Family concept idea for In-Vehicle-Battery Durability
General description of the idea for Part A (ISC-Test)

Part A (ISC-Test):

- Family concept for Part A is a mixture between IP family concept and PEMS family concept
- Worst case: sample need to be tested out of each interpolation family → big testing burden
- Idea: testing burden can be reduced by following the PEMS family concept
  - There are IPF criteria in the sample which need to be covered every single time
  - There are IPF criteria in the sample which need to be covered at least once
- Examples:
  - Transmission type → PEMS concept: at least one vehicle for each transmission type installed in the vehicles of the PEMS family shall be selected
  - Number of powered axles → PEMS concept: at least one four-wheel drive vehicle (4x4 vehicle) shall be selected for testing if such vehicles are part of the PEMS family

→ Proposal: Define criteria which are primarily relevant and which are secondarily relevant

Family concept idea for In-Vehicle-Battery Durability

Part A – OVC-HEVs: proposal for an indicator verification family concept

Sample selection for Part A:

- Samples to be selected need to cover all the parameters below in green:
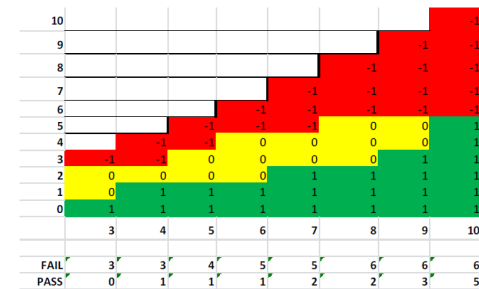
Type of traction REESS (model, capacity, nominal voltage, nominal power, type of coolant (air, liquid)) **and BMS**
Algorithm for SOCC (State of Certified Capacity)
Algorithm for SOCR (State of Certified Range)

- All selected sample nee to cover at least once the following parameters in red:

At least one vehicle of each type and number electric machines
At least one vehicle for each Type of internal combustion engine
At least one vehicle for each transmission type and transmission model
At least one vehicle for each number of powered axles
At least one vehicle for each type of electric energy converter between the electric machine and traction REESS

PART A: Sample Statistics

- 3- 10 vehicles tested for range/capacity
- Tested Range,Capacity/ Original Range,Capacity within x% of SOH

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Part A – PEVs: proposal for an indicator verification family concept

Sample selection for Part A:

- Samples to be selected need to cover all the parameters below in green:

| Type of traction REESS (model, capacity, nominal voltage, nominal power, type of coolant (air, liquid)) **and BMS** |
| Algorithm for SOCC (State of Certified Capacity) |
| Algorithm for SOCR (State of Certified Range) |

- All selected sample need to cover at least once the following parameters in red:

| At least one vehicle for type and number electric machines |
| At least one vehicle for each transmission type and transmission model |
| At least one vehicle for each number of powered axles |
| At least one vehicle for each type of electric energy converter between the electric machine and traction REESS |

PART A: Sample Statistics

- *3- 10 vehicles tested for range/capacity*
- *Tested Range,Capacity/ Original Range,Capacity within x% of SOH*

BACK UP

Input for idea

Copy the PEMS/ISC family approach to build a ISC/IV-family

Apply primary components as hard criteria and require secondary to be at least tested once

Criteria relevant for emission and consumption.	Criteria <u>primarily</u> relevant for emission testing defines the family.	Criteria <u>secondarily</u> relevant have to be tested at least once.

5.6. Interpolation family

5.6.1. *Interpolation family for pure ICE vehicles*

5.6.1.1. [...]

5.6.1.2. Only vehicles that are identical with respect to the following vehicle/ power-train/transmission characteristics may be part of the same interpolation family:

(a) Type of internal combustion engine: fuel type (or types in the case of flex-fuel or bi-fuel vehicles), combustion process, engine displacement, full-load characteristics, engine technology, and charging system, and also other engine subsystems or characteristics that have a non-negligible influence on CO_2 mass emission under WLTP conditions;

(b) Operation strategy of all CO_2 mass emission influencing components within the powertrain;

(c) Transmission type (e.g. manual, automatic, CVT) and transmission model (e.g. torque rating, number of gears, number of clutches, etc.);

(d) n/v ratios (engine rotational speed divided by vehicle speed). This requirement shall be considered fulfilled if, for all transmission ratios concerned, the difference with respect to n/v ratios of the most commonly installed transmission type is within 8 per cent;

(e) Number of powered axles;

(f) ATCT family, per reference fuel in the case of flex fuel vehicles;

(g) Number of wheels per axle.

3.2. Technical criteria

3.2.1. Propulsion type (e.g. ICE, HEV, PHEV)

3.2.2. Type(s) of fuel(s) (e.g. petrol, diesel, LPG, NG, …). Bi- or flex-fuelled vehicles may be grouped with other vehicles, with which they have one of the fuels in common.

3.2.3. Combustion process (e.g. two stroke, four stroke)

3.2.4. Number of cylinders

3.2.5. Configuration of the cylinder block (e.g. in-line, V, radial, horizontally opposed)

3.2.6. Engine volume

[...]

3.2.7. Method of engine fuelling (e.g. indirect or direct or combined injection)

3.2.8. Type of cooling system (e.g. air, water, oil)

3.2.9. Method of aspiration such as naturally aspirated, pressure charged, type of pressure charger (e.g. externally driven, single or multiple turbo, variable geometries …)

3.2.10. Types and sequence of exhaust after-treatment components (e.g. three- way catalyst, oxidation catalyst, lean NOx trap, SCR, lean NOx catalyst, particulate trap).

st gas recirculation (with or without, al, cooled/non- cooled, low/high press

4.2. Selection of vehicles for PEMS testing when validating a PEMS test family

By selecting vehicles from a PEMS test family it should be ensured that the following technical characteristics relevant for pollutant emissions are covered by a PEMS test. [...] For the validation of a PEMS test family vehicles shall be selected for PEMS testing as follows:

4.2.1. For each combination of fuels [...], on which some vehicle of the PEMS test family can operate, at least one vehicle that can operate on this combination of fuels shall be selected for PEMS testing.

4.2.2. The manufacturer shall specify a value PMR H [...] and a value PMR L [...]. [...] At least one vehicle configuration representative for the specified PMR H and one vehicle configuration representative for the specified PMR L of a PEMS test family shall be selected for testing. If the power-to-mass ratio of a vehicle deviates by not more than 5 % from the specified value for PMR H , or PMR L , the vehicle should be considered as representative for this value.

4.2.3. At least one vehicle for each transmission type [...] installed in vehicles of the PEMS test family shall be selected for testing.

4.2.4. At least one four-wheel drive vehicle (4x4 vehicle) shall be s...ed for testing if such vehicles are part of the PEMS test

h engine volume occurring on a vehicle in the at least one representative vehicle shall be tested.

"Transmission" is criteria for the IP-family but not criteria for the PEMS-family...

... but each transmission has to be tested once within the family.

Copy the PEMS/ISC family approach to build a ISC/IV-family

Apply primary components as hard criteria and require secondary to be at least tested once

Criteria relevant for range and consumption.	Criteria **primarily** relevant for indicator verification related to durability	Criteria **secondarily** relevant have to be tested at least once.

5.6.3. Interpolation family for PEVs

Only PEVs that are identical with respect to the following electric powertrain/transmission characteristics may be part of the same interpolation family:

(a) Type and number of electric machines (construction type (asynchronous/ synchronous, etc.), type of coolant (air, liquid) and any other characteristics having a non-negligible influence on electric energy consumption and range under WLTP conditions;

(b) Type of traction REESS (model, capacity, nominal voltage, nominal power, type of coolant (air, liquid));

(c) Transmission type (e.g. manual, automatic, CVT) and transmission model (e.g. torque rating, number of gears, numbers of clutches, etc.);

(d) Number of powered axles;

(e) Type of electric energy converter between the electric machine and traction REESS, between the traction REESS and low voltage power supply and between the recharge-plug-in and traction REESS, and any other characteristics having a non-negligible influence on electric energy consumption and range under WLTP conditions;

(f) Operation strategy of all components influencing the electric energy consumption within the powertrain;

(g) n/v ratios (engine rotational speed divided by vehicle speed). This requirement shall be considered fulfilled if, for all transmission ratios concerned, the difference with respect to the n/v ratios of the most commonly installed transmission type and model is within 8 per cent.

x.y. Technical criteria

x.y.1. Algorithm to determine the indicators

x.y.2. Type of traction REESS (model, ~~capacity~~, nominal voltage, nominal power, type of coolant (air, liquid));

x.y.3. REESS capacity within a range of +/- x % (maybe 20 ... 25 %?)

x.y. Selection of vehicles for ISC testing when validating an indicator family

By selecting vehicles from a IV test family it should be ensured that the following technical characteristics secondarily relevant for indicator verification are covered by a indicator verification test. For the validation of a indicator verification test family vehicles shall be selected as follows:

x.y.1. For each type of electric machine and each number of electric machine [...], at least one vehicle shall be selected for the IV-family.

x.y.2. At least one vehicle for each transmission type [...] installed in vehicles of the IV-test family shall be selected for testing.

x.y.3. At least one four-wheel drive vehicle (4x4 vehicle) shall be selected for testing if such vehicles are part of the IV-test family.

x.y.4 Energy converter nur zwischen Speicher und EM oder gar nicht als Kriterium?!