Draft Japan Proposal for Battery Durability

EVE-32

8. October. 2019

Contents

Based on the discussions written below at GRPE # 79, EVE31 Japan considered the objective, issues and schedule of the GTR

Japan to provide recommendation for overall timing to be presented to GRPE in January 2020
Japan has proposed to initially discuss and agree on the purpose of GTR in more detail before deciding on the timeline by January 2020.

a. Establishes minimum durability requirements and developing guidelines for acceptable evidence that the requirements will be met;
b. Establishes measures to prevent substandard products from entering the market;
c. Allows adequate room for continued development of the regulation as the industry continues to evolve;
d. Implements a mechanism for the collection of data that could provide a basis for refining the gtr in the future.

EVE IWG proposed a near-term durability solution;

1. Adopt predetermined deterioration factors (DF)
2. Confirm during in-use conformity tests

TimeLine ;

January 2021: Preliminary GTR available for GRPE
June 2021: Final working document for GRPE

a number of challenges in determining the DF of in-vehicle battery

EVE IWG develops **gtr text based on deterioration factors**, in a manner **similar to current requirements for air pollutant emissions from conventional vehicles**;

1. How is DF determined?

1)Conduct the existing test procedure (including improvements) or newly develop and conduct it.
2) Decide the DF from the investigation of battery degradation distribution in the market.
3) Individual company application

2. How to determine the required criteria for DF ?

There is no regulation value unlike the tail pipe emissions.

1) Decide the required DF from the investigation of battery degradation distribution in the market.
2) CP will determine certain value (such as 60% @6 years)
  * DF Should be considered about operating environment and charging / driving conditions.
  (such as ambient temperature, rapid charge frequency, etc.)

3. What kind of the documents should each OEM submit to the homologation authority ?

4. How to deal with EV Distance for certification or brochure

the value of a new car or DF should be considered?
When DF is considered, it becomes too small number compared to the actual range of a new car

Comparison of DF determination between Emissions and EV range

1. Pollutant emissions (conventional vehicle)

Development of the durability test method
1) Gather Vehicle driving information in the market
2) Analyze the load (flow and Temp.) distribution on catalysts
3) Determine the durability cycle /mode
4) Conduct the durability test on CDY or MAD

Vehicle emission data of in-use vehicles (large and extensive)

Improvement of the durability test method
1) Gather Vehicle driving information in the market
2) Analyze the degradation mode of catalyst
3) Improve or modify the durability mode
4) Develop Bench testing and/or accelerated test method

DF is determined from the degree of degradation of the exhaust emissions by accelerated test methods with an actual vehicle or engine bench which represents the degradation in the market

２. EV range compared to pollutant emissions

1) There is no market representative and/or correlated durability test method.
   ISO exists but no market correlation data

2) Degradation simulation model is being developed by JRC, but correlation data with degradation in the market is insufficient regarding EV models and/or its total numbers .

3) There is Insufficient analysis of statistical degradation data of EV vehicles in the market

JRC-TEMA Model

#1

Performance-based models

(validated on exp. at cell-level)

#2

3 vehicle reference architectures

(from cell-to-vehicle)

#3

Real-world Driving data

#4

Durability Scenarios

(Yrs and/or km to EoL)

Degradation prediction

	Capacity fade		Power fade	
	Calendar	Cycle	Calendar	Cycle
$LiFePO_4$	Sarasketa-Zabala et Al. (2013/14);	Wang et Al. (2011); Sarasketa-Zabala et Al. (2013); Sarasketa-Zabala et Al. (2015);	Sarasketa-Zabala et Al. (2013);	
NCM + spinel Mn	Wang et Al. (2014);		-	-
NCM – LMO	-	Cordoba-Arenas et Al. (2014);	-	Cordoba-Arenas et Al. (2015);

Calendar + Cycle (4 Combinations):

- **#1 ($LiFePO_4$): Sarasketa-Zabala et Al. (2013/14) model for calendar plus Wang et Al. (2011) model for cycle;**
- **#2 ($LiFePO_4$): Sarasketa-Zabala et Al. (2013/14) model for calendar plus Sarasketa-Zabala et Al. (2015) model for cycle;**
- **#3 (N**
- **#4 (N**

Verification of battery cell types (= EV models) and the market data is very limited for degradation prediction. Only Tesla and Leaf.

Degradation prediction

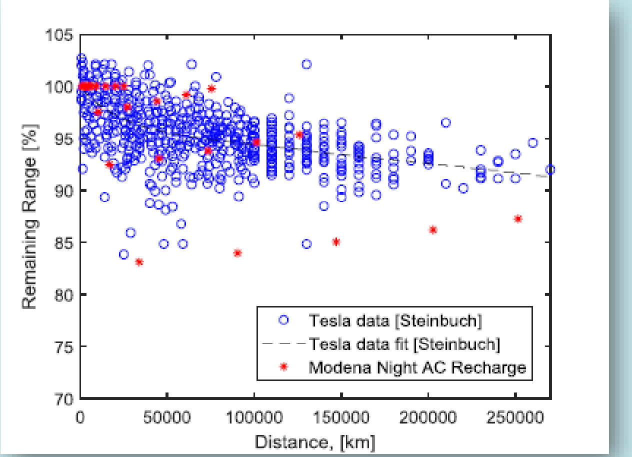
EoL @ 80% capacity fade Li-Ion NCM-LMO (2015) Years Driving to Set Threshold				0 - 500 km/month			500 – 1,000 km/month			1,000 -1,500 km/month			1,500 – 2,000 km/month			2,000+ km/month		
				Years to EoL	Years to 100,000 km	Years to 160,000 km	Years to EoL	Years to 100,000 km	Years to 160,000 km	Years to EoL	Years to 100,000 km	Years to 160,000 km	Years to EoL	Years to 100,000 km	Years to 160,000 km	Years to EoL	Years to 100,000 km	Years to 160,000 km
Recharge Strategy #1	PHEV-1	Modena Prov.	NCM-LMO (2015)	16.5	≥ 20	≥ 20	14.6	14.2	≥ 20	-			-			-		
		Amsterdam Prov.		18.3	≥ 20	≥ 20	15.3	11.6	18.6	13.7	6.9	11	12.5	4.9	7.8	11.3	3.4	5.4
		Brussels Prov.		18	≥ 20	≥ 20	15.2	12.6	≥ 20	13.6	6.9	11	12.8	4.8	7.7	12.1	3.7	5.9
		Luxembourg Prov.		17.5	≥ 20	≥ 20	15	11.5	18.4	13.6	7	11.1	12.6	5	7.9	11.4	3.4	5.4
		Paris Prov.		15.6	≥ 20	≥ 20	13.6	11.2	17.9	12.4	6.8	10.8	11.4	4.8	7.7	9.8	2.6	4.2
	BEV-1	Modena Prov.		9.7	≥ 20	≥ 20	8.6	12.8	≥ 20	8.2	7.9	12.6	-			-		
		Amsterdam Prov.		10.9	≥ 20	≥ 20	9.1	11.6	18.6	8.2	6.9	11	7.5	4.9	7.8	6.7	3.4	5.4
		Brussels Prov.		10.8	≥ 20	≥ 20	9.1	12.7	≥ 20	8.2	6.9	11	7.6	4.8	7.7	7.2	3.7	5.9
		Luxembourg Prov.		10.5	≥ 20	≥ 20	9	11.6	18.5	8.1	7	11.2	7.5	5	7.9	6.8	3.4	5.4
		Paris Prov.		9.4	≥ 20	≥ 20	8.2	11.1	17.9	7.4	6.8	10.8	6.8	4.8	7.7	5.9	2.6	4.2
	BEV-2	Modena Prov.		12.1	≥ 20	≥ 20	12.7	11.2	17.9	13.6	6.9	11	14.7	5	8.1	16.1	3.9	6.3
		Amsterdam Prov.		13.9	≥ 20	≥ 20	13.7	11.6	18.6	13.6	6.9	11	13.5	4.9	7.8	13.3	3.4	5.4
		Brussels Prov.		13.4	≥ 20	≥ 20	13.4	12.6	≥ 20	13.4	6.9	11	13.7	4.8	7.7	13.7	3.7	5.9
		Luxembourg Prov.		13.4	≥ 20	≥ 20	13.4	11.6	18.5	13.4	7	11.1	13.2	4.9	7.9	13.3	3.4	5.4
		Paris Prov.		12	≥ 20	≥ 20	12	11.2	17.9	12	6.8	10.8	11.9	4.8	7.7	11.8	2.6	4.2
Recharge Strategy #2	BEV-1	Modena Prov.	NCM-LMO (2015)	9.3	≥ 20	≥ 20	7.9	11.7	18.7	7.1	7.1	11.4	6.6	5.1	8.1	6.2	3.7	6
		Amsterdam Prov.		10.9	≥ 20	≥ 20	8.9	11.6	18.8	7.9	6.9	11	7.2	4.9	7.8	6.5	3.4	5.4
		Brussels Prov.		10.8	≥ 20	≥ 20	8.8	12.7	≥ 20	7.8	6.9	11	7.4	4.8	7.7	6.9	3.7	5.9
		Luxembourg Prov.		10.4	≥ 20	≥ 20	8.7	11.6	18.6	7.8	7	11.1	7.1	4.9	7.9	6.5	3.4	5.4
		Paris Prov.		9.3	≥ 20	≥ 20	7.9	11.3	18	7.1	6.8	10.8	6.6	4.8	7.7	5.6	2.6	4.2
	BEV-2	Modena Prov.		11.6	≥ 20	≥ 20	11.4	11	17.7	11.3	6.8	10.8	11.2	4.8	7.7	11.2	3.4	5.4
		Amsterdam Prov.		13.7	≥ 20	≥ 20	13.2	11.7	18.7	12.9	6.9	11	12.8	4.9	7.8	12.6	3.4	5.4
		Brussels Prov.		13.2	≥ 20	≥ 20	12.8	12.7	≥ 20	12.7	6.9	11	13.1	4.8	7.7	13.2	3.7	5.9
		Luxembourg Prov.		13.1	≥ 20	≥ 20	12.8	11.6	18.6	12.6	7	11.1	12.5	4.9	7.9	12.4	3.4	5.4
		Paris Prov.		11.8	≥ 20	≥ 20	11.5	11.3	18.1	11.4	6.8	10.8	11.3	4.8	7.7	11.3	2.6	4.2

Legend	
(pink)	EoL below 5.0 years;
(yellow)	EoL above or equal to 5.0 and below 10.0 years;
(green)	EoL above or equal to 10.0 years;

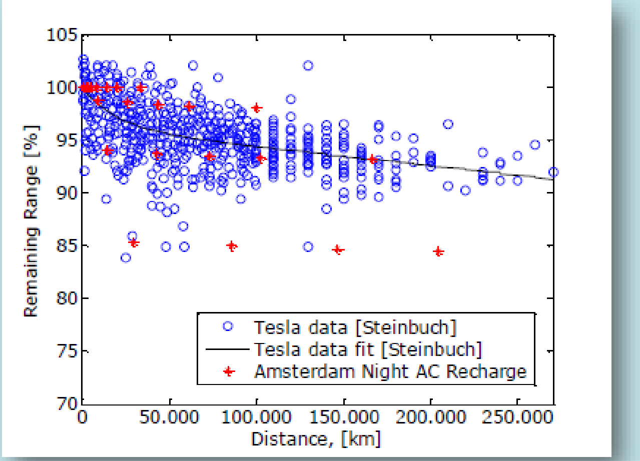
October 16th-18th, 2018, Ottawa (Canada)

JRC Validation Example: 1.Tesla , 2. LEAF@New Zealand, 3. LEAF @Canada

Data comparison: Tesla data



Night AC recharge – Modena Data

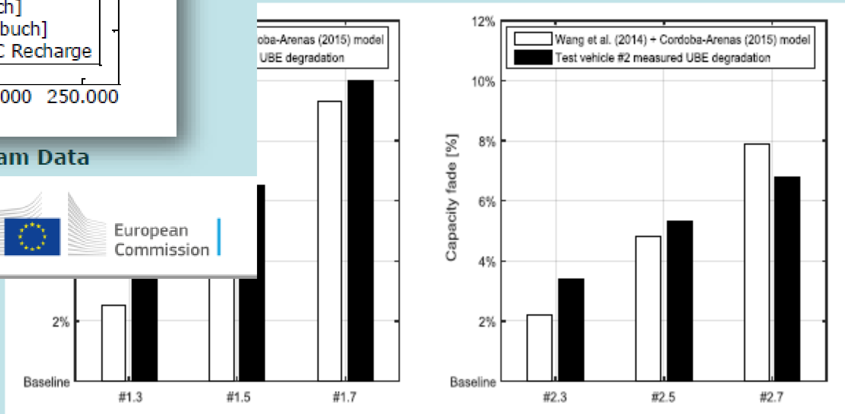


Night AC recharge – Amsterdam Data

*Technical University Eindhoven, May2018, https://steinbuch.wordpress.com/2015/01/24/tesla-model-s-battery-degradation-data

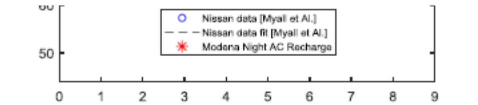
...da (Validation)

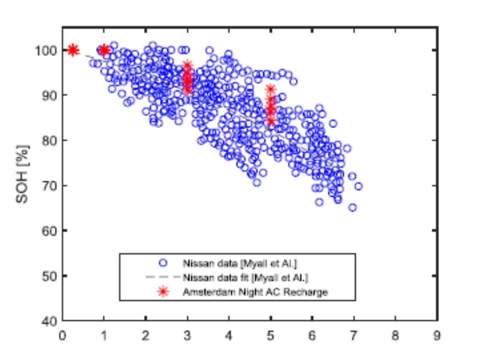
i.e. $LiMn_2O_4$ with $LiNiO_2$)



The results have been presented at the EVS 31&EVTeC 2018, Kobe, Japan and will be described in the scientific paper "Capacity fade of Lithium-ion automotive batteries under real-world use conditions", Submitted in Feb. 2018

Leaf data - #4(NCM-





Even in the few verification examples ,simulation results are not representative of degradation characteristics.

1.Two data set were SNS information from around the world and does not represent a specific region.

2.Inability to analyze variation factors due to lack of usage information (charging, temperature, etc.)

ISO test method

ISO 12405-4:2018
Electrically propelled road vehicles --Test specification for lithium-ion traction battery packs and systems -- Part 4: Performance testing

Introduction

Lithium-ion-based battery systems are an efficient alternative energy storage system for electrically propelled vehicles. The requirements for lithium-ion based battery systems for use as a power source for the propulsion of electric road vehicles are significantly different from those batteries used for consumer electronics or stationary usage.

This document provides specific test procedures for lithium-ion battery packs and systems specially developed for propulsion of road vehicles. This document specifies such tests and related requirements to ensure that a battery pack or system is able to meet the specific needs of the automobile industry. It enables vehicle manufactures to choose test procedures to evaluate the characteristics of a battery pack or system for their specific requirements.

ISO 12405 specifies test procedures for lithium-ion battery packs and systems which are connected to the electric propulsion system of electrically propelled vehicles.

The objective of ISO 12405 is to specify standard test procedures for the basic characteristics of performance, reliability and electrical functionality of lithium-ion battery packs and systems and to assist the user in comparing the test results achieved for different battery packs or systems.

NOTE 1 The general safety relevant tests and requirements are given in ISO 6469-1[1]).

NOTE 2 Environmental conditions and testing are specified in ISO 19453-6[2]).

For specifications for battery cells, see IEC 62660-1 to 3.

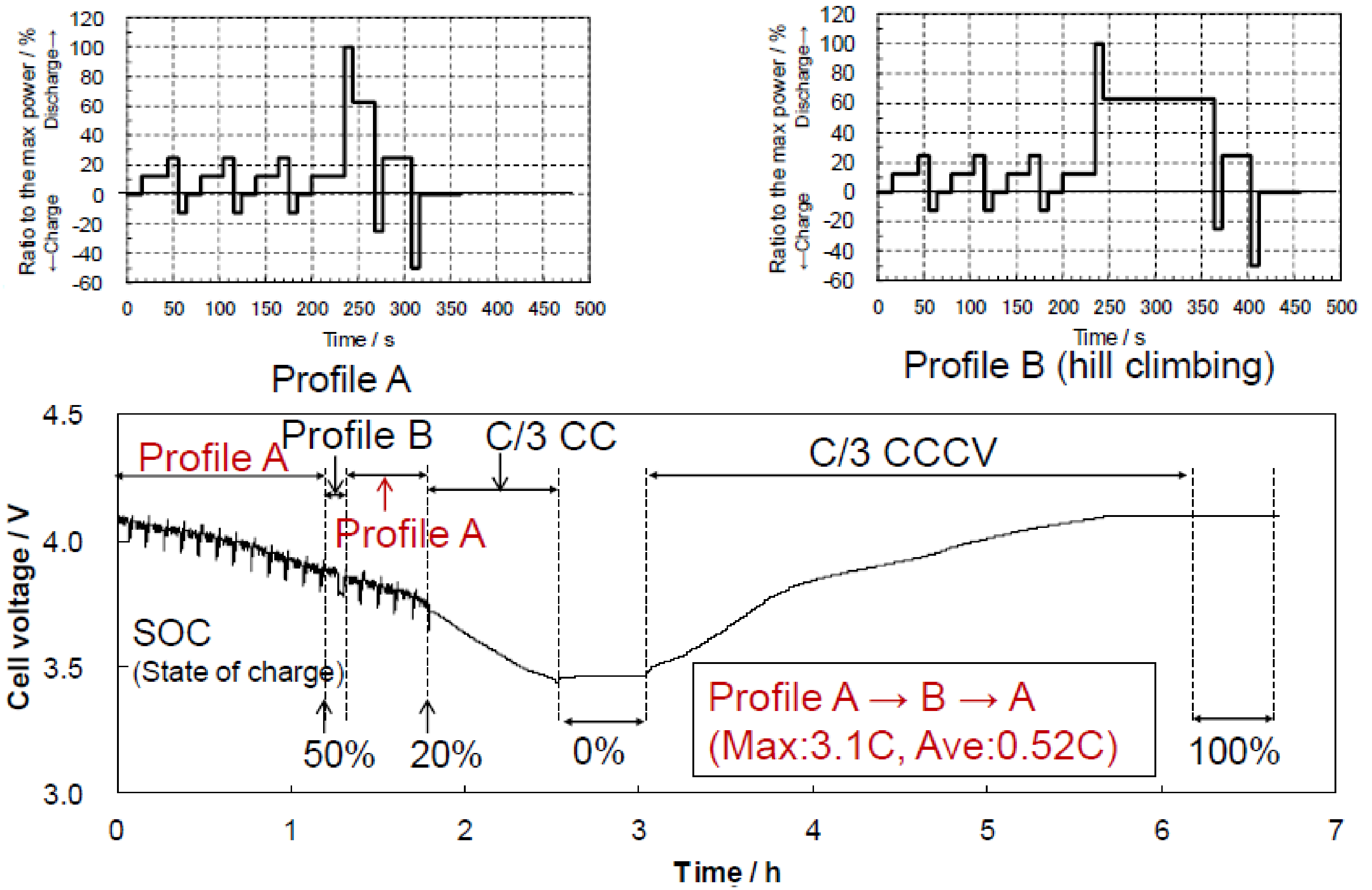
Overview of ISO12405-4

Overview of tests

- **General tests (Clause 6)**
  - Pre-conditioning cyles (Clause 6.1)
  - Standard cycle (Clause 6.2)
  - Standard Discharge (Clause 6.2.2.2)
  - Standard Charge (Clause 6.2.2.3)
- **Performance tests (Clause 7)**
  - Energy and capacity at RT (Clause 7.1)
  - Energy and capacity at different temperature and discharge rates (Clause 7.2)
  - Power and internal resistance (Clause 7.3)
  - No load SOC loss (Clause 7.4)
  - SOC loss ar storage (Clause 7.5)
  - Cranking power at low temperature (Clause 7.6)
  - Cranking power at high temperature [a] (Clause 7.7)
  - Energy efficiency [a] (Clause 7.8)
  - Energy efficiency at fast charching [b] (Clause 7.9)
  - Cycle life (Clause 7.10)

Cycle life only, no test method for temperature life effect or calendar life.

Verification of ISO12405-4 (Cycle)



- ✓ 7 hours need for one cycle, this means 3 cycles per day.
- ✓ 750 cycles (ten years), 250-day necessity.
- ✓ Evaluate by normal charge only, rapid charge is not evaluated.

Brief Summary of ISO12405-4

As a test method to determine DF,
It is **impossible to evaluate all factors affecting battery degradation.**

Factors affecting battery degradation are :

1. Climate condition of use and storage, higher temperature accelerates deterioration.
2. Width of SOC to be used, wider SOC accelerates degradation.
3. Also with width of the same SOC, degradation accelerates in area higher in voltage.
4. Charging rate, rapid or normal.
5. Cycle life.
6. Calendar life.
7. Others

Same as OICA stance presented as EVE-28-16e

The test period is much longer than that of ICE vehicles.

1. Charge/discharge which is equivalent to driving distance for investigating degradation by driving distance is necessity. For shortening test time, quick charge is necessity. Actual usage is not reflected.
2. It is difficult to accelerate test which evaluates calendar life.

[Conclusion]

JRC's TEMA model cannot be a representative durability prediction method in the market.
Therefore, the determination of DF using this model is considered to be difficult at present.

ISO 12405-4:2018 cannot be a representative durability test method in the market,
Therefore, the determination of DF using this ISO method is considered difficult at present.

Task of ISC for battery DF

1．How to select ISC vehicles （Next Page）

1) How to ensure market representativeness with large variations in battery degradation depending on environment and usage

2．How to decide ISC pass / fail criteria

(unlike tailpipe emissions, there are no regulatory values)

1) Compared to the declared DF, whether to use the average value or pass rate
2) As a result, what to do when ISC fails
   (If it includes administrative orders, what is the legal basis in such cases?)

3．ISC system for EV range

1) Law system to be developed (especially in Japan)
2) Securing resources:
   If the EV range is long, the test time is very long and the number of units must be secured

How to select ISC vehicles

１．vehicle selection for conventional ICE vehicles

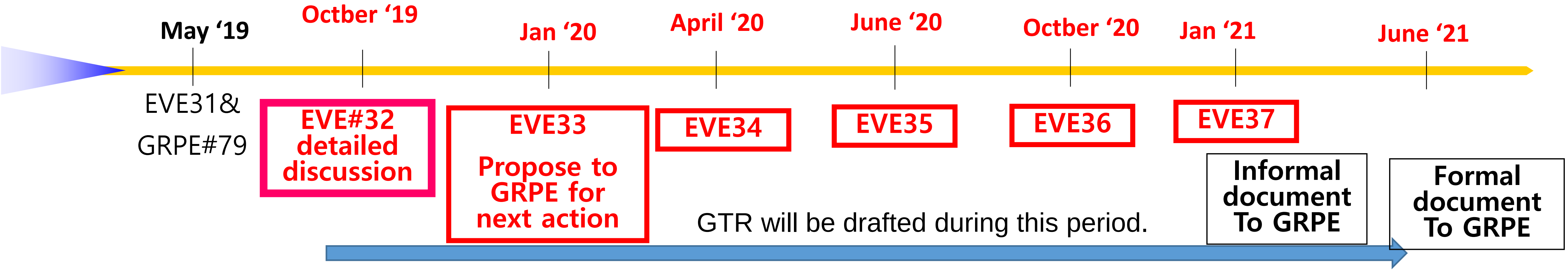
Select vehicles in consideration of mileage and model year near the test location

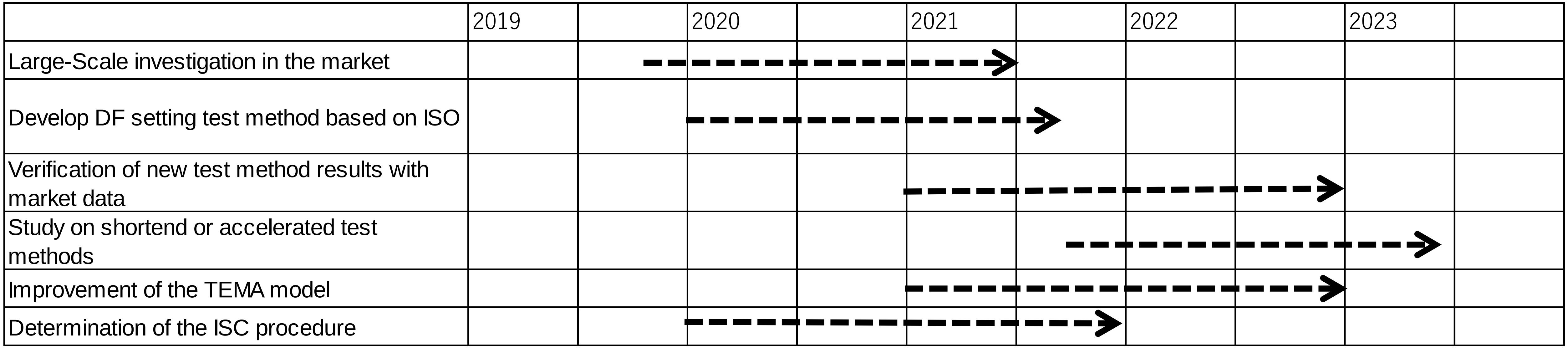
２．vehicle selection for EV /PHV

It is assumed that the degradation level varies greatly depending on the environment and usage.

１）Ambient temperature distribution
２）Charging method distribution (AC charging, DC fast charging)
３）Charge / Discharge distribution (SOC swing width, swing center, etc.)

Items for Developing “DF + ISC” and necessary tentative schedule





Completion of the GTR draft by January 2021 is extremely difficult.

The objective of the GTR proposed by Japan

For the spread of electric vehicles;

- to gain the user's confidence in the remaining capacity of the battery
- to understand the residual performance of the battery

GTR regulates the method of grasping degradation of electrified vehicles.

The objective:
To grow the sound EV market and protect consumers,
Provide the Information of in-vehicle battery performance
Can support users to understand the state of degradation of their own batteries.
<Note: NOT FOR ENVIRONMENT NOR SAFETY>

This requirement will result in the elimination of the substandard products which might use inferior batteries.

http://www.cev-pc.or.jp/xev_kyougikai/activity/#steeringcommittee

Quoted from Guideline Ver. 1.0

II. Definition of the topic

Purpose

The Guideline are designed to facilitate automakers to provide the basic methods which enable users to know state of health of LIB, so that users can get rid of excessive anxiety over battery degradation and re-sale values of EVs (Electric vehicle) and PHVs (Plug-in Hybrid Electric vehicle) can be evaluated properly. The approaches in the Guideline will also be applied to create the automotive battery reuse and repurposing markets in future.

Outline of the Guideline

The fundamental justifications to the general basic methods to indicate the state of health (hereinafter called "basic methods") are as follows:

- The basic methods shall **(1) present initial performance of electrified vehicles** and **(2) help users understand objectively how much performance the vehicles maintain compared to their initial performance**. To be more specific, **certified specification or specification in the catalogue** such as **all-electric driving range** or **battery capacity** shall be used **to indicate how much performance the vehicles still preserve**.
- Regarding reliability of the indications of the state of health, an appropriate procedures should be developed. The objectivity of indication should be proved by third party institutions.

There are two styles how to indicate the state of health – indication based on all-electric driving range and the one based on the measurement of the battery capacity. Both shows how much performance the vehicles have maintain against the initial values (certified specification / specification in the catalogue).

State of health can be indicated on an instrument panel, smartphone, or displayed on the dedicated tool through On-Board Diagnostics (OBD) port upon request of users. Besides, the direct measurement of the battery performance itself with a other measurement instrument, which is not mounted on vehicles, can also be one of the options considering users' convenience.

III. Examples

Case 1. Indication of state of health based on all-electric driving range

① This method provides **how much proportion of all-electric driving range** an EV and PHV **maintain against the range referred to in catalogue**. *1 *2
② The State of health is measured by using Electronic Control Unit in vehicles.
③ The State of health through Vehicle diagnostic tools shall be indicated on this tool, the instrumental panels, or the portable information terminals such as smartphones upon request of users.
④ The State of health is indicated in 10% increments.

*1 Catalogue specs of all-electric driving range are confirmed by national institutions when a vehicle obtains a type-approval certificate.
*2 The following method can be assumed to verify reliability of indication. A verification scheme for third party institutions may be developed in future.
1) Verifier drives a car and checks all-electric driving range following procedures required to obtain the national type-approval certificate.
2) Verifier assesses reliability of indication by comparing the all-electric driving range which the car actually traveled and catalogue specs.

Case 1. Indication of state of health based on all-electric driving range

In Japan.
The values confirmed by MLIT are written in a catalog (see above)

there is no rule for values in catalogs In Europe. (see right)

Propose to utilize the values on Certificate of Conformity

5. Pure electric vehicles and OVC hybrid electric vehicles, under Regulation (EU) 2017/1151 (if applicable)

5.1. Pure electric vehicles

Electric energy consumption		… Wh/km
Electric range		… km
Electric range city		… km

5.2 OVC hybrid electric vehicles

	Prius PHV	
Electric energy consumption ($EC_{AC,weighted}$)	100	… Wh/km
Electric range (EAER)	45	… km
Electric range city (EAER city)	55	… km

Case 2. Indication of the state of health based on **the battery capacity** (in vehicle*3)

① This method provides **how much proportion of the battery capacity** preserved in an EV and PHV **against the capacity referred to in the catalogue.** *4 *5

① The State of health is measured by using Electronic Control Unit in vehicles.

② The State of health through Vehicle diagnostic tools shall be indicated on this tool, the instrumental panels, or the portable information terminals such as smartphones upon request of users.

③ The State of health is indicated in 10% increments.

*3 The following method can also be applied to measure and indicate battery capacity other than measuring batteries in vehicle.

1) State of health of LIB is measured by dealers and others using measurement instruments which are not mounted on vehicles.

2) State of health of LIB is presented to users utilizing output data from these measurement instruments.

*4 Catalogue specs of battery capacity are not confirmed by national institutions when a vehicle obtains a type-approval certificate.

*5 The following method can be assumed to verify reliability of indication. A verification scheme for third party institutions may be developed in future.

1) The automaker discloses a measurement method of battery capacity referred to in catalogue to third party institutions.

2) Battery capacity is measured by the similar measurement method with 1)

3) Reliability of indication is verified by comparing results of the measurement 2) and catalogue specs.

Case 2: Example) Nissan LEAF

ROMOTIE | CONFIGURATOR | PRIJZEN EN UITVOERINGEN | BESPARINGEN & VOORDELEN | BEREIK & OPLADEN | VERGELIJKEN | MEER WEERGEVEN

RIJHULPMIDDELEN | BEREIK | BEREIK VERGROTEN | EENVOUDIG OPLADEN, VOLLE KRACHT VOORUIT

Nissan Belgium

TEKNA

NISSAN LEAF E+ N-CONNECTA

WAAROM
NISSAN LEAF ACENTA?

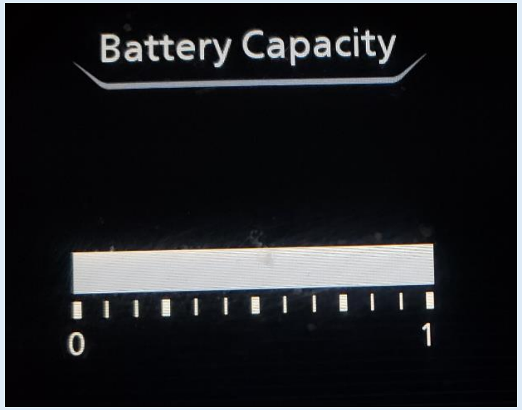
CONFIGUREER UW NISSAN LEAF

PRIJZEN EN SPECIFICATIES

TOPCONNECTIVITEIT

Nissan LEAF Acenta kenmerken:

- **Intelligente integratie**
  - Nieuw **8 inch scherm**
  - Navigatie van deur tot deur ondersteund door TomTom
  - **Apple CarPlay**
  - Volledig nieuwe app **NissanConnect Services**
- **Intelligent vermogen**
  - **Batterijcapaciteit: 40 kWh**
  - Zero Emission:
    Tot 270 km volgens WLTP gecombineerde cyclus**
  - Directe koppe
    Acceleratie:
    Max. vermog
- **Intelligent rijden**
  - 5 sterren Eur
  - **e-Pedal™**
- **Stijl**



Indication of the state of health based on the catalog battery capacity value

Remaining point of ‘Providing information guideline of in-vehicle battery’

１. What is the appropriate provision of information to customers?
（Not for assurance of battery degradation）
１）What we have to offer to customers of regions other than Japan?

２. Preciseness consideration of information
１）Grasp of the actual situation, JARI started

３. Method of information verification by third party
１）JARI started

４. System design of information collection method
１）Examining the collection information management method and necessity
２）Preciseness is mandatory or not

Not directly related to the Information Guideline, but closely related

５. Warranty
１）Depend on individual company

Schedule of developing Providing Information Guideline of in-vehicle battery performance in Japan

	2019_4Q	2020_1Q	2020_2Q	2020_3Q	2020_4Q	2021_1Q	2021_2Q
Application to SAE OBD ID	Apply☆	- - - - →	- - - - →	★Registered			
Validation tests by JARI.Prius_PHV,LEAF - - →	- - - - →	- - →					
verification of Error and variation standardization		- - - - →	- - - - →				
Guidelines ver.FY2019 completed			★				

We plan to complete the 2019 version of the guidelines by the first half of next year by applying for OBD port ID , conducting validation tests and so on

Current status of The Guideline development

1. Application to SAE OBD working Group

SAE J1979 Revised SEP2010 Page 168 of 256

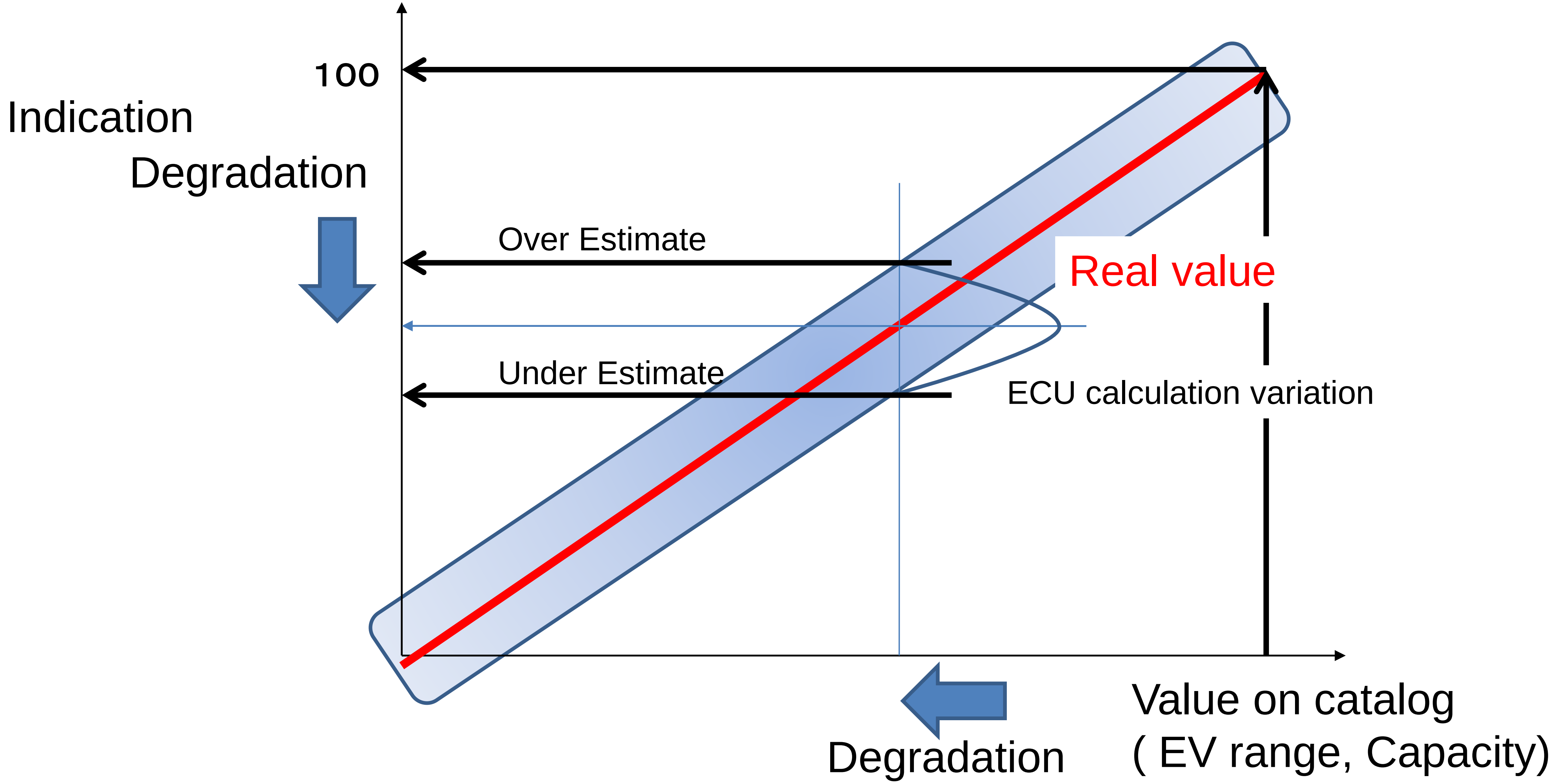
TABLE B72 - PID $5B DEFINITION

PID (hex)	Description	Data Byte	Min. Value	Max. Value	Scaling/Bit	External Test Equipment SI (Metric) / English Display
5B	Hybrid/EV Battery Pack Remaining Charge	A	0 %	100 %	100/255 %	BAT_PWR: xxx.x%
	BAT_PWR shall display the percent remaining level of charge for the hybrid battery pack, expressed as a percentage of full charge, commonly referred to as State Of Charge (SOC).					

PID (hex)	Description	Data Byte	Min.Value	Max.Value	Scaling/Bit	External Test Equipment SI(Metric)/English Display
	Battery Pack Performance Retention Rate	A	0%	100%	100/255	BAT_RET:x0.0 %
	BAT_RET shall inform the percent retention rate of in vehicle battery energy performance representative of EV range for the electrified vehicle, expressed as a percentage from the initial performance.					

Japan will submit the above application soon

2.Validation Test from September 1.Prius PHV, 2.Leaf ,3.Outlander



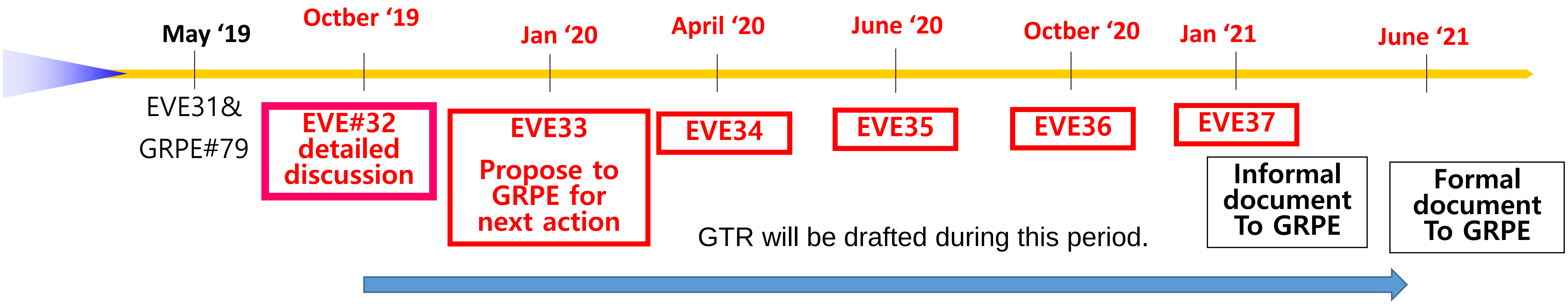
Verify the causes of errors and variations

Proposal

Japan will propose:

1) To develop GTR as a method of providing appropriate information on battery performance to customers.
2) To collect data from market to build the appropriate system for the spread of electrified vehicles.
3) A short-time plan to develop the GTR

Tentative schedule of developing GTR for Providing Information Guideline of in-vehicle battery performance



	2019_4Q	2020_1Q	2020_2Q	2020_3Q	2020_4Q	2021_1Q	2021_2Q
Application to SAE OBD ID	Apply☆	- - - →	- - - →	★Registered			
Validation tests by JARI.Prius_PHV,LEAF - - - →	- - - →	- - - →		by JRC,EPA? - - - →	- - - →		
verification of Error and variation standardization		- - - →	- - - →				
Guidelines ver.FY2019 completed			★				
Incorporation into the GTR		- - - →	- - - →	- - - →	- - - →	- - - →	

It might be possible to complete the GTR draft by January 2021

Appendix

Submitted by the EVE informal working group

Informal document **GRPE-79-28-Rev.1**
79th GRPE, 21-24 May 2019
Agenda item 9

Electric Vehicles and the Environment (EVE IWG)

REPORT TO GRPE 79TH SESSION

Status of In-Vehicle Battery Durability

- European Commission expressed concern that a durability procedure would not be available for this fall
- Japan stated that while they support the development of durability requirements they would like to better understand the goals and work, before agreeing to an appropriate timeline
- EVE IWG proposed a near-term durability solution
  - Adopt predetermined deterioration factors
  - Confirm during in-use conformity tests

Next Steps For Electrified Vehicle Durability

- Request permission from GRPE for the EVE to continue to work on the durability topic
- Include the development of a durability process in the agenda for EVE32, scheduled for this fall
  - Begin development of a durability provision informally
- Japan to provide recommendation for overall timing to be presented to GRPE in January 2020
- Potentially request new mandate to develop an in-vehicle battery durability GTR in January 2020
  - Final timing to be determined and will be discussed and hopefully resolved at EVE32 in October 2019

Proposed New Mandate (Not Finalized)

- Preliminary timeline under discussion for in-vehicle battery durability (not all contracting parties in agreement on timelines)
  - November 2019 – March 2020: Develop preliminary procedure, based on deterioration factor (DF) concept and validated by in-service conformity
  - March 2020 – January 2021: Validation testing of draft procedure and refine procedure as needed
  - January 2021: Preliminary GTR available for GRPE
  - June 2021: Final working document for GRPE
  - November 2021: Approval by AC.3
- Japan has proposed to initially discuss and agree on the purpose of GTR in more detail before deciding on the timeline by January 2020

minutes of GRPE＃７９

Documentation: Informal document GRPE-79-28-Rev.1

57. The Chair of IWG on EVE presented the status report introducing the latest activities of the group (GRPE-79-28-Rev.1). He highlighted latest discussions held during the last meeting of IWG on EVE in conjunction with GRPE provided useful guidance to the group. The representative from EC emphasized the work on battery durability was a critical element for further progress of the activities of IWGs on EVE and WLTP. She stated more in-depth discussions with other CPs will be held in the coming weeks to agree on a timeline and deliverable schedules that would satisfy all parties.

58. The expert from OICA acknowledged the proposed new timeline for the development of the in-vehicle battery durability provisions and was satisfied with the use of deterioration factors to characterize in-vehicle battery durability as a first step**. The Chair insisted initial feedback would be appreciated on the matter during the next GRPE session in January 2020**.

59. GRPE supported **the extension of the mandate of IWG on EVE until June 2021** as reflected in Annex III.
60. GRPE acknowledged the progress made by IWG on EVE and noted the request for a meeting room for half a day during the GRPE week in January 2020.

“Quoted from EVE -31 -10e”

III. Areas of work

b) Battery performance and durability

gtr for in-vehicle battery durability can be started, which:

a. Establishes **minimum durability requirements** and developing guidelines for acceptable evidence that the requirements will be met;

b. Establishes measures to prevent substandard products from entering the market;

c. Allows adequate room for continued development of the regulation as the industry continues to evolve; and

d. Implements a mechanism for the collection of data that could provide a basis for refining the gtr in the future.

V. Timeline

(b) In-vehicle battery performance and durability:

(i) November 2019: Approval from AC.3 to **develop a gtr focused on deterioration factors** on the topic of battery performance and durability;

(ii) November 2019 - March 2020:

a. EVE IWG develops **gtr text based on deterioration factors**, in a manner **similar to current requirements for air pollutant emissions from conventional vehicles**;

“Quoted from GRPE-79-28r1e”

EVE IWG proposed a near-term durability solution

Adopt predetermined deterioration factors

Confirm during **in-use conformity** tests

Battery durability

Accelerated ageing test method

EVE28にてOICAからDFを決定するための加速試験法の課題についてプレゼン済。

Battery performance degradation ”ageing”

- Four principal types of battery performance degradation
  - Capacity fade
    - Loss of cycleable Li
    - Loss of electroactive materials (anode, cathode, electrolyte)
  - Power fade
    - Loss of conductivity
    - Impedance increase – mainly contact resistance and Ohmic resistance in electrolyte
  - Reduced power efficiency
    - Associated with impedance increase – additional impedance components involved, e.g. charge transfer impedance
  - Irreversible swelling (change in physical cell dimensions)
- The ageing types do not have to proceed concurrently at the same rate
- Ageing is chemistry and cell/battery design specific
- Ageing is path dependent
- The relative importance of the different types of battery performance degradations varies between applications and system designs

Operating factors that influence battery ageing

- There are at least 5 operating conditions that have direct impact on battery life and durability
  - Discharge rate as determined by duty cycle as well as periods of activity or inactivity
  - Charge rate as determined by charge type and frequency
  - State of Charge (SOC) window of battery operation
  - Battery temperature during operation and idling
  - Time

Current battery ageing practice

- Typically involves two cell/battery degradation parameters
  - Electrical throughput (charge-discharge cycling)
  - Calendar ageing
- Acceleration of ageing processes achieved by
  - Cycling at higher current loads to shorten time of electrical throughput
  - Increasing the SOC window
  - Elevated temperatures (Arrhenius equation)

OICA

Conclusions (1/2)

- Battery life testing limitations
  - Test cycles are typically highly simplified charge-discharge cycles
  - "Fixed" SOC limits usually based on theoretical SOC window for accelerated tests
  - Test methods do not consider all parameters that contribute towards ageing
  - Inherent risk of activiting unrepresentative ageing mechanisms by acceleration
  - Ageing mechanisms are not simply additive due to complex interactions
- Practically impossible to engineer an accelerated bench test to a global fit
  - A general designed accelerated bench test <u>will not</u> correspond to the life performance of customers in all different electric vehicles
  - The battery usage stategies (represented by accelerated life tests) are designed for each specific project/vehicle and depend on
    - Customer assumptions
    - Expected Vehicle attributes
    - The specific performance characteristics of the battery cell used

OICA

Conclusions (2/2)

- Accelerating cell ageing by increasing typical test parameter values (current settings, temperatures, SOC window, etc), imposes a non-negligible risk of introducing unjustified bias, which can lead to unfair representation of the durability performance of a specific cell model.
- Significant tailoring of test method to a specific battery configuration is required to achieve equivalent ageing for fair durability comparisons between different battery systems
- If a physical regulatory durability test is required, then equivalent ageing across battery system technologies must be the objective of the test procedure, which raises a number of important questions, including but not limited to:
  - What is equivalent ageing?
  - How are different ageing processes taken into account?
  - How can equivalent ageing be realized in a test context?
  - How is equivalent ageing verified?
  - Is the outcome of the test relevant to field application operating and use conditions for a reasonable range of battery system designs?

OICA position summary

- Since the traction battery technology is still in a period of rapid development and change, a regulatory accelerated ageing test is premature
  - High risk of unjustified technology bias and unrepresentative ageing conditions
- Battery ageing and understanding the degradation mechanisms is extremely complex
- Life testing is very time and resource consuming
  - Large test matrixes and long test series (several years) are needed for confident results
- Life estimation models are under development but contain a number of uncertainties
  - Large variation in degradation due to customer usage and different applications make the models complex
  - It takes time to collect field data to verify the models
- New ageing models are needed for post Li ion cell technologies

METI Releases Interim Report by Strategic Commission for the New Era of Automobiles in Aug. 2018

Long-Term Goal and Strategy of Japan's Automotive Industry for Tackling Global Climate Change

Long-Term Goal (By the End of 2050)

<Vehicles produced by Japanese automakers>

80% reduction of GHG emissions per vehicle
(Passenger Vehicles: 90% reduction, 100% xEV)

Japan set out its goal to realize **"Well-to-Wheel Zero Emission"** in collaboration with global efforts to achieve zero emissions from energy supply and with innovation in how vehicles are used.

80% reduction of GHG emission per vehicle※
(Passenger Vehicle※: **90% reduction, 100% xEV**)
※Vehicles produced by Japanese automakers

×

Innovation of How Vehicles are Used
- MaaS
- Connected
- Autonomous Drive and So Forth

×

World's efforts for realizing zero emission of Energy Supply
(Power Source, Hydrogen Source, and Fuel to be All Zero-Emission)

Realize **"Well-to-Wheel Zero Emission"**

enhancing contributions to global environmental issues

3 Principles and Key Actions in next 5 years

Ⅰ. Promote Open Innovation | Ⅱ. Cooperate Internationally to Overcome Global Issues | Ⅲ. Establish System

Establish System

Build up a Battery System

Risk Reduction by Stabilizing Battery Resource Procurement
- FY2018 - Formulating policy on joint procurement and stockpiling of resources such as cobalt

Establish guidelines for evaluating the health of lithium ion batteries used for electric vehicles, creating battery reuse/recycle markets
- FY2018 - Formulating guidelines for evaluating state of health of lithium ion batteries used for electric vehicles
- FY2018 - Building up a joint scheme to collect used batteries toward creation of the reusable battery market
- FY2018 - Setting up an opportunity to discuss the necessary battery specifications aiming at creation of a reusable battery market with the potential user companies (Feasibility study will be implemented in Fiscal Year 2019)

END