Thermal Propagation – How to handle in EVS-GTR?

A compromise solution

Considering China's, OICA's and NHTSA's approaches

16 September 2016

Current status of TF5 and Thermal Propagation

The European Commission:

- *Appreciates the leadership role adopted by China in TF5 to address the risks associated with thermal propagation in EVs*
- *Acknowledges the safety risks associated with thermal propagation (TP) thanks to the extensive research performed and generously shared by China and other parties in TF5*
- *Recognises the rapid evolution of EV technology, the practical experience gained in recent years and the increased expected uptake of EVs*

  ⇒ *which motivate the coverage and comprehensive treatment of TP in the EVS-GTR.*

On the other hand

The European Commission:

- *Notes the divergent opinions from different TF members*
- *Observes the still dynamic situation regarding research and further evolution of proposals*
- *Recognises the urgent need to agree a practical solution for Phase 1 which guarantees an acceptable level of safety to occupants until a more robust solution is developed in Phase 2*

Accordingly

The European Commission:

- *Has evaluated the extensive research performed by China and others and has provided feedback on proposals made*
- *Proposes to proceed with this research in Phase 2 in a constructive, mutually supportive and complimentary way to arrive at an unequivocal, science-based test method which will provide the best level of safety to occupants against the risks from TP*
- *Considering the complexity of this topic and recognising the lead China and other co-sponsors have taken, requests more time to gather supportive scientific data and to understand the implications adopting such a new test will have on European testing authorities*
- *Support the immediate initiation of Phase 2 to perform research to avoid any delays in arriving at a verified solution*
- *Has requested additional resources to dedicate to research on this particular topic*

For Phase 1

The European Commission proposes for consideration:

- *To introduce a documentation requirement as a temporary solution to include TP in Phase 1.*
  - *In this respect individual proposals of NHTSA and OICA can be used and further strengthened*
- *To prepare for the introduction of a thermal propagation test in Phase 2 by documenting explicitly in Part A of the EVS-GTR (Rationale) the results from research which has already been performed.*
  - *In doing so to rely on text formulations provided by China as far as possible, including also elements (on documentation) from both the US and OICA.*

Definitions: Thermal runaway

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Definitions 3.W2. “Thermal runaway” means uncontrolled cell temperature rise caused by cyclical exothermic reactions inside the cell. Thermal runaway is characterized by a distinct rapid change in rate of temperature rise over a short time period, rather than a single steady temperature rise.”	Definitions	Definitions 3. X. “Thermal runaway” means uncontrolled increase of cell temperature rise rate caused by exothermic reactions inside the cell.	Definitions 3. X. “Thermal runaway” means uncontrolled increase of cell temperature rise [~~rate~~] caused by exothermic reactions inside the cell.

Definitions: Thermal propagation

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016) ~~(email 07/07/2016)~~	China (Proposal dated 14.09.2016)	Compromise solution
Definitions 3.W.1. "Thermal propagation" means the sequential occurrence of thermal runaway within a battery system triggered by thermal runaway of a cell in that battery system.	Definitions	Definitions 3. X. ""Thermal runaway propagation" means the sequential occurrence of thermal runaway within a battery system triggered by thermal runaway of a cell in that battery system.	Definitions 3. X. "Thermal runaway propagation" means the sequential occurrence of thermal runaway within a battery system triggered by thermal runaway of a cell in that battery system.

Definitions: Thermal event signal

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016) ~~(email 07/07/2016)~~	China (Proposal dated 14.09.2016)	Compromise solution
Definitions	Definitions	Definitions 3.x. “Thermal event signal” means the signal which indicates the occurrence of thermal runaway within a battery system.	Definitions 3.x. “Thermal event signal” means the signal which indicates the occurrence of thermal runaway within a battery system..

Rationale [1]

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Rationale Proposal for EVS-GTR technical rationale and justification (Part I): 1-10	Rationale None provided	Rationale 4.5.1 Thermal runaway propagation: ……	Rationale 4.5.1 Relevant parts of China rational to be included** *In addition to incorporating the following text*: Research on thermal propagation performed and reported by contracting parties indicate that thermal propagation is generally known as one of the mechanisms that may lead the lithium ion battery system to safety critical situations, such as fire or explosion. The test requirements of this GTR address various scenarios that will potentially cause thermal propagation, except for the case of thermal runaway initiated by an internal short circuit of the cell.

** *Evaluation the text of the new Rationale proposed by China still required. However we propose to add a clear reference to research performed and the intention to pursue further research in Phase 2.*

Rationale [continued]

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Rationale Proposal for EVS-GTR technical rationale and justification (Part I): 1-10	Rationale None provided	Rationale 4.5.1	Rationale 4.5.1** Thermal runaway is a unique feature of a REESS for electric vehicles. Thermal runaway can lead to the release of toxic gases, smoke, fire and explosion which threatens the safety of electric vehicle [occupants]. For these reasons a test method needs to be developed to evaluate and demonstrate the safety performance of a vehicle should a REESS cell, which has undergone thermal runaway initiation, lead to thermal propagation.

** *Evaluation the text of the new Rationale proposed by China still required. However we propose to add a clear reference to research performed and the intention to pursue further research in Phase 2.*

Rationale [continued]

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Rationale Proposal for EVS-GTR technical rationale and justification (Part I): 1-10	Rationale None provided	Rationale 4.5.1	Rationale 4.5.1** Several Contracting Parties, including China (EVS-06-30, EVSTF-03-22, EVSTF09-02-TF5-01 and others), Japan (EVS-06-23, EVSTF-04-23), Korea (EVSTF-03-17, EVSTF-08-65) and the US (EVS-06-35e), have conducted research programmes in order to establish the test procedures related to thermal runaway and thermal propagation and provided their reports to the informal working group for consideration.

** *Evaluation the text of the new Rationale proposed by China still required. However we propose to add a clear reference to research performed and the intention to pursue further research in Phase 2.*

Rationale [continued]

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Rationale Proposal for EVS-GTR technical rationale and justification (Part I): 1-10	Rationale None provided	Rationale 4.5.1	Rationale 4.5.1** *This research has illustrated the hazards associated with TP leading to an appreciable increase of knowledge in the field. However a number of technical issues with potential test methodologies require additional research efforts. EVS experts will seek solutions to resolve these outstanding issues in order to ensure that potential consequences of a thermal runaway event are limited and vehicle occupants are sufficiently protected.*

Rationale [continued]

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Rationale Proposal for EVS-GTR technical rationale and justification (Part I): 1-10	Rationale None provided	Rationale 4.5.1	Rationale 4.5.1** Consequently the experts *propose to continue this research in Phase 2 in a constructive, mutually supportive and complimentary way in pursuit of an unequivocal, science-based test method which will provide the best level of safety to occupants against the risks from TP.* *Until such time manufacturers are required to provide evidence that demonstrates that their EVs are in compliance with the specified requirement.*

Requirements: request of documentation

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Requirements 5.1.W. For the vehicles equipped with a REESS containing flammable electrolyte, the vehicle manufacturer shall make available to the regulatory entity designated by the Contracting Party, upon request, documentation that explains the measures taken for mitigating the risk to vehicle occupants caused by thermal runaway and thermal propagation in the REESS caused by a cell internal short circuit.	Requirements "The vehicle shall provide a warning indication in the case of a thermal event in the REESS. The warning shall be provided at least [10 minutes] before any smoke enters the occupant compartment or fire is visible external to the battery pack. Vehicle manufacturers shall make available, at the request of the regulatory entity, the following documentation:		Requirements The vehicle shall provide a warning indication in the case of a thermal event in the REESS. The warning shall be provided at least [10 minutes] before any smoke enters the occupant compartment or fire is visible external to the battery pack. Vehicle manufacturers shall make available, at the request of the regulatory entity, the following documentation:

Requirements: content of the documentation

European Commission

* TF9 Draft (proposal EVS-TF08-59e *Thermal Event*)

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Requirements a) Expected characteristics of the cells in case of an internal short circuit, including description of method (test, analysis, etc) used to determine characteristics and results of the assessments. b) Measures to prevent and/or mitigate the hazard of thermal runaway and thermal propagation initiated by a cell internal short circuit, including cell design and construction, REESS design and construction, vehicle design and packaging features, system controls and warnings, and vehicle user communication (as applicable)…….	Requirements 1. The parameters of the thermal event such as temperature, SOC, voltage and/or electrical current that trigger the warning signals. * 2. Description of the warning system.*	Requirements	Requirements A warning indicator (i.e. light) should come on in the event of a significant thermal event within the battery pack (e.g. temperature within the battery pack is significantly higher than the maximum operating temperature). At this time, a test procedure for evaluating the operation of this warning light has not been provided*. 1. The parameters of the thermal event such as temperature, SOC, voltage and/or electrical current that trigger the warning signal(s).* 2. Description of the warning system.*

Requirements: content of the documentation

European Commission

* TF9 Draft (proposal EVS-TF08-59e *Thermal Event*)

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Requirements a) Expected characteristics of the cells in case of an internal short circuit, including description of method (test, analysis, etc) used to determine characteristics and results of the assessments. b) Measures to prevent and/or mitigate the hazard of thermal runaway and thermal propagation initiated by a cell internal short circuit, including cell design and construction, REESS design and construction, vehicle design and packaging features, system controls and warnings, and vehicle user communication (as applicable).....	Requirements 1. The parameters of the thermal event such as temperature, SOC, voltage and/or electrical current that trigger the warning signals. * 2. Description of the warning system.*	Requirements	Requirements 3. Expected characteristics of the cells in case of an internal short circuit, including description of method (test, analysis, etc) used to determine characteristics and results of the assessments. 4. Measures to prevent and/or mitigate the hazard of thermal runaway and thermal propagation initiated by a cell internal short circuit, including cell design and construction, REESS design and construction, vehicle design and packaging features, system controls and warnings, and vehicle user communication (as applicable). .....

Requirements: content of the documentation

* TF9 Draft (proposal EVS-TF08-59e *Thermal Event*)

OICA (EVSTF-07-04e)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Requirements … For each measure identified, a specific description of how it works and the contribution it makes to hazard prevention and/or mitigation is required.	Requirements 1. The parameters of the thermal event such as temperature, SOC, voltage and/or electrical current that trigger the warning signals. * 2. Description of the warning system.*	Requirements	Requirements … For each measure identified, a specific description of how it works and the contribution it makes to hazard prevention and/or mitigation is required.

Requirements: Pass/fail requirement

OICA (OICA Comments on Thermal Propagation requirement proposal from NHTSA-08AUG2016)	NHTSA (email 18/08/2016)	China (Proposal dated 14.09.2016)	Compromise solution
Requirements Description of all cell, REESS and vehicle countermeasures intended to meet the requirements above. For each countermeasure identified, the description shall include a system diagram that identifies all relevant components; a written explanation describing the countermeasure's basic operational characteristics including principle of operation; and engineering documentation (e.g., test, analysis or simulation method(s) and resulting data) which demonstrates the effectiveness of the countermeasure.	Requirements 3. Test and/or simulation data showing that the warning is provided at least [10 minutes] before smoke enters the occupant compartment or fire is visible external to the battery pack.	Requirements 4.5.1. The purpose of the thermal propagation test is to verify the safety performance of the REESS when a single cell undergoes the thermal runaway. And the subsequent thermal propagation event does not result in the battery system fire and/or explosion for 5 minutes after the warning signal is transmitted	Requirements [5. Manufacturers shall demonstrate, by way of analysis and data simulation, that thermal propagation event does not result in smoke entering the occupant compartment or a battery system fire and/or explosion for [10 minutes] after the warning signal is transmitted] *More robust requirement required – suggestions from industry welcomed for discussion in TF5*

Areas benefiting from additional research

- *Data is required on the reproducibility of initiation methods and test method results - inter-laboratory comparisons.*
- *Assessment of impact of REESS modification on test outcome.*
- *Verification method of pass/fail criteria – distinguishing source of smoke/fire/explosion.*
- *Safety considerations for test execution.*
- *Selection of initiation cell.*

Summary

While this compromise does not foresee a thermal propagation test in Phase 1 of the GTR, it:

- *Documents the extensive research already performed and outlines research that has yet to be performed in Phase 2.*
- *Identifies the need to strengthen the individual documentation requirements previously proposed to provide more tangible evidence of occupant protection.*
- *Is intended as a temporary solution which gives all contracting parties more time to work together on critical aspects of the test method to find the most appropriate test methodology.*

Thank you for your consideration