United Nations ST/SG/AC.10/C.3/2022/62

Secretariat

Distr.: General
6 September 2022

Original: English

Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

Sub-Committee of Experts on the Transport of Dangerous Goods

Sixty-first session
Geneva, 28 November-6 December 2022
Item 6 (c) of the provisional agenda
Miscellaneous proposals for amendments to the Model Regulations on the Transport of Dangerous Goods: portable tanks

Sub-chapter 6.9.3 "Requirements for design, construction, inspection and testing of fibre reinforced plastic (FRP) service equipment for portables tanks" and amendments to Sub-chapter 6.9.1

Transmitted by the Chair of the informal working group for fibre reinforced plastic (FRP) service equipment for portables tanks*

Introduction

1. The informal working group was established to develop provisions for FRP service equipment for portable tanks as proposed in document ST/SG/AC.10/C.3/2021/8. The proposal was based on the comprehensive experimental study presented in informal document INF.3 (fifty-eighth session). Since the establishment of the informal working group the group has met in 2021-2022 in conjunction with each Sub-Committee session and hosted several conference calls and numerous exchanges by e-mail correspondence.

Background

2. The Sub-Committee is invited to note that the informal working group on FRP service equipment for portable tanks has finalized in general the baseline document earlier reported in informal document INF.39 (sixtieth session).

3. The Sub-Committee is also invited to note that the working group on FRP service equipment for portable tanks will be meeting in parallel to the plenary session of the Sub-Committee (sixty-first session) to continue work on developing requirements for FRP service equipment for portable tanks.

4. The work to be discussed during this working group meeting will continue based on progress made by teleconferences and correspondence prior to the meeting but will also be influenced by the Sub-Committee comments received on the draft regulatory provisions for

* A/75/6 (Sect.20), para. 20.51

FRP service equipment for portable tanks provided in the annex to this document. It is expected that the informal working group will focus on remaining issues and those identified by the Sub-Committee for further work.

5. The annex contains the draft regulatory text for provisions on FRP service equipment for portable tanks as amendments to existing chapter of the Model Regulations.

6. The informal working group will report on its work to the sixty-first plenary session of the Sub-Committee through an informal document that also solicits comments on the group's outcomes.

7. Delegates interested in participating in the next meeting of the informal working group are invited to contact the chair of the informal working group (i.sergeichev@skoltech.ru).

Actions requested

8. The Sub-Committee is invited to consider the draft regulatory text given in the annex for adoption.

9. The informal working group suggests having a one-day hybrid session running concurrently with the forthcoming sixty-first session of the Sub-Committee.

Annex

Amendments to Chapter 6.9

In 6.9.1 amend 6.9.1.4 and add 6.9.1.5 to read as follows:

"6.9.1.4 The requirements of section 6.9.3 are applied to FRP service equipment for portable tanks with shells made of metallic or FRP materials intended for the carriage of dangerous goods of Classes or Divisions 1, 3, 5.1, 6.1, 6.2, 8 and 9 by all modes of transport.

6.9.1.5 The requirements of 6.7.2.5 to 6.7.2.9, 6.7.2.11 to 6.7.2.16 shall be applied to FRP service equipment including metallic parts (springs, fixings, etc.)."

Add 6.9.3 to read as follows:

"6.9.3 Requirements for design, construction, inspection and testing of fibre reinforced plastic (FRP) service equipment for portables tanks

6.9.3.1 ***Definitions***

For the purposes of this section, the definitions of 6.7.2.1 and 6.9.2.1 are applied excepting for definitions related to metal materials for the construction of the service equipment of portable tanks.

Additionally, the following definitions are applied to FRP service equipment.

FRP service equipment means, stop valves, relief devices, manlids, manhole covers, cleaning hatches and blind flanges made of FRP including metallic parts, e.g. springs, fixings for portable tanks.

Injection molding means a process of melting plastic pellets (thermosetting/ thermoplastic polymers) that once malleable enough, are injected at pressure into a mould cavity, which fills and solidifies to produce the final product.

Compression molding means a process for producing composite parts in a wide range of volumes typically employing a matched metal tool in a heated (normally hydraulic) press to consolidate sheet materials or moulding compounds at relatively high pressures.

Reinforced reaction injection molding (RRIM) means a process of mixing of two or more resins together in the mixing chamber to form a thermosetting polymer under high pressure. Reinforcement agents like glass fibres or mica are added to the mixture. Then the resin mixture is metered into a mold with the help of high pressure pumps or injection cylinders.

Coupon-sample means a FRP sample fabricated and tested in accordance with national and / or international standards to determine design allowables. Coupon-samples are manufactured by the same technology as the appropriate FRP service equipment.

Inspection-sample means a sample cut out from the FRP service equipment to establish the identity of serial FRP device to the prototype.

FRP constituents means reinforcement fibres and/or particles, thermoset or thermoplastic polymer (matrix), adhesives, and additives.

6.9.3.2 ***General design and construction requirements***

6.9.3.2.1 For the purposes of this section, the requirements of 6.7.2.2.11, 6.7.2.5.1, 6.7.2.5.6, 6.7.2.5.10, 6.7.2.6.3, 6.7.2.8.2, 6.7.2.8.3, 6.7.2.9, 6.7.2.12, 6.7.2.13, 6.7.2.14 and 6.7.2.15 shall be applied to FRP service equipment. The FRP service equipment shall be designed and constructed in accordance with the requirements of a pressure vessel code and national and international standards, applicable to FRP materials and recognized by the competent authority.

6.9.3.2.2 *Manufacturer's quality system*

6.9.3.2.2.1 FRP service equipment manufacturer shall have a documented quality system ensuring conformity of every item of the serial production the FRP service equipment to the approved prototype. The Quality Assurance Program shall be submitted to the competent

authority for approval. All manufacturer's suppliers of material and components for FRP service equipment should have a documented quality system. The quality system should be developed in compliance with the general principles of international and national quality standards.

6.9.3.2.3 *FRP service equipment*

6.9.3.2.3.1 FRP service equipment shall have a rigid appropriate joint to the portable tank shell. The connections shall cause no dangerous local stress concentrations in the shell and the equipment exceeding the design allowables for all operating and test conditions.

6.9.3.2.3.2 FRP service equipment shall be made of suitable materials, capable of operating within a minimum design temperature range of -40 °C to +50 °C, unless temperature ranges are specified for specific more severe climatic or operating conditions (e.g. heating elements), by the competent authority of the country where the transport operation is being performed.

6.9.3.2.3.3 FRP service equipment and its bolted and/or glued joints of the portable tank shell shall be designed and constructed to withstand the test pressure which is not less than 1.5 times the design pressure. Specific provisions are stated for certain substances in the applicable portable tank instruction indicated in column 13 of the Dangerous Goods List and described in 4.2.5, or by the portable tank special provision indicated in column 14 of the Dangerous Goods List and described in 4.2.5.3.

6.9.3.2.3.4 The FRP service equipment shall withstand vibration, service impacts, exposure to substance temperature and environment effects.

6.9.3.2.3.5 Design calculations for FRP service equipment and its joints to the portable tank shell shall be performed by finite element method or the applicable pressure vessel code.

6.9.3.2.3.6 The FRP service equipment shall meet the same requirements as given in 6.9.2.2.3.14 for the carriage of substances with a flash-point of not more than 60 °C.

6.9.3.2.4 *Materials*

6.9.3.2.4.1 Resins

The processing of the resin mixture shall be carried out in strict compliance with the recommendations of the supplier. This concerns mainly the use of hardeners, initiators and accelerators. The resins can be:

- Unsaturated polyester resins;
- Vinyl ester resins;
- Epoxy resins;
- Phenolic resins;
- Thermoplastic resins.

The heat distortion temperature (HDT) of the resin, determined in accordance with ISO 75-1:2013 and ISO 75-2:2013 shall be at least 20 °C higher than the maximum service temperature of the tank, but shall in any case not be lower than 70 °C**.**

6.9.3.2.4.2 Additives

Additives necessary for the treatment of the resin, such as catalysts, accelerators, hardeners and thixotropic substances as well as materials used to improve the tank, such as fillers, colors, pigments etc. shall not cause weakening of the material, taking into account lifetime and temperature expectancy of the design.

6.9.3.2.4.3 Reinforcement fibres

The reinforcement fibres shall be short-chopped or continuous fibres of several types.

6.9.3.2.4.4 FRP service equipment shall be manufactured by compression molding, injection molding, reinforced reaction injection molding or hand lay-up. Other manufacturing technologies may be applied with the agreement of the competent authority.

6.9.3.3 Design criteria

6.9.3.3.1 FRP service equipment shall be of a design capable of being stress-analyzed mathematically and or experimentally by resistance strain gauges, or by other methods approved by the competent authority.

6.9.3.3.2 FRP service equipment shall be designed and manufactured to withstand the test pressure specified in 6.7.2.5.6 and 6.9.3.2.3.3.

6.9.3.3.3 At the specified test pressure the maximum tensile relative deformation measured in mm/mm in the FRP service equipment shall not result in the formation of microcracks, and therefore not be greater than the first measured point of elongation based fracture or damage of the resin, measured during tensile tests prescribed under 6.9.2.7.1.2 (c) and 6.9.3.4.1.1.

6.9.3.3.4 For internal test pressure specified in 6.9.3.2.3.3 failure criteria (FC) shall not exceed the following value:

$$FC \leq \frac{1}{K}$$

where:

$$K = K_0 \times K_1 \times K_2 \times K_3 \times K_4 \times K_5$$

where:

K	shall have a minimum value of 4.
$\boldsymbol{K_0, K_1, K_2, K_3, K_4}$	are given in 6.9.2.3.4.
$\boldsymbol{K_5}$	a factor related to the deterioration in the material properties due to effects of exposure of salt fog and ultraviolet.

$$K_5 = \frac{\sigma_n}{\sigma_{eff}},$$

where σ_n is the nominal (under normal conditions) tensile strength of the FRP material and σ_{eff} is the material tensile strength after consecutive salt fog exposure in accordance with ISO 12944-2, ISO 12944-6, 168 hours at +(35±2) °C and ultraviolet exposure in accordance with ISO 4892-2, 168 hours at +(23±2) °C.

σ_{eff} = min($\sigma_{eff}{}^1$, $\sigma_{eff}{}^2$ . . . . $\sigma_{eff}{}^k$), where *1,2….k* – identifiers of substances approved for transportation by the given portable tank. If protective coating is used the samples with the coating shall be fabricate and tested.

A design validation exercise using numerical analysis and a suitable composite failure criteria is to be undertaken to verify that the FRP service equipment are below the allowables. Suitable composite failure criteria include, but are not limited to Strain Invariant Failure Theory, Maximum Strain, or Maximum Stress. Other relations for the strength criteria are allowed upon agreement with the competent authority. The method and results of this design validation exercise are to be submitted to the competent authority.

The allowables are to be determined using experiments to derive parameters required by the chosen failure criteria combined with factor of safety *K*, the strength values measured according to ISO 527-4:1997 and the maximum strain in tension criteria prescribed in 6.9.2.3.5.

6.9.3.3.5 Check calculations of the strength for FRP service equipment and its joints to the portable tank shell shall be performed by finite element method. Treatment of singularities shall be undertaken using an appropriate method according to the applicable pressure vessel code.

6.9.3.4 Material testing

6.9.3.4.1 *Resins*

6.9.3.4.1.1 Resin tensile elongation according to ISO 527-2.

6.9.3.4.1.2 Heat distortion temperature according to ISO 75-1:2013 and ISO 75-2:2013.

6.9.3.4.2 *Coupon-samples*

6.9.3.4.2.1 Ultimate tensile strength and elongation according to ISO 527-4.

6.9.3.4.2.2 Flexural strength according to ISO 14125:1998.

6.9.3.4.2.3 Bearing test according to ISO 12815:2013.

6.9.3.4.2.4 Mass density according to ISO 1183–1.

6.9.3.4.2.5 Mass content and composition of the reinforcement fibres according to ISO 1172. The fibre mass content of the coupon-samples shall be between 90 % and 100 % of the minimum fibre mass content specified for the appropriate FRP service equipment and obtained from testing of the inspection-samples.

6.9.3.4.2.6 The chemical compatibility with the transported substances according to 6.9.2.7.1.3.

6.9.3.4.2.7 Hardness according to ISO 868:2003.

6.9.3.4.2.8 Heat distortion temperature according to ISO 75-1:2013 and ISO 75-2:2013.

6.9.3.4.2.9 Creep factor α according to procedure prescribed by 6.9.2.7.1.2 (e). The test samples shall be taken according to ISO 14125:1998.

6.9.3.4.2.10 Aging factor β according to procedure prescribed by 6.9.2.7.1.2 (f). The test samples shall be taken according to ISO 14125:1998.

6.9.3.4.2.11 The additional material tests shall be carried out for determination of material properties required for design calculation.

6.9.3.4.3 *Inspection-samples*

Prior to testing all coatings shall be removed from the samples. The tests shall cover 6.9.3.4.2.1 to 6.9.3.4.2.8.

6.9.3.5 Design approval

6.9.3.5.1 The competent authority or its authorized body shall issue the type approval certificate for FRP service equipment prototype. This certificate shall attest that the prototype has been surveyed by the authority and is suitable for its intended purpose and meets the requirements of this chapter.

The certificate shall have the reference that prototype testing was carried out according to 6.9.3.5.2, the information on the substances allowed for transportation, body and seal materials and certificate number.

6.9.3.5.2 The FRP service equipment prototype test report shall include at least the following:

(a) Results of the material tests used for fabrication of FRP service equipment in accordance with 6.9.3.4.1 to 6.9.3.4.3.

(b) Results of tests according to ISO 4126-1:2013 for the appropriate relief devices.

(c) Results of the pressure tests according to procedure approved by the competent authority. The test pressure shall be not less than the highest of four times the -maximum allowable working pressure (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).

(d) Results the fire resistance test according to ISO 21843:2018.

(e) Results of the electrical resistance tests according to procedure recognized by the component authority.

(f) Results of the other tests prescribed by the competent authority.

6.9.3.5.3 A service life inspection program shall be established, which shall be a part of the operation manual, to monitor the condition of the FRP service equipment at periodic inspections. The service life inspection program shall be approved by the competent authority.

6.9.3.6 Inspection and testing

6.9.3.6.1 FRP service equipment shall be inspected and tested before being put into the service. The initial inspection and test after manufacture shall include a check of the design characteristics and an external examination of FRP service equipment with due regard to the substances to be transported, and a pressure test. Before put the FRP service equipment into service, a leakproofness test and a test of the satisfactory operation shall also be performed. Relief valves should be tested for opening/closing pressure before installation. The initial inspection and testing program shall be approved by the competent authority.

6.9.3.6.2 Periodical inspection and testing of FRP service equipment shall be carried out during inspection of the portable tank according to provisions of 6.7.2.19.2, 6.7.2.19.4 and 6.7.2.19.5 according to the service life inspection program approved by the competent authority.

6.9.3.6.3 The exceptional inspection and test are necessary when FRP service equipment shows evidence of damaged, or leakage, or other conditions that indicate a deficiency that could affect to the integrity of the FRP service equipment. The exceptional inspection shall include non-destructive testing by request of the competent authority.

6.9.3.6.4 The inspections and tests in 6.9.3.6.1 to 6.9.3.6.3 shall be performed or witnessed by an expert approved by the competent authority or its authorized body.

6.9.3.6.5 In all cases where repair work has been carried out on the FRP service equipment, that work shall be approved by the competent authority, taking into account the requirements of this chapter.

6.9.3.7 Marking

6.9.3.7.1 Marking of relief devices

Each relief device shall be marked as follows:

- name of the manufacturer and the serial number of the equipment;
- name of body and seal materials;
- type approval certificate number;
- the pressure at which the devise is set to discharge (MPa or bar);
- the allowable tolerance at the discharge pressure for spring-loaded devices;
- the rated flow capacity of spring-loaded pressure relief devices under normal conditions (external pressure is 1 bar and ambient temperature is 0 °C) in standard;
- (normal) cubic meters of air per second, nm^3/s (determined according to ISO 4126-7:2013);
- cross-sectional area of spring-loaded pressure relief devices, mm^2;
- maximum allowable working pressure (MAWP);
- design temperature range.

6.9.3.7.2 *Marking of stop valves*

Each stop valves shall be marked as follows:

- name of the manufacturer and the serial number of the equipment;
- name of body and seal materials;
- type approval certificate number;
- designation of the stop device;
- nominal diameter, mm;
- maximum allowable working pressure (MAWP);
- direction of medium flow;
- design temperature range.

6.9.3.7.3 *Marking of manlids and manhole covers*

Each manlid and manhole cover shall be marked as follows:

- name of the manufacturer and the serial number of the equipment;
- type approval certificate number;
- name of body and seal materials;
- nominal diameter, mm;
- maximum allowable working pressure (MAWP);
- design temperature range.”