Conformable tanks and shells for UNGTR13

Vladimir Kovalevsky

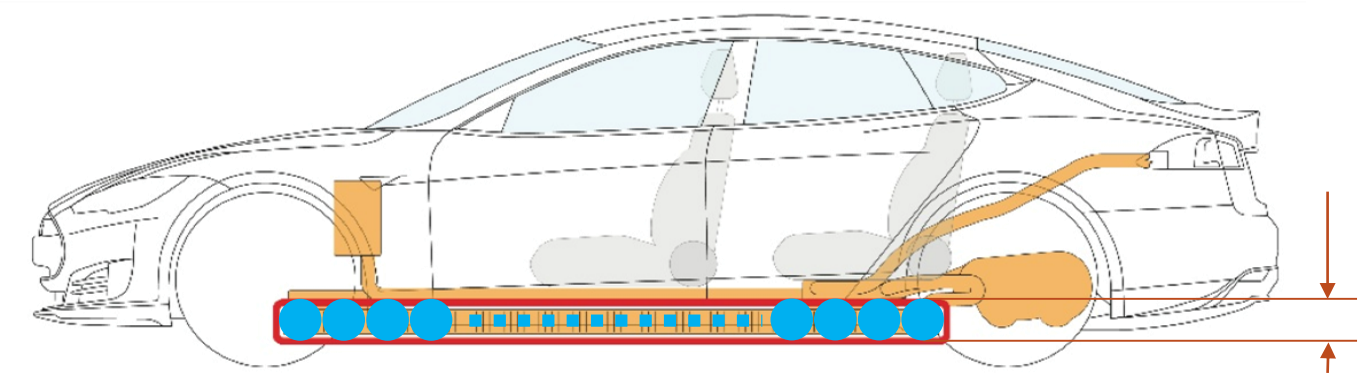
UNGTR13
June 17-20 2019
CATARC, Tianjin, PRC

Goals

1. Explain the need for conformable tanks and protective shells.
2. Submit proposal for UNGTR13.

Motivation for alternative storage concepts in FCEV

- Strong motivation in the industry to use a BEV platform as FCEV platform
  - Advantages:
    - One standard vehicle architecture for all powertrain concepts
    - Reduced development and industrialization costs
    - Reduce variety in production, increase flexibility in drivetrain types



- That leads to alternative hydrogen storage concepts and geometries
  - **Small diameter tanks,**
  - **Conformable tanks,**

  } Focus of the presentation

  - Liquid carrier,
  - Solid carrier (e.g. KMH-1),
  - And others…

Protective shell concept

- Small diameter tanks (e.g. cylindrical standard shape, conformable tank, …) will have much thinner wall thicknesses compared to larger size tanks.

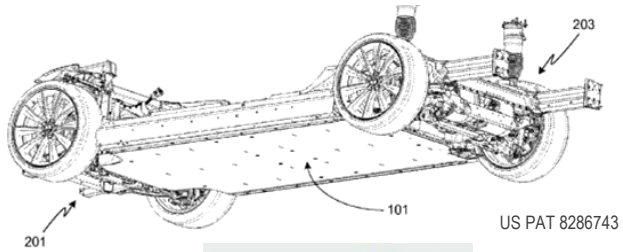
$$t \approx \frac{Pr}{\sigma}$$

- This could result in challenges for certain GTR13 tests:
  - Surface damage
  - Pendulum impact
  - Bonfire
  - Crash impact

- Natural design solution: protective shell
  - Design intent is to ensure equal or superior safety level.

- Function of protective shell similar to:
  - Dome caps
  - Coatings
  - Battery protection envelopes

Examples



US PAT 8286743

Why not pursue NGV2-2019 approach?

CSA/ANSI NGV 2-2019 Content – Conformable Tanks

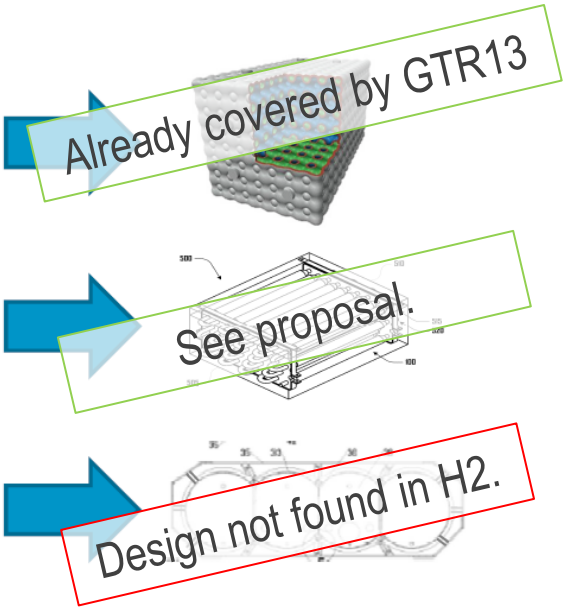
What is conformable?

NGV 2 DEFINITION: Conformable container types are designated as follows:

CT1: container or assembly of a non-spherocylindrical or non-spherical (i.e., irregular) shape **without a protective shell** (i.e., outside wall containing gas pressure);

CT2: container or assembly of possibly irregular shape **within a conformable protective shell** that is acting as a shield and **not directly assisting** the inner container with containing gas pressure; and

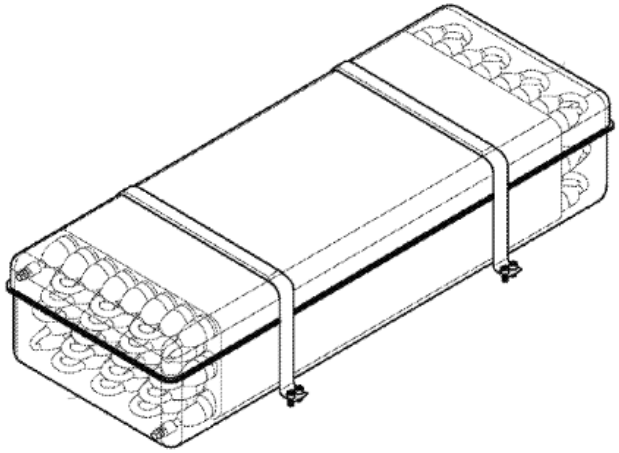
CT3: container or assembly of possibly irregular shape **within a conformable protective shell** that is acting as a shield and **directly assisting** the inner container with containing gas pressure.



GTR no. 13 Phase 2 IWG, M. Veenstra 12

Linamar proposal for UNGTR13 phase 2

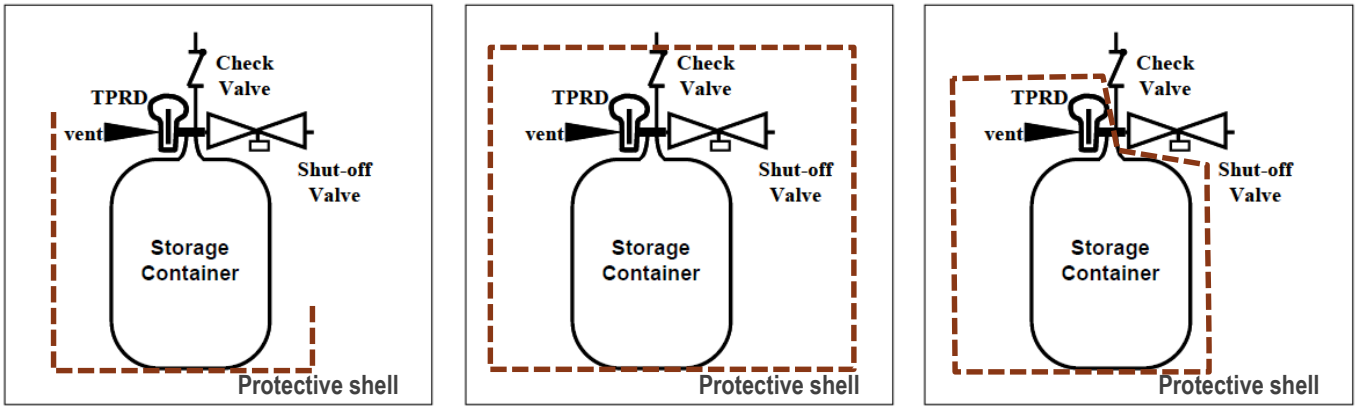
- Introduce a protective shell definition.
- Propose meaningful test edits ensuring equal level of safety.
- Maintain the performance based approach of the GTR13 regulation.
- Do not prevent the development of future technologies.



Linamar proposal for UNGTR13 phase 2 : Protective shell

- Proposed definition :
  - *"Protective shell is a shield of the hydrogen storage system that does not directly assist the storage container with containing the internal pressure."*
  - *"The parts of the protective shell that are permanently affixed to the storage system **shall be included in the qualification tests**."*

Examples

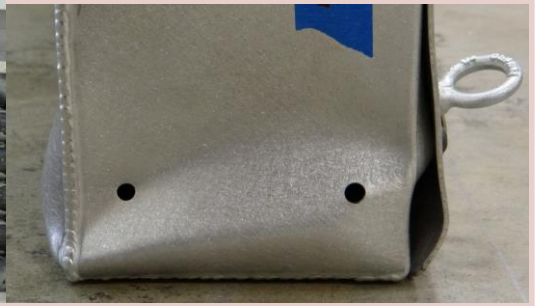
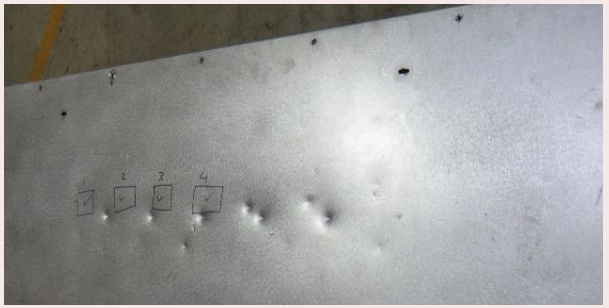


- Other examples in standards/regulation:
  - UNGTR13 : Shielding affixed directly to the container in fire test.
  - EC R79 (No 406/2010) : (15) "Container assembly" with housing shell or protective frame.
  - NGV2 – 2019 : CT1, CT2, CT3 categories.

Linamar proposal for UNGTR13 phase 2 : Protective shell

	Existing Test	Pass ?	Proposed test amendments
5.1.1.	1. Baseline initial burst pressure	V	No amendments
	2. Baseline initial pressure cycle life	V	
5.1.2.	1. Proof pressure test	V	
	2. Drop (impact) test	V	*"For irregular shape containers, perform **angled drop from worst case orientation**".*
	3. Surface damage	V	*"If the protective shell fully shields the storage container from road debris when mounted in the vehicle, **apply the pendulum impact on the protective shell."*** *"If the vehicle mounting features are manufactured and tested with the pressure container, **the cuts are not required on the pressure container."***
	4. Chemical exposure and ambient temperature pressure cycling tests	V	No amendments
	5. High temperature static pressure		
	6. Extreme temp. pressure cycling		
	7. Residual proof pressure test		
	8. Residual strength Burst test		
5.1.3.	1. Proof pressure test		
	2. Ambient and extreme temperature pneumatic cycling		
	3. Extreme temperature static gas pressure leak/permeation test	V	
	4. Residual proof pressure		
	5. Residual strength burst (hydraulic)		
5.1.4	Service terminating performance in fire		Shell already covered by "any shielding affixed to the container".

Linamar proposal for UNGTR13 phase 2 : Protective shell

Test	Test modification	Rationale	Test results
Drop test	**Permanently attached** shell parts included in drop test.	Provide additional protection.	 
Pendulum impact	Pendulum **impact the shell + pressure container assembly.**	Provide additional protection. Chemical exposure kept on the pressure container.	
Cut	For tank supports manufactured and tested with container remove cut test.	No straps = No risk of cutting the pressure container.	Vehicle mounting features   As manufactured and tested
Bonfire		In agreement with the existing definition of shielding affixed directly to the container.	

Next steps

- Linamar is working with collaborators to introduce similar changes to SAE J2579.
- Would like to introduce amendments in GTR13 phase 2.

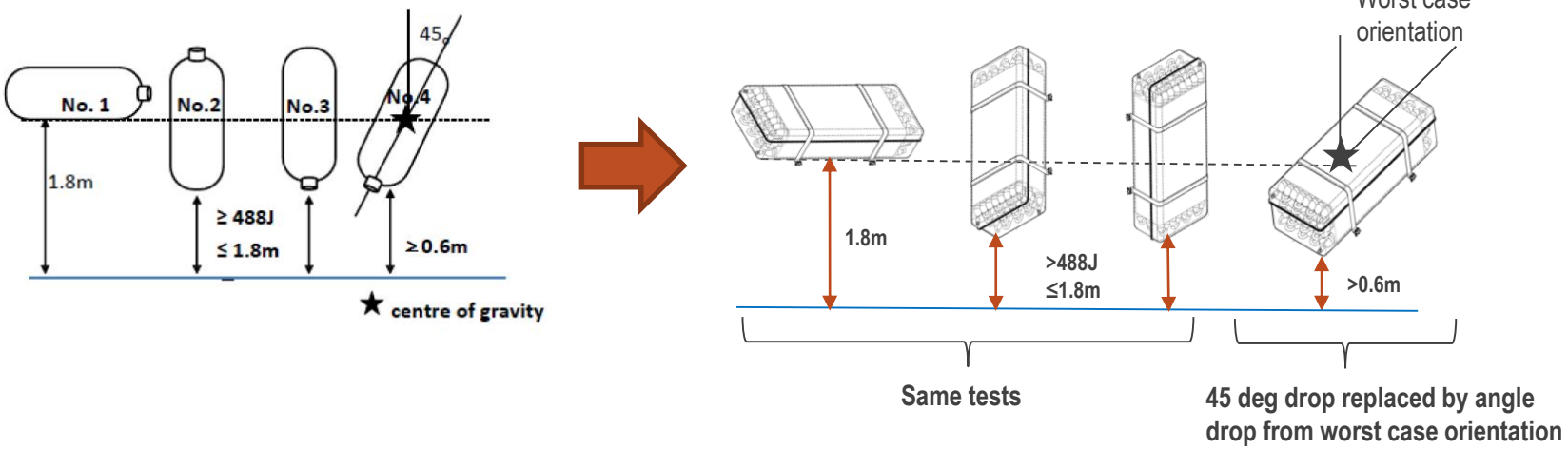
Thank You

www.linamar.com

@linamarcorp
@linamarcorp
Linamar Corporation
Linamar Corporation

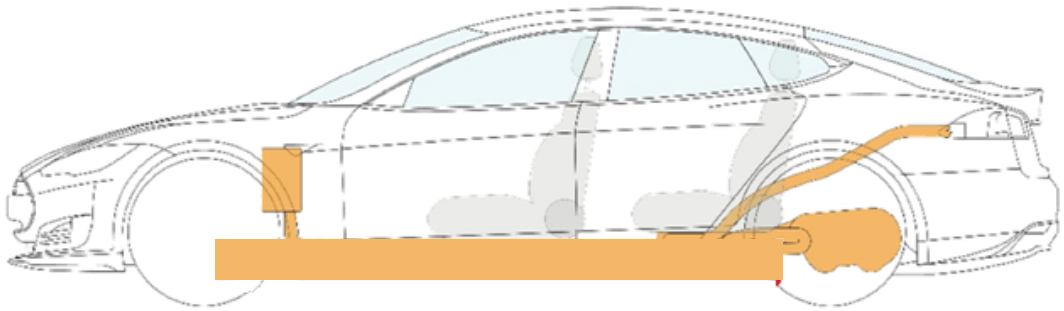
Backup slide : drop test

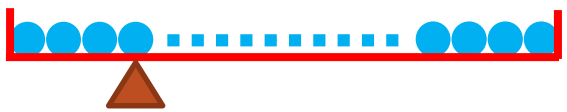
- 5.1.2.2: **Drop (impact) test:** Add comment
  - *"For irregular shape containers, perform **angled drop from worst case orientation**".*



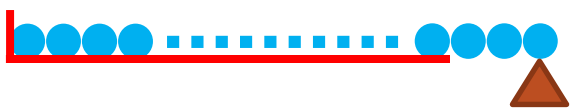
Backup slide : Pendulum impact

- 5.1.2.3 **Surface damage:** Add comment
  - *"If the protective shell fully shields the storage container from road debris when mounted in the vehicle, apply the **pendulum impact on the protective shell**."*





Shell + **Vehicle** = full debris coverage.
Pendulum impact on shell.



Shell + **Vehicle** = partial debris coverage.
Pendulum impact on pressure containers only.

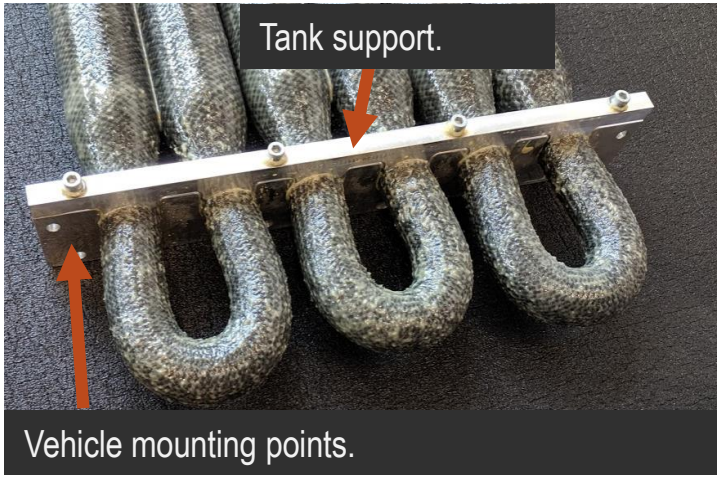
: Protective shell

: Pendulum impact

Backup slide : Cuts

- *"If the vehicle mounting features are manufactured and tested with the pressure container,* ***the cuts are not required on the pressure container.****"*

Cut and abrasion risk from straps during installation and service.



Tank support manufactured and tested with tank. No damage to pressure container during install and service.

Backup slide : other tests

- **Vibration tests.** We do not have test results justifying the need for a proposal about a mechanical interaction between the shell and the pressure container. Until then, we propose to rely on clause *E.2.a (viii) (d)*

"The hydrogen fuel system should be installed such that it is protected against damage under normal operating conditions;"

- **Reaching LFL under the shell.** In our opinion, the concern about reaching LFL under the shell is covered in *5.2.1.4.1.*

"Hydrogen leakage and/or permeation from the hydrogen storage system shall not directly vent into the passenger, luggage, or cargo compartments, or to any enclosed or semi-enclosed spaces within the vehicle that contains unprotected ignition sources."