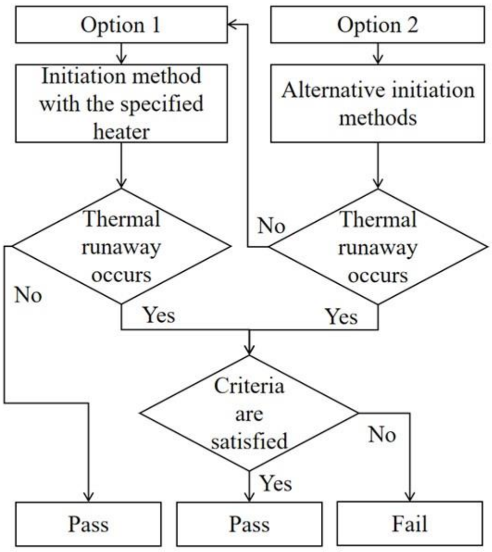
JRC replies to the comments of China on the EVS25-E1TP-0510 Draft regulatory text for the Thermal Runaway Propagation test

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

Line 23 “Initiation method”
Localized rapid external heating could be regard as main method, but alternative initiation methods are also necessary, such as nail penetration and internal heating in the ISO 6469-1 AMD:2022.
China’s idea on relationship of these methods is as follows:



As mentioned at various occasions, including the last TF-TP meeting on February 15, 2023, JRC does not consider inclusion of an alternative initiation method necessary. 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 the GTR EVS IWG.

Line 37 Table XX “Heating element selection guide – Target Parameters“
The parameter of Prismatic cell need further research, especially for large volume cell

Research by various partners has shown that localized rapid external heating can successfully be used initiating a thermal runaway in a repeatable manner in large prismatic cells with metal casing. Please see, for example, EVS22-E1TP-0400 “Thermal Runaway Initiation of Large Prismatic Cells by Rapid External Heating - Challenges and Solutions” by NRC Canada and EVS25-E1TP-0500 “JRC’s thermal runaway propagation test campaign at pack and vehicle level” by JRC.

Line 41 Figure YYY “Heating methodology profile for the localized rapid external heating test“
The figure may lead to some misleading. The starting point of phase 3 should be the TR of the target cell, not the target cell reaching the TSet point.

In addition, this figure is not significant to guide the actual experiment, so it is recommended to delete it.

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.

Line 50 "Table XXX as a guideline. The customer and supplier shall agree on specific values."
The parameter of this table is just the recommended value, which could also be another value agreed by OEM and test agencies, isn't it?

Table XXX provides typical heater parameters for implementation of localised rapid external heating methodology. Extensive research by various experts involved in the GTR EVS work shows that these parameters are key for reproducible and repetitive thermal runaway and thermal propagation test. Nevertheless, Table XXX gives a possibility to adjust target parameters for large volume and/or thick-walled cells. 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."

Line 64 Table XXX, column "Prismatic"
The parameter of Prismatic cell need further research, especially for large volume cell

Research by various partners has shown that localized rapid external heating can successfully be used initiating a thermal runaway in a repeatable manner in large prismatic cells with metal casing. Please see, for example, EVS22-E1TP-0400 "Thermal Runaway Initiation of Large Prismatic Cells by Rapid External Heating - Challenges and Solutions" by NRC Canada and EVS25-E1TP-0500 "JRC's thermal runaway propagation test campaign at pack and vehicle level" by JRC.

Line 64 Table XXX, column "Heating rate of the element"
Does the heating rate parameter refer to the "no-load" heating rate? Or it refer to the heating rate in the actual test condition (contact to target cell)

It refers to the actual test condition, i.e. heater in contact with the target cell. Please see, for example, EVS22-E1TP-0400 "Thermal Runaway Initiation of Large Prismatic Cells by Rapid External Heating - Challenges and Solutions" by NRC Canada, slides 8 and 10, and EVS25-E1TP-0500 "JRC's thermal runaway propagation test campaign at pack and vehicle level" by JRC, slides 14 to 17.

Line 88 "Test events and outcome description", event "deformation"
Difficult to judge without more executable indication

Line 96 Table XXXX "Possible test outcomes", row 1, "Target cell thermal runaway was successfully initiated."
According to definition of "thermal event" and "thermal runaway", Does the scenario this exist? If target cell is initiated to thermal runaway, there is thermal event of target cell.

Part "Test events and outcome description" and Table XXXX have been deleted from the text of the regulatory proposal.

Line 117 "This test shall be conducted at the vehicle level"
We consider that component level test is necessary. Because it is low cost and easy to implement.
For the EVS25-E1TP-0500 [EC], we consider that the JRC report did show that the thermal propagation rate in the vehicle level test was faster than that in the battery pack level test, and it was speculated that

the reason was related to better battery sealing (better strength and sealing due to the role of the vehicle body). Better sealing makes the high-temperature and high-pressure gas play a greater role.
However, there is no absolute single relationship between the tightness and the speed of thermal propagation. For systems specially designed with pressure relief channels and gas evacuation channels, better sealing also means that the gas will evacuate from the system in the safest way, and may also delay the occurrence of thermal propagation (there are some designs and studies).
Therefore, we believe that such a single result is not enough to show that the thermal propagation rate at the vehicle level is faster than that at the battery pack level.
Although the vehicle level test can best reflect the actual situation, we suggest to retain the option of battery system level in terms of the cost, convenience and feasibility of actual test execution.

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.

Line 124 "The REESS temperature shall be maintained between 18 °C to maximum permissible operating temperature, defined by the manufacturer."
The requirement of ambient temperature should be added. Considering the outdoor test environment, we consider the test shall be conducted at environment temperature between 0 to 40°C.

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. This needs to be discussed and agreed within the Informal Working Group tasked with the development of the GTR EVS.
Moreover, 40°C may in some cases exceed the maximum permissible operating temperature, defined by the manufacturer. Therefore, our suggestion, if ambient temperature for this test is to be defined, to maintain the maximum permissible operating temperature, defined by the manufacturer, as the upper limit for the ambient temperature requirement for the test. The lower ambient temperature limit needs to be discussed and agreed within the Informal Working Group tasked with the development of the GTR EVS.

Lines 151-152 "The initiation cell shall be chosen among those with a maximum number of nearest neighbours approximating the centre of the battery pack"
Sometimes, the heater couldn't be installed in the center of the battery pack.

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.

Line 242 "Detection of thermal runaway"
Enforceable is very important for the regulation test method. Some criteria is ambiguous (such as battery deformation) and should be further clarified.

Lines 263-267
"— material formation indicating high temperatures (e.g. molten and re-solidified aluminium or copper);
— specific reaction products such as e.g. metallic nickel or cobalt, lithium-aluminium oxide;
— current collector foil absence (partial or total);
— thermal decomposition of polymer materials, e.g. separator, isolation material.
Detection of TR is related to the time of stopping heating, but some criteria could only be checked after the heating.

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.