Discussion materials for new mandate on in-vehicle battery durability

EVE 33 – Geneva
January 13, 2020
Changes from conference call of 12 Dec

- Terminology
  - “DF” (Deterioration Factor) changed to “PR” (Performance Requirement)
  - “EI” (Exposure Indices) changed to “UI” (Usage Indices)

- Timeline updated to reflect mandate proposal
GTR on battery durability: Status

- General goals of a durability GTR (EVE 31):
  - Establish **minimum durability requirements**
  - Prevent substandard products from entering the market
  - Allow **continued development of the GTR** as the industry evolves
  - Implement a **data collection mechanism** for improving the GTR in the future

- EVE32, Brussels: near-term approach could be some combination of:
  - Predetermined deterioration factors (DFs)
  - Confirmation via in-service conformity (ISC)

- GRPE desires preliminary GTR by January 2021
Observations of Japan – EVE32

- Difficult to determine an appropriate DF
  - There is no durability test method that is representative and market-correlated
  - TEMA model limited by chemistries; results not yet correlated to the market
  - Other sources of degradation data are limited due to lack of information on usage (charging rate, temperature exposure, etc.)
  - Uncertain how DF would affect the driving range shown on certification label

- Need to describe how to perform ISC
  - How to select ISC vehicles (what variations in environment and usage; how many)
  - How to define pass/fail criteria – there are no regulatory values
  - Long-range PEVs impose long test time; are there other ways to evaluate at ISC?

- Accomplishing all this by January 2021 is extremely difficult
Japan proposal – EVE32

- Limit initial scope of GTR to provide information on battery condition
  - Battery State of Health (SOH) envisioned as a measure of either:
    - Remaining electric driving range, compared to original range (CoC)
    - Remaining energy capacity, compared to original capacity (catalogue)
  - SOH readable by customer and from OBD

- Scope of GTR:
  - Define SOH measurement method
  - Establish requirement for SOH on OBD

- Validation testing also would be performed

- Might be possible to have preliminary GTR by January 2021
Timeline proposed by Japan (EVE32)

- **EVE31 & GRPE#79**: May ’19
- **EVE#32 detailed discussion**: October ’19
- **EVE33**: Propose to GRPE for next action
- **EVE34**: April ‘20
- **EVE35**: June ‘20
- **EVE36**: October ‘20
- **EVE37**: Jan ‘21
- **GTR will be drafted during this period.**

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- Informal document To GRPE
- Formal document To GRPE

DRAFT – DO NOT CITE OR QUOTE - DELIBERATIVE
Observations of European Commission – EVE32

- GTR for battery durability is a must
- Japan SOH proposal contains good elements
  - Proposal needs to clearly define how the SOH is measured
  - Means of independent verification needed (not just OBD value)
    - Define verification test using WLTC
    - Define sample sizes, tolerances, etc.
- Alternative approaches:
  - Manufacturer defines and declares a capacity or range DF
  (or)
  - CPs define a maximum range deterioration performance requirement (PR)
  - Verified by ISC (need to define pass/fail criteria, vehicle selection, etc)
European Commission suggestion – EVE32

- Might define DFs or PRs (by OEM or CP) based on current knowledge

  - Information gathering component:
    - Require SOH indicator and SOH reading capability
    - Use TEMA or other models to further inform DF or PR

  - Performance definition component:
    - Use gathered information to further refine DFs or PRs

  - Performance verification component (ISC):
    - WLTC procedure for range determination, or alternative
    - Vehicle selection criteria
    - Statistical method for analysis
Observations of US

- Japan proposal is a good starting point
  - SOH on OBD helps identify “substandard” products
  - SOH data could be collected at ISC to improve GTR over time

- “Preliminary” DF could be established now, using current knowledge
  - Find consensus on clearly substandard performance (e.g. 60% @ 3 yrs, or similar)
  - Acts as baseline for all usage cases, to be made more stringent later
  - CoC should continue to show driving range at beginning-of-life
    - E.g. a 60% PR applied to 200 km range when new should not be 120 km on label

- ISC should take actual usage into account, somehow
  - Very expensive to design battery for the very rarest, extreme use cases
  - If actual usage of ISC vehicle is known, “extreme” use cases could be evaluated differently from “normal” use cases
New concept: Usage Indices (UI) on OBD

- A way to account for actual usage of vehicle at ISC
- ECU monitors actual exposure of vehicle over time
  - Converts it to a UI value (e.g. 0 to 1) that is stored in OBD
  - UI to be collected for each of several parameters that affect battery health:
    - Temperature of battery
    - Charge rates
    - Discharge rates
    - Ampere-hour throughput
    - Elapsed time since manufacture
    - Others?

- Vehicles with extreme UI values at ISC are eliminated, or adjusted
- Manufacturers are almost certainly already recording many of these parameters, to help with warranty claim assessment
### “Durability toolbox”

<table>
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<tr>
<th>Tool</th>
<th>What it does</th>
<th>Tasks</th>
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<tbody>
<tr>
<td><strong>DFs/PRs</strong></td>
<td>Establishes performance requirement</td>
<td>• Define preliminary “substandard” baseline PR</td>
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<td>• Refine using incoming SOH data</td>
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<td>• Refine using TEMA and incoming EI data</td>
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<tr>
<td><strong>SOH on OBD</strong></td>
<td>Represents actual performance</td>
<td>• Define basis for determining SOH</td>
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<td>(Japan proposal)</td>
<td>Provides data (to refine PRs)</td>
<td>• Validate via testing</td>
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<tr>
<td><strong>UIs on OBD</strong></td>
<td>Represent actual usage</td>
<td>• Identify exposures to be indexed (temp, etc)</td>
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<td>(US proposal)</td>
<td>Distinguishes between normal and extreme usage</td>
<td>• Define how to compute UI index value for each</td>
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<td>Provides data to define normal usage</td>
<td>• Define “normal” UI values using incoming data</td>
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<td><strong>TEMA model</strong></td>
<td>Relates usage to SOH (to suggest or refine PRs)</td>
<td>• Use TEMA to correlate usage with SOH</td>
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Possible framework – three phases

- **Phase 1** *(implements data collection mechanism and PR/ISC framework)*
  - Limited scope GTR with consensus PR, OBD requirements, simple ISC
  - Might allow draft GTR by January 2021 target

- **Phase 2** *(tightens PR and considers usage at ISC)*
  - SOH and UI data continues to be collected; “Normal” usage defined
  - PR refined based on TEMA modeling of “normal” usage
  - ISC focuses on vehicles with “normal” UI values from OBD

- **Phase 3** *(allows incoming data to inform PR)*
  - Data-based PR, derived from SOH and UI data from Phases 1 and 2
  - Vehicles with “extreme” UI values either eliminated or adjusted
Phase 1 – OBD and preliminary PR

- Require SOH on OBD (the Japan proposal)
- **New:** Require UIs on OBD
- **New:** Establish preliminary PR
  - Consensus of current knowledge on deterioration and customer expectations
  - It is only a “baseline” to exclude “substandard” performers
- ISC consists of:
  - Collect SOH and UIs from OBD – for data collection purposes
  - Perform range test by WLTC
  - Measured range must satisfy the preliminary PR
- Informal GTR draft might be possible by January 2021
Phase 2 – refine PR, consider UIs at ISC

- Refine PR using modeling
  - Define “normal” usage for each UI factor
  - Use TEMA to refine PR by modeling “normal” usage
  - Determine corresponding “normal” values for each UI by modeling

- ISC consists of:
  - Collect SOH and UIs from OBD
  - Evaluate only vehicles that have “normal” UIs (eliminate outliers)
  - SOH must satisfy Phase 2 PR
  - Subject to independent verification by WLTC

- Update GTR (2022-23?)
Phase 3 – data-based PR (or DF)

- By now, SOH and UI data is coming in from Phase 1 and 2 ISC
- Refine PR using incoming data and modeling \textit{(or adopt DF)}
  - SOH data collected in Phase 1 and 2
  - Additional TEMA modeling of “normal” usage
- Use incoming UI data to refine “normal” values for each UI
- ISC consists of:
  - Collect SOH and Uls from OBD
  - Evaluate only vehicles that had “normal” UIs, or apply adjustment to “extreme”
  - SOH must satisfy Phase 3 PR (or DF)
  - Subject to independent verification by WLTC
- Update GTR (2024-25?)
Proposed mandate tasks

(a) Deliver a limited scope GTR to AC.3 by May 2022 with:
   • (i) electrified vehicle battery performance criteria,
   • (ii) OBD requirements on battery health information and usage data; and
   • (iii) a provisional in-service conformity test.

(b) Refine performance criteria for in-vehicle battery durability through assessment of further modelling with data collected and developing normal usage criteria

(c) Improve GTR and in-service conformity criteria with collected data and updated modelling
### Proposed timeline for mandate

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Subject to 1 additional year for Phase 1 GTR or full mandate
Important note

- All concepts discussed here (Japan, EC, US) address only the impact of energy capacity fade on EV or PHEV electric range
- They may not fully address:
  - Effect of power fade on air pollutants or energy consumption for HEVs, or blended PHEVs
  - Uncertain if capacity fade is an adequate indication of change in energy consumption for BEV

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