Comments by JRC
Date: 22/11/2017

Single Cell Thermal Runaway Propagation

The purpose of this document is to facilitate establishment of a common understanding among EVS IWG contracting parties on thermal runaway propagation. Several contracting parties are embarking on thermal runaway propagation experimental research campaigns for Phase II and a common understanding is important to help focus research efforts especially considering the complexity of cost-intensive thermal propagation tests. This approach is expected to further facilitate coordination of contracting parties' research and to pave a path for effective round-robin testing.

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Comment [AP1]: Change to '... round-robin testing among contracting parties.'

For this purpose this document contains a non-exhaustive list of questions for discussion and agreement among experts.

EVS-GTR – Phase I

The EVS-GTR requires manufacturers to provide documentation that demonstrates their system design provides a warning to vehicle occupants in the event of a single cell thermal runaway due to internal short circuit to allow safe egress from the vehicle or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment. EVS-GTR currently does not specify a thermal runaway propagation test procedure however it does describe, within the Technical Background section, a test procedure that was developed jointly by China and Japan during Phase I. The single cell thermal runaway initiation methods initially considered in this test procedure are: nail penetration, heating, and overcharge. The EVS Working group agreed that further research was needed on the topic of thermal runaway propagation to:

- Evaluate initiation methods and their feasibility, repeatability, and reproducibility,
- Investigate the effect of manipulation of the test device on test results,
- Investigate potential new methods for initiation, including methods which minimize manipulation of the test-device, and
- Evaluate appropriateness of pass/fail criteria, e.g. how to differentiate smoke/fire emanating out of the initiation cell from smoke/fire occurring due to propagation.

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Comment [VRR2]: Proposal: Use the complete formulation from taken from the Draft GTR (page 76)

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Comment [VRR3]: Proposal: Use formulation from GTR draft text (page 9):
(c) . Evaluate appropriateness of pass/fail criteria, e.g. how to differentiate smoke/fire emanating out of the initiation cell from smoke/fire occurring due to propagation;

The EVS-GTR was developed based on the following principles:

- Safety level is equivalent to conventional vehicles with internal combustion engine and to prevent EV specific hazardous events, assuming a reasonable level of robustness,
- Assess the potential safety risks during normal use (driving, parking, charging) and post-crash
- Safety validation of entire battery system of the vehicle,
- Performance based requirements without being design restrictive,
- Requirements and test procedures that are reasonable, practicable, and effective, and
- Test procedures that are repeatable and reproducible.

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Considerations for Single Cell Thermal Runaway Propagation for EVS-GTR Phase II

Objective – The objective in Phase II is to develop a repeatable and reproducible test procedure that represents a single cell thermal runaway due to internal short circuit in a REESS and to assess the appropriateness of evaluation criterion and the associated pass/fail limits.

Special consideration is given to:

- The relevance of the test in representing a single cell thermal runaway due to internal short circuit,
- The repeatability and reproducibility of the test, and
- The extent of manipulation of the test-device and its effect on the test results.

The following questions were raised in the 14th EVS-GTR meeting regarding the development of a thermal runaway propagation test:

Is thermal propagation due to an internal short single cell thermal runaway a problem in the field?

1. *Does field data exist on this topic? Experience from different countries and industry.*
2. *Can industry provide cases of success where an internal short of a cell was detected in the field and appropriate intervention action was taken?*
3. *Does field data inform on a specific test condition or method?*

Simulation of a single cell thermal runaway

1. What are we trying to simulate?
   - Should the test specifically simulate a single cell thermal runaway due to internal short (i.e. scenario specific)?
     - Is this a realistic internal short circuit scenario?
     - *Does the test method consistently result in thermal runaway of the target cell?*
     - Would it be relevant to all technologies?
     - Would it have acceptable repeatability/reproducibility?
   - Are we trying to initiate a single cell thermal runaway in the target cell regardless of type or format of cell or cause of thermal runaway, to assess thermal propagation response (i.e. scenario independent)?
     - Would this approach bypass the cell level safety?
     - Could this approach have acceptable repeatability/reproducibility?
2. Are different methods of initiating single cell thermal runaway (nail penetration, ceramic nail penetration, slow heating, fast heating, overcharge, mechanical crush, etc) equivalent?
   - Would the different scenario independent methods of initiating single cell thermal runaway need to be equivalent?
     - Could non-equivalency of initiating method be addressed by modifying the evaluation criteria for each scenario independent initiation method?
3. Which cells in a pack should be used to initiate a single cell thermal runaway?
   - Does the cell selection depend on the type of cells and pack design and feasibility of initiation?

Comment [AP4]: As it doesn't seem clear yet if there are several criteria: 'criterion or criteria'?

Comment [AP5]: Proposed rephrased formulation:
'Does field data exist, which can provide insight for specific test conditions or methods?'

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- Does the cell selection impact the outcome of the test?

4. Are the different methods of initiating single cell thermal runaway technology neutral (can be used on different types of cells and packs)?
   - Are some methods more suited for certain technologies?
   - Are there initiation methods that are technology neutral?

Elimination of Detection and Intervention Technologies

1. *If thermal runaway propagation test is required, would this eliminate development of detection and intervention technologies?*
2. *Should battery systems that have internal short circuit detection and intervention technologies have the option of providing documentation of the operation of this system to prevent cell thermal runaway instead of conducting the thermal runaway propagation test?*

Ignition of vented gases and other risks

1. Is ignition of venting gases a necessity for a thermal propagation test or not?
2. Considering the potential of spark sources in close proximity in-situ, should ignition be caused intentionally during the test e.g. using a spark igniter?
3. As stated in Phase I EVS-GTR: "as the result of thermal propagation, the cell may emit gases which can exit from the REESS". Considerations on the risks associated to these gases will be given in Phase II.

Evaluation Criteria

1. What should be the evaluation criteria (Pass/Fail conditions)?
   - No propagation at all?
   - Total containment?
   - Egress test?
2. Is the evaluation criterion in Phase I EVS-GTR ('warning indication to allow egress or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment') appropriate?
3. Are the evaluation criteria feasible to quantify reliably with a single test? Should there be tolerances to the pass/fail limits?
   a. *One point made in the EVS-GTR meeting was that pass/fail limits should not have tolerances. The limits should be one value for enforcement purpose. The threshold limit selected should take into account the variability in test results.*
4. Is no thermal runaway after initiation a pass?
5. Should the evaluation criteria be different for different type of single cell thermal runaway initiation methods and for different types of cells?

Repeatability and Reproducibility

1. How is repeatability of the test defined? The thermal runaway initiation of the target cell or the propagation results?
   a. *The ESV-GTR group recommends evaluating repeatability of thermal runaway initiation and repeatability of test results. Both are needed.*
2. How many tests need to be conducted to evaluate repeatability and reproducibility of the test?

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Comment [VRR6]: Proposal: use the actual formulation from the GRT (Page 76): *"warning indication to allow egress or 5 minutes prior to the presence of a hazardous situation inside the passenger compartment"*

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3. *The stochastic nature of the test and test results may require more than one test to be conducted (for example 5 tests are conducted in the flammability test in ECE R. 118). How many tests are needed? Are 3 to 5 tests sufficient? It would increase test cost. Should the pass/fail limits be selected to take into consideration the stochastic nature of the test results?*

Manipulation of test-device

1. Does the initiation method manipulate the test-device and would the test results be the same without manipulation of the test-device?
2. How do we assess if the manipulation of test-device has effect on the test outcome (i.e. pass/fail)?

Specifics of initiation methods and environmental conditions

1. What are the test parameters for the choice of initiation method? Including, not exclusively the following:
   - For the heating method of initiation thermal runaway, what is the heating rate, heating area, maximum temperature of heater? What is the rationale for selection of these values?
   - For the nail penetration method, what is the size, shape, and material of nail? What is the rationale for the selection of these values?
   - *For nail penetration test – can the test be developed such that only one or two layers of the cell are penetrated instead of all the layers? This may result in a more realistic internal short circuit of the cell but such a test may not be as repeatable and reproducible. This issue may need to be investigated.*
2. What are the ambient temperature conditions for the test? (Current GRT draft considers ambient temperature at 22 ± 5 °C for component based and 20 ± 10 °C for vehicle based testing).
3. What other new methods for initiation (including those which minimize manipulation of the test-device) deserve consideration?
4. In principle, tests may cover cell, module, pack and vehicle level. Are all initiation methods relevant, suitable and practical at all levels of testing?

Documentation requirements

1. Manufacturers are required to submit engineering documentation to demonstrate the vehicle's ability to minimize the risk associated with single cell thermal runaway. Are the documentation requirements set in Phase I EVS-GTR sufficient? If not, what are additional or more appropriate documentation requirements?

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Comment [AP7]: This is a more general question and should be moved to general questions concerning specifications.

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