



**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-second session**

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Item 5 (c) of the provisional agenda

Transport of gases: Miscellaneous**Report of the intersessional working group on the pV-product
limit for pressure receptacles****Transmitted by the expert from Germany on behalf of the working
group*****Report of the working group**

1. The intersessional working group met six times under the chairmanship of Dr Georg W. Mair. Delegates from Belgium, China, Germany, Sweden, United Kingdom, United States of America, Compressed Gas Association (CGA), European Cylinder Makers Association (ECMA), European Industrial Gases Association (EIGA) and International Organization for Standardization (ISO) joined the virtual meeting. The delegation from Germany provided the secretary.

2. The working group considered the following documents in its meetings:

- fifty-seventh session: document ST/SG/AC.10/C.3/2020/18 with informal documents INF.52 (ECMA) and INF.53 (Germany), and report ST/SG/AC.10/C.3/114;
- fifty-eighth session: informal document INF.38 (58th session) and report ST/SG/AC.10/C.3/116;
- fifty-ninth session: informal document INF.18 (59th session) and report ST/SG/AC.10/C.3/118;
- sixtieth session: informal document INF.37 (60th session) and report ST/SG/AC.10/C.3/120;
- sixty-first session: informal document INF.41 (61st session) and report ST/SG/AC.10/C.3/122.

The above listed informal documents presented at the 58th, 59th, 60th and 61st sessions of the Sub-Committee provide the reports of the working group meetings and information about discussed details and rationales.

* A/77/6 (Sect. 20), table 20.6



3. The working group had its sixth online-meeting on the 9 February 2023 from 1 to 4 p.m. Geneva time (CET). In total 13 delegates from Germany, Sweden, United Kingdom, United States of America, CGA, ECMA and EIGA joined the meeting.
4. For the preparation of the meetings, the Chair drafted and distributed an agenda, which was confirmed by the participants. The first five online meetings were guided by the usage of a prepared set of slides that are appended to the relevant reports including a few additional figures as discussed. The sixth meeting was prepared without a separate set of slides and tackled two main items: Is there new input on the already determined pV-value of 1.5 million bar litres? How should the detailed proposals for the change of the wording in the UN Model Regulations look like?
5. Some representatives of EIGA and ECMA mentioned that the determined pV-value of 1.5 million bar litres does not cover a few designs approved by Special Permits in the United States of America. The representative of US Department of Transportation (DOT) and other representatives of CGA, EIGA and Germany mentioned that for those case of Special Permits additional requirements and safety measures apply, when going beyond the design standards. An implementation of a pV-limit for pressure receptacles would not restrict the use of those Special Permits. Consequently, the value of 1.5 million bar litres does not limit the market and there is no valid rationale for increasing the value beyond 1.5 million bar litres. The Chair summarized and concluded the discussion: Most representatives confirmed the value of 1.5 million bar litres (based on PH) for the intended implementation of a pV-limit for pressure receptacles.
6. One representative shared a raised question about the need of a limitation by a pV-product as no safety problems occurred in the last years. EIGA stated that there is no safety problem at the moment, but a clear market development is in evidence for pressure receptacles with increased pressure. Standards, e.g. ISO 11515, addresses designs of large tubes with very high pressures, which means pV-products far beyond the discussed 1.5 million bar litres. The Chair expressed, that new high-pressure containments with a very high water-capacity open new categories of consequences and will need a different and possibly more complex approval approach. That should potentially be based on risk assessment and more focussing on population density along the transport routes. Currently, the value of 1.5 million bar litres does not limit the market and new developments but defines a limit for unaccepted consequences in the case of an incident, which is important for the acceptance of gas transport in pressure receptacles.
7. Finally, all members of the working group agreed to the introduction of a pV-limit with a value of 1.5 million bar litres for pressure receptacles.
8. Containments with a water capacity of more than 3000 litres or a higher pV-product than 1.5 million bar litres should be approved and operated under consideration of additional requirements like a risk assessment for the design under consideration of accidental loads, fatigue and service conditions.
9. The mandate of this working group is to further discuss proposals 1 and 2 of document ST/SG/AC.10/C.3/2020/18 and to submit to the Sub-Committee a new proposal for consideration (para. 35 in report ST/SG/AC.10/C.3/114). Different proposals and options for the implementation of the pV-limit in the UN Model Regulations were presented in informal document INF.41 of the sixty-first session. At first the working group discussed and clarified whether section 1.2.1 or chapter 6.2 should be considered. As the implementation of a pV-limit for pressure receptacles is a refinement for the definition for pressure receptacles and not a requirement for the construction and testing of pressure receptacles, the working group decided to work on a proposal for section 1.2.1.
10. The working group discussed to address either the definition of pressure receptacles in general or the definitions of cylinders, tubes, bundles of cylinders, and salvage pressure receptacles. From a safety perspective all kinds of pressure receptacles that may be filled with compressed gases need to be addressed. Pressure receptacles include cylinders, tubes, pressure drums, bundles of cylinders, salvage pressure receptacles and metal hydride storage systems, closed cryogenic receptacles. Due to their liquified or solid content the consequence of pressure drums, metal hydride storage systems and closed cryogenic receptacles is not driven by the criteria of pressure, on one hand. On the other hand, the limitation of a pV-

criteria would not limit current or future developments of those pressure receptacles. Since in real life only cylinders, tubes and bundles are expected to be impacted by a pV-limit some members saw a problem in adding the pV-limit to the general definition for pressure receptacles. An individual approach of adding the pV-limitation would make it easier to add more relevant criteria appropriate for pressure drums, metal hydride storage systems and closed cryogenic receptacles. Others mentioned that there is no conflict if a type of pressure receptacle is not affected at all and preferred a simpler solution in the general definition.

11. For the sake of clarity, the working group decided to concentrate on separate definitions of cylinders, tubes, bundles of cylinders, and salvage pressure receptacles. Furthermore, the working group aims to modify those long-term used definitions with minor changes to the existing text with most attention to the impact of the proposals to the regulations.

12. For completeness, the working group asks the Sub-Committee to pay attention to the issue raised in informal document INF.41 of the sixty-first session: Each gas with its specific properties has an impact on consequences. The proposals were based on the analysis of pressure receptacles filled with hydrogen and offer a framework for the definition of a pressure receptacle but may need further pV-limitation for several gases. This discussion on gas-specific pV-limits in addition to the general limitation of the containments has not been part of the scope of the intersessional working group considerations.

13. As a last item of its sixth informal meeting, the working group revised the final wording of recommendations as presented below.

14. The working group asks the Sub-Committee to discuss the following proposals and to take decisions, as appropriate.

Proposals of the working group including rationales

15. As result from the six meetings, the working group proposes the following four amendments to the current wording of the UN Model Regulations. Since the pV-product focuses on pressure receptacles for compressed gases, proposals 1 and 2 do not address all kinds of pressure receptacles. To avoid confusion, the following proposal 1 addresses cylinders and tubes, and proposal 2 below bundles of cylinders.¹

Proposal 1

16. Amend the definition for cylinder and tube in section 1.2.1 to read as follows (new text is underlined):

Cylinder means a pressure receptacle of a water capacity not exceeding 150 litres with a test pressure volume product not exceeding 1.5 million bar litres;

Tube means a pressure receptacle of seamless or composite construction having a water capacity exceeding 150 litres but not more than 3 000 litres with a test pressure volume product not exceeding 1.5 million bar litres;”

17. Rationale for proposal 1

For supporting the well running and accepted system of pressure receptacles in global transport a limitation of the consequence resulting from an unlikely but unavoidable worst-case scenario during the transport of pressure receptacles is needed. To the best knowledge of the working group, the herewith proposed limitation of the test pressure volume product of a value of 1.5 million bar litres provides the best compromise between public safety and needs in world-wide gas transport. This value is based on an analysis of the reasonable size of consequences and the acceptance of consequences. The above presented pV-value is an estimated reference value that considers almost all expectable worst-case scenarios for a sudden rupture of a single

¹ For justification, see paragraphs 10-14 above.

pressure receptacle during the transport of compressed hydrogen². Due to the variability of scenarios with respect to people, buildings and secondary effects, the presented pV-value is considered to be conservative. The effect of projectiles is not considered explicitly but is merged in the pressure-wave-based consequence estimation. Compressed hydrogen has been chosen as the reference gas since it provides the lowest consequences of frequently transported compressed gases. A limit between a major consequence and a catastrophic consequence was considered. This limit provides a representative reference for the avoidance of catastrophic consequences without any consideration of the likelihood of a sudden rupture of a pressure receptacle. Data provided by EIGA and ECMA showed that pressure receptacles, currently available on the market, are below the proposed limit of 1.5 million bar litres. This means, the discussed limitation would not impact the current range of pressure receptacles on the market. Future developments beyond this limit are expected but should get guide rail.

Proposal 2

18. Amend the definition for bundles of cylinders in section 1.2.1 to read as follows:

“Bundle of cylinders means a pressure receptacle comprising an assembly of cylinders or cylinder shells that are fastened together, and which are interconnected by a manifold and transported as a unit. The total water capacity shall not exceed 3 000 litres except that bundles intended for the transport of gases of Division 2.3 shall be limited to 1 000 litres water capacity; the product of test pressure and total water capacity shall not exceed 1.5 million bar litres;”

19. Rationale for proposal 2

A bundle of cylinder is considered as a pressure receptacle in one unit and is handled the same way as a cylinder or tube. In the case of a failure or leakage of a bundle containing compressed gas, the whole content may be released, which would load a salvage pressure receptacle with its total pressure-volume product. Therefore, the added value accounts the product of test pressure and total water capacity.

Proposal 3

20. Amend the definition for salvage pressure receptacle in section 1.2.1 to read as follows:

“Salvage pressure receptacle means a pressure receptacle with a water capacity not exceeding 3 000 litres into which are placed damaged, defective, leaking or non-conforming pressure receptacle(s) having a total test pressure volume product not exceeding 1.5 million bar litres for the purpose of transport e.g., for recovery or disposal;”

21. Rationale for proposal 3

A salvage pressure receptacle is considered as a type of pressure receptacles. The potential consequence in the case of failure of a salvage pressure receptacle does not depend on the product of its water capacity and its test pressure. It is exclusively determined by the properties of the stored pressure receptacles. Therefore, it is necessary to limit the pV-product of the stored pressure receptacles in total and not the volume or test pressure of salvage containments, which is intended by proposal 1 and 2 in combination with proposal 3.

² except for fire engulfment, especially for type 1.

Proposal 4

22. Amend the definition for salvage pressure receptacle as in proposal 3 (in the case of the acceptance of proposal 3) to read as follows:

“*Salvage pressure receptacle* means a pressure receptacle ~~with a water capacity not exceeding 3 000 litres~~ into which are placed damaged, defective, leaking or non-conforming pressure receptacle(s) **having a total test pressure volume product not exceeding 1.5 million bar litres** for the purpose of transport e.g., for recovery or disposal;”

23. Rationale for proposal 4

The level of maximal consequence is limited by the sum of test pressure volume products of the stored pressure receptacle(s), which shall not exceed 1.5 million bar litres for the one or all pressure receptacles placed in a salvage pressure receptacle. To provide a higher water capacity of test pressure than limited for the stored content is a safety plus and should not be limited.

[With respect to 6.2.3.5, the competent authorities shall ensure that the mandatory instruction for safe handling of pressure receptacles and the approval certificate limit the total water capacity of the cylinders, tubes or bundles of cylinders placed in a salvage pressure receptacle to a value not exceeding 3000 litres in total. This could be ensured by an additional requirement in 6.2.3.5.].
