JRC replies to the comments of OICA on the EVS25-E1TP-0510 Draft regulatory text for the Thermal Runaway Propagation test

Colour code:
Black – comments of OICA
Blue – replies of JRC

1. OICA understands that "documentation" requirement will remain in parallel to the "test" requirement. It is necessary to agree how the "test" requirement will be positioned in the GTR because it will affect the level of required completeness of the test procedure prescriptions:
(a) CP may elect either "documentation" or "test" for their national regulation, or
(b) It is manufacturer's discretion to apply either "documentation" or "test" for their product certification, or
(1) If "test" is conducted for certification, no "documentation" (except for defined information document) will be required.
(2) "Test" may substitute certain part of the "documentation" to the extent applicable.
(c) "Test" will be used for compliance test/certification test conducted by the accredited bodies for national certification, while "documentation" will always be required, or
(d) Other scenarios??
This important point requires further discussion and agreement within Informal Working Group tasked with the development of the GTR EVS.

2. So far, the discussion of thermal propagation test and requirements have been made mainly focusing on passenger cars. Since electrification of heavy-duty vehicles is also important to achieve carbon neutral society, therefore the typical nature of such vehicles should also be considered.
This important point requires further discussion and agreement within Informal Working Group tasked with the development of the GTR EVS.

3. The proposal is largely based on ISO6469-1 Amd.1. Since ISO6469-1 is developed as an industry tool, many provisions may not necessarily be appropriate for regulatory purpose. For example, terminologies such as "DUT", "supplier", "customer", etc. are not consistent/relevant for GTR.
The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), substituting the "customer" with "testing entity" and "supplier" with "manufacturer". The term "DUT" is used in the text of the GTR EVS Phase 1.

4. Are there any specific intent for using "thermal runaway propagation" in this document instead of the terms defined in the GTR20, namely "thermal propagation" and "thermal runaway"?
The regulatory text proposal has been updated accordingly, substituting the term "thermal runaway propagation" with "thermal runaway" and "thermal propagation (please see an updated regulatory text proposal).

5. OICA supports that, certain boundaries of the requirements; i.e. "protection of vehicle occupants" and "a single cell thermal runaway due to an internal short circuit" are carried over from current GTR20.
These are indeed as agreed in Phase 1 of the GTR EVS.

6. "Hazardous environment" must be defined in objective manner for the test requirement.

7. Smoke/gas emissions from the initiation cell should not be considered for pass/fail criteria because it is a result of manipulation for the test. The effect of "thermal propagation" should be the assessed for this test.
In agreement with the GTR EVS Phase 1 text, the regulatory text proposal states: *"For the vehicles equipped with a REESS containing flammable electrolyte, the vehicle occupants shall not be exposed to any hazardous environment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway. To ensure this, the vehicle shall provide an advance warning indication to allow egress or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment caused by thermal propagation, which is triggered by an internal short circuit leading to a single cell thermal runaway, such as fire, explosion or smoke. This requirement is deemed to be satisfied if the thermal propagation does not lead to a hazardous situation for the vehicle occupants."*
As can be seen from the text hazards related to thermal propagation are addressed and fire, explosion and smoke are explicitly mentioned. In our view, these are currently sufficient and feasible indicators of hazardous situation. Nevertheless, we appreciate that a further discussion and agreement within Informal Working Group tasked with the development of the GTR EVS can be needed.

8. Other initiation methods should also be allowed, as long as sufficient level of thermal runaway of the target cell could be initiated. On the other side, we should avoid the situation where a manufacturer would be required to use multiple initiation methods for certifying one product. Note that equivalency between trigger methods may be an issue.
As mentioned at various occasions, e.g. TF TP meetings in April 2022, November 2022 and February 2023, JRC do not consider inclusion of an alternative initiation method necessary. Our test campaign showed that localised rapid external heating yields reproducible and repeatable results. Nevertheless, alternative initiation method(s) can be allowed, provided their equivalency, suitability for testing at vehicle level and repeatability are demonstrated. This requires further discussion and agreement within Informal Working Group tasked with the development of the GTR EVS.

9. Is the "main" method intended to define the pass route with no thermal runaway?
The [main] initiation method for triggering thermal runaway during the thermal propagation test is localised rapid external heating, which is meant for all initition outcomes both triggering thermal runaway in a target cell and not. Current practical experience shows that in all tested contemporary target cells TR has successfully been triggered using the localised rapid external heating method.

10. Parameters in tables XX and XXX are considered as a guidance only, while rationale of each parameter should be provided in any case. How could the deviations from these parameters be judged to determine the test is valid or not?
11. The test parameter will need to be adapted according to the system (e.g. cell design, chemistry, module and pack structure, etc.) Then how would the neutrality of the assessment be secured?
Tables XX and XXX provide requirements for the heating element selection and typical heater paramenters for implementation of localised rapid external heating methodology, which are defined based on the extensive research of GTR EVS IWG experts. Tables also specify a possibility to adjust target parameters for cells with different chemistries or type. Furthermore, sections "Test application and necessary modifications" and "Subsystem level testing" state that *"To ensure the test is conducted efficiently, a preliminary test on a single cell or a small number of cells should be performed… This subsystem level test permits the refinement of test parameters (heating rate, target temperature, soak time) for the specific cell used in the chosen REESS design, which vary (from those shown in Tables XX and XXX) upon change of cell chemistry and cell size/construction."*
Refinement of the parameters should be allowed within the ranges/boundaries mentioned in the regulation text.

12. Will these sub-system tests be a part of certification/compliance test?
13. In case if the sub-system test indicate that the thermal runaway will not propagate to the adjacent cells, will it be necessary to conduct full system/vehicle level test?
As mentioned in the sections "Test application and necessary modifications" and "Subsystem level testing" "*To ensure the test is conducted efficiently, a preliminary test on a single cell or a small number of cells should be performed… This subsystem level test permits the refinement of test parameters (heating rate,*

target temperature, soak time) for the specific cell used in the chosen REESS design, which vary (from those shown in Tables XX and XXX) upon change of cell chemistry and cell size/construction." Sub-system tests are meant as preliminary tests for refinement of the test parameters. A certification/compliance thermal propagation test is proposed to be conducted at the vehicle level.

14. In general, it is reasonable to test with the system operational since vehicle occupant will typically be present in such mode. Clear definition of "ON" is necessary as it is different from "active driving possible mode" defined in the GTR20.
Indeed, the intention is to conduct the test under conditions of "temporary parking" listed below in the table, shared by OICA:

Typical operation modes	Vehicle status			REESS status			Vehicle occupants
	Main SW	Shift	Energy supply	Power line	Cooling	BMS	
(a)Usual parking	OFF	P	Disconnected	Disconnected	Not operational	Not energized	Typically not present
(b)External charging	OFF	P	Connected	Connected	Limited	Energized	Typically not present
(c)Temporary parking	ON	P	Disconnected	Connected	Operational	Energized	Typically present
(d)Active driving possible mode	ON	D/R etc.	Disconnected	Connected	Operational	Energized	Present

The information on the vehicle and REESS status is added into the regulatory text proposal (please see an updated regulatory text proposal).

15. REESS level test should be allowed to assure the efficiency of the test, especially for heavy duty vehicles.
JRC research has shown that thermal propagation can occur at higher rate in a REESS installed in a vehicle compared to a REESS level test. See presentation EVS25-E1TP-0500 [EC] "JRC's thermal runaway propagation test campaign at.pdf". In addition, it is not clear how to ensure the equivalence of pass/fail criteria for vehicle and component-level tests. To be further discussed and agreed within the Informal Working Group tasked with the development of the GTR EVS, also for heavy duty vehicles.

16. The observation items and the possible test outcomes described above are not necessary for regulatory provisions. The observation of certain events, such as deformation, venting, leakage, rupture, will be difficult especially at vehicle level tests.
Part "Test events and outcome description" and Table XXXX have been deleted from the text of the regulatory proposal (please see an updated regulatory text proposal).
REESS deformation and REESS or cell rupture are listed among post-analysis criteria, which together with the supplementary criteria provide further evidence and help ascertaining the occurrence of TR.

17. Paragraph 5 (and 7) of the regulatory test should reflect the agreement as to how this test is positioned (See comment 1 above). Focusing on REESS containing flammable electrolyte can be supported.
Please see our reply to comment 1 above.

18. "No propagation" will not create "hazardous environment" and therefore such situation will be considered to satisfy the requirement.
This is also our understanding. Nevertheless, this point deserves to be discussed and agreed within the Informal Working Group tasked with the development of the GTR EVS.

19. Thermal runaway of the target cell should not be considered for the pass/fail criteria. (see comment 7 above.)
Please see our reply to comment 7 above.

20. the text saying "… if thermal runaway occurs…" should read "… if a single cell thermal runaway due to an internal short circuit occurs…" to align with requirement section. Multiple occurrences of thermal runaway or thermal runaway due to external causes (mechanical damage, overcharge, external short, etc.) are not addressed in this test.
The intention of the thermal propagation test is to verify that the vehicle occupants shall not be exposed to any hazardous environment caused by thermal propagation which is triggered by an internal short circuit leading to a single cell thermal runaway. It is not the intention to simulate conditions that can be

considered double failure, e.g. thermal runaway and thermal propagation resulting from mechanical damage.

21. More data are necessary to validate if the observation of JRC (footnote 2) will generally be applicable. REESS system level tests are more practical and will be beneficial to accelerate the development.
Please see our reply to comment 15 above.

22. If the REESS temperature would be considered as critical, the measurement procedure should be detailed.
According to regulatory text proposal, the test shall be conducted either indoors or outdoors. In our view, temperature of the REESS in the DUT is more important to be controlled than the ambient temperature. As a number of temperature sensors would be installed in the REESS for the thermal propagation test, their readings can be used to verify the temperatures within the REESS. The requirement on temperature should be respected before the test.

23. For the regulatory test, measurement parameters and conditions should be minimized since unexpected environmental events or measurement errors may lead to the test being void.
This comment is equally valid for all regulatory tests.

24. Boundary of modifications those are allowed/not-allowed should be clarified. The manufacturer should have an opportunity to observe the conditions of the modified test article. For example, additional heat insulations for the cell adjacent to the target cell may influence to the test results.
Requirements for minimising modifications to the DUT are described in, for example, lines 136-139 of the regulatory text proposal: *"(a) Required modifications shall be kept minimum compared to the original un-modified DUT. Any manipulation of REESS components, such as thermal barriers, cooling plates/channels, electrical connections, and cell to cell spacing shall be kept at a minimum and be reported. The original sealing capability of the REESS shall not be compromised through instrumentation."*
Extensive research by various experts of the GTR EVS IWG has shown that involvement of the manufacturer/automotive OEM is not mandatory. In our view, manufacturer/automotive OEM can be consulted, but it is not a mandatory requirement.

25. There will be other factors to determine the worst case, e.g. path way of vented gas, heat insulations, cooling lines, etc. Practicability will also be an important factor.
JRC appreciate that for technical reasons not all potential heater positions would be equally accessible in the REESS. For this reason, the requirement was formulated outlining the general philosophy for choosing the target cell "*among those with a maximum number of nearest neighbours approximating the centre of the battery pack*". This important question needs to be further discussed and agreed within Informal Working Group tasked with the development of the GTR EVS.

26. For the regulatory test, measurement parameters and conditions should be minimized since unexpected measurement errors may lead to the test being void. Administrative requirements (e.g. contents of test report) are not appropriate for GTR.
Please see our reply to comment 23 above. Text on administrative requirements (e.g. contents of test report) has been deleted (please see an updated regulatory text proposal).

27. In case that thermal runaway does not occur, it is important to define the conditions to terminate the initiation. The post-test observation and assessments should be clarified in order to fair judgement of the test results as either pass or void.
If no TR can be achieved, heating stops when total energy input into the heater exceeds 20% of target cells' maximum rated energy (please see Table XXX).

28. The judgement criteria of thermal runaway should be validated with sufficient data. The condition to stop the initiation should be apparent for the test operators. For certification test, supplementary criteria might not be necessary.

Main thermal runaway detection criteria are largely based on the GTR EVS text agreed in Phase 1 and are further complemented in accordance with GB 38031-2020 standard of China and ISO 6469-1/AMD1 international standard. We consider these validated with sufficient data.

The Figure YYY is meant for illustrating the methodology of localized rapid external heating. Phase 3 "Power off" commences once the target cell is detected to be able to maintain or go beyond the set point temperature, which is higher than critical temperature at which TR occurs, without externally added heat. By definition 3.46 GTR EVS Phase 1, this indicates that the target cell is then undergoing a thermal runaway. Section "Test methodology" also states: "*A temperature controller (i.e. thermostat) should be utilized to track the temperature/time profile as shown in Figure YYY via closed loop control.*" In this way, temperature controller stops supplying current to the heater to generate heat as soon as Phase 3 commences. If no TR can be achieved, heating stops when total energy input into the heater exceeds 20% of target cells' maximum rated energy (please see Table XXX).

Supplementary criteria and post-analysis criteria provide further evidence and help ascertaining the occurrence of TR. These are not meant as indicators to stop heating.