11th IWG GTR 13 Status of TF 1

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Status on September 28th, 2021

ITEM	STATUS	Contents	
Vehicle Class	Reached agreement, editorial revision of scope needed	Categories 1 and 2	✓
Installation requirement of container	Reached agreement	No need	✓
Hydrogen Leakage Criteria(in-use)	Reached agreement	After Crash, 118NL/min/1hr	✓
Permeation Criteria	Reached agreement	(LDV, HDV) 55℃, After 30hrs Less 46mL/h/L	✓
Crash requirements / Sled Test	Revision of EC proposal	Proposal: Acceleration pulses based on TRL study	Open
TPRD Direction	Revision of OICA Proposal	Proposal: 20 degrees upward, 45 degrees downward	Open
Service life	Revision of OICA Proposal	Proposal: No change needed	Open

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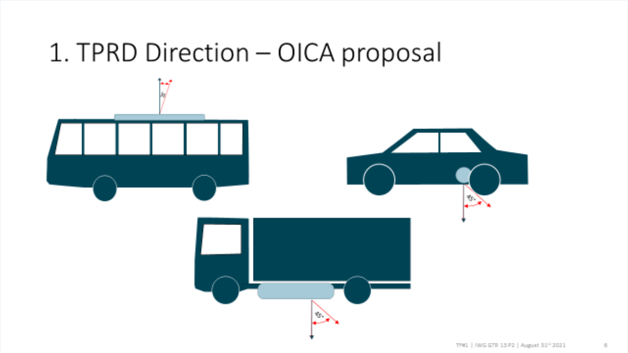
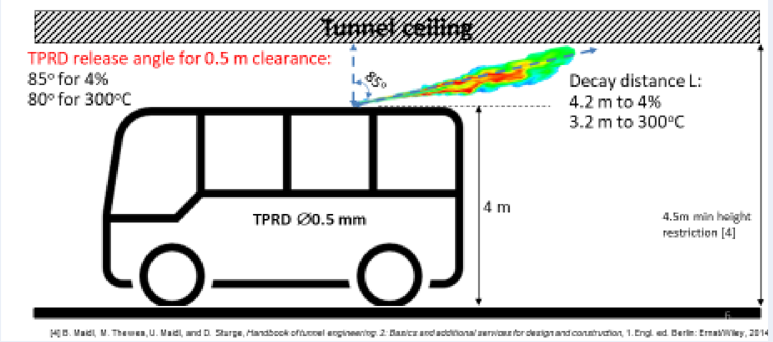
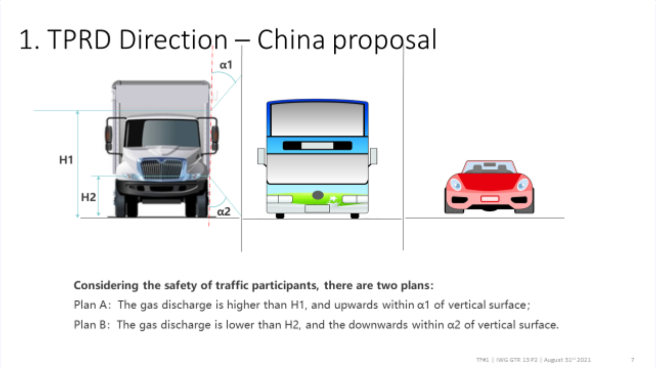
1. Summary of proposals for TPRD directions

OICA	Ulster University	CATARC
▪ With the vehicle on a level surface, the hydrogen gas discharge from TPRD(s) of the storage system shall be directed ▪ upwards within 20° of vertical relative to the level surface or ▪ downwards within 45° of vertical relative to the level surface. ▪ Additionally, the hydrogen gas discharge from TPRD(s) of the storage system shall not be directed: (i) Into enclosed or semi enclosed spaces; (ii) Into or towards any vehicle wheel housing; (iii) Towards hydrogen gas containers; (iv) Forward from the vehicle , or horizontally (parallel to road) from the back or sides of the vehicle. (v) Towards the vehicle's REESS	▪ no need to limit a release upward by 20° as the inherently safer design of TPRD release for the particular vehicle could be achieved for larger angles, e.g. to exclude the formation of the flammable layer in confined space like underground parking and tunnels ▪ For upward release from the bus or truck in a tunnel or maintenance shop the clearance between the TPRD ∅0.5mm and the ceiling should be sufficient to allow decay of the jet below 4% and 300°C, same as for the car in underground car parking ▪ Release from the TPRD towards the car exits should be avoided to minimise injury during evacuation ▪ Jet opening angle of 20° should be accounted ▪ Release for each vehicle type should be engineered to allow entrance in tunnel and underground car parking	▪ Considering the safety of traffic participants, there are two plans ： Plan A: The gas discharge is higher than H1, and upwards within α1 of vertical surface ； Plan B: The gas discharge is lower than H2, and the downwards within α2 of vertical surface. 1. not design-restrictive. 2. towards the possible static-electric points for FCVs. 3. the two angles' reason, and any test to verify? for LDV, towards at an upper angle, or for HDV, towards at a lower angle is dangerous to other road users.







1. Summary of proposals for TPRD directions

CATARC will provide more details at the next TF1 meeting in order to continue the discussions on the three proposals

CATARC

- Considering the safety of traffic participants, there are two plans：

Plan A: The gas discharge is higher than H1, and upwards within α1 of vertical surface；

Plan B: The gas discharge is lower than H2, and the downwards within α2 of vertical surface.

1. not design-restrictive.
2. towards the possible static-electric points for FCVs.
3. the two angles' reason, and any test to verify?
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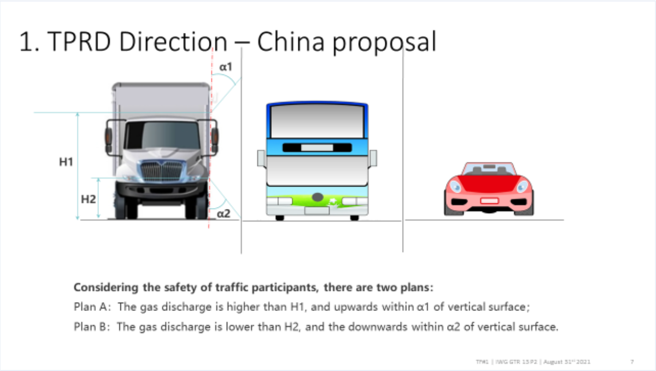

Sled test & Post-crash safety

4.2. Each contracting party under the UN 1998 Agreement shall maintain its existing national crash tests (frontal, side, rear and rollover) and use the limit values of section paragraph 5.2.2. for compliance. In absence of any such test or as an alternative to existing tests, the acceleration tests of paragraph 6.1.1. may be applied instead, to the discretion of each contracting party.

6.1.1. Post-crash compressed hydrogen storage system leak test

The crash tests used to evaluate post-crash hydrogen leakage are those already applied in the jurisdictions of each contracting party.

In case that a crash test as specified above is not applicable, or as an alternative thereto, the vehicle fuel system may, instead, be subject to the relevant alternative accelerations specified below to the discretion of each contracting party. [The hydrogen storage system shall in such case be installed in a position satisfying the requirements in paragraph XXX]. The accelerations shall be measured at the location where the hydrogen storage system is installed. The vehicle fuel system shall be mounted and fixed on the representative part of the vehicle. The mass used shall be representative for a fully equipped and filled container or container assembly.

Acceleration pulses

Accelerations for vehicles of categories 1-1, 1-2 and 2 with a gross vehicle mass (GVM) of 3,500 kilograms or less

(a) [20 or 26] g in the direction of travel (forward and rearward direction);

(b) [8 or 12] g horizontally perpendicular to the direction of travel (to left and right).

Accelerations for vehicles of categories 1-1 and 1-2 with a gross vehicle mass (GVM) of at least 3,501 kilograms up to 5,000 kilograms and category 2 with a gross vehicle mass (GVM) of at least 3,501 kilograms up to 12,000 kilograms

(a) 10 g in the direction of travel (forward and rearward direction);

(b) [5 or 8] g horizontally perpendicular to the direction of travel (to left and right).

Accelerations for vehicles of categories Category 1-1 and 1-2 with a gross vehicle mass (GVM) of at least 5,001 kilograms and category 2 with a gross vehicle mass (GVM) of at least 12,001 kilograms

(a) [6.6 or 8] g in the direction of travel (forward and rearward direction);

(b) [5 or 8] g horizontally perpendicular to the direction of travel (to left and right).

2. Sled test – OICA (revised EU proposal)

EU proposal	OICA proposal (revised EU proposal)
• Pulses originally from UN regulation no. 134 to be amended according to a study conducted by TRL • decision at GRSP level • EU to provide a rationale for this test	• Amended to reflect the status of UN regulation no. 134

EU proposal:

6. Test conditions and procedures

6.1. Compliance tests for fuel system integrity

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(a) [6.6 or 8] g in the direction of travel (forward and rearward direction);

(b) [5 or 8] g horizontally perpendicular to the direction of travel (to left and right).

Prior to conducting the crash test, instrumentation is installed in the hydrogen storage system to perform the required pressure and temperature measurements if the standard vehicle does not already have instrumentation with the required accuracy.

The storage system is then purged, if necessary, following manufacturer directions to remove impurities from the container before filling the storage system with compressed hydrogen or helium gas. Since the storage system pressure varies with temperature, the targeted fill pressure is a function of the temperature. The target pressure shall be determined from the following equation:

$P_{target} = NWP \times (273 + T_o) / 288$

OICA proposal (revised EU proposal):

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$P_{target} = NWP \times (273 + T_o) / 288$

where NWP is the nominal working pressure (MPa), T_o is the ambient temperature to which the storage system is expected to settle, and P_{target} is the targeted fill pressure after the temperature settles.

The container is filled to a minimum of 95 per cent of the targeted fill pressure and allowed to settle (stabilize) prior to conducting the crash test.

The main stop valve and shut-off valves for hydrogen gas, located in the downstream hydrogen gas piping, are in normal driving condition immediately prior to the impact.

6.1.1.1. Post-crash leak test - compressed hydrogen storage system filled with compressed hydrogen

The hydrogen gas pressure, P_0 (MPa), and temperature, T_0 (°C), is measured immediately before the impact and then at a time interval, Δt (min), after the impact. The time interval, Δt, starts when the vehicle comes to rest after the impact and continues for at least 60 minutes. The time interval, Δt, is increased if necessary in order to accommodate measurement accuracy for a storage system with a large volume operating up to 70MPa; in that case, Δt can be calculated from the following equation:

$\Delta t = V_{CHSS} \times NWP / 1000 \times ((-0.027 \times NWP + 4) \times R_s - 0.21) - 1.7 \times R_s$

where $R_s = P_s / NWP$, P_s is the pressure range of the pressure sensor (MPa), NWP is the Nominal Working Pressure (MPa), V_{CHSS} is the volume of the compressed hydrogen storage system (L), and Δt is the time interval (min). If the calculated value of Δt is less than 60 minutes, Δt is set to 60 minutes.

The initial mass of hydrogen in the storage system can be calculated as follows:

$P_o' = P_o \times 288 / (273 + T_0)$

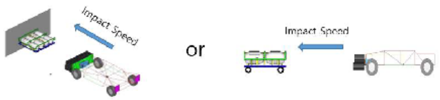
$\rho_o' = -0.0027 \times (P_0')^2 + 0.75 \times P_0' + 0.5789$

3. Impact test - Korea

2. Proposal

- To ensure robust HFC fuel crash safety and the effectiveness of the test for the HDV, need to introduce the impact tests(MDB impact test) introduced in R 134 instead of the full scale crash test
- The proposal : Sled test(OICA & EC proposal) + Impact test (R 134)
  - The objective of sled test is to evaluate fuel system risks according to the container movements due to inertial load during the crash situations.
  - The objective of MDB impact test is to evaluate fuel system risks same as fuel leakage and fractures of fuel systems due to impact load during the crash situations.

<Sled Test>



<MDB Impact Test>

3. Draft post-crash provisions in GTR 13

- To insert new paragraph in order to apply the test procedures about the impact test.
  - MDB (Movable Deformable Barrier) impact test

The compressed hydrogen storage system must be filled with hydrogen or helium. The test pressure shall be agreed by the manufacturer together with the Technical Service. Tests shall be conducted on the compressed hydrogen storage system in the position intended for the installation in the vehicle including attachments, brackets and protective structures if applicable. The protective structure shall be defined by the manufacturer. The compressed hydrogen storage system may be fixed to a representative part of the frame, to the rigid wall or on a complete vehicle in order to be applied on the compressed hydrogen storage system equivalent to impact loads through the lateral impact tests.

The MDB shall comply with the requirements of UN Regulation No. 95, Annex 5. The MDB speed at the moment of impact shall be 50 ± 1 km/h. However, if the test was performed at a higher impact speed and the compressed hydrogen storage system met the requirements, the test shall be considered satisfactory. The impact direction shall be in an angle of 90° to the longitudinal axis of the container and the height of the container shall be adjusted in a way that the middle of the front plate of the barrier matches the middle of the container in the horizontal and vertical.

- Implementation of component impact test from proposal for supplement 1 to series of amendments 01 of UN-R 134
- Korea proposes to add it as either
  1. an alternative test to the Sled test, or
  2. a separate impact test.

- Chair proposes to table the discussion on this proposal until phase 3 of GTR 13

4. Service life – JAMA (revised)

Region	Source	Max svc. life	Max lifetime miles traveled	Lifetime N of press. cycles
Japan	MLIT HD Commercial	20 yrs 25 yrs	3,400,000 km 3,900,000 km	8,500 9,800 *(400 km/fill)*
Japan	MLIT LD Commercial	20 yrs 25 yrs	2,100,000 km 2,400,000 km	6,600 7,400 *(320 km/fill)*

CONCLUSIONS

- Japanese data shows:
  Current 11,000 cycles can be applied for 25 yrs.
  HDV (400 km/fill)
  - 9,800 cycles for 25 yrs

  LDV (320 km/fill)
  - 7,400 cycles for 25 yrs

ISSUES

- OICA's UNR proposal:
  - 15,000 for 20 yrs
- Filling interval (more than 320km/LDV for HDV?)
- Other considerations (stress rupture, duty cycles for components (e.g., TPRD))

4. Service life – JAMA (rationale)

Extension of the service life of the container to 25 years
– Determination of the number of the pressure test cycles

JAMA

The maximum lifetime miles traveled within the category of LDV/T and HDV/T were estimated to determine the number of the pressure test cycles. The study is based on the vehicles in Japan.

1. Japanese (JAMA) study

(1) **Summary**

The estimated maximum lifetime miles traveled and lifetime number of pressure cycles are shown in Table 1. It is considered that the 1,1000 cycles in the pressure cycle test of current GTR13 can be applied to both heavy duty and light duty vehicles for 25 years.

The analyzed data were Japanese legal inspection records in July 2017. The number of record was about 6,000 for LDV/T and 21,000 for HDV/T.

The maximum lifetime miles traveled was calculated by summing the estimated maximum VMT (Vehicle Mileage Traveled) in each vehicle age. Number of pressure cycles were calculated by applying a fill per traveled mileage of 320 km for light duty and 400 km for heavy duty.

Table 1. Results of Japanese study

Vehicle Type	Max svc. life	Max lifetime miles traveled	Lifetime N of fills (=pressure test cycles)
HD Commercial	20 yrs 25 yrs	3,500,000 km 4,000,000 km	8,500 9,800 (fill / 400km)
LD Commercial	20 yrs 25 yrs	2,100,000 km 2,400,000 km	6,600 7,400 (fill/320km)

(2) Points of the study

① **Analyzed data**

The major items of the inspection records are shown in Table 2. They were obtained in the legal inspection in July 2017 from about 400 thousands on-road vehicles.

Special note is;

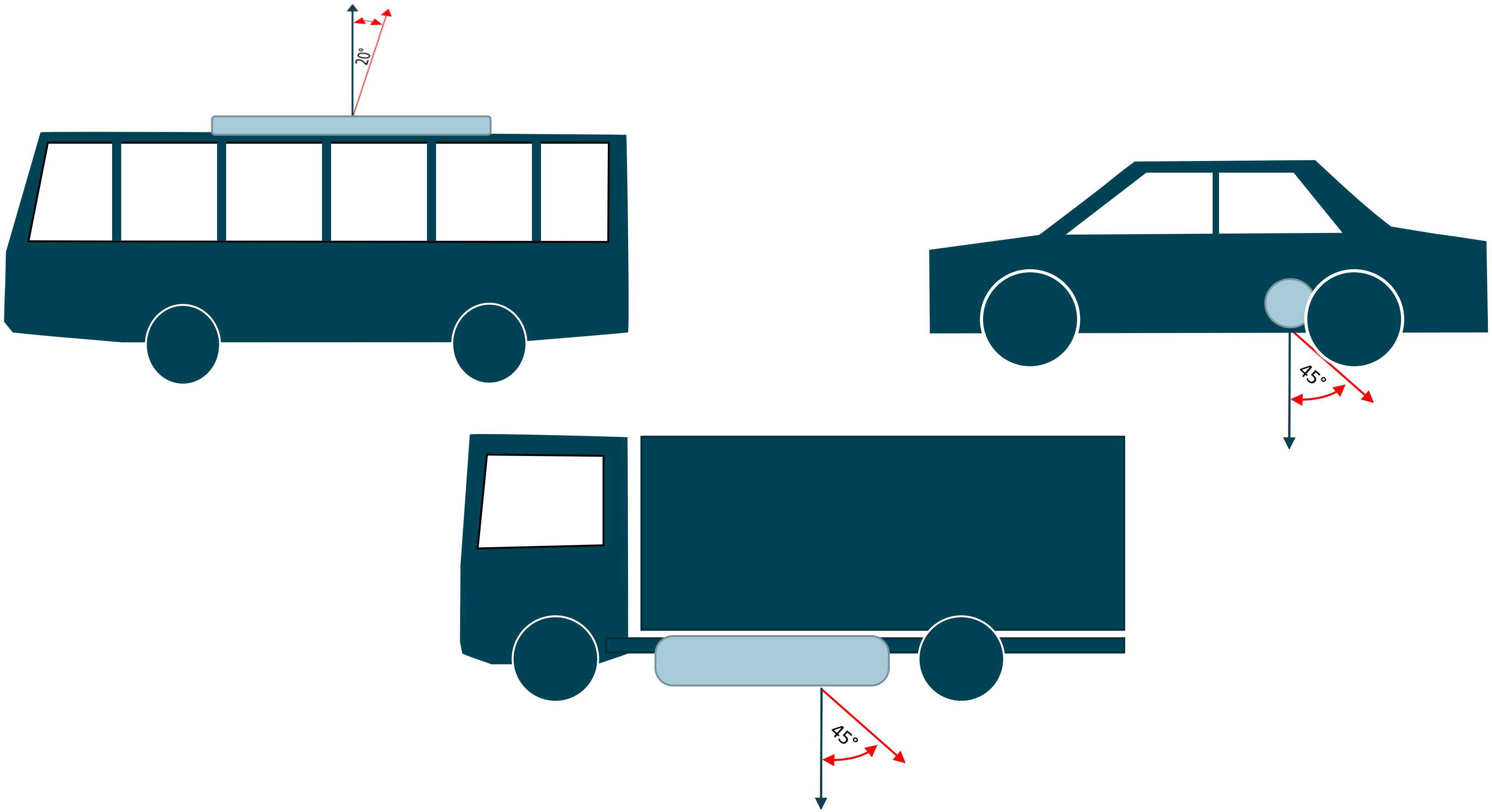
- HDV/T are defined as below:
  Number of seats>10 (according to Japanese categorization)
  Loading capacity>1250kg (assuming the vehicle weight more than 3,500kg)

5. Summary of discussion in TF1

No	Items	Status / Issues	Document	CP positions									To Do in #10IWG		Results of #10IWG	Note
				EU	JPN	KOR	CHN	CAN	USA	DEU	GBR	FRA	Who	To Do		
01. Jan	Vehicle class	TF1 to propose the draft wordings.	GTR13-6-21	Agreed	Agreed	Agreed	Agreed	Agreed	Agreed				TF0	Report to IWG		
01. Mrz	Sled test	1. How it should be regulated in GTR13. 2. EU proposal to be disscussed in TF1. 3. The nature of the test. *(1) Component test?** *(2) Leakage requirements?** (3) Alternative calculation method? *Recent revision of UNR134 at #69 GRSP includes above (1) and (2) (https://unece.org/sites/default/files/2021-05/GRSP-69-22r2e.pdf).	GTR13-7-18	Part II or CP option	Part II or CP option	Part II or CP option	Part II or CP option	TBD Review EU proposal	No need or CP option				TF1	Report to IWG		-Current proposal "GTR13-7-18" by OICA: 1. Requirements are CP option 2. Component test 3. No leakage requirement. 4. Allow calculation '-US questioned necessity of acceleration tests when there is no field incident indicating issues with fixation; an impact testwould make more sense.
	Impact test	Proposal to include component impact test from UN regulation 134														Proposal by chair to postpone this until GTR 13 phase 3
01. Apr	Installation requirements of container	Concluded: No need	GTR13-7-22	No need	No need	No need	No need	No need	No need				N/A	N/A		None
01. Jun	TPRD direction	To be disscussed in TF1	GTR13-7-11 GTR13-9-08										TF1	Report to IWG		OICA revised proposal on GTR13-7-11: 1. Keep "Shall not discharge forward". 2. Shall not discharge toward {emergency] exits for Category 1-2.
01. Jul	Extension of tank useful life	To be disscussed in TF1. TF1 reported the draft idea by OICA in #9IWG.	GTR13-9-08										TF1	Proposal or report to IWG		Germany, Japan and the US VMT data have been analyzed by OICA to extend the life from 15 years to 25 years. US prvided the report on the reliablity of CNG tanks exceeding 15yrs old GTR13-10-02).
01. Aug	Permeation criteria	Included in the TF0 draft as proposed.	GTR13-6-20	Agreed	Agreed	Agreed	Agreed	Agreed	Agreed				N/A	N/A		Apply current requirements to HDV/T also.
01. Sep	Hydrogen leakage criteria (in-use)	Included in the TF0 draft as proposed.		Agreed	Agreed	Agreed	Agreed	Agreed	Agreed				N/A	N/A		No change

Back-up

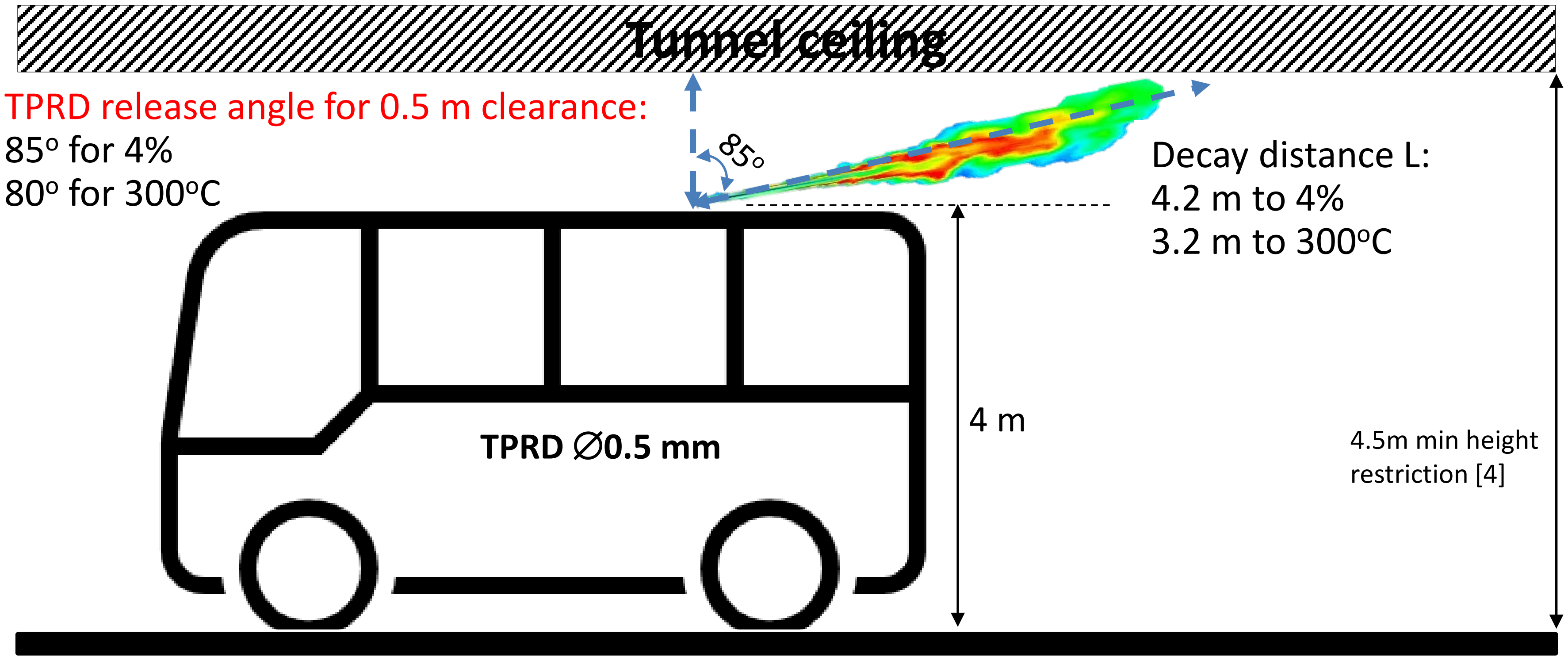
TPRD Direction – OICA proposal



Release from bus/truck in tunnel

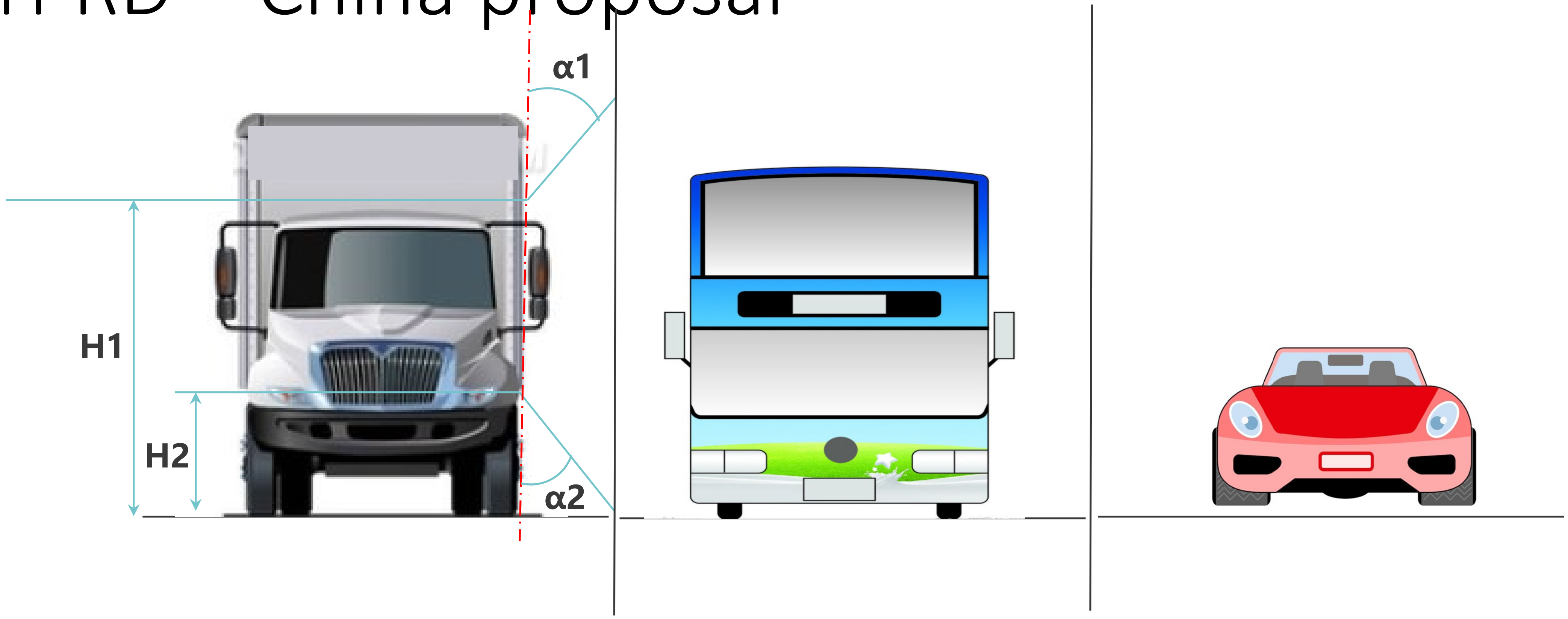
Example of angle to satisfy hazard criteria

- For upward release from the bus or track in a tunnel or maintenance shop the clearance between the TPRD ∅0.5mm and the ceiling should be sufficient to allow decay of the jet below 4% and 300°C, same as for the car in underground car parking
- Jet attachment is not considered and should be accounted



[4] B. Maidl, M. Thewes, U. Maidl, and D. Sturge, *Handbook of tunnel engineering. 2: Basics and additional services for design and construction*, 1. Engl. ed. Berlin: Ernst/Wiley, 2014

TPRD – China proposal



Considering the safety of traffic participants, there are two plans:

Plan A: The gas discharge is higher than H1, and upwards within α1 of vertical surface;

Plan B: The gas discharge is lower than H2, and the downwards within α2 of vertical surface.