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

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

	9, etc	Title, etc.		Ge	The term “thermal runaway propagation” is not defined in GTR20.	The terms “thermal runaway” and “thermal propagation” defined in GTR20 should be used consistently.
	15	Chapter title		Ge	3. The term “thermal runaway propagation” is not defined in GTR20.	The title of the chapter should be "Thermal Propagation".

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).

	18	Part I, C.3	Thermal runaway propagation	Ge	We agree to limiting the scope of protection, which is to be evaluated by the test method, to "vehicle occupants".	It has been discussed to expand the scope of protection to people and things around, so it should state in Part I the reason for limiting the scope of protection to "vehicle occupants". In some countries, vehicles went aflame while parked, but generally there’s no people in parked vehicles. For accidents involving parked vehicles, we will need to expand the scope of protection to people and things around, but the current regulations for vehicle structures have no provisions whatsoever that specify where to start and end those

						surrounding people and things to be protected. So, it would be reasonable to limit the scope of protection to occupants for the time being, which will help keep the balance with conventional vehicle as well.

JRC suggest to focus on avoiding "human harm that may occur from the electric power train" as stated in the Section II, Text of the Regulation, Purpose of GTR EVS text agreed in Phase 1. Thus, infrastructure does not need to be considered explicitly. Risks for bystanders should not be ignored in discussion; however, the ways such risks can be addressed, by e.g. providing an external warning signal, may go beyond the mandate of the IWG GTR EVS and need to be agreed with other IWGs.

	18-19	Part I, C.3	Thermal runaway propagation	Te	Cells that are forced to thermally run away should not be put to evaluation.	To be modified as follows: "... resulting from ~~either a thermal runaway or~~ thermal ~~runaway~~ propagation triggered by ..."

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal).

	21-22	Part I, C.3	Thermal runaway propagation	Te	It says, "the hazard of the thermal runaway propagation is prevented or eliminated by design," but we just can't eliminate "the hazard of the thermal runaway propagation" since there's no definition of what "hazard" is.	To be modified as follows: "the **risk** ~~hazard~~ of the thermal ~~runaway~~ propagation is prevented or **mitigated** ~~eliminated~~ by design"

The proposed text is based on the existing GTR EVS wording agreed in Phase 1, which JRC propose to keep.

	23-38	Part I, C.3	Initiation method	Ge	It should be clarified what is the requirements for an initiation method.	To be discussed

This comments is not entirely clear to JRC. Please provide more detailed information on what, in your view, needs be clarified. To be further discussed within the Informal Working Group tasked with the development of the GTR EVS.

HO	24	3.		Te.	Depending on a vehicle/pack design, a test with an optional (nail) method can be conducted more easily and appropriately than with the main (heater) method. Upon manufacturer's request, optional initiation methods that can create the initiation cell thermal runaway should also be accepted.	Delete [ ] and add sentence as follows: The ~~[~~main~~]~~ initiation method for triggering thermal runaway during the thermal runaway propagation test is localised rapid external heating. <u>Upon manufacturer's request, other (optional) initiation methods may be applied, provided that they can cause thermal runaway of the initiation</u>

						cell. However, the manufacturer must retest by the main (heating test) method in the case that thermal runaway does not happen with the optional method. As an example of the optional method, annex X shows the nail penetration test method. The nail penetration test method, which can locally generate thermal runaway without additional energy input, is ideal as an initiation method that simulates thermal runaway situation with an internal short circuit of a cell in the real world. However, depending on the battery material and cell design, the heat energy generated by the nail penetration may be too small to cause a thermal runaway. In such cases, the manufacturer must retest with using the heating test method.

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.

	28 150 161etc			Te/ed	The following wards mean the same thing. Target cell Initiation cell	we should define them clearly. If there are cases where no TR happens, then “target cell” would be better.

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), JRC agree that “target” cell is an appropriate term.

	26			Ed	The trigger method	Should unify this to "initiation method" of the same meaning.

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), substituting “trigger method” with “initiation method”.

	28-30	Part I, C.3	Initiation method	te	It should be clarified what is the requirements for an initiation method.	To be discussed

This comments is not entirely clear to JRC. Please provide more detailed information on what, in your view, needs be clarified. To be further discussed within the Informal Working Group tasked with the development of the GTR EVS.

HO	28			Te.	- According to the current draft text, it is understood that if the temperature of adjacent cell(s) exceeds the maximum operating temperature, the test is judged invalid and needs to be retested. The occurrence of cell thermal runaway under high temperature conditions is likely. It means a more serious condition. Therefore, if the REESS satisfies with the warning requirement with this high temperature adjacent cell condition, the test is valid and can be judged “Pass”. As a pass/fail judgement is possible, the limitation of adjacent cell temperatures should be mentioned as a recommendation. - Some provisions or guidelines for temperature measurement need to be provided. The temperatures differ depending on where it is measured.	Change the text as follows: It is recommended that the increase of temperature of adjacent cell(s), prior to thermal runaway in the target cell, ~~shall~~ remains below the maximum operating or storage temperature (whichever is higher) for the REESS. The surface temperatures of the target cell and adjacent cells should be measured at a location far enough away from the heater (on the back side or a different side surface where the heater is mounted) to minimize the effect of heater temperature.

The requirement that the effect of the heat generated by the heating element on the adjacent cell(s) shall be minimised and its/their temperature shall be lower than the maximum operating temperature of the REESS or storage temperature (whichever is higher) is only relevant in Phases 1 and 2 depicted in Figure YYY, where external heat is supplied to the target cell.

If the temperature of the adjacent cell(s) is allowed to increase beyond the maximum operating or storage temperature (whichever is higher), the adjacent cell(s) can go into thermal runaway along with the target cell. JRC’s concern is that this would then constitute a more severe test than intended by this regulation, where “*thermal propagation triggered by a single cell thermal runaway*” is being addressed.

Positions of the heater and the temperature sensor are described in Figure 3 of Section 23B.3.6 of the GTR EVS Phase 1 text.

HO	31			Ed.	It is unclear what the word "natural" means. If this is a strict mandatory requirement, there will be cases where the test is impossible to conduct. It should be mentioned as a recommendation. Cooling should be indicated as an example of	Change the text as follows: As much as possible, ~~such~~ thermal insulation or barriers shall not impede natural REESS functionality, such as cooling.

					REESS functionality.	

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), deleting the term “natural” and mentioning “cooling” as an example of REESS functionality not to be impeded.

HO	35			Ed.	It should be clearly stated that it is just a target parameter for reference.	Change the text as follows: <u>Examples of</u> target parameters for the heating element are listed in Table XX.

The parameters listed in Table XX are not just examples. Extensive research by various experts involved in the GTR EVS work shows that these parameters are key for reproducible and repeatable thermal propagation tests.

HO	37		Table XX - Heating element selection guide	Te.	The grounds for 5mm are unclear. For some battery structures or heater installation places, heaters with more than 5 mm thickness can be used.	Delete "<5".

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.”*

In view of the above-mentioned conditions, it would be important to include a requirement on the maximum thickness of the heater.

HO	37		Table XX	Te.	The grounds of “20% of the surface area” is not clear. In CANADA presentation “EVS25-E1TP-0400 [CA]Single Cell Thermal Runaway within EV”, heater area seems to surpass 20% of the targeted face of the cell. In some battery types (eg. LTO, LFP), it may be difficult to create an initiation cell thermal runaway with a heater less than 20% area and a heater temperature setting less than a melting point of cell casing material.	Change as follows: <s>As small as possible, but no larger and</s> <u>Less than 20 % of the surface area of the targeted face of the target initiation cell is recommended.</u>

					Less than 20% area requirement should be mentioned as a recommendation.	

The main initiation method proposed is localised rapid external heating. In our view, this necessitates a limit on surface area of the heating element to be considered “localised”.

HO	37		Table XX	Te.	The grounds for 15°C/s are unclear. It is OK if an initiation cell thermal runaway occurs with a heating rate at 10°C/s. Specifying a maximum heater temperature is sufficient.	Delete "Heating Rate [°C/s]".

The main initiation method proposed is localised rapid external heating. The underlying fundamental principle of this method is to add a minimum amount of energy into the system over a minimum period of time to achieve a single cell thermal runaway. From extensive research by various experts of the GTR EVS IWG, it is understood that with low temperature ramping speed(s) the amount of energy added to the initiation cell can be (much) higher than with high temperature ramping speed(s). Therefore, a requirement on the heating rate is important.

HO	37		Table XX	Te.	The grounds for 100°C are unclear. Generally speaking, an initiation cell thermal runaway does not occur at 100 °C.	Change the text as follows: ”~~100 °C >~~ the temperature specified by the manufacturer at which a cell thermal runaway can occur < chosen heater set point temperature”

Maximum heater temperature needs to be at least 100°C than the chosen heater set point temperature to ensure that the heater shall maintain integrity at the chosen operating temperature and to take into account temperature deviations from heater element to thermocouple upon application of high power.

HO	37		Table XX	Te.	Heater temperature feedback control with a thermistor should not be mandatory. In order to avoid melting a cell housing or rupture, heater temperature setting should be recommended to be less than the melting point of the cell housing material. A guidance of heater temperature measurement is necessary. Locations at which the heater temperature is measured need to be specified.	Change the text as follows: ~~”Thermostatic closed loop”~~ Recommended practice: "Maximum heater temperature [°C] < melting point of cell housing material". The heater temperature measurement is done by mounting the sensor directly on the back of the heater or on the cell surface in the vicinity of the sensor.

The thermostatic closed loop is necessary to avoid excessive amount of heat to be added to the target cell. It's function is stop supplying heat to the target cell once the processes taking place in the target cell are self-sustaining and capable of maintaining the set temperature or going beyond it (Phase 3 in Figure YYY). Temperature for the thermostatic closed loop control is measured directly on the heater surface. Typical temperature set points for target cells of various formats are listed in Table XXX, which are defined based on the extensive research of GTR EVS IWG experts. Linking the set point temperature to the melting point of the target cell housing is not always possible and relevant, e.g. for pouch cells.

	35-38	Part I, C.3	Initiation method Table XX	ge	Target parameters are not mandatory. It should be clarified what must be abided by as a certification test.	

Table XX provides requirements for test parameters, which are defined based on the extensive research of GTR EVS IWG experts. Table XX also specifies 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.*"

	35-38	Part I, C.3	Initiation method Table XX	te	The description of "value" under "Maximum heater temperature", which goes "100 °C > chosen heater setpoint temperature" is unclear.	"At least 100K higher than chosen heater setpoint temperature"

In the majority of the tests stipulated by the GTR EVS, degree Celsius (°C) is used to refer to a specific temperature on the Celsius scale as well as to indicate a temperature interval (a difference between two temperatures).

HO	41			Te.	"Power off" condition in the graph is unclear. Should be specified.	Add text below: <u>Heater power may be cut off at a point where thermal runaway is detected or assured to happen.</u>

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).

	50	Part I, C.3	Test methodolog	ge	The phrase "The customer and supplier shall agree on specific values." is inappropriate for	Delete.

			y		GTR.	

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), deleting this sentence.

HO	59			Ed.	The meaning of the text is unclear.	Delete the text below: ~~and shall be lower than the maximum operating temperature of the REESS or REESS subsystem~~.

As mentioned above, the requirement that the effect of the heat generated by the heating element on the adjacent cell(s) shall be minimised and its/their temperature shall be lower than the maximum operating temperature of the REESS or storage temperature (whichever is higher) is only relevant in Phases 1 and 2 depicted in Figure YYY, where external heat is supplied to the target cell.

If the temperature of the adjacent cell(s) is allowed to increase beyond the maximum operating or storage temperature (whichever is higher), the adjacent cell(s) can go into thermal runaway along with the target cell. JRC's concern is that this would then constitute a more severe test than intended by this regulation, where "*thermal propagation triggered by a single cell thermal runaway*" is being addressed.

HO	63		Table XX - Typical heater parameters for implementation of localized rapid external heating methodology	Te.	Unnecessary requirements and requirements for which the grounds are unclear should be deleted. It should be mentioned how to deal with situations where cell thermal runaway doesn't happen.	Modify the text as follows: Table XXX – ~~Typical~~ <u>Example</u> of heater parameters for implementation of localised rapid external heating methodology: Comments for discussion items: - The grounds for "Heating rate of the element [C/S]" are not clear. Since it is sufficient if a cell thermal runaway occurs, this item should be deleted. - "Set point [C]" should be below the melting point of the cell case material, which is specified by the manufacturer. - It is sufficient if thermal runaway occurs in an initiation cell. As higher energy input means a severer test condition, pass/fail judgement is

						available. The item “Soak time and power off condition” should be deleted. - If a limitation of 20% of heating energy and 5 minutes of heating time are to be required, measures how to deal with situations where thermal runaway does not occur within these limitations need to be specified. Example: "The manufacturer shall retest with a large heating area heater or higher power heater or higher temperature setting. Or, If the temperature on the other side of the surface the heater is mounted is > 300°C, then the cell shall be judged safe without any risk of thermal runaway and having passed the test.
	49-64	Part I, C.3	Test methodology Table XXX		The amount of external energy necessary to cause a thermal runaway varies depending on the battery specifications. Cells with a structure with a large heat capacity or with a chemical composition that is difficult to cause a thermal runaway will require a relatively large amount of energy. It might not be fair as a certification test.	Should add “Example:” before “Table XXX” or delete it

Table XXX provides requirements for test parameters, which are defined based on the extensive research of GTR EVS IWG experts. The main initiation method proposed is localised rapid external heating. The underlying fundamental principle of this method is to add a minimum amount of energy into the system over a minimum period of time to achieve a single cell thermal runaway. It is understood that with low temperature ramping speed(s) the amount of energy added to the initiation cell can be (much) higher than with high temperature ramping speed(s). Therefore, a requirement on the heating rate is important. Typical temperature set points for target cells of various formats are listed in Table XXX, which are defined based on the extensive research of GTR EVS IWG experts. Linking the set point temperature to the melting point of the target cell housing is not always possible and relevant, e.g. for pouch cells.

	49-64	Part I, C.3	Test methodology Table XXX		What are the conditions by which to determine that heating with an external heater cannot cause a thermal runaway? Performance limitations of the heater and thermocouples need to be considered.	According to GTR20, a cell will be judged not likely to cause a thermal runway when the cathode is heated up to 300°C, which is the temperature at which generally thermal decomposition begins in many cathodes, and yet no thermal runway happens.

Target parameters for the heating element are listed in Table XX. The requirements for temperature sensors are described in the Section 23B.3.6 of the GTR EVS Phase 1 text “*The accuracy of the temperature sensor shall be within ± 2 °C, and the sampling interval should be less than 1 s. The diameter of the tip of the*

sensor shall be less than 1 mm." Our understanding is that 300°C, mentioned in Section 23B.3.2 of the GTR EVS Phase 1 text, have not been agreed and do not refer to the cathode temperature.

					Are we right to understand that subsystem level testing is a test performed on the REESS subsystem as defined in GTR20?	To be confirmed

Yes, the 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. The thermal propagation test itself is proposed to be conducted at a vehicle level.

HO	66-79			Te.	There is no need to require a pre-test because it has nothing to do with the pass/fail judgement.	Delete text No.66-79.

Section "Test application and necessary modifications", "Subsystem level testing" is proposed to refine 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. A subsystem test can also help refining the initiation method placement within the chosen REESS cells.

	80-84	Part I, C.3	Vehicle testing		We find that, in conducting the test, "the vehicle is "on" in the "parked" mode" is a rather severe requirement under normal situation where occupants may be present in terms of cooling performance. It is a reasonable mode from a test operational point of view. We support it. (Reference: ISO only says "the vehicle is 'on', while EC added in the 'parked' mode.)	

We agree with this comment. In our view, conducting thermal propagation test while the vehicle is "on" in the "parked" mode and an initiation method which does not affect the vehicle system, permits the validation of all systems towards a single cell thermal runaway event.

	80-84	Part I, C.3	Vehicle testing		REESS level testing should be accepted. JRC shared the test data of two vehicle models and then we need to research more including the body structure affects the thermal propagation.	

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.

	86		Test events and outcome description		The regulatory document has a pass/fail criterion, so result descriptions are not necessary. It should be clarified whether it is a cell-level event or a REESS-level event. In vehicle tests, it is difficult to observe deformation, leakage, etc.	To be deleted
HO	87-94			Ed.	Line No.86 "Test events and outcome description" and No.182 “Recorded data and measurement” should be integrated. “Test events and outcome description” should be removed.	Delete the text below: ~~Test events and outcome description~~ ~~During the test, observation of at least the occurrences of the following events should be noted:~~ ~~— deformation,~~ ~~— venting,~~ ~~— leakage,~~ ~~— smoking,~~ ~~— rupture,~~ ~~— fire,~~ ~~— explosion.~~
	95		Table XXXX		The UNR document includes a pass/fail criterion, so the result description isn’t necessary.	To be deleted
HO	95-96			Te.	“Table XXXX-possible test outcome” is irrelevant to test conditions and results for pass/fail judgement. It should be deleted.	“Table XXXX-possible test outcome” should be removed.

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), deleting “Test events and outcome description” section and Table XXXX.

	102-111	5	Performance requirements		It should be clarified how 5.4.12 of the current GTR20 is to be modified.	It is unlikely that this test method can be made applicable to all REESS (including flammable electrolytes). Considering cases where the test method cannot be applied objectively and fairly, the Documentation requirement should remain as an option that can be applied at the manufacturer's discretion. We find it reasonable to add the testing requirement as one of the options in 5.4.12.2.

JRC support testing approach as mentioned in previous discussions. Discussion continue in the Informal Working Group tasked with the development of the GTR EVS on the documentation approach.

	103-105	5	Performance requirements		"For the vehicles equipped with a REESS containing flammable electrolyte, the vehicle occupants shall not be exposed to any hazardous environment caused by thermal ~~runaway~~ propagation which is triggered by an internal short circuit leading to a single cell thermal runaway." is mostly the same as the beginning of 5.4.12. in the current GTR20.	We agree to focus to the scope of occupant protection

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal), deleting the word "runaway".

HO	106			Te.	The pass/fail criterion "5 minutes prior to the presence of a hazardous situation inside the passenger compartment …-, such as fire, explosion or smoke." should be elaborate more.	Add the text below: <u>Specific safety criteria for evaluation:</u> <u>- Fire or explosion isn't visually confirmed from inside or outside of the vehicle.</u> <u>- Smoke intrusion into the vehicle isn't visually confirmed. If smoke intrusion is observed, the gas concentration doesn't reach the hazardous level specified in AEGL2_10min.</u> <u>Note: Smoke evaluation in REESS component test is TBD.</u>

JRC do not see the need to exclude smoke from the criteria, agreed in GTR EVS Phase 1. As mentioned previously, smoke can obstruct the view for the driver in addition to introducing toxic, flammable and corrosive substances into the cabin's air and can be verified by e.g. visual inspection, even though it is acknowledged not to be a quantitative solution. In our view visual observation would be an adequate verification method for fire and explosion.

	106-109	II Text of regulation	5. Performance requirements 2nd para		Assumed events are different from GTR20 caused **either by thermal runaway or thermal runaway propagation,** which is triggered by an internal short circuit leading to a single cell thermal runaway	To be aligned with GTR20

The regulatory text proposal has been updated accordingly (please see an updated regulatory text proposal) to align with GTR 20.

	113-115	6	Purpose	Ed	The statement "The purpose of the thermal runaway propagation test is to ensure the occupant safety in a vehicle if thermal runaway occurs in the battery system" is not consistent with paragraph 5.	The purpose of the thermal ~~runaway~~ propagation test is to ensure the occupant safety in a vehicle if thermal **propagation** ~~runaway~~ occurs in the battery system.

The regulatory text proposal is in line with the GTR EVS text agreed in Phase 1 (please see section 23B.1.)

	117		Installations		It is stated that the test is at the vehicle level. If equivalent results and signal system can be explained, it is acceptable to the extent that the battery pack level is shown. With JRC test data available only for two vehicle models, we haven't fully verified yet the hypothesis that the vehicle body structure affects the thermal propagation.	Should sanction that testing at the battery pack level as acceptable.

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.

	124		Procedures Environmental conditions		It is not clear which temperature the term "REESS temperature" refers to. The period of time that the REESS temperature should be held for should be clarified. The temperature cannot be held after the start of external overheating.	To be clarified Should specify where to measure the temperature and how long to take before initiation.

The requirement on temperature should be respected before the test. 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.

HO	126			Te.	The grounds of the wind speed setting are unclear.	The grounds and/or citation of the wind speed setting should be mentioned.

Our understanding is that the requirements on wind speed have been aligned with similar requirements in other standards for outdoor testing during discussions in TC of ISO 6469-1/AMD1.

	135-142		DUT conditions (a)		The involvement of the manufacturer should be allowed in judging whether or not to approve the	Should make it clear that the manufacturer checks the state of modification prior to

					modification of DUT.	conducting the test.

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.

	145		DUT conditions(c)		It is unclear whether "all test devices" refers to vehicles or test equipment (though we guess it is the vehicle system.) Should clarify until when the term “during the test" means. It is possible the system stops working due to an event during the test.	To be clarified The word "during" to be deleted.

In our view, it is impossible to set a requirement for the duration of operation of all test devices. Our suggestion would be to state: ”At the beginning of and for as long as possible during the test, all test devices shall be operational”. Please see an updated regulatory text proposal.

HO	145			Te.	There may be battery structures where a modification needed for the heater installation leads to a reduction of cooling capacity. In addition, testing with cooling OFF can be considered a severer test condition as the battery temperature becomes higher, and then, thermal propagation is easy to occur. The operation of cooling function should be specified as a recommendation.	Change as follows: (c) If applicable, at the beginning of and during the test, all test devices shall be operational; Defined cooling/safety strategy and the battery management system used within the REESS ~~shall be~~ are fully operational. The coolant flow could be null or active depending on the BMS. The native cooling strategy (if installed), battery control unit (BCU) and any other battery control systems, which are necessary for the test, ~~shall be~~ are operational during the test.

In our view, testing under realistic conditions, i.e. with a native, fully operational, cooling system would suffice. Test with a non-operational cooling system would place severer requirements and can even be considered as simulating a double failure.

HO	151			Te.	It is assumed that some pack and module structures may make it difficult to install a heater on a cell with a maximum number of nearest surrounding cells and located at the center of the battery pack.	Change as follows: If applicable, the initiation cell shall be chosen among those with a maximum number of nearest neighbours approximating the centre of the battery pack.

						If it is not possible to conduct a test with this cell selection method, the manufacturer shall select another cell and explain the reason and validity of the cell selection.
	151-152		Initiation cell		Need to clarify considerations and priorities to be given in selecting the initiation cells. In addition to the number of adjacent cells, consideration should be given to test feasibility, pack structure (wiring, piping, vent mechanism), etc. Self-certification also does not need to be specified for compliance testing, since it is left to the authority's discretion.	To be discussed

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.

	154-155		DUT preparation		To install a heater, we need to modify the structures around the cell as well. Can we consider the following a limitation to REESS enclosure modification? The installation of the chosen heating element should only modify the REESS by permitting electrical and thermocouple connections to the heating element.	

The regulatory text proposal is updated to clarify that the installation of a feedthrough of the heating element is meant. Please see an updated regulatory text proposal.

HO	155			Te.	It is unclear what is specifically required by this sentence. Modify the text for seal integrity.	Change as follows: ~~These connections shall provide greater~~ Seal integrity shall be considered for these connections ~~than the other connectors in the REESS~~.

In our view, the feedthrough connections need to be gastight and therefore they need to provide a greater seal integrity than the other, native, connectors in the REESS.

	183-184		Recorded data and measurements		Provisions for inclusion in reports aren't necessary for GTRs. The following information shall be recorded during the test, during the observation period and shall be presented in the test report. Parameters related to the pass/fail criterion need to be recorded.	To be revised as follows: The following information shall be recorded during the test~~,~~ **as well as** during the observation period ~~and shall be presented in the test report~~.

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal).

HO	185			Te.	Requirements that are irrelevant to the pass/fail judgement aren't necessary. They should be removed.	Delete the text below: ~~"All data measurement systems shall be referenced to the same starting time and shall be recorded for an observation period of at least 1 h.~~

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal).

HO	190			Te.	Requirements that are irrelevant to the pass/fail judgement aren't necessary. They should be removed.	Change as follows: battery management system live-data, if available (e.g. single cell voltages, temperatures, ~~isolation faults, other warnings~~) ~~recorded at a rate that matches the systems' maximum output rate~~

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), moving this requirement into "data … as additional information" section.

HO	192-193			Te.	It needs to be specified where to measure temperatures.	Change as follows: —heating element temperature <u>should be</u>

						measured at back side or vicinity of the heater —initiation cell temperature should be measured at a place far enough away from the heater (on the back side or a different side surface where the heater is attached) to minimize the effect of heater temperature

Positions of the heater and the temperature sensor are already described in Figure 3 of Section 23B.3.6 of the GTR EVS Phase 1 text. The word "surface" is added to the footnote of Table XX to specify that "Ideally the heating rate is measured directly by a thermocouple on the surface of the chosen heater."

HO	194			Te.	It is unclear why the current is measured. Requirements that are irrelevant to the pass/fail judgement aren't necessary. They should be removed.	Change as follows: — ~~current and~~ voltage of the initiation cell during heating.

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), deleting the word "current".

HO	195			Te.	Same requirements are specified in the text of line No.195 and No.201. Redundant requirements in line No.195 should be removed.	Delete the text below: ~~— temperature of one adjacent cell (if possible);~~

Line 195 specifies the requirement to measure temperature of one adjacent cell, while line 201 does that for the initiation module and adjacent modules.

HO	203			Te.	The purpose of the temperature measurement at the battery pack surface and open valve is unclear. Requirements that are irrelevant to the pass/fail criterion aren't necessary. They should be removed.	Delete the text below: ~~— additional temperature measurement with distributed sensors at the battery surface and at the venting port (if applicable);~~

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), moving this requirement into "data … as additional information" section.

HO	205			Te.	The purpose of the insulation resistance measurement at the end of the test is unclear. Requirements that are irrelevant to the pass/fail criterion aren't necessary. They should be	Delete the text below: ~~— at the end of the test measure the isolation resistance on REESS or REESS subsystem~~

					removed.	~~level.~~

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), moving this requirement into “data … as additional information” section.

HO	207			Te.	Data necessary for the pass/fail judgement should be recorded.	Change as follows: — The time when warning indications or alarms are provided to vehicle occupants.

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), specifying “the time stamp of warning indications or alarms to vehicle occupants”.

HO	211			Te.	Data necessary for the pass/fail judgement should be recorded. Smoke data in the passenger compartment is necessary for the pass/fail judgement. It should be specifically stated. The types of the toxic gases to be measured should be specified by the manufacturer’s pretest results.	Change as follows: — ~~multi-gas measurement inside the vehicle for~~ Insertion of relevant flammable and toxic gases into the passenger compartment e.g. CO, H2, CH4 and VOCs levels ~~by agreement between customer and supplier~~. In that case, the measurement method and result shall be reported. Typical measured toxic gas is CO. Other gases to be measured are determined by the manufacture, based on manufacturer’s pre-test results.

This requirement is among “data may be provided as additional information”.

HO	235			Te.	Should prescribe specifically what should be done.	Change as follows: — If a thermal runaway reaction occurs: ~~— monitor and observe until the maximum temperature of all temperature measurements, drops below 60 °C, then continue recording for an additional 2 h.~~ ~~— external vehicle temperatures may be viewed through IR cameras.~~ - Heater may be turned off. - To confirm that hazardous situations due to explosion, ignition, or smoke do not occur in 5 minutes after a warning is provided.
HO	239			Te.	Prescribe specifically what should be done.	Change as follows: — If a thermal runaway reaction does not occur: ~~— monitor and observe for a minimum of 2 h.~~ ~~— Wait 24 h with remote monitoring of test vehicle to ensure no further thermal reactions.~~ ~~External vehicle temperatures may be viewed through IR cameras.~~ —In the case that the initiation cell temperature reaches a specified criterion (=300C?), it can be judged that the battery passes the thermal propagation requirement. —In the case that the initiation cell temperature does not reach a specified criterion (=300C?), the battery needs to be retested with larger area or higher power heaters.

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), deleting
"— If a thermal runaway reaction occurs:
— monitor and observe until the maximum temperature of all temperature measurements, drops below 60 °C, then continue recording for an additional 2 h.
— external vehicle temperatures may be viewed through IR cameras.
— If a thermal runaway reaction does not occur:
— monitor and observe for a minimum of 2 h.

—Wait 24 h with remote monitoring of test vehicle to ensure no further thermal reactions".

HO	252			Te.	The grounds for the pressure threshold of "dP/dt ≥ 0.01 bar/s of the measured pressure in the pack for at least 3s" are unclear. Is the criterion adjusted according to the battery pack volume? Is it available for battery packs applying air-cooling systems?	The grounds of 0.01 bar/s should be elaborated.

JRC research has shown that the pressure change rate can be up to ca. 0.13 bar/s, depending on the DUT (please see EVS25-E1TP-0500).
Value of 0.01 bar/s was chosen after investigating typical rates of atmospheric pressure changes, see e.g. Karstens, C. D., Samaras, T. M., Lee, B. D., Gallus, W. A., & Finley, C. A. (2010) "Near-ground pressure and wind measurements in tornadoes", Monthly Weather Review, 138(7), 2570-2588.

HO	253			Te.	There are cases where valve opening to electrolyte vapor release occurs prior to the occurrence of thermal runaway. This should be excluded.	Change as follows: — smoke release (<u>emission of electrolyte vapor before cell thermal runaway is excluded</u>);

Smoke is defined as one of the hazards associated with thermal runaway and thermal propagation in GTR EVS text agreed in Phase 1. In our view and as discussed in Phase 1 of the GTR EVS, it would neither be appropriate nor feasible to introduce differentiation between smoke release due to venting valve opening to release electrolyte vapor prior to the occurrence of thermal runaway and smoke release due to thermal runaway.

	244—271		Detection of thermal runaway		Need to clarify the evidence for TR detection condition. Supplementary criterion needs to discuss the evidence	

To be discussed and agreed within Informal Working Group tasked with the development of the GTR EVS.

HO	255			Te.	There is little relationship between BMS failure and cell thermal runaway. Parameters that are irrelevant to thermal runaway should be removed.	Delete the sentence below: ~~— failure of the BMS or signal faults (if the BMS is still active). Logged faults in the BMS shall be analysed. Thermal runaway indicators shall be specified and documented~~

						~~if required.~~

The regulatory text proposal is updated accordingly (please see an updated regulatory text proposal), deleting this supplementary criterion.