GRSP TF on the transposition of GTR 13 Phase 2 to UN-R 134 (14)

Meeting Date: 10/07/2023 1:00 pm – 12/07/2023 12:00 pm (CET)
Location: RDW Office, Rue Froissart 95, Brussels, Belgium & Microsoft Teams Meeting

Subgroup 1: Remote TPRDs

Dates: 10/07/2023 1 pm – 5 pm (CET)
11/07/2023 9 am – 12 pm (CET)

Participants:

- ☑ Alex Milward (LUXFER)
- ☑ Anais Garo (UTAC)
- ☑ Annett Schuessling (LIFTE H2)
- ☑ Antoine Azzopardi (FRANCE)
- ☑ Bill Mezher (LUXFER)
- ☑ Christian Bonato (EU COM / JRC)
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- ☑ Klaus Weis (HEXAGON)
- ☑ Matthias Kuntz (BOSCH)
- ☑ Morinaga (KHK)
- ☑ Myrna Cashatt (LINAMAR)
- ☑ Phan Vuthy (VOLVO)
- ☑ Richard Trott (FORVIA)
- ☑ Romary Daval (LUXFER)
- ☑ Salim Abdennadher (RENAULT)
- ☑ Seonghoon Kim (HYUNDAI)
- ☑ Tatsumi Takehana (KHK)
- ☑ Tohru Nakanishi (METI, JAPAN)
- ☑ Volker Rothe (STELLANTIS)
- ☑ Yoshio Fujimoto (NTSEL)
- ☑ Yuto Sekiya (KHK)

Minutes

1. Welcome
   - ☐ Introduction of participants

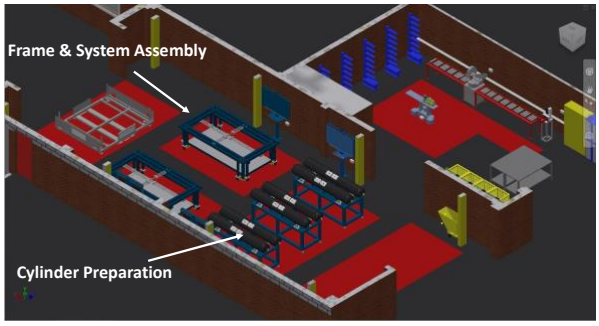
2. Minutes of last meeting
   - ☐ Review of minutes of last meeting before the GRSP on May 12th 2023

3. Revision of informal document adopted at 73rd GRSP in May 2023
   - ☐ Brief introduction of the document

4. Presentations of the discussion items
   - ☐ Presentation by Luxfer on drop testing cylinders

Drop Test

"The drop test is intended to account for a potential internal damage to the container during handling operations."



LUXFER GAS CYLINDERS

Production Facility

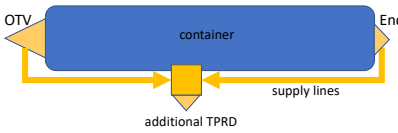
CUSTOMER FIRST • INTEGRITY • ACCOUNTABILITY • INNOVATION • PERSONAL DEVELOPMENT • TEAMWORK

1

See document: *R134 RTPRD.pdf*

☐ Review of OICA's proposal on additional TPRDs (originally Feb. 2023)

CHSS: Allow to locate additional TPRDs in alternative locations on the container

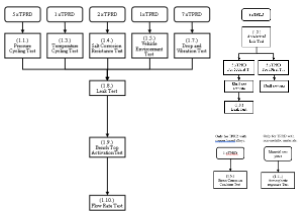


Container and CHSS including remote TPRDs and their supply lines:

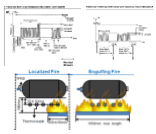
1. Durability of the supply lines mounted directly to the container will be validated based on the hydraulic sequential test. The test setup in § 5.2 may be performed by replacing the On Tank Valve/End plug by suitable adapters representative for the connection of the remote TPRD line.
2. The leak tightness, over accelerated vehicle lifetime usage, of Remote TPRDs with their supply lines, will be validated using the pneumatic sequential test of § 5.3
3. Fire test of § 5.4

Durability for additional TPRD. The supply lines durability assessed in § 5.2 test

§ 6.1 TPRD + supply pipes performance & stress tests

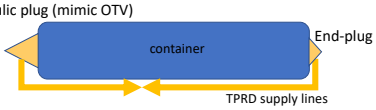


Requirement section	*Test article*
5.1. Verification tests for baseline metrics	Container or container plus container attachments, as applicable
5.2. Verification test for performance durability	Container or container plus container attachments, as applicable
5.3. Verification test for expected on-road performance	CHSS
5.4. Verification test for service terminating performance in fire	CHSS



Test set-up adaptation with the supply lines for the §5.2

Hydraulic plug (mimic OTV)



5. Discussion
   - ☐ Hydraulic sequential tests for supply lines, except Drop test (worst case aproach)
   - ☐ CoP: Check supply lines and fittings for damages occurred during transport by visual inspection before initial fill
     - Luxfer provided a presentation on standards relevant for visual inspection, see document *Inspection Requirements.pdf*
   - ☐ CoP: Any container with supply lines that has been dropped or mechanically impacted must not enter into service.
   - ☐ Pneumatic test as is (worst case approach), bonfire test (on each potential assembly option)
   - ☐ Alternative test procedure in square brackets:

- Instead of hydraulic sequential test use HGV 3.1:2022, chapter 19 for "Stainless steel rigid fuel line" and limit the supply lines to steel until new materials can be qualified.

- □ For non-metallic materials the hydraulic test (without drop test) would be mandatory
- □ Use of Worst Case Approach in agreement with the Technical Service and the Type-Approval Authority to qualify supply lines. E.g. longest lines, largest diameter, smallest bend radius and highest number of fittings. The test needs to be conducted for each material separately
  - Worst-case approach is a common approach in UN regulations as well as the European Union, as described in the **European Framework Regulation (EU) 2018/858**:

    "(58) When performing compliance verification testing, technical services should be able to choose the parameters of the tests freely and in a non-predictable manner from within the range provided for in the relevant regulatory acts. This should help them verify that the vehicles tested are compliant across the whole range of parameters, including the parameters that correspond to the **worst case** for the test"
  - And as described in: **Revision 3** of the **"Agreement concerning the adoption of harmonised technical United Nations Regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the"** (1958 agreement)

    "Schedule 3

    Procedures for UN type-approvals

    1. Application for and conduct of UN type-approval

    …

    1.6. Compliance with the requirements laid down in the UN Regulations shall be demonstrated by means of appropriate tests performed on wheeled vehicles, equipment and parts which are representative of the type to be approved.

    The approval authority shall apply the principle of '**worst-casing**', by selecting the variant or version from the specified type that for the purpose of testing will represent the type to be approved under the worst conditions. The decisions taken along with their justification shall be recorded in the approval documentation.

    However, the applicant may select, in agreement with the approval authority, a vehicle, equipment or part which, while not representative of the type to be approved, combines a number of most unfavourable features with regard to the level of performance required by the UN Regulations (worst-casing). Virtual testing methods may be used to aid the decision-making on the selection of the **worst case**."

6. Review of open items
   - □ Potential separate Annex for qualification of supply lines
   - □ Should the qualification tests be in a separate chapter, like TPRD and Check valve requirements?

Subgroup 2: Material Compatibility

Dates: 11/07/2023 1 pm – 5 pm (CET)
12/07/2023 9 am – 10.30 am (CET)

Participants:

- ☑ Alex Milward (LUXFER)
- ☑ Anais Garo (UTAC)
- ☑ Annett Schuessling (LIFTE H2)
- ☑ Ansgar Pott (HYUNDAI)
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- ☑ Harald Beck (MAN)
- ☑ Hyoung-Gu Kim (KATRI, KOREA)
- ☑ Klaus Weis (HEXAGON)
- ☑ Koie Masato (METI, JAPAN)
- ☑ Masaaki Iwasaki (TOYOTA)
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Minutes

1. Welcome

2. Minutes of last meeting
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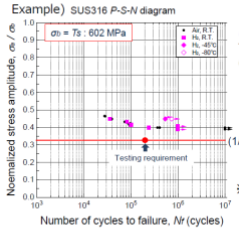
4. Presentations of the discussion items
   - ☐ Presentation by Forvia on the two different approaches

GTR 13 Ph2 part 1

Guarantee of the infinite life of components

■ **Explanation based on the material evaluation**

Example) SUS316 *P-S-N* diagram



● **Requirement for fatigue life test of Option 2**
The stress at maximum load during fatigue cycling shall be greater than or equal to 1/3 of S*

σ_a : Stress amplitude
σ_b = Ts : certified (mill sheet) tensile strength at R.T. in air
≒ S* : the average tensile strength measured at R.T. in air

※Data provided by NEDO project

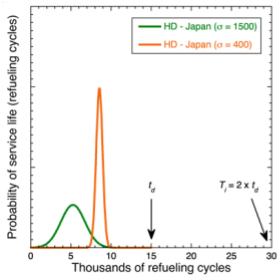
Passing this test means that an infinite life design is guaranteed in any environmental conditions within the elastic range.

Source: UN R134 Material Compatibility Issue (Concerns from material experts in Japan) - Jan. 25. 2023

Infinite life approach

- NEDO project provided data to 10^6 cycles for SUS 316
- SUS 316 Data showed not significant difference between durability testing in air and H2
- If I understand correctly the **performance requirement was based on this SUS 316 performance**
- Validation of materials for general use in CHSS as a minimal requirement, individual components can be hydraulically tested

Approach provided by Chris San Marchi (V3)



Heavy duty refueling scenarios: para. 78

- HD Commercial (Japan) = 9,750
- LD commercial (Japan) = 7,440
- HD Commercial (Germany) = 6,390
- Semi-trailer truck(Germany) = 7,987

Distributions are not provided, therefore:

- assume worst-case from LD: σ = 1500
  - Since probability is driven by standard deviation (σ)
- assume lifetime = μ + 3 σ
  - Since values are considered lifetime, they should be upper end of distribution

Worst case: $t_d > \mu + 6\sigma$, $T_i > \mu + 16\sigma$

Source: Rationale for component testing - Chris San Marchi (with help from Dusty Brooks) - Sandia National Laboratories Livermore, CA - 5 April 2023

This safe life approach is fundamentally different compared to GTR 13 infinite life approach:

- Safety / conservatism cannot directly be compared
- Especially number of test cycles cannot be directly compared

Safe life approach

- Based on worst case refueling cycles over lifetime (just like cycle numbers for CHSS are derived)
- Standard deviation methods applied
- Conservativity of proposed cycle numbers for testing on components is assessed
- Intention for test on valve components and only validating material compatibly for the component under test

Summary

- Weibayes analysis shows that to achieve 99% reliability at the design life with extended life testing of 3 samples (and assuming β = 5.2):

$$T_i = 1.96 \, x \, t_d$$

  - In other words, a 'safety factor' of 2x on number of cycles in component evaluation with achieve 99% reliability at design life (t_d)

- However, considering the predicted number of refuelings, design life (t_d) of 15,000 cycles is >6 standard deviations more than the mean (cycles)

My interpretation: component testing at 15,000 cycles (1x) is sufficient for exceptional reliability (refueling cycles)

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- ☐ General disagreement on the understanding of the items agreed during IWG GTR 13 phase 2.
- ☐ Japanese experts consider the material requirements as included in part 1 as agreed in principle by material experts.
- ☐ Representatives from industry and research do not agree to this and are concerned that the test requirements as currently proposed become a hinderance for manufacturers outside of Japan in lieu of test facilities able to conduct the tests. Although laboratories are currently being built, the ramp up will require more time. Therefore, sufficient alternative test methods should be included.
- ☐ The general understanding of the outcome of GTR 13 phase 2 is, that material compatibility requirements need further discussion and will be addressed in phase 3 of GTR 13.

Proposals made for draft document:

- ☐ General understanding of alternative material test methods:

- Qualification of Material using component testing with hydrogen only qualifies the component with this material for this specific application.
- It does not grant a general qualification certificate for applications outside of the scope of UN-R 134

□ SAE TIR 3294 „Guidance for material selection for use with hydrogen storage systems and components" is scheduled to be finalized in August 2023 and to be balloted by SAE in September 2023. Any reference to the report will be put in square brackets, since the document is not yet available and a revision by the TF could not be conducted.

□ Instead of a generic reference to standards provide examples such as ISO 11114-4:2017 and SAE J2579:2023 like in (EU) 2021/535 and delete scientific papers.

□ Netherlands proposes to shift responsibility from Technical Service to manufacturer by requiring a manufacturer declaration on material compatibility backed up by documentation justifying the compatibility.

□ Four options were identified during the discussion:

Option A: Annex 9* Part 1 [with potential reference to SAE TIR 3294 "Guidance for material selection for use with hydrogen storage systems and components"]

Option B: Annex 9* Part 1 + alternative component cycling with hydrogen [with potential reference to SAE TIR 3294 "Guidance for material selection for use with hydrogen storage systems and components"]

Option C: Manufacturer declaration of compliance [with potential reference to SAE TIR 3294 "Guidance for material selection for use with hydrogen storage systems and components"]

Option D: No Material compatibility requirements (keep status quo, CPs use their national or regional requirements)

**Note: Due to the previously adopted document including Annex 8 on the Alternative lateral impact test for CHSS, Material compatibility requirements should become Annex 9 if added.*

□ Feedback from CP and experts present:
- France: need to review
- Japan: need to review
- Netherlands: C
- European Commission (JRC): need to review
- Technical Service Arrowhead (UK): C
- Technical Service KHK (Japan): cannot agree to option C

- Industry: need to review

□ Annex 8 part 2 “Humid gas stress corrosion cracking test” (HG-SCC)
  - There was a concern that “HG-SCC” may not be the practical problem. Japan replied that there are facts that liquefied water was found in the hydrogen tanks which were collected from the market. it is theoretically shown by Japanese representative in GTR Phase2 that the water in the hydrogen can be liquefied under the low temperature during re-fueling or de-fueling since the relative humidity becomes more than 100%. It is also possible to contaminate during re-fueling. Japan also commented that the concerns are the risks in the future new aluminums though there is no problem with currently used good aluminums..
  - There have been concerns by test institute in Germany (MPA) about the reproducibility of this test.
  - The industry argues that no component / metal will see any humidity like that throughout the lifetime of the vehicle.
  - France questions the feasibility of this test; it blocks the test facility for 90 days and will be rejected by most laboratories due to the time commitment. In addition, the tests need to be performed in air at 95% humidity which is difficult for test labs to achieve.
  - Japan considers this test to be applicable only for new material, however, cannot provide a list of proven materials (white list) at the moment.

□ The discussions on the HG-SCC has not progressed since the beginning of this TF and therefore the secretariat recommends to defer discussions back to GTR 13 phase 3. Annex 8 part 2 will be deleted from the proposal document.

Overall Wrap-up

Dates: 12/07/2023 10.30 am – 11.52 am (CET)

Participants:

☑ Alex Milward (LUXFER)
☑ Anais Garo (UTAC)
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Minutes

1. Additional discussion item – Subgroup 3: Change of design table:
   - ☐ Hyundai suggests forming a third subgroup on the Change of Design table.
   - ☐ It aims to discuss all relevant topics to this matter in particular the provisions for conformable tanks.
   - ☐ The discussion can be conducted via email with 2 or 3 virtual meetings to be finalized before the submission deadline of the working document on September 11th 2023

2. Wrap-up – Subgroup 1: Remote TPRDs:
   - ☐ Great progress made during discussions
   - ☐ Language drafted during the meeting needs to be reviewed
   - ☐ Proposals, comments, questions to be provided before the next meeting
   - ☐ A separate proposal document was created to facilitate the potential separation from material compatibility discussion.
     See document: *R134_ECE-TRANS-WP.29-GRSP-2023-xxxe.remote_TPRDs.docx*

3. Wrap-up – Subgroup 2: Material
   - ☐ Review the identified options
   - ☐ A decision on SAE TIR 3294 cannot be made until the document has been published
   - ☐ Annex 8 part 2 on Humid gas stress corrosion cracking test to be deleted

4. Next steps:
   - ☐ Revision of drafted language
   - ☐ For practicality reasons, the document has been split into two:
     - *R134_ECE-TRANS-WP.29-GRSP-2023-xxxe.remote_TPRDs.docx:* reflects the outcome of discussions of subgroup 1 and Option D of the material compatibility discussion
     - *R134_ECE-TRANS-WP.29-GRSP-2023-xxxe.Mat_Comp.docx:* reflects options A to C of the material compatibility discussion
   - ☐ Provide comments or proposals before next meeting on August 28th 2023

Next meeting for entire TF:

- ☐ August 28th 2023
  - 9 am – 11 am (CET)
  - 4 pm – 6 pm (JST /KST)