

## Chapter 6.7

### Requirements for the design, construction, inspection and testing of portable tanks and UN multiple element gas containers (MEGCs)

**NOTE:** For tank-wagons, demountable tanks and tank-containers and tank swap bodies, with shells made of metallic materials, and battery-wagons and multiple element gas containers (MEGCs), other than UN MEGCs see Chapter 6.8; for fibre-reinforced plastics tank-containers, see Chapter 6.9; for vacuum-operated waste tanks, see Chapter 6.10.

#### 6.7.1 Application and general requirements

**6.7.1.1** The requirements of this Chapter apply to portable tanks intended for the carriage of dangerous goods, and to MEGCs intended for the carriage of non-refrigerated gases of Class 2, by all modes of carriage. In addition to the requirements of this Chapter, unless otherwise specified, the applicable requirements of the International Convention for Safe Containers (CSC) 1972, as amended, shall be fulfilled by any multimodal portable tank or MEGC which meets the definition of a "container" within the terms of that Convention. Additional requirements may apply to offshore portable tanks or MEGCs that are handled in open seas.

**6.7.1.2** In recognition of scientific and technological advances, the technical requirements of this Chapter may be varied by alternative arrangements. These alternative arrangements shall offer a level of safety not less than that given by the requirements of this Chapter with respect to the compatibility with substances carried and the ability of the portable tank or MEGC to withstand impact, loading and fire conditions. For international carriage, alternative arrangement portable tanks or MEGCs shall be approved by the applicable competent authorities.

**6.7.1.3** When a substance is not assigned a portable tank instruction (T1 to T23, T50 or T75) in Column (10) of Table A of in Chapter 3.2, interim approval for carriage may be issued by the competent authority of the country of origin. The approval shall be included in the documentation of the consignment and contain as a minimum the information normally provided in the portable tank instructions and the conditions under which the substance shall be carried.

#### 6.7.2 Requirements for the design, construction, inspection and testing of portable tanks intended for the carriage of substances of Class 1 and Classes 3 to 9

##### 6.7.2.1 Definitions

For the purposes of this section:

*Alternative arrangement* means an approval granted by the competent authority for a portable tank or MEGC that has been designed, constructed or tested to technical requirements or testing methods other than those specified in this Chapter:

*Design pressure* means the pressure to be used in calculations required by a recognized pressure vessel code. The design pressure shall be not less than the highest of the following pressures:

- (a) The maximum effective gauge pressure allowed in the shell during filling or discharge; or
- (b) The sum of:
  - (i) the absolute vapour pressure (in bar) of the substance at 65 °C, minus 1 bar;
  - (ii) 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 an increase in mean bulk temperature of  $t_r - t_f$  ( $t_f$  = filling temperature usually 15 °C;  $t_r$  = maximum mean bulk temperature, 50 °C); and
  - (iii) a head pressure determined on the basis of the static forces specified in 6.7.2.2.12, but not less than 0.35 bar; or
- (c) Two thirds of the minimum test pressure specified in the applicable portable tank instruction in 4.2.5.2.6;

*Design temperature range* for the shell shall be -40 °C to 50 °C for substances carried under ambient conditions. For the other substances handled under elevated temperature conditions the design temperature shall be not less than the maximum temperature of the substance during filling, discharge or carriage. More severe design temperatures shall be considered for portable tanks subjected to severe climatic conditions;

*Fine grain steel* means steel which has a ferritic grain size of 6 or finer when determined in accordance with ASTM E 112-96 or as defined in EN 10028-3, Part 3;

*Fusible element* means a non-reclosable pressure relief device that is thermally actuated;

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

*Maximum allowable working pressure (MAWP)* means a pressure that shall be not less than the highest of the following pressures measured at the top of the shell while in operating position:

- (a) The maximum effective gauge pressure allowed in the shell during filling or discharge; or
- (b) The maximum effective gauge pressure to which the shell is designed which shall be not less than the sum of:
  - (i) the absolute vapour pressure (in bar) of the substance at 65 °C, minus 1 bar; and
  - (ii) 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 an increase in mean bulk temperature of  $t_r - t_f$  ( $t_f$  = filling temperature, usually 15 °C;  $t_r$  = maximum mean bulk temperature, 50 °C);

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

*Mild steel* means a steel with a guaranteed minimum tensile strength of 360 N/mm<sup>2</sup> to 440 N/mm<sup>2</sup> and a guaranteed minimum elongation at fracture conforming to 6.7.2.3.3.3;

*Offshore portable tank* means a portable tank specially designed for repeated use for carriage to, from and between offshore facilities. An offshore portable tank is designed and constructed in accordance with the guidelines for the approval of containers handled in open seas specified by the International Maritime Organization in document MSC/Circ.860;

*Portable tank* means a multimodal tank used for the carriage of substances of Class 1 and Classes 3 to 9. The portable tank includes a shell fitted with service equipment and structural equipment necessary for the carriage of dangerous substances. The portable tank shall be capable of being filled and discharged without the removal of its structural equipment. It shall possess stabilizing members external to the shell, and shall be capable of being lifted when full. It shall be designed primarily to be loaded onto a transport vehicle or ship and shall be equipped with skids, mountings or accessories to facilitate mechanical handling. Tank-vehicles, tank-wagons, non-metallic tanks and intermediate bulk containers (IBCs) are not considered to fall within the definition for portable tanks;

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

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

*Shell* means the part of the portable tank which retains the substance intended for carriage (tank proper), including openings and their closures, but does not include service equipment or external structural equipment;

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

*Test pressure* means the maximum gauge pressure at the top of the shell during the hydraulic pressure test equal to not less than 1.5 times the design pressure. The minimum test pressure for portable tanks intended for specific substances is specified in the applicable portable tank instruction in 4.2.5.2.6.

## **6.7.2.2 General design and construction requirements**

- 6.7.2.2.1** Shells shall be designed and constructed in accordance with the requirements of a pressure vessel code recognized by the competent authority. Shells shall be made of metallic materials suitable for forming. The materials shall in principle conform to national or international material standards. For welded shells only a material whose weldability has been fully demonstrated shall be used. Welds shall be skilfully made and afford complete safety. When the manufacturing process or the materials make it necessary, the shells shall be suitably heat-treated to guarantee adequate toughness in the weld and in the heat affected zones. In choosing the material, the design temperature range shall be taken into account with respect to risk of brittle fracture, to stress corrosion cracking and to resistance to impact. When fine grain steel is used, the guaranteed value of the yield strength shall be not more than 460 N/mm<sup>2</sup> and the guaranteed value of the upper limit of the tensile strength shall be not more than 725 N/mm<sup>2</sup> according to the material specification. Aluminium may only be used as a construction material when indicated in a portable tank special provision assigned to a specific substance in Column (11) of Table A of Chapter 3.2 or when approved by the competent authority. When aluminium is authorized, it shall be insulated to prevent significant loss of physical properties when subjected to a heat load of 110 kW/m<sup>2</sup> for a period of not less than 30 minutes. The insulation shall remain effective at all temperatures less than 649 °C and shall be jacketed with a material with a melting point of not less than 700 °C. Portable tank materials shall be suitable for the external environment in which they may be carried.

- 6.7.2.2.2** Portable tank shells, fittings, and pipework shall be constructed from materials which are:
- (a) Substantially immune to attack by the substance(s) intended to be carried; or
  - (b) Properly passivated or neutralized by chemical reaction; or
  - (c) Lined with corrosion-resistant material directly bonded to the shell or attached by equivalent means.
- 6.7.2.2.3** Gaskets shall be made of materials not subject to attack by the substance(s) intended to be carried.
- 6.7.2.2.4** When shells are lined, the lining shall be substantially immune to attack by the substance(s) intended to be carried, homogeneous, non porous, free from perforations, sufficiently elastic and compatible with the thermal expansion characteristics of the shell. The lining of every shell, shell fittings and piping shall be continuous, and shall extend around the face of any flange. Where external fittings are welded to the tank, the lining shall be continuous through the fitting and around the face of external flanges.
- 6.7.2.2.5** Joints and seams in the lining shall be made by fusing the material together or by other equally effective means.
- 6.7.2.2.6** Contact between dissimilar metals which could result in damage by galvanic action shall be avoided.
- 6.7.2.2.7** The materials of the portable tank, including any devices, gaskets, linings and accessories, shall not adversely affect the substance(s) intended to be carried in the portable tank.
- 6.7.2.2.8** Portable tanks shall be designed and constructed with supports to provide a secure base during carriage and with suitable lifting and tie-down attachments.
- 6.7.2.2.9** Portable tanks shall be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads during normal conditions of handling and carriage. The design shall demonstrate that the effects of fatigue, caused by repeated application of these loads through the expected life of the portable tank, have been taken into account.
- 6.7.2.2.10** A shell which is to be equipped with a vacuum-relief device shall be designed to withstand, without permanent deformation, an external pressure of not less than 0.21 bar above the internal pressure. The vacuum-relief device shall be set to relieve at a vacuum setting not greater than minus (–)0.21 bar unless the shell is designed for a higher external over pressure, in which case the vacuum-relief pressure of the device to be fitted shall be not greater than the tank design vacuum pressure. A shell used for the carriage of solid substances (powdery or granular) of packing groups II or III only, which do not liquefy during carriage, may be designed for a lower external pressure, subject to the approval of the competent authority. In this case, the vacuum valve shall be set to relieve at this lower pressure. A shell that is not to be fitted with a vacuum-relief device shall be designed to withstand, without permanent deformation an external pressure of not less than 0.4 bar above the internal pressure.
- 6.7.2.2.11** Vacuum-relief devices used on portable tanks intended for the carriage of substances meeting the flash-point criteria of Class 3, including elevated temperature substances carried at or above their flash-point, shall prevent the immediate passage of flame into the shell, or the portable tank shall have a shell capable of withstanding, without leakage an internal explosion resulting from the passage of flame into the shell.
- 6.7.2.2.12** Portable tanks and their fastenings shall, under the maximum permissible load, be capable of absorbing the following separately applied static forces:
- (a) In the direction of travel: twice the MPGM multiplied by the acceleration due to gravity ( $g$ )<sup>1</sup>;
  - (b) Horizontally at right angles to the direction of travel: the MPGM (when the direction of travel is not clearly determined, the forces shall be equal to twice the MPGM) multiplied by the acceleration due to gravity ( $g$ )<sup>1</sup>;
  - (c) Vertically upwards: the MPGM multiplied by the acceleration due to gravity ( $g$ )<sup>1</sup>; and
  - (d) Vertically downwards: twice the MPGM (total loading including the effect of gravity) multiplied by the acceleration due to gravity ( $g$ )<sup>1</sup>.
- 6.7.2.2.13** Under each of the forces in 6.7.2.2.12, the safety factor to be observed shall be as follows:
- (a) For metals having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; or
  - (b) 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.

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<sup>1</sup> For calculation purposes  $g = 9.81 \text{ m/s}^2$ .

- 6.7.2.2.14 The values of yield strength or proof strength shall be the values according to national or international material standards. When austenitic steels are used, the specified minimum values of yield strength or proof strength according to the material standards may be increased by up to 15% when these greater values are attested in the material inspection certificate. When no material standard exists for the metal in question, the value of yield strength or proof strength used shall be approved by the competent authority.
- 6.7.2.2.15 Portable tanks shall be capable of being electrically earthed when intended for the carriage of substances meeting the flash-point criteria of Class 3 including elevated temperature substances carried at or above their flash-point. Measures shall be taken to prevent dangerous electrostatic discharge.
- 6.7.2.2.16 When required for certain substances by the applicable portable tank instruction indicated in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6 or by a portable tank special provision indicated in Column (11) of Table A of Chapter 3.2 and described in 4.2.5.3, portable tanks shall be provided with additional protection, which may take the form of additional shell thickness or a higher test pressure, the additional shell thickness or higher test pressure being determined in the light of the inherent risks associated with the carriage of the substances concerned.

### 6.7.2.3 Design criteria

- 6.7.2.3.1 Shells shall be of a design capable of being stress-analysed mathematically or experimentally by resistance strain gauges, or by other methods approved by the competent authority.
- 6.7.2.3.2 Shells shall be designed and constructed to withstand a hydraulic test pressure not less than 1.5 times the design pressure. Specific requirements are laid down for certain substances in the applicable portable tank instruction indicated in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6 or by a portable tank special provision indicated in Column (11) of Table A of Chapter 3.2 and described in 4.2.5.3. Attention is drawn to the minimum shell thickness requirements specified in 6.7.2.4.1 to 6.7.2.4.10.
- 6.7.2.3.3 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 primary membrane stress  $\sigma$  (sigma) in the shell shall not exceed 0.75 Re or 0.50 Rm, whichever is lower, at the test pressure, where:  
 Re = yield strength in N/mm<sup>2</sup>, or 0.2% proof strength or, for austenitic steels, 1% proof strength;  
 Rm = minimum tensile strength in N/mm<sup>2</sup>.
- 6.7.2.3.3.1 The values of Re and Rm to be used shall be the specified minimum values according to national or international material standards. 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% when greater values are attested in the material inspection certificate. When no material standard exists for the metal in question, the values of Re and Rm used shall be approved by the competent authority or its authorized body.
- 6.7.2.3.3.2 Steels which have a Re/Rm ratio of more than 0.85 are not allowed for the construction of welded shells. The values of Re and Rm to be used in determining this ratio shall be the values specified in the material inspection certificate.
- 6.7.2.3.3.3 Steels used in the construction of shells shall have an elongation at fracture, in %, of not less than 10 000/Rm with an absolute minimum of 16% for fine grain steels and 20% for other steels. Aluminium and aluminium alloys used in the construction of shells shall have an elongation at fracture, in %, of not less than 10 000/6Rm with an absolute minimum of 12%.
- 6.7.2.3.3.4 For the purpose of determining actual values for materials, it shall be noted that for sheet metal, the axis of the tensile test specimen shall be at right angles (transversely) to the direction of rolling. The permanent elongation at fracture shall be measured on test specimens of rectangular cross sections in accordance with ISO 6892:1998 using a 50 mm gauge length.

### 6.7.2.4 Minimum shell thickness

- 6.7.2.4.1 The minimum shell thickness shall be the greater thickness based on:
  - (a) The minimum thickness determined in accordance with the requirements of 6.7.2.4.2 to 6.7.2.4.10;
  - (b) The minimum thickness determined in accordance with the recognized pressure vessel code including the requirements in 6.7.2.3; and
  - (c) The minimum thickness specified in the applicable portable tank instruction indicated in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6 or by a portable tank special provision indicated in Column (11) of Table A of Chapter 3.2 and described in 4.2.5.3.

**6.7.2.4.2** The cylindrical portions, ends (heads) and manhole covers of shells not more than 1.80 m in diameter shall be not less than 5 mm thick in the reference steel or of equivalent thickness in the metal to be used. Shells more than 1.80 m in diameter shall be not less than 6 mm thick in the reference steel or of equivalent thickness in the metal to be used, except that for powdered or granular solid substances of packing group II or III the minimum thickness requirement may be reduced to not less than 5 mm thick in the reference steel or of equivalent thickness in the metal to be used.

**6.7.2.4.3** When additional protection against shell damage is provided, portable tanks with test pressures less than 2.65 bar may have the minimum shell thickness reduced, in proportion to the protection provided, as approved by the competent authority. However, shells not more than 1.80 m in diameter shall be not less than 3 mm thick in the reference steel or of equivalent thickness in the metal to be used. Shells more than 1.80 m in diameter shall be not less than 4 mm thick in the reference steel or of equivalent thickness in the metal to be used.

**6.7.2.4.4** The cylindrical portions, ends (heads) and manhole covers of all shells shall be not less than 3 mm thick regardless of the material of construction.

**6.7.2.4.5** The additional protection referred to in 6.7.2.4.3 may be provided by overall external structural protection, such as suitable "sandwich" construction with the outer sheathing (jacket) secured to the shell, double wall construction or by enclosing the shell in a complete framework with longitudinal and transverse structural members.

**6.7.2.4.6** The equivalent thickness of a metal other than the thickness prescribed for the reference steel in 6.7.2.4.2 shall be determined using the following formula:

$$e_1 = \frac{21.4 e_0}{\sqrt[3]{Rm_1 A_1}}$$

where:

$e_1$  = required equivalent thickness (in mm) of the metal to be used;

$e_0$  = minimum thickness (in mm) of the reference steel specified in the applicable portable tank instruction indicated in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6 or by a portable tank special provision indicated in Column (11) of Table A of Chapter 3.2 and described in 4.2.5.3;

$Rm_1$  = guaranteed minimum tensile strength (in N/mm<sup>2</sup>) of the metal to be used (see 6.7.2.3.3);

$A_1$  = guaranteed minimum elongation at fracture (in %) of the metal to be used according to national or international standards.

**6.7.2.4.7** When in the applicable portable tank instruction in 4.2.5.2.6, a minimum thickness of 8 mm or 10 mm is specified, it shall be noted that these thicknesses are based on the properties of the reference steel and a shell diameter of 1.80 m. When a metal other than mild steel (see 6.7.2.1) is used or the shell has a diameter of more than 1.80 m, the thickness shall be determined using the following formula:

$$e_1 = \frac{21.4 e_0 d_1}{1.8 \sqrt[3]{Rm_1 A_1}}$$

where:

$e_1$  = required equivalent thickness (in mm) of the metal to be used;

$e_0$  = minimum thickness (in mm) of the reference steel specified in the applicable portable tank instruction indicated in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6 or by a portable tank special provision indicated in Column (11) of Table A of Chapter 3.2 and described in 4.2.5.3;

$d_1$  = diameter of the shell (in m), but not less than 1.80 m;

$Rm_1$  = guaranteed minimum tensile strength (in N/mm<sup>2</sup>) of the metal to be used (see 6.7.2.3.3);

$A_1$  = guaranteed minimum elongation at fracture (in %) of the metal to be used according to national or international standards.

**6.7.2.4.8** In no case shall the wall thickness be less than that prescribed in 6.7.2.4.2, 6.7.2.4.3 and 6.7.2.4.4. All parts of the shell shall have a minimum thickness as determined by 6.7.2.4.2 to 6.7.2.4.4. This thickness shall be exclusive of any corrosion allowance.

**6.7.2.4.9** When mild steel is used (see 6.7.2.1), calculation using the formula in 6.7.2.4.6 is not required.

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

### **6.7.2.5 Service equipment**

- 6.7.2.5.1** Service equipment shall be so arranged as to be protected against the risk of being wrenched off or damaged during handling and carriage. When the connection between the frame and the shell allows relative movement between the sub-assemblies, the equipment shall 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 shall 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 any protective caps shall be capable of being secured against unintended opening.
- 6.7.2.5.2** All openings in the shell, intended for filling or discharging the portable tank shall be fitted with a manually operated stop-valve located as close to the shell as reasonably practicable. Other openings, except for openings leading to venting or pressure-relief devices, shall be equipped with either a stop-valve or another suitable means of closure located as close to the shell as reasonably practicable.
- 6.7.2.5.3** All portable tanks shall 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 shall have a manhole or other inspection openings for each compartment.
- 6.7.2.5.4** As far as reasonably practicable, external fittings shall be grouped together. For insulated portable tanks, top fittings shall be surrounded by a spill collection reservoir with suitable drains.
- 6.7.2.5.5** Each connection to a portable tank shall be clearly marked to indicate its function.
- 6.7.2.5.6** Each stop-valve or other means of closure shall be designed and constructed to a rated pressure not less than the MAWP of the shell taking into account the temperatures expected during carriage. All stop-valves with screwed spindles shall close by a clockwise motion of the handwheel. For other stop-valves the position (open and closed) and direction of closure shall be clearly indicated. All stop-valves shall be designed to prevent unintentional opening.
- 6.7.2.5.7** No moving parts, such as covers, components of closures, etc., shall be made of unprotected corrodible steel when they are liable to come into frictional or percussive contact with aluminium portable tanks intended for the carriage of substances meeting the flash-point criteria of Class 3 including elevated temperature substances carried at or above their flash-point.
- 6.7.2.5.8** Piping shall be designed, constructed and installed so as to avoid the risk of damage due to thermal expansion and contraction, mechanical shock and vibration. All piping shall be of a suitable metallic material. Welded pipe joints shall be used wherever possible.
- 6.7.2.5.9** Joints in copper tubing shall be brazed or have an equally strong metal union. The melting point of brazing materials shall be no lower than 525 °C. The joints shall not decrease the strength of the tubing as may happen when cutting threads.
- 6.7.2.5.10** The burst pressure of all piping and pipe fittings shall be not less than the highest of four times the MAWP of the shell or four times the pressure to which it may be subjected in service by the action of a pump or other device (except pressure-relief devices).
- 6.7.2.5.11** Ductile metals shall be used in the construction of valves and accessories.

### **6.7.2.6 Bottom openings**

- 6.7.2.6.1** Certain substances shall not be carried in portable tanks with bottom openings. When the applicable portable tank instruction identified in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6 indicates that bottom openings are prohibited there shall be no openings below the liquid level of the shell when it is filled to its maximum permissible filling limit. When an existing opening is closed it shall be accomplished by internally and externally welding one plate to the shell.
- 6.7.2.6.2** Bottom discharge outlets for portable tanks carrying certain solid, crystallizable or highly viscous substances shall be equipped with not less than two serially fitted and mutually independent shut-off devices. The design of the equipment shall be to the satisfaction of the competent authority or its authorized body and shall include:
- (a) An external stop-valve fitted as close to the shell as reasonably practicable; and
  - (b) A liquid tight closure at the end of the discharge pipe, which may be a bolted blank flange or a screw cap.
- 6.7.2.6.3** Every bottom discharge outlet, except as provided in 6.7.2.6.2, shall be equipped with three serially fitted and mutually independent shut-off devices. The design of the equipment shall be to the satisfaction of the competent authority or its authorized body and include:
- (a) 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:

- (i) The control devices for the operation of the valve are designed so as to prevent any unintended opening through impact or other inadvertent act;
  - (ii) The valve may be operable from above or below;
  - (iii) If possible, the setting of the valve (open or closed) shall be capable of being verified from the ground;
  - (iv) Except for portable tanks having a capacity of not more than 1 000 litres, it shall be possible to close the valve from an accessible position of the portable tank that is remote from the valve itself; and
  - (v) The valve shall continue to be effective in the event of damage to the external device for controlling the operation of the valve;
- (b) An external stop-valve fitted as close to the shell as reasonably practicable; and
- (c) A liquid tight closure at the end of the discharge pipe, which may be a bolted blank flange or a screw cap.

**6.7.2.6.4** For a lined shell, the internal stop-valve required by 6.7.2.6.3 (a) may be replaced by an additional external stop-valve. The manufacturer shall satisfy the requirements of the competent authority or its authorized body.

**6.7.2.7 Safety-relief devices**

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

**6.7.2.8 Pressure-relief devices**

**6.7.2.8.1** Every portable tank with a capacity not less than 1 900 litres and every independent compartment of a portable tank with a similar capacity, shall 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 6.7.2.8.3 in the applicable portable tank instruction in 4.2.5.2.6. The pressure-relief devices shall have sufficient capacity to prevent rupture of the shell due to over pressurization or vacuum resulting from filling, discharging, or from heating of the contents.

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

**6.7.2.8.3** When required for certain substances by the applicable portable tank instruction indicated in Column (10) of Table A of Chapter 3.2 and described in 4.2.5.2.6, portable tanks shall have a pressure-relief device approved by the competent authority. Unless a portable tank in dedicated service is fitted with an approved relief device constructed of materials compatible with the substance carried, the relief device shall comprise a frangible disc preceding a spring-loaded pressure-relief device. When a frangible disc is inserted in series with the required pressure-relief device, the space between the frangible disc and the pressure-relief device shall be provided with a pressure gauge or suitable tell-tale indicator for the detection of disc rupture, pinholing, or leakage which could cause a malfunction of the pressure-relief system. The frangible disc shall rupture at a nominal pressure 10% above the start to discharge pressure of the relief device.

**6.7.2.8.4** Every portable tank with a capacity less than 1 900 litres shall be fitted with a pressure-relief device which may be a frangible disc when this disc complies with the requirements of 6.7.2.11.1. When no spring-loaded pressure-relief device is used, the frangible disc shall be set to rupture at a nominal pressure equal to the test pressure.

**6.7.2.8.5** When the shell is fitted for pressure discharge, the inlet line shall be provided with a suitable pressure-relief device set to operate at a pressure not higher than the MAWP of the shell, and a stop-valve shall be fitted as close to the shell as reasonably practicable.

**6.7.2.9 Setting of pressure-relief devices**

**6.7.2.9.1** It shall be noted that the pressure-relief devices shall operate only in conditions of excessive rise in temperature, since the shell shall not be subject to undue fluctuations of pressure during normal conditions of carriage (see 6.7.2.12.2).

**6.7.2.9.2** The required pressure-relief device shall be set to start-to-discharge at a nominal pressure of five-sixths of the test pressure for shells having a test pressure of not more than 4.5 bar and 110% of two-thirds of the test pressure for shells having a test pressure of more than 4.5 bar. After discharge the device shall close at a pressure not more than 10% below the pressure at which the discharge starts. The device shall remain closed at all lower pressures. This requirement does not prevent the use of vacuum-relief or combination pressure-relief and vacuum-relief devices.

### 6.7.2.10 Fusible elements

6.7.2.10.1 Fusible elements shall operate at a temperature between 110 °C and 149 °C on condition that the pressure in the shell at the fusing temperature will be not more than the test pressure. They shall be placed at the top of the shell with their inlets in the vapour space and in no case shall they be shielded from external heat. Fusible elements shall not be utilized on portable tanks with a test pressure which exceeds 2.65 bar. Fusible elements used on portable tanks intended for the carriage of elevated temperature substances shall be designed to operate at a temperature higher than the maximum temperature that will be experienced during carriage and shall be to the satisfaction of the competent authority or its authorized body.

### 6.7.2.11 Frangible discs

6.7.2.11.1 Except as specified in 6.7.2.8.3, frangible discs shall be set to rupture at a nominal pressure equal to the test pressure throughout the design temperature range. Particular attention shall be given to the requirements of 6.7.2.5.1 and 6.7.2.8.3 if frangible discs are used.

6.7.2.11.2 Frangible discs shall be appropriate for the vacuum pressures which may be produced in the portable tank.

### 6.7.2.12 Capacity of pressure-relief devices

6.7.2.12.1 The spring-loaded pressure-relief device required by 6.7.2.8.1 shall have a minimum cross sectional flow area equivalent to an orifice of 31.75 mm diameter. Vacuum-relief devices, when used, shall have a cross sectional flow area not less than 284 mm<sup>2</sup>.

6.7.2.12.2 The combined delivery capacity of the pressure relief system (taking into account the reduction of the flow when the portable tank is fitted with frangible-discs preceding spring-loaded pressure-relief devices or when the spring-loaded pressure-relief devices are provided with a device to prevent the passage of the flame), in condition of complete fire engulfment of the portable tank shall be sufficient to limit the pressure in the shell to 20% above the start-to-discharge pressure of the pressure limiting device. Emergency pressure-relief devices may be used to achieve the full relief capacity prescribed. These devices may be fusible, spring loaded or frangible disc components, or a combination of spring-loaded and frangible disc devices. The total required capacity of the relief devices may be determined using the formula in 6.7.2.12.2.1 or the table in 6.7.2.12.2.3.

6.7.2.12.2.1 To determine the total required capacity of the relief devices, which shall be regarded as being the sum of the individual capacities of all the contributing devices, the following formula shall 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 second (m<sup>3</sup>/s) 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<sup>-2</sup>·K<sup>-1</sup>, at 38 °C;

t = actual temperature of the substance during filling (in °C);

when 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 accordance with 6.7.2.12.2.4;

A = total external surface area of shell in m<sup>2</sup>;

Z = the gas compressibility factor in the accumulating condition (when this factor is unknown, let Z = 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 is derived from one of the following formulae as a function of the ratio k of specific heats:

$$k = \frac{c_p}{c_v}$$



- 6.7.2.12.2.4** Insulation systems, used for the purpose of reducing venting capacity, shall be approved by the competent authority or its authorized body. In all cases, insulation systems approved for this purpose shall:
- (a) Remain effective at all temperatures up to 649 °C; and
  - (b) Be jacketed with a material having a melting point of 700 °C or greater.
- 6.7.2.13 Marking of pressure-relief devices**
- 6.7.2.13.1** Every pressure-relief device shall be clearly and permanently marked with the following particulars:
- (a) The pressure (in bar or kPa) or temperature (in °C) at which it is set to discharge;
  - (b) The allowable tolerance at the discharge pressure for spring-loaded devices;
  - (c) The reference temperature corresponding to the rated pressure for frangible discs;
  - (d) The allowable temperature tolerance for fusible elements; and
  - (e) The rated flow capacity of the spring-loaded pressure relief devices, frangible discs or fusible elements in standard cubic metres of air per second (m<sup>3</sup>/s);
- When practicable, the following information shall also be shown:
- (f) The manufacturer's name and relevant catalogue number of the device.
- 6.7.2.13.2** The rated flow capacity marked on the spring-loaded pressure-relief devices shall be determined according to ISO 4126-1:1991.
- 6.7.2.14 Connections to pressure-relief devices**
- 6.7.2.14.1** Connections to pressure-relief devices shall be of sufficient size to enable the required discharge to pass unrestricted to the safety device. No stop-valve shall 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 shall 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 or pipes from the pressure-relief device outlets, when used, shall deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving devices.
- 6.7.2.15 Siting of pressure-relief devices**
- 6.7.2.15.1** Each pressure-relief device inlet shall 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 shall under maximum filling conditions be situated in the vapour space of the shell and the devices shall be so arranged as to ensure the escaping vapour is discharged unrestrictedly. For flammable substances, the escaping vapour shall 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.
- 6.7.2.15.2** Arrangements shall 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.
- 6.7.2.16 Gauging devices**
- 6.7.2.16.1** Glass level-gauges and gauges made of other fragile material, which are in direct communication with the contents of the tank shall not be used.
- 6.7.2.17 Portable tank supports, frameworks, lifting and tie-down attachments**
- 6.7.2.17.1** Portable tanks shall be designed and constructed with a support structure to provide a secure base during carriage. The forces specified in 6.7.2.2.12 and the safety factor specified in 6.7.2.2.13 shall be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.
- 6.7.2.17.2** The combined stresses caused by portable tank mountings (e.g. cradles, framework, etc.) and portable tank lifting and tie-down attachments shall not cause excessive stress in any portion of the shell. Permanent lifting and tie-down attachments shall be fitted to all portable tanks. Preferably they shall be fitted to the portable tank supports but may be secured to reinforcing plates located on the shell at the points of support.
- 6.7.2.17.3** In the design of supports and frameworks the effects of environmental corrosion shall be taken into account.
- 6.7.2.17.4** Forklift pockets shall be capable of being closed off. The means of closing forklift pockets shall 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:
- (a) The shell including all the fittings are well protected from being hit by the forklift blades; and

- (b) The distance between the centres of the forklift pockets is at least half of the maximum length of the portable tank.

**6.7.2.17.5** When portable tanks are not protected during carriage, according to 4.2.1.2, the shells and service equipment shall be protected against damage to the shell and service equipment resulting from lateral or longitudinal impact or overturning. External fittings shall be protected so as to preclude the release of the shell contents upon impact or overturning of the portable tank on its fittings. Examples of protection include:

- (a) Protection against lateral impact which may consist of longitudinal bars protecting the shell on both sides at the level of the median line;
- (b) Protection of the portable tank against overturning which may consist of reinforcement rings or bars fixed across the frame;
- (c) Protection against rear impact which may consist of a bumper or frame;
- (d) Protection of the shell against damage from impact or overturning by use of an ISO frame in accordance with ISO 1496-3:1995.

#### **6.7.2.18 Design approval**

**6.7.2.18.1** The competent authority or its authorized body shall issue a design approval certificate for any new design of a portable tank. This certificate shall attest that a portable tank has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this Chapter and where appropriate, the provisions for substances provided in Chapter 4.2 and in Table A of Chapter 3.2. When a series of portable tanks are manufactured without change in the design, the certificate shall be valid for the entire series. The certificate shall refer to the prototype test report, the substances or group of substances allowed to be carried, the materials of construction of the shell and lining (when applicable) and an approval number. The approval number shall 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. Any alternative arrangements according to 6.7.1.2 shall 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.

**6.7.2.18.2** The prototype test report for the design approval shall include at least the following:

- (a) The results of the applicable framework test specified in ISO 1496-3:1995;
- (b) The results of the initial inspection and test according to 6.7.2.19.3; and
- (c) The results of the impact test in 6.7.2.19.1, when applicable.

#### **6.7.2.19 Inspection and testing**

**6.7.2.19.1** Portable tanks meeting the definition of container in the International Convention for Safe Containers (CSC), 1972, as amended, shall not be used unless they are successfully qualified by subjecting a representative prototype of each design to the Dynamic, Longitudinal Impact Test prescribed in the Manual of Tests and Criteria, Part IV, Section 41.

**6.7.2.19.2** The shell and items of equipment of each portable tank shall 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. The 2.5 year inspection and test may be performed within 3 months of the specified date. An exceptional inspection and test shall be performed regardless of the date of the last periodic inspection and test when necessary according to 6.7.2.19.7.

**6.7.2.19.3** The initial inspection and test of a portable tank shall 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 carried, and a pressure test. Before the portable tank is placed into service, a leakproofness test and a check of the satisfactory operation of all service equipment shall also be performed. When the shell and its fittings have been pressure-tested separately, they shall be subjected together after assembly to a leakproofness test.

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

**6.7.2.19.5** The intermediate 2.5 year periodic inspection and test shall at least include an internal and external examination of the portable tank and its fittings with due regard to the substances intended to be carried, a leakproofness test and a check of the satisfactory operation of all service equipment. Sheathing, thermal insulation and the like shall be removed only to the extent required for reliable appraisal of the condition of the portable tank. For portable tanks intended for the carriage of a single substance, the 2.5 year internal ex-

amination may be waived or substituted by other test methods or inspection procedures specified by the competent authority or its authorized body.

**6.7.2.19.6** A portable tank may not be filled and offered for carriage after the date of expiry of the last 5 year or 2.5 year periodic inspection and test as required by 6.7.2.19.2. However, a portable tank filled prior to the date of expiry of the last periodic inspection and test may be carried for a period not to exceed three months beyond the date of expiry of the last periodic test or inspection. In addition, a portable tank may be carried after the date of expiry of the last periodic test and inspection:

- (a) After emptying but before cleaning, for purposes of performing the next required test or inspection prior to refilling; and
- (b) Unless otherwise approved by the competent authority, for a period not to exceed six months beyond the date of expiry of the last periodic test or inspection, in order to allow the return of dangerous goods for proper disposal or recycling. Reference to this exemption shall be mentioned in the **transport document**.

**6.7.2.19.7** 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 shall depend on the amount of damage or deterioration of the portable tank. It shall include at least the 2.5 year inspection and test according to 6.7.2.19.5.

**6.7.2.19.8** The internal and external examinations shall ensure that:

- (a) 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 carriage;
- (b) The piping, valves, heating/cooling system, and gaskets are inspected for corroded areas, defects, or any other conditions, including leakage, that might render the portable tank unsafe for filling, discharge or carriage;
- (c) Devices for tightening manhole covers are operative and there is no leakage at manhole covers or gaskets;
- (d) Missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;
- (e) 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 shall be operated to demonstrate proper operation;
- (f) Linings, if any, are inspected in accordance with criteria outlined by the lining manufacturer;
- (g) Required markings on the portable tank are legible and in accordance with the applicable requirements; and
- (h) The framework, supports and arrangements for lifting the portable tank are in a satisfactory condition.

**6.7.2.19.9** The inspections and tests in 6.7.2.19.1, 6.7.2.19.3, 6.7.2.19.4, 6.7.2.19.5 and 6.7.2.19.7 shall be performed or witnessed by an expert approved by the competent authority or its authorized body. When the pressure test is a part of the inspection and test, the test pressure shall be the one indicated on the data plate of the portable tank. While under pressure, the portable tank shall be inspected for any leaks in the shell, piping or equipment.

**6.7.2.19.10** In all cases when cutting, burning or welding operations on the shell have been effected, that work shall 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 shall be performed after the work is completed.

**6.7.2.19.11** When evidence of any unsafe condition is discovered, the portable tank shall not be returned to service until it has been corrected and the test is repeated and passed.

#### **6.7.2.20 Marking**

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

Country of manufacture

U	Approval	Approval	For Alternative Arrangements (see 6.7.1.2)
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 \_\_\_\_\_ bar/kPa gauge<sup>2</sup>

MAWP \_\_\_\_\_ bar/kPa gauge<sup>2</sup>

External design pressure<sup>3</sup> \_\_\_\_\_ bar/kPa gauge<sup>2</sup>

Design temperature range \_\_\_\_\_ °C to \_\_\_\_\_ °C

Water capacity at 20 °C \_\_\_\_\_ litres

Water capacity of each compartment at 20 °C \_\_\_\_\_ litres

Initial pressure test date and witness identification

MAWP for heating/cooling system \_\_\_\_\_ bar/kPa gauge<sup>2</sup>

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

Equivalent thickness in reference steel \_\_\_\_\_ mm

Lining material (when applicable)

Date and type of most recent periodic test(s)

Month \_\_\_\_\_ Year \_\_\_\_\_ Test pressure \_\_\_\_\_ bar/kPa gauge<sup>2</sup>

Stamp of expert who performed or witnessed the most recent test

**6.7.2.20.2** The following particulars shall 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 carried and maximum mean bulk temperature when higher than 50 °C

Maximum permissible gross mass (MPGM) \_\_\_\_\_ kg

Unladen (tare) mass \_\_\_\_\_ kg

**NOTE:** For the identification of the substances being carried, see also Part 5.

**6.7.2.20.3** If a portable tank is designed and approved for handling in open seas, the words "OFFSHORE PORTABLE TANK" shall be marked on the identification plate.

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<sup>2</sup> The unit used shall be marked.

<sup>3</sup> See 6.7.2.2.10.

## 6.7.3 Requirements for the design, construction, inspection and testing of portable tanks intended for the carriage of non-refrigerated liquefied gases

### 6.7.3.1 Definitions

For the purposes of this section:

*Alternative arrangement* means an approval granted by the competent authority for a portable tank or MEGC that has been designed, constructed or tested to technical requirements or testing methods other than those specified in this Chapter;

*Design pressure* means the pressure to be used in calculations required by a recognized pressure vessel code. The design pressure shall be not less than the highest of the following pressures:

- (a) The maximum effective gauge pressure allowed in the shell during filling or discharge; or
- (b) The sum of:
  - (i) the maximum effective gauge pressure to which the shell is designed as defined in (b) of the MAWP definition (see above); and
  - (ii) a head pressure determined on the basis of the static forces specified in 6.7.3.2.9, but not less than 0.35 bar;

*Design reference temperature* means the temperature at which the vapour pressure of the contents is determined for the purpose of calculating the MAWP. The design reference temperature shall be less than the critical temperature of the non-refrigerated liquefied gas intended to be carried to ensure that the gas at all times is liquefied. This value for each portable tank type is as follows:

- (a) Shell with a diameter of 1.5 metres or less: 65 °C;
- (b) Shell with a diameter of more than 1.5 metres:
  - (i) without insulation or sun shield: 60 °C;
  - (ii) with sun shield (see 6.7.3.2.12): 55 °C; and
  - (iii) with insulation (see 6.7.3.2.12) : 50 °C;

*Design temperature range* for the shell shall be –40 °C to 50 °C for non-refrigerated liquefied gases carried under ambient conditions. More severe design temperatures shall be considered for portable tanks subjected to severe climatic conditions;

*Filling density* means the average mass of non-refrigerated liquefied gas per litre of shell capacity (kg/l). The filling density is given in portable tank instruction T50 in 4.2.5.2.6;

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

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

- (a) The maximum effective gauge pressure allowed in the shell during filling or discharge; or
- (b) The maximum effective gauge pressure to which the shell is designed, which shall be:
  - (i) for a non-refrigerated liquefied gas listed in the portable tank instruction T50 in 4.2.5.2.6, the MAWP (in bar) given in T50 portable tank instruction for that gas;
  - (ii) for other non-refrigerated liquefied gases, not less than the sum of:
    - the absolute vapour pressure (in bar) of the non-refrigerated liquefied gas at the design reference temperature minus 1 bar; and
    - 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 an increase of the mean bulk temperature of  $t_r - t_f$  ( $t_f$  = filling temperature, usually 15 °C,  $t_r$  = maximum mean bulk temperature, 50 °C);

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

*Mild steel* means a steel with a guaranteed minimum tensile strength of 360 N/mm<sup>2</sup> to 440 N/mm<sup>2</sup> and a guaranteed minimum elongation at fracture conforming to 6.7.3.3.3.3;

*Portable tank* means a multimodal tank having a capacity of more than 450 litres used for the carriage of non-refrigerated liquefied gases of Class 2. The portable tank includes a shell fitted with service equipment and structural equipment necessary for the carriage of gases. The portable tank shall be capable of being filled and discharged without the removal of its structural equipment. It shall possess stabilizing members external to the shell, and shall be capable of being lifted when full. It shall be designed primarily to be

loaded onto a transport vehicle or ship and shall be equipped with skids, mountings or accessories to facilitate mechanical handling. Tank-vehicles, 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;

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

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

*Shell* means the part of the portable tank which retains the non-refrigerated liquefied gas intended for carriage (tank proper), including openings and their closures, but does not include service equipment or external structural equipment;

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

*Test pressure* means the maximum gauge pressure at the top of the shell during the pressure test.

### **6.7.3.2 General design and construction requirements**

**6.7.3.2.1** Shells shall be designed and constructed in accordance with the requirements of a pressure vessel code recognized by the competent authority. Shells shall be made of steel suitable for forming. The materials shall in principle conform to national or international material standards. For welded shells, only a material whose weldability has been fully demonstrated shall be used. Welds shall be skilfully made and afford complete safety. When the manufacturing process or the materials make it necessary, the shells shall 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 shall be taken into account with respect to risk of brittle fracture, to stress corrosion cracking and to resistance to impact. When fine grain steel is used, the guaranteed value of the yield strength shall be not more than 460 N/mm<sup>2</sup> and the guaranteed value of the upper limit of the tensile strength shall be not more than 725 N/mm<sup>2</sup> according to the material specification. Portable tank materials shall be suitable for the external environment in which they may be carried.

**6.7.3.2.2** Portable tank shells, fittings and pipework shall be constructed of materials which are:

- (a) Substantially immune to attack by the non-refrigerated liquefied gas(es) intended to be carried; or
- (b) Properly passivated or neutralized by chemical reaction.

**6.7.3.2.3** Gaskets shall be made of materials compatible with the non-refrigerated liquefied gas(es) intended to be carried.

**6.7.3.2.4** Contact between dissimilar metals which could result in damage by galvanic action shall be avoided.

**6.7.3.2.5** The materials of the portable tank, including any devices, gaskets, and accessories, shall not adversely affect the non-refrigerated liquefied gas(es) intended for carriage in the portable tank.

**6.7.3.2.6** Portable tanks shall be designed and constructed with supports to provide a secure base during carriage and with suitable lifting and tie-down attachments.

**6.7.3.2.7** Portable tanks shall be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads during normal conditions of handling and carriage. The design shall demonstrate that the effects of fatigue, caused by repeated application of these loads through the expected life of the portable tank, have been taken into account.

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

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

- (a) In the direction of travel: twice the MPGM multiplied by the acceleration due to gravity ( $g$ )<sup>4</sup>;
- (b) Horizontally at right angles to the direction of travel: the MPGM (when the direction of travel is not clearly determined, the forces shall be equal to twice the MPGM) multiplied by the acceleration due to gravity ( $g$ )<sup>4</sup>;
- (c) Vertically upwards: the MPGM multiplied by the acceleration due to gravity ( $g$ )<sup>4</sup>; and
- (d) Vertically downwards: twice the MPGM (total loading including the effect of gravity) multiplied by the acceleration due to gravity ( $g$ )<sup>4</sup>.

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<sup>4</sup> For calculation purposes  $g = 9.81 \text{ m/s}^2$ .

- 6.7.3.2.10** Under each of the forces in 6.7.3.2.9, the safety factor to be observed shall be as follows:
- (a) For steels having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; or
  - (b) 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.
- 6.7.3.2.11** The values of yield strength or proof strength shall be the values according to national or international material standards. When austenitic steels are used, the specified minimum values of yield strength and proof strength according to the material standards may be increased by up to 15% when these greater values are attested in the material inspection certificate. When no material standard exists for the steel in question, the value of yield strength or proof strength used shall be approved by the competent authority.
- 6.7.3.2.12** When the shells intended for the carriage of non-refrigerated liquefied gases are equipped with thermal insulation, the thermal insulation systems shall satisfy the following requirements:
- (a) It shall consist of a shield covering not less than the upper third but not more than the upper half of the surface of the shell and separated from the shell by an air space about 40 mm across;
  - (b) It shall consist of a complete cladding of adequate thickness of insulating materials protected so as to prevent the ingress of moisture and damage under normal conditions of carriage and so as to provide a thermal conductance of not more than  $0.67 \text{ (W}\cdot\text{m}^{-2}\cdot\text{K}^{-1}\text{)}$ ;
  - (c) When the protective covering is so closed as to be gas-tight, a device shall 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; and
  - (d) The thermal insulation shall not inhibit access to the fittings and discharge devices.
- 6.7.3.2.13** Portable tanks intended for the carriage of flammable non-refrigerated liquefied gases shall be capable of being electrically earthed.
- 6.7.3.3 Design criteria**
- 6.7.3.3.1** Shells shall be of a circular cross-section.
- 6.7.3.3.2** Shells shall be designed and constructed to withstand a test pressure not less than 1.3 times the design pressure. The shell design shall take into account the minimum MAWP values provided in portable tank instruction T50 in 4.2.5.2.6 for each non-refrigerated liquefied gas intended for carriage. Attention is drawn to the minimum shell thickness requirements for these shells specified in 6.7.3.4.
- 6.7.3.3.3** 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 primary membrane stress  $\sigma$  (sigma) in the shell shall not exceed  $0.75 R_e$  or  $0.50 R_m$ , whichever is lower, at the test pressure, where:
- $R_e$  = yield strength in  $\text{N}/\text{mm}^2$ , or 0.2% proof strength or, for austenitic steels, 1% proof stress;
- $R_m$  = minimum tensile strength in  $\text{N}/\text{mm}^2$ .
- 6.7.3.3.3.1** The values of  $R_e$  and  $R_m$  to be used shall be the specified minimum values according to national or international material standards. When austenitic steels are used, the specified minimum values for  $R_e$  and  $R_m$  according to the material standards may be increased by up to 15% when these greater values are attested in the material inspection certificate. When no material standard exists for the steel in question, the values of  $R_e$  and  $R_m$  used shall be approved by the competent authority or its authorized body.
- 6.7.3.3.3.2** Steels which have a  $R_e/R_m$  ratio of more than 0.85 are not allowed for the construction of welded shells. The values of  $R_e$  and  $R_m$  to be used in determining this ratio shall be the values specified in the material inspection certificate.
- 6.7.3.3.3.3** Steels used in the construction of shells shall have an elongation at fracture, in %, of not less than  $10\,000/R_m$  with an absolute minimum of 16% for fine grain steels and 20% for other steels.
- 6.7.3.3.3.4** For the purpose of determining actual values for materials, it shall be noted that for sheet metal, the axis of the tensile test specimen shall be at right angles (transversely) to the direction of rolling. The permanent elongation at fracture shall be measured on test specimens of rectangular cross sections in accordance with ISO 6892:1998 using a 50 mm gauge length.
- 6.7.3.4 Minimum shell thickness**
- 6.7.3.4.1** The minimum shell thickness shall be the greater thickness based on:
- (a) The minimum thickness determined in accordance with the requirements in 6.7.3.4; and
  - (b) The minimum thickness determined in accordance with the recognized pressure vessel code including the requirements in 6.7.3.3.

- 6.7.3.4.2** The cylindrical portions, ends (heads) and manhole covers of shells of not more than 1.80 m in diameter shall be not less than 5 mm thick in the reference steel or of equivalent thickness in the steel to be used. Shells of more than 1.80 m in diameter shall be not less than 6 mm thick in the reference steel or of equivalent thickness in the steel to be used.
- 6.7.3.4.3** The cylindrical portions, ends (heads) and manhole covers of all shells shall be not less than 4 mm thick regardless of the material of construction.
- 6.7.3.4.4** The equivalent thickness of a steel other than the thickness prescribed for the reference steel in 6.7.3.4.2 shall be determined using the following formula:

$$e_1 = \frac{21.4 e_0}{\sqrt[3]{Rm_1 A_1}}$$

where:

- $e_1$  = required equivalent thickness (in mm) of the steel to be used;  
 $e_0$  = minimum thickness (in mm) for the reference steel specified in 6.7.3.4.2;  
 $Rm_1$  = guaranteed minimum tensile strength (in N/mm<sup>2</sup>) of the steel to be used (see 6.7.3.3.3);  
 $A_1$  = guaranteed minimum elongation at fracture (in %) of the steel to be used according to national or international standards.

- 6.7.3.4.5** In no case shall the wall thickness be less than that prescribed in 6.7.3.4.1 to 6.7.3.4.3. All parts of the shell shall have a minimum thickness as determined by 6.7.3.4.1 to 6.7.3.4.3. This thickness shall be exclusive of any corrosion allowance.
- 6.7.3.4.6** When mild steel is used (see 6.7.3.1), calculation using the formula in 6.7.3.4.4 is not required.
- 6.7.3.4.7** There shall be no sudden change of plate thickness at the attachment of the ends (heads) to the cylindrical portion of the shell.

### **6.7.3.5 Service equipment**

- 6.7.3.5.1** Service equipment shall be so arranged as to be protected against the risk of being wrenched off or damaged during handling and carriage. When the connection between the frame and the shell allows relative movement between the sub-assemblies, the equipment shall 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 shall 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 any protective caps shall be capable of being secured against unintended opening.
- 6.7.3.5.2** All openings with a diameter of more than 1.5 mm in shells of portable tanks, except openings for pressure-relief devices, inspection openings and closed bleed holes, shall be fitted with at least 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.
- 6.7.3.5.2.1** When a portable tank is fitted with an excess flow valve, the excess flow valve shall be so fitted that its seating is inside the shell or inside a welded flange or, when fitted externally, its mountings shall be designed so that in the event of impact its effectiveness shall be maintained. The excess flow valves shall 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 shall have a capacity for a flow more than the rated flow of the excess flow valve.
- 6.7.3.5.3** For filling and discharge openings, the first shut-off device shall be an internal stop-valve and the second shall be a stop-valve placed in an accessible position on each discharge and filling pipe.
- 6.7.3.5.4** For filling and discharge bottom openings of portable tanks intended for the carriage of flammable and/or toxic non-refrigerated liquefied gases the internal stop-valve shall be a quick closing safety device which closes automatically in the event of unintended movement of the portable tank during filling or discharge or fire engulfment. Except for portable tanks having a capacity of not more than 1 000 litres, it shall be possible to operate this device by remote control.
- 6.7.3.5.5** In addition to filling, discharge and gas pressure equalizing orifices, shells may have openings in which gauges, thermometers and manometers can be fitted. Connections for such instruments shall be made by suitable welded nozzles or pockets and not be screwed connections through the shell.
- 6.7.3.5.6** All portable tanks shall be fitted with manholes or other inspection openings of suitable size to allow for internal inspection and adequate access for maintenance and repair of the interior.
- 6.7.3.5.7** External fittings shall be grouped together so far as reasonably practicable.

- 6.7.3.5.8 Each connection on a portable tank shall be clearly marked to indicate its function.
- 6.7.3.5.9 Each stop-valve or other means of closure shall be designed and constructed to a rated pressure not less than the MAWP of the shell taking into account the temperatures expected during carriage. All stop-valves with a screwed spindle shall close by a clockwise motion of the handwheel. For other stop-valves the position (open and closed) and direction of closure shall be clearly indicated. All stop-valves shall be designed to prevent unintentional opening.
- 6.7.3.5.10 Piping shall be designed, constructed and installed so as to avoid the risk of damage due to thermal expansion and contraction, mechanical shock and vibration. All piping shall be of suitable metallic material. Welded pipe joints shall be used wherever possible.
- 6.7.3.5.11 Joints in copper tubing shall be brazed or have an equally strong metal union. The melting point of brazing materials shall be no lower than 525 °C. The joints shall not decrease the strength of tubing as may happen when cutting threads.
- 6.7.3.5.12 The burst pressure of all piping and pipe fittings shall be not less than the highest of four times the MAWP of the shell or four times the pressure to which it may be subjected in service by the action of a pump or other device (except pressure-relief devices).
- 6.7.3.5.13 Ductile metals shall be used in the construction of valves and accessories.

**6.7.3.6 Bottom openings**

- 6.7.3.6.1 Certain non-refrigerated liquefied gases shall not be carried in portable tanks with bottom openings when portable tank instruction T50 in 4.2.5.2.6 indicates that bottom openings are not allowed. There shall be no openings below the liquid level of the shell when it is filled to its maximum permissible filling limit.

**6.7.3.7 Pressure-relief devices**

- 6.7.3.7.1 Portable tanks shall be provided with one or more spring-loaded pressure-relief devices. The pressure-relief devices shall 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 shall, after discharge, close at a pressure not lower than 10% below the pressure at which discharge starts and shall remain closed at all lower pressures. The pressure-relief devices shall be of a type that will resist dynamic forces including liquid surge. Frangible discs not in series with a spring-loaded pressure-relief device are not permitted.
- 6.7.3.7.2 Pressure-relief devices shall be designed to prevent the entry of foreign matter, the leakage of gas and the development of any dangerous excess pressure.
- 6.7.3.7.3 Portable tanks intended for the carriage of certain non-refrigerated liquefied gases identified in portable tank instruction T50 in 4.2.5.2.6 shall have a pressure-relief device approved by the competent authority. Unless a portable tank in dedicated service is fitted with an approved relief device constructed of materials compatible with the load, such device shall comprise a frangible disc preceding a spring-loaded device. The space between the frangible disc and the device shall 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 shall rupture at a nominal pressure 10% above the start-to-discharge pressure of the relief device.
- 6.7.3.7.4 In the case of multi-purpose portable tanks, the pressure-relief devices shall open at a pressure indicated in 6.7.3.7.1 for the gas having the highest maximum allowable pressure of the gases allowed to be carried in the portable tank.

**6.7.3.8 Capacity of relief devices**

- 6.7.3.8.1 The combined delivery capacity of the relief devices shall 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 shall be used to achieve the full relief capacity prescribed. In the case of multi-purpose tanks, the combined delivery capacity of the pressure-relief devices shall be taken for the gas which requires the highest delivery capacity of the gases allowed to be carried in portable tanks.
- 6.7.3.8.1.1 To determine the total required capacity of the relief devices, which shall be regarded as being the sum of the individual capacities of the several devices, the following formula<sup>5</sup> shall be used:

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<sup>5</sup> This formula applies only to non-refrigerated 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 shall consider further thermodynamic properties of the gas (see for example CGA S-1.2-2003 "Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases").

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

where:

Q = minimum required rate of discharge in cubic metres of air per second (m<sup>3</sup>/s) 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<sup>-2</sup>·K<sup>-1</sup>, at 38 °C;

t = actual temperature of the non-refrigerated liquefied gas during filling (°C); when 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 accordance with 6.7.3.8.1.2;

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

Z = the gas compressibility factor in the accumulating condition (when this factor is unknown, let Z =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 is derived from one of the following formulae as a function of the ratio k of specific heats

$$k = \frac{c_p}{c_v}$$

where

c<sub>p</sub> is the specific heat at constant pressure; and

c<sub>v</sub> is the specific heat at constant volume.

when k > 1:

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

when k = 1 or k is unknown:

$$C = \frac{1}{\sqrt{e}} = 0.607$$

where e is the mathematical constant 2.7183.

C may also be taken from the following table:

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		

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

(a) Remain effective at all temperatures up to 649 °C; and

(b) Be jacketed with a material having a melting point of 700 °C or greater.

### **6.7.3.9 Marking of pressure-relief devices**

**6.7.3.9.1** Every pressure-relief device shall be plainly and permanently marked with the following particulars:

- (a) The pressure (in bar or kPa) at which it is set to discharge;
- (b) The allowable tolerance at the discharge pressure for spring-loaded devices;
- (c) The reference temperature corresponding to the rated pressure for frangible discs; and
- (d) The rated flow capacity of the device in standard cubic metres of air per second ( $\text{m}^3/\text{s}$ ).

When practicable, the following information shall also be shown:

- (e) The manufacturer's name and relevant catalogue number of the device.

**6.7.3.9.2** The rated flow capacity marked on the pressure-relief devices shall be determined according to ISO 4126-1:1991.

### **6.7.3.10 Connections to pressure-relief devices**

**6.7.3.10.1** Connections to pressure-relief devices shall be of sufficient size to enable the required discharge to pass unrestricted to the safety device. No stop-valve shall be installed between the shell and the pressure-relief devices except when 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 capable of meeting the requirements of 6.7.3.8. There shall 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, when used, shall deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving device.

### **6.7.3.11 Siting of pressure-relief devices**

**6.7.3.11.1** Each pressure-relief device inlet shall 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 shall under maximum filling conditions be situated in the vapour space of the shell and the devices shall be so arranged as to ensure that the escaping vapour is discharged unrestrictedly. For flammable non-refrigerated liquefied gases, the escaping vapour shall 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.

**6.7.3.11.2** Arrangements shall 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.

### **6.7.3.12 Gauging devices**

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

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

**6.7.3.13.1** Portable tanks shall be designed and constructed with a support structure to provide a secure base during carriage. The forces specified in 6.7.3.2.9 and the safety factor specified in 6.7.3.2.10 shall be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.

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

**6.7.3.13.3** In the design of supports and frameworks the effects of environmental corrosion shall be taken into account.

**6.7.3.13.4** Forklift pockets shall be capable of being closed off. The means of closing forklift pockets shall 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:

- (a) The shell and all the fittings are well protected from being hit by the forklift blades; and
- (b) The distance between the centres of the forklift pockets is at least half of the maximum length of the portable tank.

**6.7.3.13.5** When portable tanks are not protected during carriage, according to 4.2.2.3, the shells and service equipment shall be protected against damage to the shell and service equipment resulting from lateral or longitudinal impact or overturning. External fittings shall be protected so as to preclude the release of the shell contents upon impact or overturning of the portable tank on its fittings. Examples of protection include:

- (a) Protection against lateral impact which may consist of longitudinal bars protecting the shell on both sides at the level of the median line;
- (b) Protection of the portable tank against overturning which may consist of reinforcement rings or bars fixed across the frame;
- (c) Protection against rear impact which may consist of a bumper or frame;
- (d) Protection of the shell against damage from impact or overturning by use of an ISO frame in accordance with ISO 1496-3:1995.

#### **6.7.3.14 Design approval**

**6.7.3.14.1** The competent authority or its authorized body shall issue a design approval certificate for any new design of a portable tank. This certificate shall attest that a portable tank has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this Chapter and where appropriate the provisions for gases provided in portable tank instruction T50 in 4.2.5.2.6. When a series of portable tanks are manufactured without change in the design, the certificate shall be valid for the entire series. The certificate shall refer to the prototype test report, the gases allowed to be carried, the materials of construction of the shell and an approval number. The approval number shall 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. Any alternative arrangements according to 6.7.1.2 shall 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.

**6.7.3.14.2** The prototype test report for the design approval shall include at least the following:

- (a) The results of the applicable framework test specified in ISO 1496-3:1995;
- (b) The results of the initial inspection and test in 6.7.3.15.3; and
- (c) The results of the impact test in 6.7.3.15.1, when applicable.

#### **6.7.3.15 Inspection and testing**

**6.7.3.15.1** Portable tanks meeting the definition of container in the International Convention for Safe Containers (CSC), 1972, as amended, shall not be used unless they are successfully qualified by subjecting a representative prototype of each design to the Dynamic, Longitudinal Impact Test prescribed in the Manual of Tests and Criteria, Part IV, Section 41.

**6.7.3.15.2** The shell and items of equipment of each portable tank shall 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. The 2.5 year inspection and test may be performed within 3 months of the specified date. An exceptional inspection and test shall be performed regardless of the last periodic inspection and test when necessary according to 6.7.3.15.7.

**6.7.3.15.3** The initial inspection and test of a portable tank shall include a check of the design characteristics, an internal and external examination of the portable tank and its fittings with due regard to the non-refrigerated liquefied gases to be carried, and a pressure test referring to the test pressures according to 6.7.3.3.2. 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 shall also be performed. When the shell and its fittings have been pressure-tested separately, they shall be subjected together after assembly to a leakproofness test. All welds subject to full stress level in the shell shall be inspected during the initial test by radiographic, ultrasonic, or another suitable non-destructive test method. This does not apply to the jacket.

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

**6.7.3.15.5** The intermediate 2.5 year periodic inspection and test shall at least include an internal and external examination of the portable tank and its fittings with due regard to the non-refrigerated liquefied gases intended to be carried, a leakproofness test and a check of the satisfactory operation of all service equipment. Sheathing thermal insulation and the like shall be removed only to the extent required for reliable appraisal of the condition of the portable tank. For portable tanks intended for the carriage of a single non-refrigerated liquefied gas, the 2.5 year internal examination may be waived or substituted by other test methods or inspection procedures specified by the competent authority or its authorized body.

- 6.7.3.15.6** A portable tank may not be filled and offered for carriage after the date of expiry of the last 5 year or 2.5 year periodic inspection and test as required by 6.7.3.15.2. However a portable tank filled prior to the date of expiry of the last periodic inspection and test may be carried for a period not to exceed three months beyond the date of expiry of the last periodic test or inspection. In addition, a portable tank may be carried after the date of expiry of the last periodic test and inspection:
- (a) After emptying but before cleaning, for purposes of performing the next required test or inspection prior to refilling; and
  - (b) Unless otherwise approved by the competent authority, for a period not to exceed six months beyond the date of expiry of the last periodic test or inspection, in order to allow the return of dangerous goods for proper disposal or recycling. Reference to this exemption shall be mentioned in the **transport document**.
- 6.7.3.15.7** 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 shall depend on the amount of damage or deterioration of the portable tank. It shall include at least the 2.5 year inspection and test according to 6.7.3.15.5.
- 6.7.3.15.8** The internal and external examinations shall ensure that:
- (a) 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 carriage;
  - (b) The piping, valves, and gaskets are inspected for corroded areas, defects, or any other conditions, including leakage, that might render the portable tank unsafe for filling, discharge or carriage;
  - (c) Devices for tightening manhole covers are operative and there is no leakage at manhole covers or gaskets;
  - (d) Missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;
  - (e) 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 shall be operated to demonstrate proper operation;
  - (f) Required markings on the portable tank are legible and in accordance with the applicable requirements; and
  - (g) The framework, the supports and the arrangements for lifting the portable tank are in satisfactory condition.
- 6.7.3.15.9** The inspections and tests in 6.7.3.15.1, 6.7.3.15.3, 6.7.3.15.4, 6.7.3.15.5 and 6.7.3.15.7 shall be performed or witnessed by an expert approved by the competent authority or its authorized body. When the pressure test is a part of the inspection and test, the test pressure shall be the one indicated on the data plate of the portable tank. While under pressure, the portable tank shall be inspected for any leaks in the shell, piping or equipment.
- 6.7.3.15.10** In all cases when cutting, burning or welding operations on the shell have been effected, that work shall 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 shall be performed after the work is completed.
- 6.7.3.15.11** When evidence of any unsafe condition is discovered, the portable tank shall not be returned to service until it has been corrected and the pressure test is repeated and passed.

**6.7.3.16 Marking**

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

Country of manufacture

U	Approval	Approval	For Alternative Arrangements (see 6.7.1.2)
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 \_\_\_\_\_ bar/kPa gauge<sup>6</sup>

MAWP \_\_\_\_\_ bar/kPa gauge<sup>6</sup>

External design pressure<sup>7</sup> \_\_\_\_\_ bar/kPa gauge<sup>6</sup>

Design temperature range \_\_\_\_\_ °C to \_\_\_\_\_ °C

Design reference temperature \_\_\_\_\_ °C

Water capacity at 20 °C \_\_\_\_\_ litres

**Initial** pressure test date and witness identification

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 \_\_\_\_\_ bar/kPa gauge<sup>6</sup>

Stamp of expert who performed or witnessed the most recent test

**6.7.3.16.2** The following information shall 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 non-refrigerated liquefied gas(es) permitted for carriage

Maximum permissible load mass for each non-refrigerated liquefied gas permitted \_\_\_\_\_ kg

Maximum permissible gross mass (MPGM) \_\_\_\_\_ kg

Unladen (tare) mass \_\_\_\_\_ kg

**NOTE:** For the identification of the non-refrigerated liquefied gases being carried, see also Part 5.

**6.7.3.16.3** If a portable tank is designed and approved for handling in open seas, the words "OFFSHORE PORTABLE TANK" shall be marked on the identification plate.

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<sup>6</sup> The unit used shall be marked.

<sup>7</sup> See 6.7.3.2.8.

## 6.7.4 Requirements for the design, construction, inspection and testing of portable tanks intended for the carriage of refrigerated liquefied gases

### 6.7.4.1 Definitions

For the purposes of this section:

*Alternative arrangement* means an approval granted by the competent authority for a portable tank or MEGC that has been designed, constructed or tested to technical requirements or testing methods other than those specified in this Chapter;

*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);

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

*Leakproofness test* means a test using gas subjecting the shell and its service equipment, to an effective internal pressure not less than 90% of the MAWP;

*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;

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

*Minimum design temperature* means the temperature which is used for the design and construction of the shell not higher than the lowest (coldest) temperature (service temperature) of the contents during normal conditions of filling, discharge and carriage;

*Portable tank* means a thermally insulated multimodal tank having a capacity of more than 450 litres fitted with service equipment and structural equipment necessary for the carriage of refrigerated liquefied gases. The portable tank shall be capable of being filled and discharged without the removal of its structural equipment. It shall possess stabilizing members external to the tank, and shall be capable of being lifted when full. It shall be designed primarily to be loaded onto a transport vehicle or ship and shall be equipped with skids, mountings or accessories to facilitate mechanical handling. Tank-vehicles, 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;

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

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

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

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

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

- (a) 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 a thermal insulation system; or
- (b) A jacket and an inner shell with an intermediate layer of solid thermally insulating material (e.g. solid foam);

*Test pressure* means the maximum gauge pressure at the top of the shell during the pressure test.

### 6.7.4.2 General design and construction requirements

- 6.7.4.2.1 Shells shall be designed and constructed in accordance with the requirements of a pressure vessel code recognized by the competent authority. Shells and jackets shall be made of metallic materials suitable for forming. Jackets shall be made of steel. Non-metallic materials may be used for the attachments and supports between the shell and jacket, provided their material properties at the minimum design temperature are proven to be sufficient. The materials shall in principle conform to national or international material standards. For welded shells and jackets only materials whose weldability has been fully demonstrated shall be used. Welds shall be skilfully made and afford complete safety. When the manufacturing process or the materials make it necessary, the shell shall 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 shall be taken into account with respect to risk of brittle fracture, to hydrogen embrittlement, to stress corro-

sion cracking and to resistance to impact. When fine grain steel is used, the guaranteed value of the yield strength shall be not more than 460 N/mm<sup>2</sup> and the guaranteed value of the upper limit of the tensile strength shall be not more than 725 N/mm<sup>2</sup> in accordance with the material specifications. Portable tank materials shall be suitable for the external environment in which they may be carried.

- 6.7.4.2.2** Any part of a portable tank, including fittings, gaskets and pipe-work, which can be expected normally to come into contact with the refrigerated liquefied gas carried shall be compatible with that refrigerated liquefied gas.
- 6.7.4.2.3** Contact between dissimilar metals which could result in damage by galvanic action shall be avoided.
- 6.7.4.2.4** The thermal insulation system shall include a complete covering of the shell(s) with effective insulating materials. External insulation shall be protected by a jacket so as to prevent the ingress of moisture and other damage under normal carriage conditions.
- 6.7.4.2.5** When a jacket is so closed as to be gas-tight, a device shall be provided to prevent any dangerous pressure from developing in the insulation space.
- 6.7.4.2.6** Portable tanks intended for the carriage of refrigerated liquefied gases having a boiling point below minus (–)182 °C at atmospheric pressure shall not include materials which may react with oxygen or oxygen enriched atmospheres in a dangerous manner, when located in parts of the thermal insulation when there is a risk of contact with oxygen or with oxygen enriched fluid.
- 6.7.4.2.7** Insulating materials shall not deteriorate unduly in service.
- 6.7.4.2.8** A reference holding time shall be determined for each refrigerated liquefied gas intended for carriage in a portable tank.
- 6.7.4.2.8.1** The reference holding time shall be determined by a method recognized by the competent authority on the basis of the following:
- (a) The effectiveness of the insulation system, determined in accordance with 6.7.4.2.8.2;
  - (b) The lowest set pressure of the pressure limiting device(s);
  - (c) The initial filling conditions;
  - (d) An assumed ambient temperature of 30 °C;
  - (e) The physical properties of the individual refrigerated liquefied gas intended to be carried.
- 6.7.4.2.8.2** The effectiveness of the insulation system (heat influx in watts) shall be determined by type testing the portable tank in accordance with a procedure recognized by the competent authority. This test shall consist of either:
- (a) A constant pressure test (for example at atmospheric pressure) when the loss of refrigerated liquefied gas is measured over a period of time; or
  - (b) A closed system test when the rise in pressure in the shell is measured over a period of time.
- When performing the constant pressure test, variations in atmospheric pressure shall be taken into account. When performing either tests corrections shall be made for any variation of the ambient temperature from the assumed ambient temperature reference value of 30 °C.
- NOTE:** For the determination of the actual holding time before each journey, refer to 4.2.3.7.
- 6.7.4.2.9** The jacket of a vacuum-insulated double-wall tank shall have either an external design pressure not less than 100 kPa (1 bar) (gauge pressure) calculated in accordance with a recognized technical code or a calculated critical collapsing pressure of not less than 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.
- 6.7.4.2.10** Portable tanks shall be designed and constructed with supports to provide a secure base during carriage and with suitable lifting and tie-down attachments.
- 6.7.4.2.11** Portable tanks shall be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads during normal conditions of handling and carriage. The design shall demonstrate that the effects of fatigue, caused by repeated application of these loads through the expected life of the portable tank, have been taken into account.
- 6.7.4.2.12** Portable tanks and their fastenings under the maximum permissible load shall be capable of absorbing the following separately applied static forces:
- (a) In the direction of travel: twice the MPGM multiplied by the acceleration due to gravity (g)<sup>8</sup>;

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<sup>8</sup> For calculation purposes  $g = 9.81 \text{ m/s}^2$ .

- (b) Horizontally at right angles to the direction of travel: the MPGM (when the direction of travel is not clearly determined, the forces shall be equal to twice the MPGM) multiplied by the acceleration due to gravity ( $g$ )<sup>8</sup>;
- (c) Vertically upwards: the MPGM multiplied by the acceleration due to gravity ( $g$ )<sup>8</sup>; and
- (d) Vertically downwards: twice the MPGM (total loading including the effect of gravity) multiplied by the acceleration due to gravity ( $g$ )<sup>8</sup>.

**6.7.4.2.13** Under each of the forces in 6.7.4.2.12, the safety factor to be observed shall be as follows:

- (a) For materials having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; and
- (b) For materials with no clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed 0.2% proof strength or, in case of austenitic steels, the 1% proof strength.

**6.7.4.2.14** The values of yield strength or proof strength shall be the values according to national or international material standards. When austenitic steels are used, the specified minimum values according to the material standards may be increased by up to 15% when greater values are attested in the material inspection certificate. When no material standard exists for the metal in question, or when non-metallic materials are used the values of yield strength or proof strength shall be approved by the competent authority.

**6.7.4.2.15** Portable tanks intended for the carriage of flammable refrigerated liquefied gases shall be capable of being electrically earthed.

### **6.7.4.3 Design criteria**

**6.7.4.3.1** Shells shall be of a circular cross section.

**6.7.4.3.2** Shells shall be designed and constructed to withstand a test pressure not less than 1.3 times the MAWP. For shells with vacuum insulation the test pressure shall not be less than 1.3 times the sum of the MAWP and 100 kPa (1 bar). In no case shall the test pressure be less than 300 kPa (3 bar) (gauge pressure). Attention is drawn to the minimum shell thickness requirements, specified in 6.7.4.4.2 to 6.7.4.4.7.

**6.7.4.3.3** 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 primary membrane stress  $\sigma$  (sigma) in the shell shall not exceed 0.75 Re or 0.50 Rm, whichever is lower, at the test pressure, where:  
 Re = yield strength in N/mm<sup>2</sup>, or 0.2% proof strength or, for austenitic steels, 1% proof strength;  
 Rm = minimum tensile strength in N/mm<sup>2</sup>.

**6.7.4.3.3.1** The values of Re and Rm to be used shall be the specified minimum values according to national or international material standards. 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% when greater values are attested in the material inspection certificate. When no material standard exists for the metal in question, the values of Re and Rm used shall be approved by the competent authority or its authorized body.

**6.7.4.3.3.2** Steels which have a Re/Rm ratio of more than 0.85 are not allowed for the construction of welded shells. The values of Re and Rm to be used in determining this ratio shall be the values specified in the material inspection certificate.

**6.7.4.3.3.3** Steels used in the construction of shells shall have an elongation at fracture, in %, of not less than 10 000/Rm with an absolute minimum of 16% for fine grain steels and 20% for other steels. Aluminium and aluminium alloys used in the construction of shells shall have an elongation at fracture, in %, of not less than 10 000/6Rm with an absolute minimum of 12%.

**6.7.4.3.3.4** For the purpose of determining actual values for materials, it shall be noted that for sheet metal, the axis of the tensile test specimen shall be at right angles (transversely) to the direction of rolling. The permanent elongation at fracture shall be measured on test specimens of rectangular cross sections in accordance with ISO 6892:1988 using a 50 mm gauge length.

### **6.7.4.4 Minimum shell thickness**

**6.7.4.4.1** The minimum shell thickness shall be the greater thickness based on:

- (a) The minimum thickness determined in accordance with the requirements in 6.7.4.4.2 to 6.7.4.4.7; or
- (b) The minimum thickness determined in accordance with the recognized pressure vessel code including the requirements in 6.7.4.3.

**6.7.4.4.2** Shells of not more than 1.80 m in diameter shall be not less than 5 mm thick in the reference steel or of equivalent thickness in the metal to be used. Shells of more than 1.80 m in diameter shall be not less than 6 mm thick in the reference steel or of equivalent thickness in the metal to be used.

- 6.7.4.4.3** Shells of vacuum-insulated tanks of not more than 1.80 m in diameter shall be not less than 3 mm thick in the reference steel or of equivalent thickness in the metal to be used. Such shells of more than 1.80 m in diameter shall be not less than 4 mm thick in the reference steel or of equivalent thickness in the metal to be used.
- 6.7.4.4.4** For vacuum-insulated tanks, the aggregate thickness of the jacket and the shell shall correspond to the minimum thickness prescribed in 6.7.4.4.2, the thickness of the shell itself being not less than the minimum thickness prescribed in 6.7.4.4.3.
- 6.7.4.4.5** Shells shall be not less than 3 mm thick regardless of the material of construction.
- 6.7.4.4.6** The equivalent thickness of a metal other than the thickness prescribed for the reference steel in 6.7.4.4.2 and 6.7.4.4.3 shall be determined using the following formula:

$$e_1 = \frac{21.4 e_0}{\sqrt[3]{Rm_1 A_1}}$$

where:

- $e_1$  = required equivalent thickness (in mm) of the metal to be used;
- $e_0$  = minimum thickness (in mm) of the reference steel specified in 6.7.4.4.2 and 6.7.4.4.3;
- $Rm_1$  = guaranteed minimum tensile strength (in N/mm<sup>2</sup>) of the metal to be used (see 6.7.4.3.3);
- $A_1$  = guaranteed minimum elongation at fracture (in %) of the metal to be used according to national or international standards.

- 6.7.4.4.7** In no case shall the wall thickness be less than that prescribed in 6.7.4.4.1 to 6.7.4.4.5. All parts of the shell shall have a minimum thickness as determined by 6.7.4.4.1 to 6.7.4.4.6. This thickness shall be exclusive of any corrosion allowance.

- 6.7.4.4.8** There shall be no sudden change of plate thickness at the attachment of the ends (heads) to the cylindrical portion of the shell.

#### **6.7.4.5 Service equipment**

- 6.7.4.5.1** Service equipment shall be so arranged as to be protected against the risk of being wrenched off or damaged during handling and carriage. When the connection between the frame and the tank or the jacket and the shell allows relative movement, the equipment shall 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 shall 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 any protective caps shall be capable of being secured against unintended opening.
- 6.7.4.5.2** Each filling and discharge opening in portable tanks used for the carriage of flammable refrigerated liquefied gases shall be fitted with at least three mutually 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. The shut-off device closest to the jacket shall be a quick closing device, which closes automatically in the event of unintended movement of the portable tank during filling or discharge or fire engulfment. This device shall also be possible to operate by remote control.
- 6.7.4.5.3** Each filling and discharge opening in portable tanks used for the carriage of non-flammable refrigerated liquefied gases shall be fitted with at least two mutually 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.
- 6.7.4.5.4** For sections of piping which can be closed at both ends and where liquid product can be trapped, a method of automatic pressure relief shall be provided to prevent excess pressure build-up within the piping.
- 6.7.4.5.5** Vacuum insulated tanks need not have an opening for inspection.
- 6.7.4.5.6** External fittings shall be grouped together so far as reasonably practicable.
- 6.7.4.5.7** Each connection on a portable tank shall be clearly marked to indicate its function.
- 6.7.4.5.8** Each stop-valve or other means of closure shall be designed and constructed to a rated pressure not less than the MAWP of the shell taking into account the temperature expected during carriage. All stop-valves with a screwed spindle shall be closed by a clockwise motion of the handwheel. In the case of other stop-valves the position (open and closed) and direction of closure shall be clearly indicated. All stop-valves shall be designed to prevent unintentional opening.

- 6.7.4.5.9** When pressure-building units are used, the liquid and vapour connections to that unit shall be provided with a valve as close to the jacket as reasonably practicable to prevent the loss of contents in case of damage to the pressure-building unit.
- 6.7.4.5.10** Piping shall be designed, constructed and installed so as to avoid the risk of damage due to thermal expansion and contraction, mechanical shock and vibration. All piping shall be of a suitable material. To prevent leakage due to fire, only steel piping and welded joints shall be used between the jacket and the connection to the first closure of any outlet. The method of attaching the closure to this connection shall be to the satisfaction of the competent authority or its authorized body. Elsewhere pipe joints shall be welded when necessary.
- 6.7.4.5.11** Joints in copper tubing shall be brazed or have an equally strong metal union. The melting point of brazing materials shall be no lower than 525 °C. The joints shall not decrease the strength of the tubing as may happen when cutting threads.
- 6.7.4.5.12** The materials of construction of valves and accessories shall have satisfactory properties at the lowest operating temperature of the portable tank.
- 6.7.4.5.13** The burst pressure of all piping and pipe fittings shall be not less than the highest of four times the MAWP of the shell or four times the pressure to which it may be subjected in service by the action of a pump or other device (except pressure-relief devices).
- 6.7.4.6 Pressure-relief devices**
- 6.7.4.6.1** Every shell shall be provided with not less than two independent spring-loaded pressure-relief devices. The pressure-relief devices shall open automatically at a pressure not less than the MAWP and be fully open a pressure equal to 110% of the MAWP. These devices shall, after discharge, close at a pressure not lower than 10% below the pressure at which discharge starts and shall remain closed at all lower pressures. The pressure-relief devices shall be of the type that will resist dynamic forces including surge.
- 6.7.4.6.2** Shells for non-flammable refrigerated liquefied gases and hydrogen may in addition have frangible discs in parallel with the spring-loaded devices as specified in 6.7.4.7.2 and 6.7.4.7.3.
- 6.7.4.6.3** Pressure-relief devices shall be designed to prevent the entry of foreign matter, the leakage of gas and the development of any dangerous excess pressure.
- 6.7.4.6.4** Pressure-relief devices shall be approved by the competent authority or its authorized body.
- 6.7.4.7 Capacity and setting of pressure-relief devices**
- 6.7.4.7.1** In the case of the 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 shall be sufficient so that the pressure (including accumulation) inside the shell does not exceed 120% of the MAWP.
- 6.7.4.7.2** For non-flammable refrigerated liquefied gases (except oxygen) and hydrogen, this capacity may be achieved by the use of frangible discs in parallel with the required safety-relief devices. Frangible discs shall rupture at nominal pressure equal to the test pressure of the shell.
- 6.7.4.7.3** Under the circumstances described in 6.7.4.7.1 and 6.7.4.7.2 together with complete fire engulfment the combined capacity of all pressure-relief devices installed shall be sufficient to limit the pressure in the shell to the test pressure.
- 6.7.4.7.4** The required capacity of the relief devices shall be calculated in accordance with a well-established technical code recognized by the competent authority<sup>9</sup>.
- 6.7.4.8 Marking of pressure-relief devices**
- 6.7.4.8.1** Every pressure-relief device shall be plainly and permanently marked with the following particulars:
- (a) The pressure (in bar or kPa) at which it is set to discharge;
  - (b) The allowable tolerance at the discharge pressure for spring-loaded devices;
  - (c) The reference temperature corresponding to the rated pressure for frangible discs; and
  - (d) The rated flow capacity of the device in standard cubic meters of air per second (m<sup>3</sup>/s).
- When practicable, the following information shall also be shown:
- (e) The manufacturer's name and relevant catalogue number of the device.

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<sup>9</sup> See for example CGA S-1.2-2003 "Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases".

- 6.7.4.8.2** The rated flow capacity marked on the pressure-relief devices shall be determined according to ISO 4126-1:1991.
- 6.7.4.9 Connections to pressure-relief devices**
- 6.7.4.9.1** Connections to pressure-relief devices shall be of sufficient size to enable the required discharge to pass unrestricted to the safety device. No stop-valve shall be installed between the shell and the pressure-relief devices except when 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 6.7.4.7 are always fulfilled. There shall 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. Pipework to vent the vapour or liquid from the outlet of the pressure-relief devices, when used, shall deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving device.
- 6.7.4.10 Siting of pressure-relief devices**
- 6.7.4.10.1** Each pressure-relief device inlet shall 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 shall under maximum filling conditions be situated in the vapour space of the shell and the devices shall be so arranged as to ensure that the escaping vapour is discharged unrestrictedly. For refrigerated liquefied gases, the escaping vapour shall 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.
- 6.7.4.10.2** Arrangements shall be made to prevent access to the devices by unauthorized persons and to protect the devices from damage caused by the portable tank overturning.
- 6.7.4.11 Gauging devices**
- 6.7.4.11.1** Unless a portable tank is intended to be filled by weight, it shall be equipped with one or more gauging devices. Glass level-gauges and gauges made of other fragile material, which are in direct communication with the contents of the shell shall not be used.
- 6.7.4.11.2** A connection for a vacuum gauge shall be provided in the jacket of a vacuum-insulated portable tank.
- 6.7.4.12 Portable tank supports, frameworks, lifting and tie-down attachments**
- 6.7.4.12.1** Portable tanks shall be designed and constructed with a support structure to provide a secure base during carriage. The forces specified in 6.7.4.2.12 and the safety factor specified in 6.7.4.2.13 shall be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.
- 6.7.4.12.2** The combined stresses caused by portable tank mountings (e.g. cradles, frameworks, etc.) and portable tank lifting and tie-down attachments shall not cause excessive stress in any portion of the tank. Permanent lifting and tie-down attachments shall be fitted to all portable tanks. Preferably they shall be fitted to the portable tank supports but may be secured to reinforcing plates located on the tank at the points of support.
- 6.7.4.12.3** In the design of supports and frameworks the effects of environmental corrosion shall be taken into account.
- 6.7.4.12.4** Forklift pockets shall be capable of being closed off. The means of closing forklift pockets shall 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:
- The tank and all the fittings are well protected from being hit by the forklift blades; and
  - The distance between the centres of the forklift pockets is at least half of the maximum length of the portable tank.
- 6.7.4.12.5** When portable tanks are not protected during carriage, according to 4.2.3.3, the shells and service equipment shall be protected against damage to the shell and service equipment resulting from lateral or longitudinal impact or overturning. External fittings shall be protected so as to preclude the release of the shell contents upon impact or overturning of the portable tank on its fittings. Examples of protection include:
- Protection against lateral impact which may consist of longitudinal bars protecting the shell on both sides at the level of the median line;
  - Protection of the portable tank against overturning which may consist of reinforcement rings or bars fixed across the frame;
  - Protection against rear impact which may consist of a bumper or frame;
  - Protection of the shell against damage from impact or overturning by use of an ISO frame in accordance with ISO 1496-3:1995;
  - Protection of the portable tank from impact or overturning by a vacuum insulation jacket.

### 6.7.4.13 Design approval

**6.7.4.13.1** The competent authority or its authorized body shall issue a design approval certificate for any new design of a portable tank. This certificate shall attest that a portable tank has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this Chapter. When a series of portable tanks are manufactured without change in the design, the certificate shall be valid for the entire series. The certificate shall refer to the prototype test report, the refrigerated liquefied gases allowed to be carried, the materials of construction of the shell and jacket and an approval number. The approval number shall 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. Any alternative arrangements according to 6.7.1.2 shall 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.

**6.7.4.13.2** The prototype test report for the design approval shall include at least the following:

- (a) The results of the applicable frame-work test specified in ISO 1496-3:1995;
- (b) The results of the initial inspection and test in 6.7.4.14.3; and
- (c) The results of the impact test in 6.7.4.14.1, when applicable.

### 6.7.4.14 Inspection and testing

**6.7.4.14.1** Portable tanks meeting the definition of container in the International Convention for Safe Containers (CSC), 1972, as amended, shall not be used unless they are successfully qualified by subjecting a representative prototype of each design to the Dynamic, Longitudinal Impact Test prescribed in the Manual of Tests and Criteria, Part IV, Section 41.

**6.7.4.14.2** The shell and items of equipment of each portable tank shall 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. The 2.5 year inspection and test may be performed within 3 months of the specified date. An exceptional inspection and test shall be performed regardless of the last periodic inspection and test when necessary according to 6.7.4.14.7.

**6.7.4.14.3** The initial inspection and test of a portable tank shall include a check of the design characteristics, an internal and external examination of the portable tank shell and its fittings with due regard to the refrigerated liquefied gases to be carried, and a pressure test referring to the test pressures according to 6.7.4.3.2. 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 check of the satisfactory operation of all service equipment shall also be performed. When the shell and its fittings have been pressure-tested separately, they shall be subjected together after assembly to a leakproofness test. All welds subject to full stress level shall be inspected during the initial test by radiographic, ultrasonic, or another suitable non-destructive test method. This does not apply to the jacket.

**6.7.4.14.4** The 5 and 2.5 year periodic inspection and test shall include an external examination of the portable tank and its fittings with due regard to the refrigerated liquefied gases carried, a leakproofness test, a check of the satisfactory operation of all service equipment and a vacuum reading, when applicable. In the case of non-vacuum insulated tanks, the jacket and insulation shall be removed during a 2.5 year and a 5 year periodic inspection but only to the extent necessary for a reliable appraisal.

**6.7.4.14.5** In addition, at the 5 year periodic inspection and test of non-vacuum insulated tanks the jacket and insulation shall be removed, but only to the extent necessary for a reliable appraisal.

**6.7.4.14.6** A portable tank may not be filled and offered for carriage after the date of expiry of the last 5 year or 2.5 year periodic inspection and test as required by 6.7.4.14.2. However a portable tank filled prior to the date of expiry of the last periodic inspection and test may be carried for a period not to exceed three months beyond the date of expiry of the last periodic test or inspection. In addition, a portable tank may be carried after the date of expiry of the last periodic test and inspection:

- (a) After emptying but before cleaning, for purposes of performing the next required test or inspection prior to refilling; and
- (b) Unless otherwise approved by the competent authority, for a period not to exceed six months beyond the date of expiry of the last periodic test or inspection, in order to allow the return of dangerous goods for proper disposal or recycling. Reference to this exemption shall be mentioned in the transport document.

- 6.7.4.14.7** The exceptional inspection and test is necessary when the portable tank shows evidence of damaged or corroded areas, leakage, or any other conditions that indicate a deficiency that could affect the integrity of the portable tank. The extent of the exceptional inspection and test shall depend on the amount of damage or deterioration of the portable tank. It shall include at least the 2.5 year inspection and test according to 6.7.4.14.4.
- 6.7.4.14.8** The internal examination during the initial inspection and test shall ensure that the shell is inspected for pitting, corrosion, or abrasions, dents, distortions, defects in welds or any other conditions, that might render the portable tank unsafe for carriage.
- 6.7.4.14.9** The external examination shall ensure that:
- (a) The external piping, valves, pressurizing/cooling systems when applicable and gaskets are inspected for corroded areas, defects, or any other conditions, including leakage, that might render the portable tank unsafe for filling, discharge or carriage;
  - (b) There is no leakage at any manhole covers or gaskets;
  - (c) Missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;
  - (d) 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 shall be operated to demonstrate proper operation;
  - (e) Required markings on the portable tank are legible and in accordance with the applicable requirements; and
  - (f) The framework, the supports and the arrangements for lifting the portable tank are in satisfactory condition.
- 6.7.4.14.10** The inspections and tests in 6.7.4.14.1, 6.7.4.14.3, 6.7.4.14.4, 6.7.4.14.5 and 6.7.4.14.7 shall be performed or witnessed by an expert approved by the competent authority or its authorized body. When the pressure test is a part of the inspection and test, the test pressure shall be the one indicated on the data plate of the portable tank. While under pressure, the portable tank shall be inspected for any leaks in the shell, piping or equipment.
- 6.7.4.14.11** In all cases when cutting, burning or welding operations on the shell of a portable tank have been effected, that work shall 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 shall be performed after the work is completed.
- 6.7.4.14.12** When evidence of any unsafe condition is discovered, the portable tank shall not be returned to service until it has been corrected and the test is repeated and passed.

**6.7.4.15 Marking**

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

Country of manufacture

U	Approval	Approval	For Alternative Arrangements (see 6.7.1.2)
N	country	number	

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 \_\_\_\_\_ bar/kPa gauge<sup>10</sup>

MAWP \_\_\_\_\_ bar/kPa gauge<sup>10</sup>

\_\_\_\_\_

<sup>10</sup> The unit used shall be marked.

Minimum design temperature \_\_\_\_\_ °C

Water capacity at 20 °C \_\_\_\_\_ litres

Initial pressure test date and witness identification

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 \_\_\_\_\_ bar/kPa gauge<sup>10</sup>

Stamp of expert who performed or witnessed the most recent test

The name, in full, of the gas(es) for whose carriage the portable tank is approved

Either "thermally insulated" or "vacuum insulated" \_\_\_\_\_

Effectiveness of the insulation system (heat influx) \_\_\_\_\_ Watts (W)

Reference holding time \_\_\_\_\_ days (or hours) and initial pressure \_\_\_\_\_ bar/kPa gauge<sup>10</sup> and degree of filling \_\_\_\_\_ in kg for each refrigerated liquefied gas permitted for carriage.

**6.7.4.15.2** The following particulars shall 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 carried (and minimum mean bulk temperature)

Maximum permissible gross mass (MPGM) \_\_\_\_\_ kg

Unladen (tare) mass \_\_\_\_\_ kg

Actual holding time for gas being carried \_\_\_\_\_ days (or hours)

**NOTE:** For the identification of the refrigerated liquefied gas(es) being carried, see also Part 5.

**6.7.4.15.3** If a portable tank is designed and approved for handling in open seas, the words "OFFSHORE PORTABLE TANK" shall be marked on the identification plate.

## **6.7.5 Requirements for the design, construction, inspection and testing of UN multiple-element gas containers (MEGCs) intended for the carriage of non-refrigerated gases**

### **6.7.5.1 Definitions**

For the purposes of this section:

*Alternative arrangement* means an approval granted by the competent authority for a portable tank or MEGC that has been designed, constructed or tested to technical requirements or testing methods other than those specified in this Chapter;

*Elements* are cylinders, tubes or bundles of cylinders;

*Leakproofness test* means a test using gas subjecting the elements and the service equipment of the MEGC to an effective internal pressure of not less than 20% of the test pressure;

*Manifold* means an assembly of piping and valves connecting the filling and/or discharge openings of the elements;

*Maximum permissible gross mass (MPGM)* means the sum of the tare mass of the MEGC and the heaviest load authorized for carriage;

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

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

*UN multiple-element gas containers (MEGCs)* are multimodal assemblies of cylinders, tubes and bundles of cylinders which are interconnected by a manifold and which are assembled within a framework. The MEGC includes service equipment and structural equipment necessary for the carriage of gases.

### **6.7.5.2 General design and construction requirements**

**6.7.5.2.1** The MEGC shall be capable of being filled and discharged without the removal of its structural equipment. It shall possess stabilizing members external to the elements to provide structural integrity for handling and carriage. MEGCs shall be designed and constructed with supports to provide a secure base during carriage and with lifting and tie-down attachments which are adequate for lifting the MEGC including when filled to its maximum permissible gross mass. The MEGC shall be designed to be loaded onto a transport unit or ship and shall be equipped with skids, mountings or accessories to facilitate mechanical handling.

**6.7.5.2.2** MEGCs shall be designed, manufactured and equipped in such a way as to withstand all conditions to which they will be subjected during normal conditions of handling and carriage. The design shall take into account the effects of dynamic loading and fatigue.

**6.7.5.2.3** Elements of an MEGC shall be made of seamless steel and be constructed and tested according to 6.2.5. All of the elements in an MEGC shall be of the same design type.

**6.7.5.2.4** Elements of MEGCs, fittings and pipework shall be:  
(a) compatible with the substances intended to be carried (see ISO 11114-1:1997 and ISO 11114-2:2000);  
or  
(b) properly passivated or neutralized by chemical reaction.

**6.7.5.2.5** Contact between dissimilar metals which could result in damage by galvanic action shall be avoided.

**6.7.5.2.6** The materials of the MEGC, including any devices, gaskets, and accessories, shall not adversely affect the gas(es) intended for carriage in the MEGC.

**6.7.5.2.7** MEGCs shall be designed to withstand, without loss of contents, at least the internal pressure due to the contents, and the static, dynamic and thermal loads during normal conditions of handling and carriage. The design shall demonstrate that the effects of fatigue, caused by repeated application of these loads through the expected life of the multiple-element gas container, have been taken into account.

**6.7.5.2.8** MEGCs and their fastenings shall, under the maximum permissible load, be capable of withstanding the following separately applied static forces:  
(a) in the direction of travel: twice the MPGM multiplied by the acceleration due to gravity (g)<sup>11</sup>;

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<sup>11</sup> For calculation purposes  $g = 9.81 \text{ m/s}^2$ .

- (b) horizontally at right angles to the direction of travel: the MPGM (when the direction of travel is not clearly determined, the forces shall be equal to twice the MPGM) multiplied by the acceleration due to gravity ( $g$ )<sup>11</sup>;
- (c) vertically upwards: the MPGM multiplied by the acceleration due to gravity ( $g$ )<sup>11</sup>; and
- (d) vertically downwards: twice the MPGM (total loading including the effect of gravity) multiplied by the acceleration due to gravity ( $g$ )<sup>11</sup>.

**6.7.5.2.9** Under the forces defined in 6.7.5.2.8, the stress at the most severely stressed point of the elements shall not exceed the values given in either the relevant standards of 6.2.5.2 or, if the elements are not designed, constructed and tested according to those standards, in the technical code or standard recognised or approved by the competent authority of the country of use (see 6.2.3).

**6.7.5.2.10** Under each of the forces in 6.7.5.2.8, the safety factor for the framework and fastenings to be observed shall be as follows:

- (a) for steels having a clearly defined yield point, a safety factor of 1.5 in relation to the guaranteed yield strength; or
- (b) 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.

**6.7.5.2.11** MEGCs intended for the carriage of flammable gases shall be capable of being electrically earthed.

**6.7.5.2.12** The elements shall be secured in a manner that prevents undesired movement in relation to the structure and the concentration of harmful localized stresses.

### **6.7.5.3 Service equipment**

**6.7.5.3.1** Service equipment shall be configured or designed to prevent damage that could result in the release of the pressure receptacle contents during normal conditions of handling and carriage. When the connection between the frame and the elements allows relative movement between the sub-assemblies, the equipment shall be so fastened as to permit such movement without damage to working parts. The manifolds, the discharge fittings (pipe sockets, shut-off devices), and the stop-valves shall be protected from being wrenched off by external forces. Manifold piping leading to shut-off valves shall be sufficiently flexible to protect the valves and the piping from shearing, or releasing the pressure receptacle contents. The filling and discharge devices (including flanges or threaded plugs) and any protective caps shall be capable of being secured against unintended opening.

**6.7.5.3.2** Each element intended for the carriage of toxic gases (gases of groups T, TF, TC, TO, TFC and TOC) shall be fitted with a valve. The manifold for liquefied toxic gases (gases of classification codes 2T, 2TF, 2TC, 2TO, 2TFC and 2TOC) shall be so designed that the elements can be filled separately and be kept isolated by a valve capable of being sealed. For the carriage of flammable gases (gases of group F), the elements shall be isolated by a valve into assemblies of not more than 3 000 litres.

**6.7.5.3.3** For filling and discharge openings of the MEGC, two valves in series shall be placed in an accessible position on each discharge and filling pipe. One of the valves may be a non-return valve. The filling and discharge devices may be fitted to a manifold. For sections of piping which can be closed at both ends and where a liquid product can be trapped, a pressure-relief valve shall be provided to prevent excessive pressure build-up. The main isolation valves on an MEGC shall be clearly marked to indicate their directions of closure. Each stop-valve or other means of closure shall be designed and constructed to withstand a pressure equal to or greater than 1.5 times the test pressure of the MEGC. All stop-valves with screwed spindles shall close by a clockwise motion of the handwheel. For other stop-valves, the position (open and closed) and direction of closure shall be clearly indicated. All stop-valves shall be designed and positioned to prevent unintentional opening. Ductile metals shall be used in the construction of valves or accessories.

**6.7.5.3.4** Piping shall be designed, constructed and installed so as to avoid damage due to expansion and contraction, mechanical shock and vibration. Joints in tubing shall be brazed or have an equally strong metal union. The melting point of brazing materials shall be no lower than 525 °C. The rated pressure of the service equipment and of the manifold shall be not less than two thirds of the test pressure of the elements.

### **6.7.5.4 Pressure-relief devices**

**6.7.5.4.1** **The elements of MEGCs used for the carriage of UN No. 1013 carbon dioxide and UN No. 1070 nitrous oxide shall be isolated by a valve into assemblies of not more than 3000 litres. Each assembly shall be fitted with one or more pressure relief devices.** MEGCs for other gases shall be fitted with pressure relief devices as specified by the competent authority for the country of use.

**6.7.5.4.2** When pressure relief devices are fitted, every element or group of elements of an MEGC that can be isolated shall then be fitted with one or more pressure relief devices. Pressure relief devices shall be of a type that will resist dynamic forces including liquid surge and shall be designed to prevent the entry of foreign matter, the leakage of gas and the development of any dangerous excess pressure.

- 6.7.5.4.3** MEGCs used for the carriage of certain non-refrigerated gases identified in portable tank instruction T50 in 4.2.5.2.6 may have a pressure-relief device as required by the competent authority of the country of use. Unless an MEGC in dedicated service is fitted with an approved pressure relief device constructed of materials compatible with the gas carried, such a device shall comprise a frangible disc preceding a spring-loaded device. The space between the frangible disc and the spring-loaded device may be equipped with a pressure gauge or a suitable telltale indicator. This arrangement permits the detection of disc rupture, pinholing or leakage which could cause a malfunction of the pressure relief device. The frangible disc shall rupture at a nominal pressure 10% above the start-to-discharge pressure of the spring-loaded device.
- 6.7.5.4.4** In the case of multi-purpose MEGCs used for the carriage of low-pressure liquefied gases, the pressure-relief devices shall open at a pressure as specified in 6.7.3.7.1 for the gas having the highest maximum allowable working pressure of the gases allowed to be carried in the MEGC.
- 6.7.5.5 Capacity of pressure relief devices**
- 6.7.5.5.1** The combined delivery capacity of the pressure relief devices when fitted shall be sufficient that, in the event of total fire engulfment of the MEGC, the pressure (including accumulation) inside the elements does not exceed 120% of the set pressure of the pressure relief device. The formula provided in CGA S-1.2-2003 "Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases" shall be used to determine the minimum total flow capacity for the system of pressure relief devices. CGA S-1.1-2003 "Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases" may be used to determine the relief capacity of individual elements. Spring-loaded pressure relief devices may be used to achieve the full relief capacity prescribed in the case of low pressure liquefied gases. In the case of multi-purpose MEGCs, the combined delivery capacity of the pressure-relief devices shall be taken for the gas which requires the highest delivery capacity of the gases allowed to be carried in the MEGC.
- 6.7.5.5.2** To determine the total required capacity of the pressure relief devices installed on the elements for the carriage of liquefied gases, the thermodynamic properties of the gas shall be considered (see, for example, CGA S-1.2-2003 "Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases" for low pressure liquefied gases and CGA S-1.1-2003 "Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases" for high pressure liquefied gases).
- 6.7.5.6 Marking of pressure-relief devices**
- 6.7.5.6.1** Pressure relief devices shall be clearly and permanently marked with the following:
- (a) the manufacturer's name and relevant catalogue number;
  - (b) the set pressure and/or the set temperature;
  - (c) the date of the last test.
- 6.7.5.6.2** The rated flow capacity marked on spring loaded pressure relief devices for low pressure liquefied gases shall be determined according to ISO 4126-1:1991.
- 6.7.5.7 Connections to pressure-relief devices**
- 6.7.5.7.1** Connections to pressure-relief devices shall be of sufficient size to enable the required discharge to pass unrestricted to the pressure relief device. No stop-valve shall be installed between the element and the pressure-relief devices, except when 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 capable of meeting the requirements of 6.7.5.5. There shall be no obstruction in an opening leading to or leaving from a vent or pressure-relief device which might restrict or cut-off the flow from the element to that device. The opening through all piping and fittings shall have at least the same flow area as the inlet of the pressure relief device to which it is connected. The nominal size of the discharge piping shall be at least as large as that of the pressure relief device outlet. Vents from the pressure-relief devices, when used, shall deliver the relieved vapour or liquid to the atmosphere in conditions of minimum back-pressure on the relieving device.
- 6.7.5.8 Siting of pressure-relief devices**
- 6.7.5.8.1** Each pressure relief device shall, under maximum filling conditions, be in communication with the vapour space of the elements for the carriage of liquefied gases. The devices, when fitted, shall be so arranged as to ensure that the escaping vapour is discharged upwards and unrestrictedly as to prevent any impingement of escaping gas or liquid upon the MEGC, its elements or personnel. For flammable, pyrophoric and oxidizing gases, the escaping gas shall be directed away from the element in such a manner that it cannot impinge upon the other elements. Heat resistant protective devices which deflect the flow of gas are permissible provided the required pressure relief device capacity is not reduced.
- 6.7.5.8.2** Arrangements shall be made to prevent access to the pressure-relief devices by unauthorized persons and to protect the devices from damage caused by the MEGC overturning.

### **6.7.5.9 Gauging devices**

**6.7.5.9.1** When an MEGC is intended to be filled by mass, it shall be equipped with one or more gauging devices. Level-gauges made of glass or other fragile material shall not be used.

### **6.7.5.10 MEGC supports, frameworks, lifting and tie-down attachments**

**6.7.5.10.1** MEGCs shall be designed and constructed with a support structure to provide a secure base during carriage. The forces specified in 6.7.5.2.8 and the safety factor specified in 6.7.5.2.10 shall be considered in this aspect of the design. Skids, frameworks, cradles or other similar structures are acceptable.

**6.7.5.10.2** The combined stresses caused by element mountings (e.g. cradles, frameworks, etc.) and MEGC lifting and tie-down attachments shall not cause excessive stress in any element. Permanent lifting and tie-down attachments shall be fitted to all MEGCs. In no case shall mountings or attachments be welded onto the elements.

**6.7.5.10.3** In the design of supports and frameworks, the effects of environmental corrosion shall be taken into account.

**6.7.5.10.4** When MEGCs are not protected during carriage, according to 4.2.5.3, the elements and service equipment shall be protected against damage resulting from lateral or longitudinal impact or overturning. External fittings shall be protected so as to preclude the release of the elements' contents upon impact or overturning of the MEGC on its fittings. Particular attention shall be paid to the protection of the manifold. Examples of protection include:

- (a) protection against lateral impact which may consist of longitudinal bars;
- (b) protection against overturning which may consist of reinforcement rings or bars fixed across the frame;
- (c) protection against rear impact which may consist of a bumper or frame;
- (d) protection of the elements and service equipment against damage from impact or overturning by use of an ISO frame in accordance with the relevant provisions of ISO 1496-3:1995.

### **6.7.5.11 Design approval**

**6.7.5.11.1** The competent authority or its authorized body shall issue a design approval certificate for any new design of an MEGC. This certificate shall attest that the MEGC has been surveyed by that authority, is suitable for its intended purpose and meets the requirements of this Chapter, the applicable provisions for gases of Chapter 4.1 and of packing instruction P200. When a series of MEGCs are manufactured without change in the design, the certificate shall be valid for the entire series. The certificate shall refer to the prototype test report, the materials of construction of the manifold, the standards to which the elements are made and an approval number. The approval number shall consist of the distinguishing sign or mark of the country granting the approval, i.e. the distinguishing sign for use in international traffic, as prescribed by the Convention on Road Traffic, Vienna 1968, and a registration number. Any alternative arrangements according to 6.7.1.2 shall be indicated on the certificate. A design approval may serve for the approval of smaller MEGCs made of materials of the same type and thickness, by the same fabrication techniques and with identical supports, equivalent closures and other appurtenances.

**6.7.5.11.2** The prototype test report for the design approval shall include at least the following:

- (a) the results of the applicable framework test specified in ISO1496-3:1995;
- (b) the results of the initial inspection and test specified in 6.7.5.12.3;
- (c) the results of the impact test specified in 6.7.5.12.1; and
- (d) certification documents verifying that the cylinders and tubes comply with the applicable standards.

### **6.7.5.12 Inspection and testing**

**6.7.5.12.1** MEGCs meeting the definition of container in the International Convention for Safe Containers (CSC), 1972, as amended, shall not be used unless they are successfully qualified by subjecting a representative prototype of each design to the Dynamic, Longitudinal Impact Test prescribed in the Manual of Tests and Criteria, Part IV, Section 41.

**6.7.5.12.2** The elements and items of equipment of each MEGC shall be inspected and tested before being put into service for the first time (initial inspection and test). Thereafter, MEGCs shall be inspected at no more than five-year intervals (5 year periodic inspection). An exceptional inspection and test shall be performed, regardless of the last periodic inspection and test, when necessary according to 6.7.5.12.5.

- 6.7.5.12.3** The initial inspection and test of an MEGC shall include a check of the design characteristics, an external examination of the MEGC and its fittings with due regard to the gases to be carried, and a pressure test performed at the test pressures according to packing instruction P200 of 4.1.4.1. The pressure test of the manifold 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 MEGC is placed into service, a leakproofness test and a test of the satisfactory operation of all service equipment shall also be performed. When the elements and their fittings have been pressure-tested separately, they shall be subjected together after assembly to a leakproofness test.
- 6.7.5.12.4** The 5-year periodic inspection and test shall include an external examination of the structure, the elements and the service equipment in accordance with 6.7.5.12.6. The elements and the piping shall be tested at the periodicity specified in packing instruction P200 and in accordance with the provisions described in 6.2.1.6. When the elements and equipment have been pressure-tested separately, they shall be subjected together after assembly to a leakproofness test.
- 6.7.5.12.5** An exceptional inspection and test is necessary when the MEGC shows evidence of damaged or corroded areas, leakage, or other conditions that indicate a deficiency that could affect the integrity of the MEGC. The extent of the exceptional inspection and test shall depend on the amount of damage or deterioration of the MEGC. It shall include at least the examinations required under 6.7.5.12.6.
- 6.7.5.12.6** The examinations shall ensure that:
- (a) the elements are inspected externally for pitting, corrosion, abrasions, dents, distortions, defects in welds or any other conditions, including leakage, that might render the MEGC unsafe for carriage;
  - (b) the piping, valves, and gaskets are inspected for corroded areas, defects, and other conditions, including leakage, that might render the MEGC unsafe for filling, discharge or carriage;
  - (c) missing or loose bolts or nuts on any flanged connection or blank flange are replaced or tightened;
  - (d) 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 shall be operated to demonstrate proper operation;
  - (e) required markings on the MEGC are legible and in accordance with the applicable requirements; and
  - (f) the framework, the supports and the arrangements for lifting the MEGC are in satisfactory condition.
- 6.7.5.12.7** The inspections and tests in 6.7.5.12.1, 6.7.5.12.3, 6.7.5.12.4 and 6.7.5.12.5 shall be performed or witnessed by a body authorized by the competent authority. When the pressure test is a part of the inspection and test, the test pressure shall be the one indicated on the data plate of the MEGC. While under pressure, the MEGC shall be inspected for any leaks in the elements, piping or equipment.
- 6.7.5.12.8** When evidence of any unsafe condition is discovered, the MEGC shall not be returned to service until it has been corrected and the applicable tests and verifications are passed.

**6.7.5.13 Marking**

- 6.7.5.13.1** Every MEGC shall be fitted with a corrosion resistant metal plate permanently attached to the MEGC in a conspicuous place readily accessible for inspection. The elements shall be marked in accordance with Chapter 6.2. At least the following information shall be marked on the plate by stamping or by any other similar method:

Country of manufacture

U	Approval	Approval	For Alternative Arrangements (see 6.7.1.2)
N	country	number	

Manufacturer's name or mark

Manufacturer's serial number

Authorized body for the design approval

Owner's registration number

Year of manufacture

Test pressure: \_\_\_\_\_ bar gauge

Design temperature range \_\_\_\_\_ °C to \_\_\_\_\_ °C

Number of elements \_\_\_\_\_

Total water capacity \_\_\_\_\_ litres

Initial pressure test date and identification of the authorized body

Date and type of most recent periodic tests

Month \_\_\_\_\_ Year \_\_\_\_\_

Stamp of the authorized body which performed or witnessed the most recent test

**NOTE:** No metal plate may be fixed to the elements.

**6.7.5.13.2** The following information shall be marked on a metal plate firmly secured to the MEGC:

Name of the operator

Maximum permissible load mass \_\_\_\_\_ kg

Working pressure at 15 °C: \_\_\_\_\_ bar gauge

Maximum permissible gross mass (MPGM) \_\_\_\_\_ kg

Unladen (tare) mass \_\_\_\_\_ kg