.9 and the safety factors specified in 12.27.10 should be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.

12.38.2 The combined stresses caused by portable tank mountings (e.g. cradles, frameworks, etc.) and portable tank lifting and tie-down attachments should not cause excessive stress in any portion of the shell. Permanent lifting and tie-down attachments should be fitted to all portable tanks. Preferably they should be fitted to the portable tank supports but may be secured to reinforcing plates located on the shell at the points of support.

12.38.3 In the design of supports and frameworks the effects of environmental corrosion should be taken into account.

12.38.4 Forklift pockets should be capable of being closed off. The means of closing forklift pockets should be a permanent part of the framework or permanently attached to the framework. Single compartment portable tanks with a length less than 3.65 m need not have closed off forklift pockets provided that:

12.38.4.1 the shell and all the fittings are well protected from being hit by the forklift blades; and

12.38.4.2 the distance between the centres of the forklift pockets is at least half of the maximum length of the portable tank.

12.38.5 If portable tanks are not protected during transport, according to 12.44.2, the shells and service equipment should be protected against collision. Examples of protection of shells against collision include:

12.38.5.1 protection against lateral impact may consist, for example, of longitudinal bars protecting the shell on both sides at the level of the median line;

12.38.5.2 protection of portable tanks against overturning may consist, for example, of reinforcement rings or bars fixed across the frame;

12.38.5.3 protection against rear impact may consist of a bumper or frame;

13.38.5.4 external fittings should be designed or protected so as to preclude the release of contents upon impact or overturning of the portable tank upon the fittings.

12.39 **Design approval**

12.39.1 The competent authority or its authorized body should issue a design approval certificate for any new design of a portable tank. This certificate should attest that the portable tank has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this chapter. If a series of portable tanks are manufactured without change in the design, the certificate should be valid for the entire series. The certificate should refer to the prototype test report, the gases allowed to be transported, the materials of construction of the shell and an approval number. The approval number should consist of the distinguishing sign or mark of the State in whose territory the approval was granted, i.e. the distinguishing sign for use in international traffic, as prescribed by the Convention on Road Traffic, Vienna 1968, and a registration number. Alternative arrangements according to 12.1.2, if any, should be indicated on the certificate. A design approval may serve for the approval of smaller portable tanks made of materials of the same kind and thickness, by the same fabrication techniques and with identical supports, equivalent closures and other appurtenances.

12.39.2 The prototype test report for the design approval should include at least the following:

12.39.2.1 the results of the applicable frame-work test specified in ISO 1496-3:1995;

12.39.2.2 the results of the impact test in 12.39.3 when applicable; and

12.39.2.3 the results of the initial inspection and test in 12.40.2.

12.39.3 For portable tanks meeting the definition of container in the CSC, a prototype representing each design should be subjected to an impact test. The prototype portable tank should be shown to be capable of absorbing the forces resulting from an impact equivalent to at least 4 times (4 g) the maximum gross mass of the fully loaded portable tank at a duration typical of the mechanical shocks experienced in rail transport. The following is a listing of standards describing methods acceptable for performing the impact test:

12.39.3.1 Association of American Railroads,
Manual of Standards and Recommended Practices,
Specifications for Acceptability of Tank Containers (AAR.600), 1992

12.39.3.2 Canadian Standards Association,
Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods
(B620-1987).

12.39.3.3 Société Nationale des Chemins de fer Français
C.N.E.S.T. 002-1966
Tank containers, longitudinal external stresses and dynamic impact tests.

12.40 **Inspection and testing**

12.40.1 The shell and items of equipment of each portable tank should be inspected and tested before being put into service for the first time (initial inspection and test) and thereafter at not more than five-year intervals (5 year periodic inspection and test) with an intermediate periodic inspection and test (2.5 year periodic inspection and test) midway between the 5 year periodic inspections and tests. An exceptional inspection and test should be performed regardless of the last periodic inspection and test when necessary according to 12.40.6.

12.40.2 The initial inspection and test of a portable tank should include a check of the design characteristics, an internal and external examination of the portable tank and its fittings with due regard to the liquefied gases to be transported, and a pressure test referring to the test pressures according to 12.28.2. The pressure test may be performed as a hydraulic test or by using another liquid or gas with the agreement of the competent authority or its authorized body. Before the portable tank is placed into service, a leakproofness test and a test of the satisfactory operation of all service equipment should also be conducted. If the shell and its fittings have been pressure-tested separately, they should be subjected together after assembly to a leakproofness test. All welds subject to full stress level in the shell should be inspected during the initial test by radiographic, ultrasonic, or another suitable non-destructive test method. This does not apply to the jacket.

12.40.3 The 5 year periodic inspection and test should include an internal and external examination and, as a general rule, a hydraulic pressure test. Sheathing, thermal insulation and the like should be removed only to the extent required for reliable appraisal of the condition of the portable tank. If the shell and equipment have been pressure-tested separately, they should be subjected together after assembly to a leakproofness test.

12.40.4 The intermediate 2.5 year periodic inspection and test should at least include:

12.40.4.1 an internal and external examination of the portable tank and its fittings with due regard to the liquefied gases transported;

12.40.4.2 a leakproofness test;

12.40.4.3 a test of the satisfactory operation of all service equipment.

12.40.4.4 The internal examination may be waived or substituted by other test methods or inspection procedures by the competent authority or its authorized body, for portable tanks intended for the transport of a single liquefied gas.

12.40.5 Portable tanks, empty and uncleaned, may be moved after the expiration of the 5 year periodic inspection and test. In addition, the 2.5 year inspection and test may be performed within 3 months before and after the specified date.

12.40.6 The exceptional inspection and test is necessary when the portable tank shows evidence of damaged or corroded areas, or leakage, or other conditions that indicate a deficiency that could affect the integrity of the portable tank. The extent of the exceptional inspection and test should depend on the amount of damage or deterioration of the portable tank. It should include at least the 2.5 year inspection and test according to 12.40.4.

12.40.7 The internal and external examination should ensure that:

12.40.7.1 the shell is inspected for pitting, corrosion, or abrasions, dents, distortions, defects in welds or any other conditions, including leakage, that might render the portable tank unsafe for transport;

12.40.7.2 the piping, valves, and gaskets are inspected for corroded areas, defects, and other conditions, including leakage, that might render the portable tank unsafe for loading, discharge or transport;

12.40.7.3 devices for tightening manhole covers are operative and there is no leakage at manhole covers or gaskets;

12.40.7.4 missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;

12.40.7.5 all emergency devices and valves are free from corrosion, distortion and any damage or defect that could prevent their normal operation. Remote closure devices and self-closing stop-valves should be operated to demonstrate proper operation;

12.40.7.6 required markings on the portable tank are legible and in accordance with the applicable requirements;

12.40.7.7 the framework, the supports and the arrangements for lifting the portable tank are in satisfactory condition.

12.40.8 The inspections and tests in 12.40.2, 12.40.3, 12.40.4 and 12.40.6 should be performed or witnessed by an expert approved by the competent authority or its authorized body. If the pressure test is a part of the inspection and test, the test pressure should be the one indicated on the data plate of the portable tank. While under pressure, the shell should be inspected for any leaks in the shell, piping or equipment.

12.40.9 In all cases where cutting, burning or welding operations on the shell have been effected, that work should be to the approval of the competent authority or its authorized body taking into account the pressure vessel code used for the construction of the shell. A pressure test to the original test pressure should be performed.

12.40.10 If evidence of any unsafe condition is discovered, the portable tank should not be returned to service until it has been corrected and the test is repeated and passed.

12.41 **Document retention**

12.41.1 The design approval certificate, the test report and the certificate showing the results of the initial inspection and test for each portable tank issued by the competent authority or its authorized body should be retained by the authority or body and the owner. Owners should be able to provide this documentation upon the request of any competent authority.

12.42 **Filling**

12.42.1 Prior to filling the shipper should ensure that the portable tank is approved for the non-refrigerated liquefied gas to be transported and that the portable tank is not loaded with liquefied gases which in contact with the materials of the shell, gaskets and service equipment, are likely to react dangerously with them to form dangerous products or appreciably weaken the material. During filling, the temperature of the liquefied gas should fall within the limits of the design temperature range.

12.42.2 The maximum mass of liquefied gas per litre of tank capacity (kg/l) should not exceed the density of liquefied gas at 50°C multiplied by 0.95. Furthermore, the tank should not be liquid-full at 60°C.

12.42.3 Portable tanks should not be filled above their maximum permissible gross mass and the maximum permissible load mass specified for each gas to be transported.

12.43 **Marking**

12.43.1 Every portable tank should be fitted with a corrosion resistant metal plate permanently attached to the portable tank in a conspicuous place readily accessible for inspection. If for reasons of portable tank arrangements, the plate cannot be permanently attached to the shell, the shell should be marked with at least the information required by the pressure vessel code. As a minimum at least the following information should be marked on the plate by stamping or by any other similar method.

Country of manufacture

U	Approval	Approval	For Alternate Arrangements
N	COUNTRY	NUMBER	"AA"

Manufacturer's name or mark . . . .

Manufacturer's serial number . . . .

Authorized body for the design approval . . . .

Owner's Registration number . . . .

Year of manufacture . . . .

Pressure Vessel Code to which the shell is designed . . . .

Test pressure . . . . bars or kilopascals(kPa) gauge

MAWP . . . . bars or kilopascals(kPa) gauge

Water capacity at 20°C . . . . litres

Water capacity at 20°C of each compartment . . . . litres

Initial pressure test date and witness identification

Design temperature range . . . . °C to . . . . °C

Design reference temperature . . . . °C

Shell material(s) and material standard reference(s)

Equivalent thickness in reference steel . . . . mm

Date and type of most recent periodic test(s)

Month . . . . Year . . . . Test Pressure . . . . bars or kilopascals(kPa) gauge

Stamp of expert who performed or witnessed the most recent test . . . .

12.43.2 The following information should be marked either on the portable tank itself or on a metal plate firmly secured to the portable tank:

Name of the operator . . . .

Name of gases permitted for transport (and maximum mean bulk temperature if greater than 50°C)

Maximum permissible load mass for each gas permitted . . . . kg

Maximum permissible gross mass . . . . kg

Unladen (tare) mass . . . . kg

12.43.3 The liquefied gases intended for transport should be identified as specified in Chapter 13 of the Recommendations.

12.44 Transport requirements

12.44.1 Portable tanks should not be offered for transport:

12.44.1.1 in an ullage condition liable to produce an unacceptable hydraulic force due to surge within the tank;

12.44.1.2 that are leaking;

12.44.1.3 that are damaged to such an extent that the integrity of the tank or its lifting or securing arrangements may be affected; and

12.44.1.4 unless the service equipment has been examined and found to be in good working order.

12.44.2 During transport, portable tanks should be adequately protected against lateral and longitudinal impact and against overturning. This protection is not required if portable tanks are constructed to withstand impact or overturning. Examples of such protection are given in 12.38.5.

12.44.3 Certain gases are chemically unstable. They are accepted for transport only if the necessary steps have been taken to prevent their dangerous decomposition, transformation or polymerization during transport. To this end, care should in particular be taken to ensure that portable tanks do not contain any liquefied gases liable to promote these reactions.

12.44.4 Empty portable tanks not cleaned and not gas-free should comply with the same requirements as portable tanks filled with the previous liquefied gas.

ANNEX 2

REPORT OF THE DRAFTING GROUP ON GUIDELINES FOR ASSIGNING PORTABLE TANK REQUIREMENTS TO SUBSTANCES IN CLASSES 3 TO 9

1. These guidelines for assigning portable tank requirements to substances in Classes 3 to 9 are provided as a reference to be used for assigning portable tank requirements to specific substances. The guidelines were developed taking into consideration the hazards of dangerous goods and their physical and chemical characteristics.

2. The guidelines provide guidance for assigning specific requirements including minimum test pressures, minimum shell thicknesses, pressure-relief device arrangements, bottom opening closure requirements and filling limits for portable tanks used to transport substances in Classes 3 through 9.

3. For certain substances the tank requirements recommended by these guidelines may not be appropriate owing to unique characteristics of the substance not addressed in these guidelines. In these instances expert judgement should be applied in assigning appropriate requirements.

4. The guidelines are provided in two parts. Part I provides general guidance. Part II provides specific guidance for groups of substances organized on the basis of the Class or Division, Packing Group and subsidiary risk.

Part I General:

5. In assigning tank requirements to a substance the following should be taken into account:

5.1 **Prohibited Substances**: Some substances should be prohibited from transport in portable tanks. These substances are considered too dangerous for transport typically because of their instability or because they pose an unacceptably high level of risk when transported in bulk quantities under normal conditions of transport. The following substances are prohibited from transport in portable tanks:

- Substances of Class 1;
- Desensitised explosives in Division 4.1;
- Self-reactive substances (other than type F) and related substances of Division 4.1;
- Organic peroxides of Division 5.2 other than Type F;
- Radioactive materials other than Low Specific Activity (LSA) non-fissile or fissile excepted materials.

Additional substances as specifically identified in the Recommendations. Furthermore, some substances may only be transported on the basis of an approval by the competent authority.

5.2 **Minimum Shell Thicknesses:** The minimum shell thicknesses prescribed are provided in thicknesses relevant to reference steel with a guaranteed minimum tensile strength of 370 N/mm^2 and a guaranteed minimum elongation of 27%. When other materials are used equivalent thickness calculations should be performed. Minimum thicknesses range from 5mm to 10 mm. Part II of the guidelines provide guidance for assigning minimum thicknesses. Granular or powdered solid substances may be transported in tanks with minimum shell thicknesses of 5mm regardless of the tank diameter when 12.5.2 is specified relevant to a given substance. Regardless of the minimum thickness specified

in Part II, if the thickness determined in accordance with the provisions of sections 12.5.2 to 12.5.10 is greater, the greater thickness applies.

5.3 **Corrosive Effects of Substances on Materials of Construction**: The minimum thicknesses prescribed do not take a substance's corrosive effects into account. The consignor must ensure that the tank materials of construction are compatible with the lading.

5.4 **Minimum Test Pressures**: Irrespective of the pressure assigned in these guidelines, the minimum test pressure assigned to an individual substance should be the greater of the pressure determined on the basis of 12.2.8 in the Recommendations and the pressure assigned in these guidelines.

5.5 **Pressure-Relief Devices Requirements**: Two pressure relief device requirements are possible, (1) Normal (N) (where the provisions of paragraph 12.9.1 apply) or (2) 12.9.3. When paragraph 12.9.3 is referenced, a frangible disk must be provided in series preceding the pressure relief device. Paragraph 12.9.3 should be assigned to substances that:

- have the potential to polymerize or to produce solid or highly viscous substances capable of preventing proper operation of the relief valve.

In addition, 12.9.3 is also specified for individual substances.

5.6 **Bottom Openings**: Three bottom opening arrangements are proposed, 12.7.3 (which indicates three serially mounted means of closure), 12.7.2 (two serially mounted means of closure) or NA (Not Allowed).

5.7 **Filling Limits**: Three different filling restrictions are possible. The filling limits are considered operational requirements. The filling limits do not have a direct relationship to the construction of the tank or the arrangement of the servivce equipment. On this basis, filling limits are not addressed in Part II of this Annex and will not be included the tank type designations. The maximum filling limit for a substance should be consistent with the provisions under "Filling" in section 12.22 of the Recommendations. The shipper of the dangerous goods has the ultimate responsibility for assuring portable tanks are not filled in excess of the specified limits for each substance, solution or mixture transported.

6.0 Part II Specific Guidelines for Assigning Portable Tank Requirements to Groups of Substances

6.1 For substances in CLASS 3, PG III without a subsidiary risk the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	1.5 bar*	12.5.2	N	12.7.3

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

6.2 For substances in CLASS 3, PG III with a Division 6.1 or a Class 8 subsidiary risk the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	2.65 bar*	12.5.2	N	12.7.3**

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

** Bottom openings are not allowed for substances highly corrosive to steel.

6.3 For substances in CLASS 3, PG II with or without a Div. 6.1 or Class 8 subsidiary risk, the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar*	12.5.2	N	12.7.3**

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

** Bottom openings are not allowed for substances highly corrosive to steel.

6.4 For substances in CLASS 3, PG I,
substances in CLASS 3, PG I with a Div. 6.1 PG II or III subsidiary risk and
substances in CLASS 3, PG I with a Class 8 PG II or III subsidiary risk,
the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	6 bar*	12.5.2	N**	12.7.3***

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

** Some substances in this category require 12.9.3.

*** Bottom openings are not allowed for substances highly corrosive to steel.

6.5 For: substances in CLASS 3, PG I with 6.1, PG I subsidiary risk, and substances in CLASS 3, PG I with Class 8, PG I subsidiary risk, the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	6 bar*	6mm	12.9.3	NA

* A higher or lower minimum test pressure (4 bar minimum) may be used depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

6.6 For: Flammable solids in Division 4.1, PG II and III
Solid substances in Divsion 4.2, PG II and III,
Solid substances in Division 4.3, PG II and III,
Solid substances in Division 5.1, PG II and III
Solid substances in Division 6.1, PG II and III
Solid substances in Class 8, PG II and III
Solid substances in Class 9, PG II and III,
the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	1.5 bar	12.5.2	N	12.7.2

6.7 For liquid substances in DIVISION 4.2, PG I the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	10 bar	10 mm	N	NA

6.8 For substances in DIVISION 4.3, PG I with or without subsidiary risks the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar	6mm	N	NA

Note: There are exceptions where more stringent requirements (minimum test pressure and minimum shell thickness) have been applied on the basis of industry practice (e.g. Metal Alkylls).

6.9 For solutions of solid oxidizers in DIVISION 5.1, PG II and III, the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	2.65	12.5.2	N	12.7.3

6.10 For substances in DIVISION 5.1, PG II (hydrogen peroxides solutions) with a subsidiary risk of Class 8 the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar	12.5.2	N*	12.7.3**

* Certain substances require a breathing device.
** Bottom openings are not allowed for substances highly corrosive to steel.

6.11 For substances in DIVISION 5.1, PG I with subsidiary risk of Class 8 the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar	6mm	12.9.3	NA

6.12 For substances in DIVISION 5.1, PG I with a Class 8 and a Division 6.1 subsidiary risk the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	10 bar	10mm	12.9.3	NA

6.13 For substances in DIVISION 5.2, PG II (Type F Organic Peroxides) the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar	12.5.2	12.9.2 12.556 12.557 12.558	12.7.3

Note: Organic peroxides, Type F are only permitted in portable tanks when they are listed in Table 11.5. All others are prohibited unless approved by the competent authority.

These requirements are also considered appropriate for Division 4.1, PG II, Type F, Self Reactive Substances.

6.14 For liquid substances in DIVISION 6.1 PG III the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	2.65 bar*	12.5.2	N	12.7.3

* A higher or lower minimum test pressure (4 bar minimum) may be used depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

6.15 For liquid substances in DIVISION 6.1 PG II with or without subsidiary risks the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar*	12.5.2	N	12.7.3**

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

** Bottom openings are not allowed for substances highly corrosive to steel.

6.16 For substances in DIVISION 6.1 PG I (non-inhalation hazard) with or without subsidiary risks the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	6 bar*	6 mm	12.9.3	NA

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

Higher minimum test pressure and higher minimum thickness requirements should be considered for Division 6.1 substances that are classified as toxic on the basis of an inhalation hazard at the PG I level.

6.17 Class 7 assignments are not dealt with in this document.

6.18 For liquid substances in CLASS 8 PG III the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	1.5 bar*	12.5.2	N	12.7.3**

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

** Bottom openings are not allowed for substances highly corrosive to steel.

6.19 For liquid substances in CLASS 8 PG II with or without a subsidiary risk the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar	12.5.2	N	12.7.3

* A higher minimum test pressure may be required depending on the absolute vapor pressure of the substance at 65 °C and the pressure prescribed using the definitions for design and test pressure in paragraphs 12.2.7 and 12.2.8 of the Recommendations.

** Bottom openings are not allowed for substances highly corrosive to steel.

6.20 For liquid substances in CLASS 8 PG I with or without a subsidiary risk the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	4 bar	6 mm	12.9.3	NA

6.21 For liquid substances in CLASS 9, the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	1.5 bar	12.5.2	N	12.7.3

6.22 For Molten Substances and elevated temperature substances in Class 9 the following requirements should apply:

Tank Type	Minimum Test Pressure	Minimum Shell Thickness	Pressure Relief Device	Bottom Openings
	2.65 bar	12.5.2	N	12.7.2

Note: Assignments for molten substances in classes other than Class 9 should be assigned based on the requirements established for the particular class, division, packing group and subsidiary risk of the substance.

Decisions on Portable Tank Notes:

Note: The numbers refer to the existing numbers of notes to Table 12.2 of the Recommendations.

1. Notes 1,3,5,7,9,10 and 11 should be deleted.

2. The contents of notes 2,6,8,12,13 and 14 should be retained and these notes should be transformed into notes appearing in the Dangerous Goods List of the reformatted Recommendations.

3. Note 4 should read: "This substance may only be transported in tanks under an approval by the competent authority". (text as it will appear in the reformatted Recommendations)

CHAPTER 17

PORTABLE TANK REQUIREMENTS FOR REFRIGERATED LIQUEFIED GASES OF CLASS 2

17.1 Preamble

17.1.1 The provisions of this Chapter apply to portable tanks (including tank-containers) intended for the transport of refrigerated liquefied gases by all modes of transport. In addition to the provisions of this Chapter, and unless otherwise specified, the applicable requirements of the International Convention for Safe Containers (CSC) should be fulfilled by any portable tank which meets the definition of a "container" within the terms of the Convention. Additional requirements may apply to offshore portable tanks that are handled in open seas.

17.1.2 In recognition of scientific and technological advances, the technical provisions of this Chapter may be varied by alternative arrangements. These alternate arrangements should offer a level of safety not less than that given by the provisions of this Chapter with respect to the compatibility with refrigerated liquefied gases transported and resistance to impact, loading and fire. For international transport alternate arrangement portable tanks should be approved by the applicable competent authorities.

17.1.3 The refrigerated liquefied gases covered by this chapter are listed in Table 17.1 which also shows the special requirements which modify or supplement the general requirements for each particular refrigerated liquefied gas. Table 17.1 will be required to be brought up to date from time to time by the possible addition of new refrigerated liquefied gases and in the light of technical progress.

17.1.4 If a refrigerated liquefied gas is not listed in Table 17.1 interim approval for transport may be issued by the competent authority of the country of origin. The approval should be included in the documentation of the consignment and contain the conditions under which the refrigerated liquefied gas should be transported. Appropriate measures should be initiated by the competent authority to include the refrigerated liquefied gas in Table 17.1.

17.2 Definitions

17.2.1 The following requirements apply to portable tanks intended for the transport of refrigerated liquefied gases:

17.2.2 *Portable tank* means a thermally insulated multimodal portable tank having a capacity of more than 450 litres fitted with service equipment and structural equipment necessary for the transport of refrigerated liquefied gases. The portable tank should be capable of being loaded and discharged without the removal of its structural equipment. It should possess stabilizing members external to the tank, and should be capable of being lifted when full. It should be designed primarily to be loaded onto a transport vehicle or ship and should be equipped with skids, mountings, or accessories to facilitate mechanical handling. Road tank-vehicles, rail tank-wagons, non-metallic tanks, intermediate bulk containers (IBCs), gas cylinders and large receptacles are not considered to fall within the definition for portable tanks;

17.2.3 *Tank* means a construction which normally consists of either:

17.2.3.1 a jacket and one or more inner shells where the space between the shell(s) and the jacket is exhausted of air (vacuum insulation) and may incorporate thermal insulation system; or

17.2.3.2 a jacket and an inner shell with a intermediate layer of solid thermally insulating material (e.g. solid foam);

17.2.4 *Shell* means that part of the portable tank which retains the refrigerated liquefied gas intended for transport, including openings and their closures, but does not include service equipment or external structural equipment;

17.2.5 *Jacket* means the outer insulation cover or cladding which may be part of the insulation system;

17.2.6 *Service equipment* means measuring instruments and filling, discharge, venting, safety, pressurizing, cooling and thermal insulation devices;

17.2.7 *Structural equipment* means the reinforcing, fastening, protective and stabilizing members external to the shell;

17.2.8 *Maximum allowable working pressure (MAWP)* means the maximum effective gauge pressure permissible at the top of the shell of a loaded portable tank in its operating position including the highest effective pressure during filling and discharge;

17.2.9 *Test pressure* means the maximum gauge pressure at the top of the shell taken during the pressure test;

17.2.10 *Leakproofness test* means a test using gas which consists of subjecting the shell and its service equipment, to an effective internal pressure equivalent to at least 90% of the MAWP;

17.2.11 *Maximum permissible gross mass (MPGM)* means the sum of the tare mass of the portable tank and the heaviest load authorized for transport;

17.2.12 *Holding time* means the time that will elapse from the establishment of the initial filling condition until the pressure has risen due to heat influx to the lowest set pressure of the pressure limiting device(s);

17.2.13 *Reference steel* means a steel with a tensile strength of 370 N/mm^2 and an elongation at fracture of 27%;

17.2.14 *Mild steel* means a steel with a guaranteed minimum tensile strength of 360 N/mm^2 to 440 N/mm^2 and a guaranteed minimum elongation at fracture conforming to 17.4.3.2.1;

17.2.15 *Minimum design temperature* means the temperature which should be considered in the design and construction of the shell taking into account the lowest (coldest) temperature of the contents during normal filling, discharge and transport conditions.

17.3 General requirements for the design and construction of portable tanks for refrigerated liquefied gases of Class 2

17.3.1 Shells should be designed and constructed in accordance with the provisions of a pressure vessel code recognized by the competent authority. Shells and jackets should be made of metallic materials suitable for forming. Jackets should be made of steel. The materials should in principle conform to national or international material standards. For welded shells and jackets only materials whose weldability has been fully demonstrated should be used. Welds should be skilfully made and afford complete safety. Welds should be skilfully made and afford complete safety. If the manufacturing process or the materials make it necessary, the shell(s) should be suitably heat treated to guarantee adequate toughness in the weld and in the heat affected zones. In choosing the material, the minimum design temperature should be taken into account with respect to risk of brittle fracture, to hydrogen embrittlement, to stress corrosion cracking and to resistance to impact. If fine grain steel is used, the guaranteed value of the yield strength, Re should not exceed 460 N/mm^2 and the guaranteed value of the upper limit of the tensile strength, Rm should not exceed 725 N/mm^2 in accordance with the material specifications. Portable tank materials should be suitable for the external environment in which they may be transported.

17.3.2 Any part of a portable tank, including fittings and pipe-work, which can be expected normally to come into contact with the refrigerated liquefied gas transported should be compatible with that refrigerated liquefied gas.

17.3.3 Contact between dissimilar metals which could result in damage by galvanic reaction should be avoided.

17.3.4 The thermal insulation system should include a complete covering of the shell(s) with effective insulating materials. External insulation should be protected by a jacket so as to prevent the ingress of moisture and other damage under normal transport conditions.

17.3.5 If a jacket is so closed as to be gas-tight, a device should be provided to prevent any dangerous pressure from developing in the insulation space in the event of inadequate gas-tightness of the shell or of its items of equipment.

17.3.6 Portable tanks intended for the transport of refrigerated liquefied gases having a boiling point below minus 182 °C at atmospheric pressure should not include materials, which may react with oxygen or oxygen enriched atmospheres in a dangerous manner, if located in parts of the thermal insulation where there is a risk of contact with oxygen or with oxygen enriched fluid. Compact means of attachment between the shell and jacket may contain plastics materials, provided their material properties at their service temperature are proven to be sufficient.

17.3.7 Insulating materials should not deteriorate unduly in service.

17.3.8 A holding time should be determined for each portable tank intended for the transport of refrigerated liquefied gases and for each liquefied gas transported within the portable tank.

17.3.8.1 In determining the holding time the following factors should be taken into account:

17.3.8.1.1 the effectiveness of the insulation system provided;

17.3.8.1.2 the lowest set pressure of the pressure limiting device(s);

17.3.8.1.3 the initial filling conditions;

17.3.8.1.4 an assumed ambient temperature of 30°C;

17.3.8.1.5 the physical properties of the individual refrigerated liquefied gas intended to be transported.

17.3.8.2 The effectiveness of the insulation system (heat influx in watts) should be determined by type testing of the portable tank in accordance with a procedure recognized by the competent authority. This test should consist of either:

17.3.8.2.1 a constant pressure test (for example at atmospheric pressure) where the loss of lading is measured over a period of time; or

17.3.8.2.2 a closed system test where the rise in pressure in the shell is measured over a period of time.

17.3.8.3 In the constant pressure test account should be taken of the variation in atmosheric pressure. For each of the tests in 17.8.3.2.1 and 17.3.8.2.2, it may be necessary to make corrections for any variation of the ambient temperature from the assumed ambient temperature reference value of 30°C.

17.3.8.4 The reference holding time should be determined from the values given below:

17.3.8.4.1 the determined heat flux in 17.3.8.2;

17.3.8.4.2 the maximum allowable filling density in 17.17.2;

17.3.8.4.3 the initial pressure of the refrigerated liquefied gas;

17.3.8.4.4 the final pressure of the refrigerated liquefied gas which is equivalent to the MAWP of the shell.

17.3.8.5 The actual holding time for each journey should be calculated in accordance with a procedure recognized by the competent authority. The actual holding time should be determined on the basis of the following:

17.3.8.5.1 the determined heat influx in 17.3.8.2;

17.3.8.5.2 the actual filling density;

17.3.8.5.3 the actual filling pressure;

17.3.8.5.4 the lowest set pressure of the pressure limiting device(s);

17.3.8.5.5 the reference holding time for the refrigerated liquefied gas being transported.

17.3.9 The jacket of a vacuum-insulated double-wall tank should have either an external design pressure of at least 100 kPa (1 bar) gauge pressure calculated in accordance with a recognized technical code or a calculated critical collapsing pressure of at least 200 kPa (2 bar) gauge pressure.
Internal and external reinforcements may be included in calculating the ability of the jacket to resist the

external pressure.

17.3.10 Portable tanks should be designed and constructed with supports to provide a secure base during transport and with suitable lifting and tie-down attachments.

17.3.11 Portable tanks should be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads including the effects of fatigue during normal conditions of handling and transport.

17.3.12 Portable tanks and their fastenings under the maximum permissible load should be capable of absorbing the following separately applied static forces:

17.3.12.1 in the direction of travel: twice the maximum permissible gross mass multiplied by acceleration (g)*/;

17.3.12.2 horizontally at right angles to the direction of travel: the maximum permissible gross mass (where the direction of travel is not clearly determined, the forces should be equal to twice the maximum permissible gross mass) multiplied by acceleration (g)*/;

17.3.12.3 vertically upwards: the maximum permissible gross mass multiplied by acceleration (g)*/.; and

17.3.12.4 vertically downwards: twice the maximum permissible gross mass (total loading including the effect of gravity)multiplied by acceleration (g)*/.

17.3.13 Under each of these forces, the safety factors to be observed should be as follows:

17.3.13.1 for materials having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; or

17.3.13.2 for materials with no clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed 0.2% proof strength and, in case of austenitic steels, the 1% proof strength.

17.3.14 The values of yield strength or proof strength should be the values according to the material standards. When austenitic steels are used, the specified minimum values according to the material standards may be increased up to 15% if this value is provided in the material inspection certificate. If no material standard exists for the metal in question, or when non-metallic materials are used the values of yield strength or proof strength used should be approved by the competent authority or its authorized body.

17.3.15 Portable tanks intended for the transport of flammable gases should be capable of being electrically earthed.

17.4 Design Criteria

17.4.1 Shells should be of a circular cross section.

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*/ For calculation purposes $g = 9.81\ m/s^2$.

17.4.2 Shells should be designed and constructed to withstand a test pressure equal to at least 1.3 times the MAWP. For shells with vacuum insulation the test pressure should not be less than 1.3 times the sum of the MAWP and 100 kPa (1 bar). In no case should the test pressure be less than 300 kPa (3 bar) gauge pressure. Attention is drawn to the minimum shell thickness requirements, specified in 17.5.2 to 17.5.5.

17.4.3 At the test pressure the primary membrane stress σ in the shell should conform to the material-dependent limitations prescribed below:

17.4.3.1 for metals exhibiting a clearly defined yield point or characterized by a guaranteed proof strength (0.2% proof strength generally or 1% proof strength for austenitic steels), the membrane stress σ at the test pressure should not exceed 0.75 Re or 0.50 Rm, whichever is lower, where:

Re = yield strength, or 0.2% proof strength or, in the case austenitic steels, 1% proof strength;

Rm = minimum tensile strength.

17.4.3.2 The values of Re and Rm to be used should be the specified minimum values according to national or international material standards. Where no material standard exists for the metal or alloy in question, the values of Re and Rm used should be approved by the competent authority or its authorized body. When austenitic steels are used, the specified minimum values of Re and Rm according to the material standards may be increased by up to 15% if these higher values are provided in the material inspection certificate. Ratios of Re/Rm exceeding 0.85 are not allowed for steels in the construction of welded tanks. In determining the ratio Re/Rm, the values specified in the material inspection certificate should be used. The values in the material inspection certificate should conform with the following provisions:

17.4.3.2.1 For steel, the elongation at fracture, in %, should not be less than 10,000/Rm where Rm is in N/mm^2, with an absolute minimum of 16% for fine grained steels and 20% for other steels.

17.4.3.2.2 For aluminium, the elongation at fracture, in %, should not be less than 10,000/6 Rm where Rm is in N/mm^2, with an absolute minimum of 12%.

17.4.3.3 For the purpose of determining actual values of materials, it should be noted that in the case of sheet metal, the axis of the tensile test specimen should be at right angles (transversely) to the direction of rolling. The permanent elongation at fracture should be measured on test specimens of rectangular cross sections in accordance with ISO 6892:1984 using a 50 mm gauge length.

17.5 Minimum shell thickness

17.5.1 The minimum thickness of the shell should be the greatest thickness based on:

17.5.1.1 the minimum thickness determined in accordance with the provisions of sections 17.5.2 to 17.5.7; and

17.5.1.2 the minimum thickness determined in accordance with the recognized pressure vessel code including the provisions in 17.4.3.

17.5.2 Shells of not more than 1.80 m in diameter should be not less than 5 mm thick in the reference steel or of equivalent thickness in the actual metal. Shells of more than 1.80 m in diameter should be not less than 6 mm thick in the reference steel or of equivalent thickness in the actual metal.

17.5.3 Shells of vacuum-insulated tanks of not more than 1.80 m in diameter should be not less than 3 mm thick in the reference steel or of equivalent thickness in the actual metal. Such shells of more than 1.80 m in diameter should be not less than 4 mm thick in the reference steel or of equivalent thickness in the actual metal.

17.5.4 For the vacuum-insulated tanks, the aggregate thickness of the jacket and the shell wall should correspond to the minimum wall thickness prescribed in 17.5.2, the thickness of the shell itself being not less than the minimum thickness prescribed in 17.5.3.

17.5.5 All shells should be not less than 3 mm thick regardless of the material of construction.

17.5.6 The thickness of a metal other than the reference steel to that prescribed in 17.5.2 and 17.5.3 should be determined by using the following equation:

$$e_1 = \frac{21.4 \text{ x } e_o}{3 \sqrt{Rm_1 \text{ x } A_1}}$$

where: e_1 = the required equivalent thickness of the metal to be used in mm;
e_o = minimum thickness for the reference steel specified in 17.5.2 and 17.5.3;
Rm_1 = guaranteed minimum tensile strength of the metal to be used in N/mm^2 (see 17.4.3);
A_1 = guaranteed minimum elongation (as a percentage) of the metal to be used on fracture under tensile stress according to national or international standards.

17.5.7 If mild steel conforming to the definition of 17.2.14 is used, calculation using the equation according to 17.5.6 is not required.

17.5.8 There should be no sudden change of plate thickness at the attachment of the ends (heads) to the cylindrical portion of the shell.

17.6 Service equipment

17.6.1 Service equipment should be so arranged as to be protected against the risk of being wrenched off or damaged during conditions of handling and transport. If the connection between the frame and the shell, tank or the jacket and the shell allows relative movement, the equipment should be so fastened as to permit such movement without risk of damage to working parts. The external discharge fittings (pipe sockets, shut-off devices), the stop-valve and its seating should be protected against the danger of being wrenched off by external forces (for example using shear sections). The filling and discharge devices (including flanges or threaded plugs) and protective caps (if any) should be capable of being secured against any unintended opening.

17.6.2 Each filling and discharge opening used for the transport of flammable gases should be fitted with three independent shut-off devices in series, the first being a stop valve situated as close as reasonably practicable to the jacket, the second being a stop valve and the third being a blank flange or equivalent device. In the case of flammable gases, that shut-off device nearest to the refrigerated liquefied gas being transported should be a quick closing device which closes automatically in the event of fire engulfment. It should also be possible to operate this device by remote control. Each filling and

each discharge opening in portable tanks used for the transport of non-flammable gases should be provided with at least two independent shut-off devices in series, the first being a stop valve situated as close as reasonably practicable to the jacket, the second a blank flange or equivalent device.

17.6.3 For sections of piping which can be closed at both ends and where liquid lading can be trapped, a method of automatic pressure relief should be provided to prevent excess pressure buildup within the piping.

17.6.4 Vacuum insulated tanks need not have an opening for inspection.

17.6.5 So far as reasonably practicable, external fittings should be grouped together.

17.6.6 All portable tank connections should be clearly marked to indicate the function of each.

17.6.7 Each stop valve or other means of closure should be designed and constructed to a rated pressure not less than the MAWP of the tank and to the temperature expected in transport. Each stop valve with a screwed spindle should be closed by a clockwise motion of the handwheel. In the case of other stop valves the position and/or direction of closure should be clearly indicated. All stop valves should be constructed to prevent unintentional opening.

17.6.8 When pressure-building units are used, the liquid and vapour connections to that unit should be provided with a valve as close to the jacket as reasonably practicable to prevent the loss of lading from the tank in case of damage to the pressure-building unit.

17.6.9 All piping should be of a suitable material. To prevent leakage due to fire, only steel piping and welded joints should be used between the jacket and the connection to the first closure of any outlet. The method of attaching the closure to this connection should be to the satisfaction of the competent authority. Elsewhere pipe joints should be welded wherever necessary.

17.6.10 Joints of copper tubing should be brazed or have an equally strong metal union. Such joints should in any event be such as not to decrease the strength of the tubing as may happen by cutting of threads. The melting point of brazing materials should be no lower than 525°C.

17.6.11 Only materials which remain compatible at the lowest operating temperatures should be used in the construction of valves and accessories.

17.6.12 The bursting strength of all piping and pipe fittings should be at least four times the strength at the MAWP of the tank and at least four times the strength at the pressure to which it may be subjected in service by the action of a pump or other device (except pressure-relief devices).

17.6.13 Suitable provisions should be made in every case to prevent damage to piping due to thermal expansion and contraction, mechanical shock and vibration.

17.7 Pressure-relief devices

17.7.1 Every shell should be provided with at least two independent pressure-relief devices of the spring-loaded type.

17.7.2 Shells for refrigerated liquefied gases may in addition have frangible discs in parallel with the spring-loaded devices as specified in 17.6.2 and 17.6.3.

17.7.3 Pressure-relief devices should be designed to prevent:

17.7.3.1 accumulation of moisture and foreign matters in the way of the seat on the external side;

17.7.3.2 leakage of gas and the development of any dangerous excess pressure.

17.7.4 Pressure-relief devices should be approved by the competent authority or its authorized body.

17.8 Capacity and setting of pressure-relief devices

17.8.1 The capacity of each spring-loaded pressure-relief valve should be sufficient to limit the pressure to 110% of the MAWP due to normal pressure rise. These valves should be set to start to discharge at the nominal pressure equal to the MAWP and should after discharge close at a pressure not lower than 90% of the MAWP and remain closed at all lower pressures.

17.8.2 In the case of loss of vacuum in a vacuum-insulated tank or of loss of 20% of the insulation of a tank insulated with solid materials, the combined capacity of all pressure-relief devices installed should be sufficient to limit the pressure to 120% of the MAWP. For helium and hydrogen, this capacity may be achieved by the use of frangible discs in parallel with the required safety-relief valves. These discs should rupture at nominal pressure equal to the test pressure.

17.8.3 Under the circumstances prescribed in 17.8.2 together with complete fire engulfment the combined capacity of all pressure-relief devices installed should be sufficient to limit the pressure to the test pressure. Frangible discs, if used, should rupture at a nominal pressure equal to the test pressure.

17.8.4 The required capacity of the relief devices should be calculated in accordance with a well-established technical code recognized by the competent authority*/.

17.9 Marking pressure-relief devices

17.9.1 Every pressure-relief device should be plainly and permanently marked with the pressure at which it is set to discharge and the rated flow capacity of the device in standard cubic metres per second. Where practicable the following information should be shown:

17.9.1.1 the manufacturer's name and the relevant catalogue number;

17.9.1.2 allowable tolerances at start-to-discharge pressure (frangible disc).

17.9.2 The rated flow capacity marked on the pressure-relief valves should be determined according to ISO 4126-1:1996.

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*/ See for example CGA Pamphlet S-1.2-1995.

17.10 Connections to pressure-relief devices

17.10.1 Connections to pressure-relief devices should be of sufficient size to enable the required discharge to pass unrestricted to the safety device. No stop-valve should be installed between the shell and the pressure-relief devices except where duplicate devices are provided for maintenance or other reasons and the stop-valves serving the devices actually in use are locked open or the stop-valves are interlocked so that the requirements of 17.8 are always fulfilled. There should be no obstruction in an opening leading to a vent or pressure relief device which might restrict or cut-off the flow from the shell to that device. Vents from the pressure-relief devices, where used, should deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving device.

17.11 Siting pressure-relief devices

17.11.1 All pressure-relief device inlets should be situated on top of the shell in a position as near the longitudinal and transverse centre of the shell as reasonably practicable. All pressure relief device inlets should under maximum filling conditions be situated in the vapour space of the shell and the devices should be so arranged as to ensure that the escaping vapour is discharged unrestrictedly. For flammable liquefied gases, the escaping vapour should be directed away from the tank and in such a manner that it cannot impinge upon the tank. Protective devices which deflect the flow of vapour are permissible provided the required relief-device capacity is not reduced.

17.11.2 Arrangements should be made to prevent access to the devices by unauthorized persons and to protect the devices from damage caused by the portable tank overturning.

17.12 Gauging devices

17.12.1 Unless a portable tank is intended to be filled by weight, it should be equipped with one or more gauging devices. Glass level-gauges, or gauges made of other fragile material, which are in direct communication with the contents of the shell should not be used.

17.12.2 A connection for a vacuum gauge should be provided in the jacket of a vacuum-insulated portable tank.

17.13 **Portable tank supports, frameworks, lifting and tie-down attachments**

17.13.1 Portable tanks should be designed and constructed with a support structure to provide a secure base during transport. The forces specified in 17.3.12 and the safety factors specified in 17.3.13 should be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.

17.13.2 The combined stresses caused by portable tank mountings (e.g. cradles, frameworks, etc.) and portable tank lifting and tie-down attachments should not cause excessive stress in any portion of the tank. Permanent lifting and tie-down attachments should be fitted to all portable tanks. Preferably they should be fitted to the portable tank supports but may be secured to reinforcing plates located on the tank at the points of support.

17.13.3 In the design of supports and frameworks the effects of environmental corrosion should be taken into account.

17.13.4 Forklift pockets should be capable of being closed off. The means of closing forklift pockets should be a permanent part of the framework or permanently attached to the framework. Single compartment portable tanks with a length less than 3.65 m need not have closed off forklift pockets provided that:

17.13.4.1 the tank and all the fittings are well protected from being hit by the forklift blades; and

17.13.4.2 the distance between the centres of the forklift pockets is at least half of the maximum length of the portable tank.

17.13.5 If portable tanks are not protected during transport, according to 17.19.3, the shells and service equipment should be protected against collision. Examples of protection of shells against collision include:

17.13.5.1 protection against lateral impact may consist, for example, of longitudinal bars protecting the shell on both sides at the level of the median line;

17.13.5.2 protection of the portable tank against overturning may consist, for example, of reinforcement rings or bars fixed across the frame;

17.13.5.3 protection against rear impact may consist of a bumper or frame;

17.13.5.4 external fittings should be designed or protected so as to preclude the release of contents upon impact or overturning of the portable tank upon the fittings.

17.14 **Design approval**

17.14.1 The competent authority or its authorized body should issue a design approval certificate for any new design of a portable tank. This certificate should attest that a portable tank has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this chapter. If a series of portable tanks are manufactured without change in the design, the certificate should be valid for the entire series. The certificate should refer to the prototype test report, the refrigerated liquefied gases allowed to be transported, the materials of construction of the tank and jacket and an approval number. The approval number should consist of the distinguishing sign or mark of the State in whose territory the approval was granted, i.e. the distinguishing sign for use in international traffic, as prescribed by the Convention on Road Traffic, Vienna 1968, and a registration number. Alternative arrangements according to 17.1.2, if any, should be indicated on the certificate. A design approval may serve for the approval of smaller portable tanks made of materials of the same kind and thickness, by the same fabrication techniques and with identical supports, equivalent closures and other appurtenances.

17.14.2 The prototype test report for the design approval should include at least the following:

17.14.2.1 the results of the applicable frame-work test specified in ISO 1496-3: 1995;

17.14.2.2 the results of the impact test in 17.14.3 when applicable; and

17.14.2.3 the results of the initial inspection and test in 17.15.2.

17.14.3 For portable tanks meeting the definition of container in the CSC, a prototype representing each design should be subjected to an impact test. The prototype portable tank should be shown to be capable of absorbing the forces resulting from an impact equivalent to at least 4 times (4 g) the maximum gross mass of the fully loaded portable tank at a duration typical of the mechanical shocks experienced in rail transport. The following is a listing of standards describing methods acceptable for performing the impact test:

17.14.3.1 Association of American Railroads,
Manual of Standards and Recommended Practices,
Specifications for Acceptability of Tank Containers (AAR.600), 1992

17.14.3.2 Canadian Standards Association,
Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods
(B620-1987).

17.14.3.3 Société Nationale des Chemins de fer Français
C.N.E.S.T. 002-1966
Tank containers, longitudinal external stresses and dynamic impact tests.

17.15 **Inspection and testing**

17.15.1 The tank and items of equipment of each portable tank should be inspected and tested before being put into service for the first time (initial inspection and test) and thereafter at not more than five-year intervals (5 year periodic inspection and test) with an intermediate periodic inspection and test (2.5 year periodic inspection and test) midway between the 5 year periodic inspections and tests. An exceptional inspection and test should be performed regardless of the last periodic inspection and test when necessary according to 17.15.6.

17.15.2 The initial inspection and test of a portable tank should include a check of the design characteristics, an internal and external examination of the portable tank and its fittings with due regard to the refrigerated liquefied gases to be transported, and a pressure test referring to the test pressures according to 17.4.2. The pressure test may be performed as a hydraulic test or by using another liquid or gas with the agreement of the competent authority or its authorized body. Before the portable tank is placed into service, a leakproofness test and a test of the satisfactory operation of all service equipment should also be conducted. If the shell and its fittings have been pressure-tested separately, they should be subjected together after assembly to a leakproofness test. All welds subject to full stress level (e.g. longitudinal and circumferential welds) in the shell should be tested during the initial test by radiographic, ultrasonic, or another suitable non-destructive test method. This does not apply to the jacket.

17.15.3 The 5 year periodic inspection and test should include the following:

17.15.3.1 an external examination of the portable tank and its fittings with due regard to the refrigerated liquefied gases transported;

17.15.3.2 a leakproofness test;

17.15.3.3 a test of the satisfactory operation of all service equipment;

17.15.3.4 a vacuum reading, where applicable.

17.15.4 In addition, in the case of non-vacuum insulated tanks the jacket and insulation should be removed, but only to the extent necessary for a reliable appraisal.

17.15.5 Portable tanks, empty and uncleaned, may be moved after the expiration of the 5 year periodic inspection and test. In addition, the 2.5 year inspection and test may be performed within 3 months before and after the specified date.

17.15.6 The exceptional inspection and test is necessary when the portable tank shows evidence of damaged or corroded areas, or leakage, or other conditions that indicate a deficiency that could affect the integrity of the portable tank. The extent of the exceptional inspection and test should depend on the amount of damage or deterioration of the portable tank. It should include at least the 2.5 year inspection and test according to 17.15.3.

17.15.7 The internal examination should ensure that the shell is inspected for pitting, corrosion, or abrasions, dents, distortions, defects in welds or any other conditions, including leakage, that might render the portable tank unsafe for transport.

17.15.7. The external examination of the portable tank should ensure that:

17.15.7.1 the external piping, valves, pressurizing/cooling systems if applicable and gaskets are inspected for corroded areas, defects, and other conditions, including leakage, that might render the portable tank unsafe for loading, discharge or transport;

17.15.7.2 devices for tightening manhole covers are operative and there is no leakage at manhole covers or gaskets;

17.15.7.3 missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;

17.15.7.4 all emergency devices and valves are free from corrosion, distortion and any damage or defect that could prevent their normal operation. Remote closure devices and self-closing stop-valves should be operated to demonstrate proper operation;

17.15.7.5 required markings on the portable tank are legible and in accordance with the applicable requirements;

17.15.7.6 the framework, the supports and the arrangements for lifting the portable tank are in satisfactory condition.

17.15.8 The inspections and tests in 17.15.2, 17.15.3, 17.15.4 and 17.15.6 should be performed or witnessed by an expert approved by the competent authority or its authorized body. If the test is a part of the inspection and test, the test pressure should be the one indicated on the data plate of the portable tank. While under pressure, the tank should be inspected for any leaks in the shell, piping or equipment.

17.15.9 In all cases where cutting, burning or welding operations on the shell of a portable tank have been effected, that work should be to the approval of the competent authority or its authorized body taking into account the pressure vessel code used for the construction of the shell. A pressure test to the original test pressure should be performed.

17.15.10 If evidence of any unsafe condition is discovered, the portable tank should not be placed or returned to service until it has been corrected and the test is repeated and passed.

17.16 **Document retention**

17.16.1 The design approval certificate, the test report and the certificate showing the results of the initial inspection and test for each portable tank issued by the competent authority or its authorized body should be retained by the authority or body and the owner. Owners should be able to provide this documentation upon the request of any competent authority.

17.17 **Filling**

17.17.1 Prior to filling the shipper should ensure that the portable tank is approved for the refrigerated liquefied gas to be transported and that the portable tank is not loaded with refrigerated liquefied gases which in contact with the materials of the shell, gaskets and service equipment, are likely to react dangerously with them to form dangerous products or appreciably weaken the material. During filling, the temperature of the liquefied gas should fall within the limits of the design temperature range.

17.17.2 In estimating the initial degree of filling the necessary holding time for the intended journey including any delays which might be encountered should be taken into consideration. The initial degree of filling of a shell should be such that if the contents, except helium, were to be raised to a temperature at which the vapour pressure is equal to the MAWP the volume occupied by liquid would not exceed 98%.

17.17.3 Shells intended for the transport of helium can be filled up to but not above the inlet of the pressure-relief device. Provided the competent authority is satisfied with modified portable tank arrangements, a higher initial degree of filling may be allowed when the intended duration of transport is considerably shorter than the holding time.

17.18 **Marking**

17.18.1 Every portable tank should be fitted with a corrosion resistant metal plate permanently attached to the portable tank in a conspicuous place readily accessible for inspection. If for reasons of portable tank arrangements, the plate cannot be permanently attached to the shell, the shell should be marked with at least the information required by the pressure vessel code. As a minimum at least the following information should be marked on the plate by stamping or by any other similar method.

Country of manufacture

U	Approval	Approval	In case of Alternate Arrangements
N	Country	Number	"AA"

Manufacturer's name or mark . . . .
Manufacturer's serial number . . . .
Authorized body for the design approval . . . .
Owner's registration number . . . .
Year of manufacture . . . .
Pressure Vessel Code to which the tank is designed . . . .
Test pressure . . . . bars or kilopascals(kPa) gauge
MAWP . . . . bars or kilopascals(kPa) gauge
Water capacity at 20°C . . . . litres
Water capacity at 20°C of each compartment . . . . litres
Initial pressure test date and witness identification
Minimum design temperature . . . . °C
Shell material(s) and material standard reference(s) . . . .
Equivalent thickness in reference steel . . . . mm
Date and type of most recent periodic test(s) . . . .
Month. . . . . Year . . . . Test Pressure . . . . bars or kilopascals(kPa) gauge
Stamp of expert who performed or witnessed the most recent test . . . .
The names, in full, of the gases for whose transport the portable tank is approved . . . .
Either "thermally insulated" or "vacuum insulated" . . . .
Heat influx . . . . Watts (W)
Reference Holding Time . . . . days or hours and initial pressure . . . . bars or kilopascals gauge and degree of filling . . . . in kgs for each refrigerated liquefied gas being transported.

17.18.2 The following information should be durably marked either on the portable tank itself or on a metal plate firmly secured to the portable tank.

Name of the owner and the operator . . . .
Name of the refrigerated liquefied gas being transported (and minimum mean bulk temperature) . . . . .
Date of the last inspection . . . .
Maximum permissible gross mass . . . . kg
Unladen (tare) mass . . . . kg
Actual holding time for each gas authorized for transport . . . . days (or hours)

17.18.3 The contents should be identified as specified in Chapter 13.

17.18.4 Unless the name of the gas being transported appears on the metal plate described in 17.14.1, a copy of the certificate specified in 17.13.1 should be made available if requested by a competent authority and be provided readily by the consignor, consignee or agent, as appropriate.

17.19 **Transport requirements**

17.19.1 Portable tanks should not be offered for transport:

17.19.1.1 in an ullage condition liable to produce an unacceptable hydraulic force due to surge within the shell;

17.19.1.2 if leaking;

17.19.1.3 if damaged to such an extent that the integrity of the portable tank or its lifting or securing arrangements may be affected;

17.19.1.4 unless the service equipment has been examined and found to be in good working order;

17.19.1.5 unless the actual holding for the lading being transported has been determined in accordance with 17.3.8.3 and the portable tank is marked in accordance with 17.18.2; and

17.19.1.6 unless the duration of transport, after taking into consideration any delays which might be encountered, does not exceed the actual holding time.

17.19.2 Empty portable tanks not cleaned and not gas-free should comply with the same requirements as portable tanks filled with the previous refrigerated liquefied gas.

17.19.3 During transport, portable tanks should be adequately protected against lateral and longitudinal impact and against overturning. If the tanks and the service equipment are so constructed as to withstand impact or overturning they need not be protected in this way. Examples of such protection are given in 12.38.5.