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**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-second 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****Impact testing of portable tanks and MEGCs: proposal to  
revise Section 41 of the Manual of Tests and Criteria****Transmitted by the expert from Canada\*****Introduction**

1. The Canadian competent authority has been the leading international expert on the dynamic longitudinal impact test protocol for portable tanks and multiple-element gas containers (MEGCs) designs that meet the definition of “container” under the International Convention for Safe Containers, 1972, as amended (CSC). This interest began when Canada developed domestic impact test requirements to affirm the ability of portable tanks and MEGCs to withstand impacts encountered in its rail transport environment and having these marked “TC IMPACT APPROVED” or “CTC IMPACT APPROVED”. This was followed by Canada sponsoring research in the 1990s to determine a reliable and universally applicable method for test facilities located worldwide to quantify impact severity, leading to the development of the shock response spectrum (SRS) test protocol. Finally, Canada submitted document ST/SG/AC.10/C.3/2004/97 proposing that the Model Regulations require portable tank and MEGC designs that satisfy the SRS test protocol. The experts agreed and the requirements are now found in paragraphs 6.7.2.19.1, 6.7.3.15.1,

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\* In accordance with the programme of work of the Sub-Committee for 2017-2018 approved by the Committee at its eighth session (see ST/SG/AC.10/C.3/100, paragraph 98 and ST/SG/AC.10/44, paragraph 14).

6.7.4.14.1 and 6.7.5.12.1 of the Model Regulations and the SRS protocol is defined in the Manual of Tests and Criteria, Part IV, Section 41.

2. The Canadian competent authority maintains a high degree of contact with international stakeholders in the impact testing of portable tanks and MEGCs. This is achieved through Canada's oversight program consisting of the registration of test facilities and witnessing agencies, conducting compliance audits, reviewing test reports and exchanging technical expertise with key personnel of the testing and witnessing bodies.

3. Since the development of the SRS test protocol in the 1990s, there has been significant technological improvements in data acquisition systems. Many test facilities employ systems with data sampling capabilities that greatly exceed the baseline system envisaged by the current SRS test protocol. These modern systems render certain requirements redundant while necessitating the imposition of new requirements to ensure test integrity.

4. This document proposes to modernize the SRS test protocol to account for the higher-capability data acquisition systems that are in use today. The proposed revisions would not, however, preclude the use of any data acquisition system that conforms to the current requirements. The Canadian competent authority has surveyed the registered test facilities and has generally received supportive comments, including from facilities in China, Germany and South Africa.

5. Furthermore, the document proposes to better address the variety of designs found today, i.e. portable tanks and MEGCs of lengths other than 20 ft., to make a correction to one of the defined variables in the calculations of the SRS test protocol, and clarify the terminology used in the Section 41.

## **Proposal 1**

6. Given that many of the modern data acquisition systems being employed can sample at frequencies far in excess of the specified minimum of 1 kHz, it is important to ensure that the accelerometer design is appropriate for such higher sampling frequencies. If the resonant frequency is not sufficiently high, inaccuracies will result as the input signal becomes coupled with the accelerometer response. This proposal suggests introducing a requirement that the accelerometers have a resonant frequency of at least five times the sampling frequency. This threshold is satisfactorily achieved by commercially available equipment which are currently being employed by test facilities.

7. Revise the UN Manual of Tests and Criteria paragraph 41.3.3.2(a) as follows:

“The following equipment shall be available for the test: (a) Two accelerometers with a minimum amplitude range of 200 g, a maximum lower frequency limit of 1 Hz, and a minimum upper frequency limit of 3000 Hz, and a resonant frequency of at least five times the sampling frequency...”

## **Proposal 2**

8. The current anti-aliasing requirement of paragraph 41.3.3.2(c) is of a prescriptive nature and is appropriate for a data acquisition system meeting only the minimum system requirements of the test protocol. However, for a data acquisition system that can sample at much greater frequencies than 1 kHz, facilities should be able to implement anti-aliasing as needed to achieve the same performance requirement. Indeed, data acquisition systems that sample at 4 kHz or greater would be less susceptible to signal aliasing in the signal frequency range of interest, i.e. 2 Hz to 100 Hz. If needed, an analog or digital filter could

be used to attenuate any aliasing in the signal frequency range of interest. This proposal suggests a performance requirement to attenuate aliasing to 1% or less, which corresponds to the currently specified filter roll-off rate of 40 dB/octave.

9. Revise the Manual of Tests and Criteria paragraph 41.3.3.2(c) as follows.

“The following equipment shall be available for the test... (c) an analogue-to-digital data acquisition system capable of recording the shock disturbance as an acceleration versus time history at a minimum sampling frequency of 1000 Hz. ~~The data acquisition system shall incorporate a low pass anti aliasing analogue filter with a corner frequency set to a minimum of 200 Hz and a maximum of 20% of the sampling rate, and a minimum roll off rate of 40 dB/octave~~ Aliasing must not exceed 1%, which may require the incorporation of an anti-aliasing filter into the data acquisition system...”

### Proposal 3

10. There is an increasing number of portable tanks being designed with lengths other than 20 ft. (6.1 m), such as 40-ft. (12.2 m) designs. When successive impacts of a non-20-ft. portable tank design or any MEGC design approach the critical speed of the test platform without achieving the minimum SRS, the provisions of alternate test severity validation method should be made available.

11. Revise the title of the Manual of Tests and Criteria paragraph 41.3.7 as follows:

“Alternate test severity validation method ~~for portable tanks with frame length of 20 feet~~”

### Proposal 4

12. There is an error in the Manual of Tests and Criteria paragraph 41.3.5.1(b)(i), as the undamped frequency variable in the calculations is missing the reciprocal of time component in its units. Since the test protocol measures frequencies in Hz, the appropriate unit of time is the second.

13. Revise the Manual of Tests and Criteria paragraph 41.3.5.1(b)(i) as follows;

“ $\omega_n$  = undamped natural frequency (~~in~~ radians/second)”

Alternative proposed text: “ $\omega_n$  = undamped natural frequency (~~in~~ radians-rad/s)”

### Proposal 5

14. Throughout Section 41, the term “container” is used repeatedly but has several different meanings depending on the context: (a) a container satisfying the requirements of the CSC; (b) a portable tank only; or (c) either a portable tank or MEGC. It is proposed to streamline the use of the term “container” in Section 41 to the definition in (a).

15. Revise the Manual of Tests and Criteria paragraph 41.2 as follows:

“The following variations in ~~container~~ portable tank or MEGC design from an already tested prototype are permitted without additional testing:”

16. Revise the Manual of Tests and Criteria paragraph 41.3.1 as follows:
- “The test platform may be any suitable structure capable of sustaining without significant damage a shock of the prescribed severity with the ~~container under test~~ prototype mounted securely in place. The test platform shall be:
- (a) Configured so as to allow the ~~container under test~~ prototype to be mounted as close as possible to the impacting end;
  - (b) Equipped with four devices, in good condition, for securing the ~~container under test~~ prototype in accordance with ISO 1161:1984 (Series 1 Freight containers – Corner fittings – Specification); and
  - (c) Equipped with a cushioning device to provide a suitable duration of impact.”
17. Revise the Manual of Tests and Criteria paragraph 41.3.4 as follows:
- “41.3.4.1 Filling the ~~container under test~~ prototype may be undertaken before or after mounting on the test platform, as follows:
- (a) Portable tanks: The tank shall be filled with water or any other non-pressurized substance to approximately 97% of the tank volumetric capacity. The tank shall not be pressurized during the test. If for reasons of overload it is not desirable to fill to 97% of capacity, the tank shall be filled so that the mass of the ~~container under test~~ prototype (tare and product) is as close as practicable to its maximum rated mass (R);
  - (b) MEGCs: Each element shall be filled with an equal quantity of water or any other non-pressurized substance. The MEGC shall be filled so that its mass is as close as practicable to its maximum rated mass (R) but in any event, to no more than 97% of its volumetric capacity. The MEGC shall not be pressurized during the test. Filling a MEGC is not required when its tare mass is equal to or higher than 90% of R.
- 41.3.4.2 The mass of the ~~container~~ prototype, as tested, shall be measured and recorded.
- 41.3.4.3 The ~~container under test~~ prototype shall be oriented in a manner that will result in the most severe test. The container shall be mounted on the test platform, as close as possible to the impacting end and secured using all four of its corner fittings so as to restrain its movement in all directions. Any clearance between the corner fittings of the ~~container under test~~ prototype and the securing devices at the impacting end of the test platform shall be minimised. In particular, impacting masses shall be free to rebound after impact.
- 41.3.4.4 An impact shall be created (see 41.3.2) such that for a single impact the as tested Shock Response Spectrum (SRS, see 41.3.5.1) curve at both corner fittings at the impacting end equals or exceeds the minimum SRS curve shown in Figure 1 at all frequencies within the range from 3 Hz to 100 Hz. Repeated impacts may be required to achieve this result but the test results for each impact shall be considered individually;
- 41.3.4.5 Following an impact described in 41.3.4.4, the ~~container under test~~ prototype shall be examined and the results recorded. To satisfy the test, the ~~container~~ portable tank or MEGC shall show no leakage, permanent deformation or damage that would render it unsuitable for use, and shall be in conformity with the dimensional requirements regarding handling, securing and transfer from one means of transport to another.”

18. Revise the Manual of Tests and Criteria paragraph 41.3.7 as follows:

“41.3.7.1 If the design of a ~~tank-container under test~~ prototype is significantly different from other ~~containers portable tanks or MEGCs~~ successfully subjected to this test and the SRS curves obtained have correct features but remain below the minimum SRS curve, the test severity may be considered acceptable if three successive impacts are performed as follows:

- (a) First impact at a speed higher than 90% of the critical speed referred to in 41.3.7.2; and
- (b) Second and third impact at a speed higher than 95 % of the critical speed referred to in 41.3.7.2.

41.3.7.2 The alternate validation method described in 41.3.7.1, shall be used only if the platform’s “critical speed” had been determined beforehand. The critical speed is the speed where the platform’s cushioning devices reach their maximum travel and energy absorption capacity beyond which the minimum SRS curve is normally obtained or exceeded. The critical speed shall have been determined from a minimum of five documented tests on five different ~~tank-containers~~ prototype designs. Each such test shall have been performed using the same equipment, measuring system and procedure.”

19. Revise the Manual of Tests and Criteria paragraph 41.3.8 as follows:

“At least the following data shall be recorded in the application of this procedure:

- (a) Date, time, ambient temperature, and location of test;
- (b) ~~Container~~ Prototype tare mass, maximum rated mass, and as-tested payload mass;
- (c) ~~Container~~ Prototype manufacturer, type, registration number if applicable, certified design codes and approvals if applicable;
- (d) Test platform mass;
- (e) Impact velocity;
- (f) Direction of impact with respect to ~~container~~ the prototype; and
- (g) For each impact, an acceleration versus time history for each instrumented corner fitting.”

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