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 **25 November 2022**

Sixty-first session
Geneva, 28 November-6 December 2022
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 Chair of the informal working group

1. The working group met under the chairmanship of Dr Georg W. Mair (Germany) a fifth time on the seventh of November 2022 from 1 to 5 p.m. Geneva time (CET). In total 15 delegates from Belgium, Germany, Sweden, The United Kingdom, The United States of America, CGA, ECMA and EIGA joined the meeting. The delegation from Germany provided the secretary.

2. The working group considered the following documents in the meeting:

- 57th Session: ST/SG/AC.10/C.3/2020/18 with informal document INF 52 (ECMA) and informal document INF 53 (GER) and the report ST/SG/AC.10/C.3/114
- 58th Session: informal document INF 38 (58th session) and the report ST/SG/AC.10/C.3/116
- 59th Session: informal document INF 18 (59th session) and the report ST/SG/AC.10/C.3/118
- 60th Session: informal document INF 37 (60th session) and the report ST/SG/AC.10/C.3/120

3. For preparation of the meeting the Chair drafted and distributed an agenda, which was confirmed by the participants. This agenda addressed the parts mentioned in the following items. Again, this online meeting was guided by the usage of a prepared set of slides that are appended to this report including a few additional figures as discussed.

4. The chair repeated all results elaborated so far. These are especially the reference values for the criticality of consequences: 30 fatalities or 450 injured persons at a reference population density of 6000 pers./km^2.

5. Representatives from EIGA and ECMA reminded the group that there are ongoing discussions in both societies. CGA explained a planned test series, which is expected to provide detailed results for better simulations of consequences. The Chair welcomed this effort and asked CGA for providing relevant data as soon as they will be available. With respect to the exercised approach, he recollected that the unavoidable imponderabilia of a general consequence analysis are high and reflected by the “range” (see slides 11, 12 and 18 of the appended presentation).

6. The remaining open issue was the determination of a final value for the pV-product for the chosen example of hydrogen. The group decided to stay conservative and fixed the

1.5 Mio. bar-litres-value on the basis of the test pressure PH and the water capacity of the pressure receptacle.

7. During the meeting, EIGA and ECMA volunteered to check the pV product of pressure receptacles in usage today. The data provided in the meantime show that pressure receptacles, which are currently on the market, are below the proposed limit of 1.5 Mio bar litres. This means, the discussed limitation would not impact the current range of pressure receptacles on the market. Future developments are predictable but should get guide rail. EIGA commented that increasing the pV-limit to 1.8 Mio bar litres would only slightly change the limitation in the near future.

8. A discussion on the differences in worst case scenarios of gases transported in pressure receptacles took place. As exemplarily shown on slide 18 for nitrogen and CNG (methane), other gases may provide more severe consequences than hydrogen. A discussion developed on the role of a definition for a containment in opposite to the limitations as provided in e.g., P200.

9. The Chair explained that a discussion on eventually necessary gas-specific filling limits in addition to the general limitation of the containments is currently not part of the scope of the intersessional working group and would need an additional mandate from the Sub-Committee for a much more extensive work; comparable with the determination of the gas-specific LC_{50}-values in P200.

10. The group discussed the remaining open proposals from the initial paper 2020/18. Since just cylinders, tubes and bundles are expected to be impacted by a pV-limit in real life some members saw a problem in adding the pV-limit to the general definition for pressure receptacles. Others mentioned that there is no conflict if a type of pressure receptacle is not affected at all and preferred the simpler solution in the general definition. Therefore, and for some other remaining needs for consultation, this item has been postponed to the last session planned for the beginning of 2023.

11. As last item of this meeting the final wording of recommendations of the Working Group was revised and is presented for preliminary information as appendix below. The majority asked for not mentioning the determined reference value in the final paper, which we expect to be able to provide to the Sub-Committee at its 62nd Session as a formal document.

12. The group is interested in finalizing its work. Therefore, the working group asks the Sub-Committee to confirm the continuation of this work.

- END OF THE REPORT -–

Appendix

For giving a deeper impression of the status of work the considered changes are presented here in the format of proposals

1. Proposal 1 (compare ST-SG-AC10-C3-2020-18, proposal 1) modify paragraph 1.2.1 as follows (choose one alternative out of a), b) or c)):

a)
Pressure receptacle means a transportable receptacle with a test pressure volume product not exceeding 1.5 million bar litres intended for holding substances under pressure including its closure(s) and other service equipment and is a collective term that includes cylinders, tubes, pressure drums, closed cryogenic receptacles, metal hydride storage systems, bundles of cylinders and salvage pressure receptacles;

b)
Pressure receptacle means a transportable receptacle intended for holding substances under pressure including its closure(s) and other service equipment and is a collective term that includes cylinders, tubes, pressure drums, closed cryogenic receptacles, metal hydride storage systems, bundles of cylinders and salvage pressure receptacles with a test pressure volume product not exceeding 1.5 million bar litres;

c)
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;

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;

2. Proposal 2 (compare ST-SG-AC10-C3-2020-18, proposal 2)

Modify the definition of salvage pressure receptacles in Para 1.2.1 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) with a test pressure volume product not exceeding 1.5 million bar litres for the purpose of transport e.g., for recovery or disposal;

3. Rational

The above presented pV-value is an estimated reference value that considers almost all expectable worst-case scenarios for the sudden rupture of a single pressure receptacle during the transport of compressed hydrogen[1]. 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.

[1] with exception of fire engulfment, especially for type 1

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 projectile 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.

In the special case of hydrogen, the pressure wave caused by a potential explosion of the hydrogen is lower than the pressure wave resulting from the sudden rupture of a pressure receptacle itself.

Pressure receptacles filled with gases other than hydrogen can in some cases lead to more severe consequences than those filled with compressed hydrogen, which might require lower gas-specific pV-values. This is not part of the scope of the work of this group.

The proposed definition of pressure receptacles does not change the limitations of their water capacity.

Containments with a water capacity of more than 3000 litres or a higher pV-product than 1.5 Mio 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.

BAM
Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

November 7th, 2022

5TH MEETING
TDG - INTERSESSIONAL WG on pV-PRODUCT

1

Agenda (drafted)

BAM

Start at 13:00 CEST

Top 1:	**Agenda, attendance and a short introduction round**
Top 2:	**Summary of the SCETDG-reports**
Top 3:	**Recollection of the status of discussion**

Break at about 15:00

Top 4:	**Check of the arguments on the determined figure for an appropriate pV-value**
Top 5:	**Next steps**

End at about 17:00

2

Top 2:
Summary of the SCETDG-reports

3

Outcome of 57th UN-SubCom ETDG

held in Geneva from 30 Nov to 8 Dec 2020

Report ST/SG/AC.10/C.3/114 says:

Modifications concerning salvage pressure receptacles
Document: ST/SG/AC.10/C.3/2020/18 (Germany)
Informal documents: INF.52 (ECMA) INF.53 (Germany)

35. Following the comments received during the informal session on informal documents INF.52 and INF.53, the Sub-Committee adopted the amendments under proposal 3 in ST/SG/AC.10/C.3/2020/18 (see annex I). It was agreed to set up an intersessional working group led by Germany to further discuss proposals 1 and 2, and to submit a new proposal for consideration during the next biennium.

4

Proposal 1

Compare ST-SG-AC10-C3-2020-18, proposal 1

1.2.1

Pressure receptacle means a transportable receptacle intended for holding substances under pressure including its closure(s) and other service equipment and is a collective term that includes cylinders, tubes, pressure drums, closed cryogenic receptacles, metal hydride storage systems, bundles of cylinders and salvage pressure receptacles with a test pressure volume product not exceeding 1.5 million bar litres;

5

Proposal 2

Compare ST-SG-AC10-C3-2020-18, proposal 2

1.2.1

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) for the purpose of transport e.g. for recovery or disposal;

6

Outcome of 58th UN-SubCom ETDG

BAM

UN-SubCom ETDG Report of the Sub-Committee of Experts on the Transport of Dangerous Goods on its fifty-eigth session

held in Geneva from 28 June to 2 July 2021

Report ST/SG/AC.10/C.3/116 concerning INF.38

VII. Transport of gases (agenda item 5) - C. Miscellaneous

60. The Sub-Committee welcomed the outcome of the intersessional working group on the pV-product limit for pressure receptacles and encouraged the group to continue its work. It was clarified that the group's discussions on the level of risk assessment was linked to the specific risks of pressure receptacles only and not to a general type of risk.

7

Outcome of 59th UN-SubCom ETDG

BAM

UN-SubCom ETDG Report of the Sub-Committee of Experts on the Transport of Dangerous Goods on its fifty-nineth session

held in Geneva from 29 November to 8 December 2021

Report ST/SG/AC.10/C.3/118 concerning INF.18

VII. Transport of gases (agenda item 5) - C. Miscellaneous

51. The Sub-Committee noted the work progress of the informal working group on the pV-product limit for pressure receptacles at its meeting on 25 October 2021. It encouraged the group to continue its work and to report back at the next session. The Chair invited all experts interested to participate in the group’s work to contact the expert from Germany.

8

Outcome of 60th UN-SubCom ETDG

UN-SubCom ETDG Report of the Sub-Committee of Experts on the Transport of Dangerous Goods on its fifty-nineth session

held in Geneva from 27 June to 6 July 2022

Report ST/SG/AC.10/C.3/120 concerning INF.37

VII. Transport of gases - C. Miscellaneous

73. The Sub-Committee noted the report of the intersessional working group on the pV-product limit for pressure receptacles. It confirmed the continuation of the work and invited the group to report back at the next session.

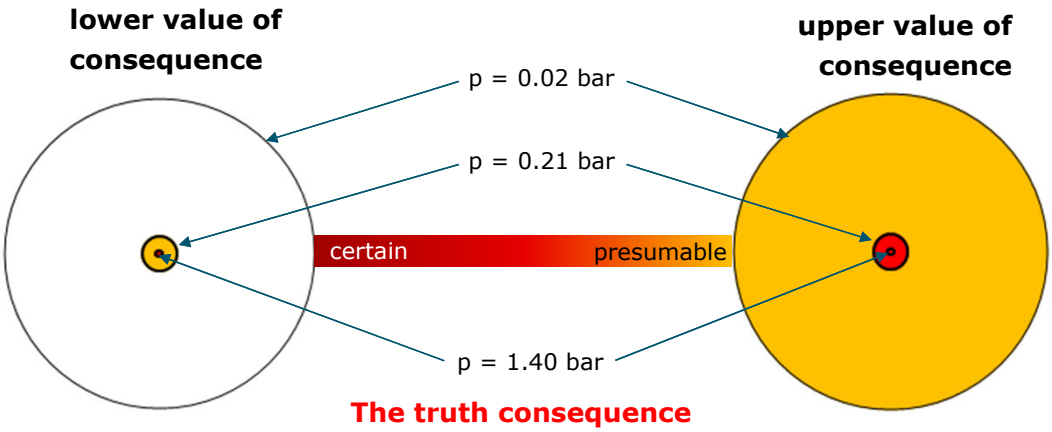
9

Top 3: Recollection of the status of discussion

10

Estimation of consequence

(without effects of splinters)



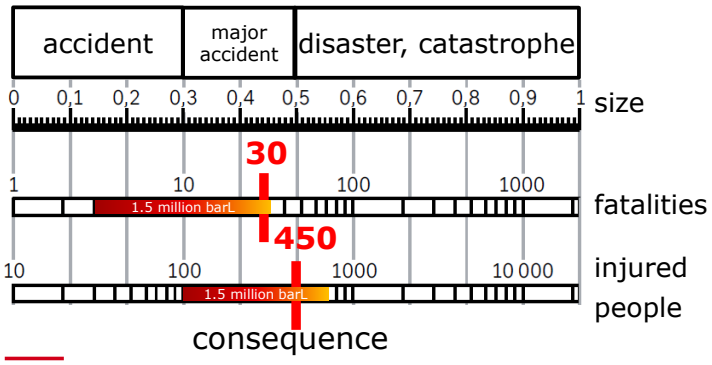
The truth consequence depends on local aspects and is assumed to be somewhere in-between.

Interpretation of areas: 100% fatalities 100% injuries

11

Results of last discussion

In the last discussion we finalized the work in principle and agreed to give time for further national consideration. Under the condition of national agreement the majority was in favor for operating the lowest consequence level that had been analysed: 1.5 Mio bar litres.



pV-product = **1.5 mio barL**
population density
= **6000 people/km²**

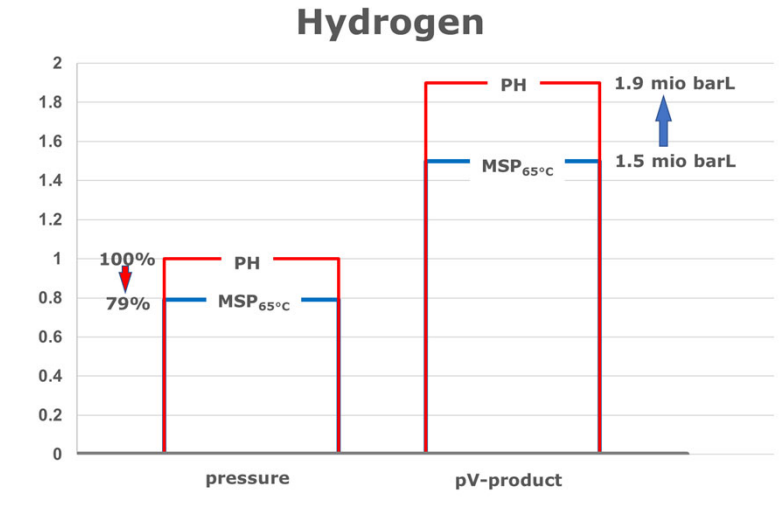
3 to 33 fatalities
$size_{1.5MiobarL}$ = 0.15 to 0.46
101* to 706* injured people
$size_{1.5MiobarL}$ = 0.30* to 0.55

12

Top 4: Check of the arguments on the determined figure for an appropriate pV-value

13

Results of last discussion



The consequence depends on the water capacity V and the current pressure p that may go up to the maximum service pressure $MSP_{65°C}$ during transport*. Therefore, the ratio of MSP/PH and the pV-limit depend on the gas.

**with exception of fire engulfment, especially for type 1*

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Outcome

With respect to the more severe behaviour of a lot of gases in comparison with *CGH_2 (calculated for a sudden rupture of pressure receptacles)* the majority of the WG is not in favour for taking into account the maximum service pressure (MSP) that is lower than test pressure PH in case of hydrogen.
This leads to the conclusion:

A test pressure volume product not exceeding 1.5 million bar litres is appropriate to limit the consequence to an acceptable level.

15

Proposal for a final remark in the report

(revised – based on item 17 of UN/SCETDG/60/INF.37) 1/3

The above presented pV-value is an estimated reference value that considers almost all expectable worst-case scenarios for the sudden rupture of a single pressure receptacle during the transport of compressed hydrogen*. A limit between a major consequence and a catastrophic consequence was considered. As such 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.

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 projectile is not considered explicitly but is merged in the pressure-wave-based consequence estimation.

**with exception of fire engulfment, especially for type 1*

16

Proposal for a final remark in the report

(revised – based on item 17 of UN/SCETDG/60/INF.37) 2/3

Compressed hydrogen has been chosen as the reference gas since it provides the lowest consequences of frequently transported compressed gases.

In the special case of hydrogen the pressure wave caused by a potential explosion of the hydrogen is lower than the pressure wave resulting from the sudden rupture of a pressure receptacle itself.

Pressure receptacles filled with gases other than hydrogen can in some cases lead to more severe consequences than those filled with compressed hydrogen, which might require lower gas-specific pV-values. This is not part of the scope of the work of this group.

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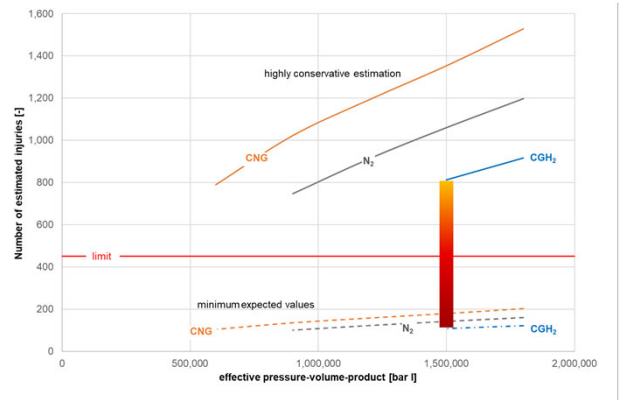
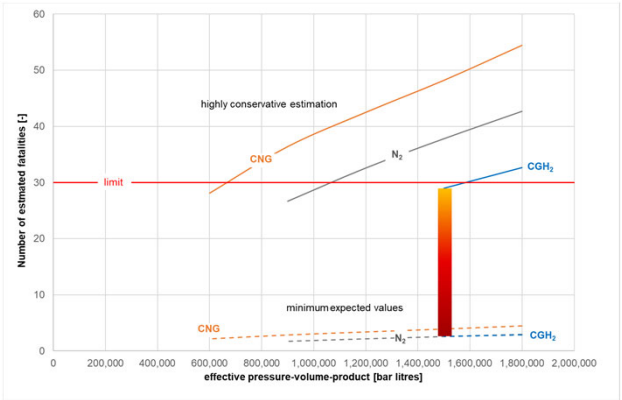
Gas-specific pV-values





This shows the dependency on gas properties by the help of examples CNG, N2 and CGH2.

18

Proposal for a final remark in the report

(revised – based on item 17 of UN/SCETDG/60/INF.37) 3/3

The proposed definition of pressure receptacles does not change the limitations of their water capacity.

Containments with a water capacity of more of 3000 litres or a higher pV-product than 1.5 mio 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.

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Top 6: Resulting proposals concerning the task

20

Proposal 1

Compare ST-SG-AC10-C3-2020-18, proposal 1

1.2.1

Pressure receptacle means a transportable receptacle <either: "with a test pressure volume product not exceeding 1.5 million bar litres"> intended for holding substances under pressure including its closure(s) and other service equipment and is a collective term that includes cylinders, tubes, pressure drums, closed cryogenic receptacles, metal hydride storage systems, bundles of cylinders and salvage pressure receptacles;

<or: "Test pressure volume product of pressure receptacles shall not exceed 1.5 million bar litres.">

<or: c&p individually new text in the definitions for cylinders, tubes and bundles.>

21

Proposal 2

Compare ST-SG-AC10-C3-2020-18, proposal 2

1.2.1

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) for the purpose of transport e.g. for recovery or disposal;

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Preparation of next SubCom-meeting

(AC.10/C.3) ECOSOC Sub-Committee of Experts on the Transport of Dangerous Goods (61st session)

28 Nov - 06 Dec 2022; a further INF-paper will be presented!

At Jan. 2023 a 6th meeting will take place for finalizing the work. For the June-Meeting an official paper is planned.

Thank you for your contribution

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