



**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****Fifty-eighth session**

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Item 6 (c) of the provisional agenda

**Miscellaneous proposals for amendments to the Model Regulations
on the Transport of Dangerous Goods: portable tanks****Resilience of fibre-reinforced plastics (FRP) portable tanks****Transmitted by the expert from the United Kingdom******Summary**

1. Subsequent to the outcome of the fifty-seventh session of the Sub-Committee of Experts on the Transport of Dangerous Goods from 30 November to 8 December 2020, the United Kingdom remains concerned that in the twenty-second edition of the UN Model Regulations the new provisions in Chapter 6.9 on fibre-reinforced plastics (FRP) portable tanks do not require the resilience of such tanks to accidental and in-service damage in likely impact situations to be equivalent to (namely, the same as, or better than) that of conventional metallic portable tanks. The United Kingdom proposes that if there are others of a similar opinion then those who are interested should develop proposals for the fifty-ninth session.

Background

2. Although a decision by the Sub-Committee of Experts on the Transport of Dangerous Goods was taken at the fifty-seventh session from 30 November to 8 December 2020 to adopt the new provisions on FRP portable tanks to Chapter 6.9 for inclusion into the twenty-second edition of the UN Model Regulations, the United Kingdom remains concerned that contrary to the principal of equivalence in paragraphs 6.7.2.4.2 and 6.7.2.4.3 of the Model Regulations the resilience of FRP portable tanks to accidental and in-service damage in likely impact situations is not required to be the same as, or better than, that of conventional metallic portable tanks.

3. During discussions in the meetings of the informal working group on FRP portable tanks, the United Kingdom asked if, in the absence of such a requirement in the proposals, the group could be provided with any results from suitable physical or virtual tests which

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

** This document was scheduled for publication after the standard publication date owing to circumstances beyond the submitter's control.

could be used to benchmark and validate the provisions to demonstrate the resilience of FRP portable tanks. Unfortunately, no such results were provided, although as in the fifty-seventh session of the Sub-Committee of Experts on the Transport of Dangerous Goods and in the spring 2021 session of the Joint Meeting of the RID Committee of Experts and the Working Party on the Transport of Dangerous Goods at which similar concerns were raised in an informal document from the European Commission and the International Tank Container Organisation (ITCO), several experts supported the new provisions based on experience and were confident that the requirements would ensure that FRP portable tanks would be sufficiently strong and perform better than conventional metallic portable tanks.

4. Nevertheless, given the importance of these new provisions, and the potential consequences if expectations are not fulfilled, the United Kingdom continues to believe that for the provisions to be considered, with sufficient confidence, to be fit for purpose and suitable for the various modes, further work should be done in good time before the requirements enter into force to be certain that FRP portable tanks are designed and constructed such that in likely impact situations the level of safety provided is equivalent to (namely, the same as, or better than) that of conventional metallic portable tanks.

5. During this time the United Kingdom further believes that other aspects should also be considered such as product compatibility and fire resistance, and for reference has reproduced in full in the annex to this document the comments put by the United Kingdom to the informal working group on FRP portable tanks for which there was not sufficient time available for discussion before the proposal was submitted for a decision.

Proposal

6. If other experts are also of the opinion that the principal of equivalence in paragraphs 6.7.2.4.2 and 6.7.2.4.3 of the Model Regulations should apply to FRP portable tanks to ensure the level of safety provided is equivalent to (namely, the same as, or better than) that of conventional metallic portable tanks, then the United Kingdom would propose that those who are interested develop proposals for consideration at the fifty-ninth session of the Sub-Committee of Experts on the Transport of Dangerous Goods.

Annex

Comments on proposals for fibre-reinforced plastics (FRP) portable tanks

In addition to the informal documents and comments already provided, the United Kingdom would also like to offer the following comments on the proposals for FRP portable tanks in UN/SCETDG/57/INF.43 (some paragraphs were renumbered according to the twenty-second edition of the UN Model Regulations).

6.9.1.1

It is proposed that FRP tanks should be allowed for the transport of substances of Class 5.1, but such tanks are thought to be unsuitable for dangerous goods of UN 2014, 2015 and 2984.

6.9.2.1

“*FRP shell* means a closed part of cylindrical shape with an interior volume intended for storage and transport of chemical substances”

If the definition of shell in 6.7.2.1, or a version of the definition of shell in 6.7.2.1, is not used, to avoid conflict with the regulations to control major accident hazards, the word “storage” should be removed or clarified as follows:

“*FRP shell* means a closed part of cylindrical shape with an interior volume intended for ~~storage and~~ transport of chemical substances”

or

“*FRP shell* means a closed part of cylindrical shape with an interior volume intended for **temporary storage in transit** and transport of chemical substances”

6.9.2.1

“*FRP tank* means a tank constructed with a FRP shell, and heads, with service equipment, safety relief devices and other installed equipment”

If the definition of tank in 1.2.1, or a version of the definition of tank in 1.2.1, is not used, it is not clear if it is only the shell that may be constructed in FRP and all else using metallic materials.

6.9.2.1

“*Liner* means a layer on the inner surface of an FRP shell preventing contact with the dangerous goods being transported”

As “lining” seems to be the standard term, it is suggested that “liner” is replaced with “lining” in this definition and elsewhere, as necessary.

6.9.2.1

“*Parallel shell-sample* means an FRP specimen, which must be representative of the tank shell, constructed in parallel to the shell construction if it is not possible to use cut-outs from the shell itself. The parallel shell-sample may be flat or curved.”

There is a typo in this definition – the full stop between “shell” and “constructed” should be replaced with a comma.*

6.9.2.2.3

“**The** FRP shell shall have a secure connection with structural elements of the portable tank frame. FRP shell supports and attachments to the frame ~~shell~~ shall cause no local stress concentrations exceeding the **allowable** design ~~allowables~~ **stresses** of the shell structure in accordance with the provisions stated in this Chapter for all operating and test conditions.”

* *Note by the secretariat:* this editorial correction was already done in the twenty-second edition of the UN Model Regulations.

The modification above of the text is suggested to ease the translation into other languages.

6.9.2.2.3.2

“Shells 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.”

A modification of the text would be beneficial – the current wording is somewhat clumsy. It should be made clear that the material shall be suitable with respect to both ambient temperatures and the temperature(s) of the cargo(s) to be transported.

6.9.2.2.3.4

“Shells shall consist of the following ~~functions~~ **elements**:

- Liner;
- Structural layer;
- External layer.

Note: The layers may be combined if all applicable functional criteria are met.”

Again, the above modification of the text would be beneficial – it is doubtful that the word “functions” will properly be translated into other languages – and it is suggested that the word “elements” be considered.

6.9.2.2.3.5

“The internal liner is the inner element of the shell designed as the primary barrier to provide for the long-term chemical resistance in relation to the substances to be carried, to prevent any dangerous reaction with the contents or the formation of dangerous compounds and any substantial weakening of the structural layer owing to the diffusion of products through the internal liner. Chemical compatibility shall be verified in accordance with 6.9.2.7.1.3~~6.9.2.7.2.1.4~~.”

The internal liner may be an FRP liner or a thermoplastic liner, ~~or a metallic liner.~~”

The first sentence is long, unlikely to be translatable into other languages, and so should be recast / restructured (taking apart and putting back together to improve the wording). The removal of a metallic liner and related requirements from **6.9.2.2.9** may be troubling.

6.9.2.2.3.6

“FRP liners shall consist of the following two components:

- (a) Surface layer ("gel-coat"): adequate resin rich surface layer, reinforced with a **veil**, compatible with the resin and contents. This layer shall have a maximum fibre mass content of 30 % and have a minimum thickness of 0.25 and a maximum thickness of 0.60 mm;
- (b) Strengthening layer(s): layer or several layers with a minimum thickness of 2 mm, containing a minimum of 900 g/m² of glass mat or chopped fibres with a mass content in glass of not less than 30 % unless equivalent safety is demonstrated for a lower glass content.”

The term “veil” should be defined, or a more appropriate word used so as to better translate into other languages.

6.9.2.2.3.7

“If the liner consists of thermoplastic sheets, they shall be welded together in the required shape, using a qualified welding procedure and personnel. ~~Furthermore, and the~~ welded liners shall have a layer of electrically conductive media placed against the non-liquid contact surface of the welds to facilitate spark testing. Durable bonding between liners and the structural layer shall be achieved by the use of an appropriate method.”

The word “furthermore” may create translation differences.

[6.9.2.2.9

“Metal liners consist of a layer of metal in order to improve the chemical, thermo-mechanical, electrical characteristics to the FRP tank. The liner shall be manufactured by **experienced metal workshops** and made of **metallic** materials suitable for forming. The materials shall in principle conform to national or international material standards. For welded liners only a material whose weldability has been fully demonstrated shall be used. When the manufacturing process or the materials make it necessary, the liners 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/mm² and the guaranteed value of the upper limit of the tensile strength shall be not more than 725 N/mm² according to the material specification. layer shall be achieved by using of an appropriate method.”

If the requirements in 6.9.2.2.9 are reintroduced, the term “experienced metal workshops” should either be defined or some other form of wording be used as in 6.8.2.1.23. It has been suggested that fine grain steels should not be allowed to be used for linings as there are doubts that they could be used and fit for this purpose. There is also a typo – the full stop between “specification” and “layer”.

In addition, something should then also be said about the thermal expansion characteristics of metal liners – in parallel to 6.7.2.2.4 for metal portable tanks – homogenous, non-porous, suitable for the design temperature range, particularly if the thermal expansion characteristics of the FRP may differ. A wording such as the following is therefore suggested: “The expansion rate of the metal liner shall be such that it will not induce stress in the FRP material”.

It also says in **6.9.2.2.9** that “The **stresses in the** complete structure comprising the load-sharing liner and the structural layer shall be calculated by **finite element calculations**. The metal part shall not exceed the values specified in 6.7.2.3.3”

What in the complete structure shall be calculated by finite element calculations? Although “finite element calculations” is not a term used in Chapter 6.7 even though most metal portable tank manufactures use such techniques in their design calculations – thus this term should be defined. More importantly, different software of differing quality and therefore differing output is possible and subject to the caliber of the analyst, so something more needs to be said about the use of the finite element method (such as in Annex A.3 of EN 13094).

It also says in **6.9.2.2.9** that “The thermomechanical behavior of the combined metallic and FRP material shall be ~~characterized~~ **assessed** by thermal and mechanical tests to guarantee the bonding.”

The word “characterized” is unclear and difficult to translate into other languages.

NOTE: Comment on 6.9.2.2.9 is no longer relevant as this paragraph was deleted with consequential changes in paragraph numbers.]

6.9.2.2.3.9

“The external layer of resin or paint shall provide adequate protection of the structural layers of the tank from environmental and service exposure, including to UV radiation and **salt fog**, and occasional **splash exposure** to cargoes.”

This paragraph may need to be recast if it is to translate into other languages, and if retained the terms “salt fog” and “splash exposure” defined.

6.9.2.2.3.11

“The reinforcement material of the structural layers shall be selected such that they meet the requirements of the structural layer.

For the internal surface liner glass fibres of at a minimum type C or ECR according to ISO 2078:1993 + Amendment 1:2015 shall be used. Thermoplastic **veils** may only be used for the internal liner when their compatibility with the intended contents has been demonstrated.”

The term “veil” should be defined or a more appropriate word used so as to better translate into other languages.

6.9.2.2.3.14

“Special requirements for the carriage of substances with a flash-point of not more than 60 °C.”

6.9.2.2.3.14.1

“FRP tanks used for the carriage of flammable liquids of Class 3 with a flash-point of not more than 60 °C shall be constructed so as to ensure the elimination of static electricity from the various component parts so as to avoid the accumulation of dangerous charges.”

The text would be better stated as in 6.7.2.2.3.14 to ensure that it also covers substances where the flammable liquid danger is the subsidiary hazard and also to cover substances with higher flashpoint temperatures transported at or above their flashpoint temperature, i.e. UN 3256.

The alternative below based on 6.7.2.2.3.14.1 is suggested:

“FRP tanks shall be capable of being electrically earthed when intended for the transport of substances meeting the flashpoint criteria of Class 3 including elevated-temperature substances transported at or above their flashpoint temperature. Measures shall be taken to prevent dangerous electrostatic discharge.”

6.9.2.2.3.14.2, 6.9.2.2.3.14.3, 6.9.2.2.3.14.4 and 6.9.2.2.3.14.5

Consideration should be given to including these paragraphs in Chapter 6.7, although if a suitable standard exists a reference is needed to an acceptable test method including for measuring methodology, and for both metallic and FRP tanks a requirement should be inserted to ensure that the earthing circuit works both when new and at intermediate periodic and periodic inspections.

6.9.2.2.3.15

“The tank shall be designed to withstand, without significant leakage, the effects of a full engulfment in fire for **30 minutes** as specified by the test requirements in 6.9.2.7.1.5. Testing may be waived with the agreement of the competent authority, where sufficient proof can be provided by tests with comparable tank designs.”

In light of the Tianjin fire and the position of such tanks during carriage consideration should be given as to whether the proposed limit of 30 minutes should be increased significantly.

6.9.2.3.2

“FRP shells shall be designed and constructed to withstand the test pressure. Specific provisions ...”

This is true up to a point but looking at the definitions of design pressure and maximum allowable working pressure in 6.7.2.1, there are other variables which can dictate the test pressure than just the minimum requirements expressed through the T-code. If for any reason a pressure higher than the test pressure derived from the T-code is to be used in loading and discharge, this would have an overriding effect on the required test pressure. Similarly, e.g. for substances transported under collective entries (such as the commonly used UN 1993 FLAMMABLE LIQUID, N.O.S. and others) if the vapour pressure of substances carried under these collective entries is high, then a higher test pressure than derived from the T-code would be needed. These situations are seemingly not fully reflected in the opening sentence of the paragraph.

6.9.2.3.7

The text “adhesive bondlines and/or overlay laminates” is used. There seems to be sufficient indication in earlier text as to what is meant by the word “laminates” but this appears to be the first time the term “bondlines” appears. Both terms, especially “bondlines”, seem to need to be defined and/or changed to text that can better translate into other languages.

6.9.2.4.2

“Minimum thickness of the FRP shell structural layers shall be determined in accordance with 6.9.2.3.4, however, in any case the minimum thickness of the structural layers shall be at least 3 mm.”

A minimum thickness of 3 mm seems insufficient – perhaps 5 mm for shell diameters up to 1.8 m and 6 mm for diameters over 1.8 metres to maintain parity with metallic portable tanks? More importantly what should be said about the thickness for T-codes.

There seems to be no equivalent to reference steel thickness. For very dangerous products, in steel tanks, there are categories of T19, T20 and T22. These have the same pressure requirements, the same requirements for top discharge and the same requirement for hermetic sealing, but a T19 requires equivalent to 6 mm reference steel, a T20 requires equivalent to 8 mm reference steel and a T22 requires equivalent to 10 mm reference steel. For all T-codes for FRP tanks, the requirement seems to be the same as for the least dangerous T1 tank.

Without the equivalent to a reference steel calculation in the proposal, new and unproven technology is being permitted whilst omitting one of the key essential safety measures that had made the transport of metallic tanks safe.

[NOTE: Although the factor K_5 has been added to paragraph 6.9.2.3.4 to increase strength, this does not necessarily ensure adequate resilience, which is a function of both strength and elongation to failure as is recognised for metallic tanks in paragraphs 6.7.2.4.6 and 6.7.2.4.7.]

[6.9.2.6.3]

These provisions should also be introduced into Chapter 6.7 akin to the tank record required for RID/ADR tanks.

6.9.2.7.1.3

“The chemical compatibility of the liner...” – change to “lining”.

There is nothing in this paragraph about the other two aspects of chemical compatibility that should be included. As far as reasonably practicable, appreciating that at the time of manufacture the substances which will be transported during their lifetime are rarely known, it should also be said that it shall not be possible for any substance carried to be affected adversely by coming into contact with the shell and service equipment – see 6.7.2.2.7 for metallic portable tanks.

Also, it may be necessary to include the possibility of permeation of the substance(s) to be carried into the walls of the FRP tanks – see 4.1.1.2 (c).

6.9.2.7.1.3

“(a) In order to establish any deterioration of the shell, **representative samples** taken from the shell, including any internal liners with welds, shall be subjected to the chemical compatibility test according to EN 977:1997 for a period of 1000 hours at 50 °C or the maximum temperature at which a particular substance is approved for transport. Compared with a virgin sample, the loss of strength and elasticity modulus measured by the bending test according to EN 978:1997 shall not exceed 25 %. Cracks, bubbles, pitting effects as well as separation of layers and liners and roughness shall not be acceptable.”

Depending upon what is meant by “representative samples”, this does not seem to be a practical requirement, given the products likely to be transported in the life of a tank including e.g. dangerous goods wastes which can vary by virtually every consignment even from the same source. This could perhaps be addressed with something similar to the model liquids regime used when testing plastics packagings in RID/ADR.

6.9.2.7.1.4

In the sentence “No visible damage inside or outside the tank shall occur.” - replace the word “tank” by the word “shell”?

6.9.2.7.1.5.1

“A representative prototype tank with its service and structural equipment in place and filled to 80 % of its maximum capacity with water, shall be exposed to a full engulfment in fire for **30 minutes**, caused by an open heating oil pool fire or any other type of fire with the same effect. The fire shall be equivalent to a theoretical fire with a flame temperature of 800 °C, emissivity of 0.9 and to the tank a heat transfer coefficient of 10 W/(m²K) and surface absorptivity of 0.8. A minimum net heat flux of 75 kW/m² shall be calibrated according to ISO 21843:2018. The dimensions of the pool shall exceed those of the tank by at least 50 cm to each side and the distance between fuel level and tank shall be between 50 cm and 80 cm. The rest of the tank below liquid level, including openings and closures, shall remain leakproof except for drips.”

Considering the Tianjin fire and the position of such tanks during carriage consideration should be given as to whether the proposed limit of 30 minutes should be increased significantly.

6.9.2.8.1

“Inspection and testing of portable FRP tanks shall be carried out as per provisions of 6.7.2.19. In addition, welded thermoplastic liners shall be spark tested under a **suitable standard**, after pressure tests performed in accordance with the periodic inspections specified in 6.7.2.19.4.”

The provisions in 6.7.2.19 are not sufficient to ensure that the resilience of FRP portable tanks to accidental and in-service damage in likely impact situations is the same as, or better than, that of conventional metallic portable tanks - suitable back-to-back tests to benchmark and validate the FRP portable tank in likely impact situations in the various modes should be considered.

Also, is it not possible to name a standard for spark testing welded thermoplastic liners.

6.9.2.10.1

At figure 6.7.2.20.1 there is an example of a data plate content and layout for metallic tanks – a similar example of a data plate should be included for FRP portable tanks.
