

WLTP DTP Lab Processes subgroup	
Title	Discussion Paper on the subject of “Families and their possible inclusion in the WLTP gtr”
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Introduction:

The subject of Families has often been mentioned in WLTP discussions. There is a concept that the content of a global technical regulation (gtr) should be strictly restricted to technical issues such as test cycles and procedures and therefore is no place for definitions of families. Family concepts are however a fundamental and indispensable part of the process of vehicle approval/certification. Without a concept of families (or more accurately, several concepts of families) it would be necessary to test every single vehicle to demonstrate its compliance.

The intention of this paper is to explore a compromise for inclusion in the WLTP gtr which utilises the knowledge and experience of the experts involved in WLTP to provide guidance for Contracting Parties when deciding on regional family definitions.

Analysis of current legislative example (ECE Regulation 83.06)

An analysis of R83 revealed that the subject of vehicle families is represented in different ways which can be separated into 3 concepts:

- a. where a concept of approval of a family of vehicle specifications is clearly described in a technical annex and rules are set for inclusion or exclusion of a specific vehicle in a family. In R83 this includes in-service conformity, OBD, gas fuelled vehicles, and periodically regenerating systems (Ki factors).
- b. where terminology related to the concept of vehicle families is formally defined. In R83 this is limited to the approval of gas fuelled vehicles which is covered by group a) above and vehicle types which are covered by group c) below.
- c. where a concept of families is implied either;
 - i. in the rules for amending the approved vehicle type, or
 - ii. in the rules for extension of approval.

the two points under c. are obviously very regionally dependent and point c.ii. perhaps needs more explanation. In ECE R83 there are rules for the original approval and further rules for the extension of approval. It would however be nonsense to obtain an approval on one day and be able to extend it under different rules on the next day, it is therefore common practice to apply the extension rules to the original approval which creates an implicit family concept.

Proposal (for comment and development)

Scope

The subjects where a family concept is required should be identified and an assessment should be made of their significance in terms of the WLTP gtr or gtrs in general. An initial list is;

Subject	Subject for gtr ?	IN WLTP Phase I ?
In-Service conformity testing	?	✗
OBD	✓	✗
Approval of gas fuelled vehicles	✓	✓
Ki factors for periodically regenerating systems	✓	✓
General Emission approval, on the basis of:	?	✓
Vehicle mass		
Transmission ratios		
Vehicle classification / type, variant, version		
Evaporative emissions	✓	✗
Durability of emission control system	✓	✗

Content

There needs to be a decision which elements of a family structure could be integrated into the WLTP Phase I gtr. As the concept of a guideline as mentioned in the introduction to this paper, here is a proposed list of parameters and criteria that could be considered:

Subject	Parameter	Criteria	Comments
Approval of gas fuelled vehicles	approved emission limits	same	
	engine power	+15% / -30% of engine(s) tested	
	catalyst type	type i.e. three way, oxidation, de-NOx.	
	fuel system type:	type: induction, vapour or liquid injection (single point, multipoint)	
	fuel system ECU	type and technical specification, software principles and control strategy	

Subject	Parameter	Criteria	Comments
Ki factors for periodically regenerating systems	Engine:	Combustion process.	
	Periodically regenerating system (i.e. catalyst, particulate trap):	Construction (i.e. type of enclosure, type of precious metal, type of substrate, cell density);	
		Type and working principle;	
		Dosage and additive system;	
		Volume ± 10 per cent;	
		Location (temperature ± 50 °C at 120 km/h or 5 per cent difference of maximum temperature/pressure).	

Subject	Parameter	Criteria	Comments / proposal
General Emission approval	Vehicle mass	next two higher equivalent inertia or any lower equivalent inertia (emissions standards must be upheld if inertia class dependant)	
	Transmission ratios	< 8 %	

Appendix 1: Analysis of family concepts in ECE R83.06

a) Test Families

In ECE R83.06:

In Service Family

The in-service family may be defined by basic design parameters which shall be common to vehicles within the family. Accordingly, vehicle types may be considered as belonging to the same in-service family if they have in common, or within the stated tolerances, the following parameters:

- Combustion process (two stroke, four stroke, rotary);
- Number of cylinders;
- Configuration of the cylinder block (in-line, V, radial, horizontally opposed, other). The inclination or orientation of the cylinders is not a criteria);
- Method of engine fuelling (e.g. indirect or direct injection);
- Type of cooling system (air, water, oil);
- Method of aspiration (naturally aspirated, pressure charged);
- Fuel for which the engine is designed (petrol, diesel, NG/biomethane, LPG, etc.). Bi-fuelled vehicles may be grouped with dedicated fuel vehicles providing one of the fuels is common;
- Type of catalytic converter (three-way catalyst, lean NO_x trap, SCR, lean NO_x catalyst or other(s));
- Type of particulate trap (with or without);
- Exhaust gas recirculation (with or without, cooled or non cooled); and
- Engine cylinder capacity of the largest engine within the family minus 30 per cent.

Annex 11 On-Board diagnostics (OBD) for motor vehicles Appendix 2

"*Vehicle family*" means a manufacturer's grouping of vehicles which, through their design, are expected to have similar exhaust emission and OBD system characteristics. Each vehicle of this family shall have complied with the requirements of this Regulation as defined in Appendix 2 to this annex.

The OBD family may be defined by basic design parameters which shall be common to vehicles within the family. In some cases there may be interaction of parameters. These effects shall also be taken into consideration to ensure that only vehicles with similar exhaust emission characteristics are included within an OBD family.

2. To this end, those vehicle types whose parameters described below are identical are considered to belong to the same engine/emission control/OBD system combination.

- Engine:

- (a) Combustion process (i.e. positive-ignition, compression-ignition, twostroke, four-stroke/rotary);
- (b) Method of engine fuelling (i.e. single or multi-point fuel injection);
- (c) Fuel type (i.e. petrol, diesel, flex fuel petrol/ethanol, flex fuel diesel/biodiesel, NG/biomethane, LPG, bi fuel petrol/NG/biomethane, bifuel petrol/LPG).
- Emission control system:
 - (a) Type of catalytic converter (i.e. oxidation, three-way, heated catalyst, SCR, other);
 - (b) Type of particulate trap;
 - (c) Secondary air injection (i.e. with or without);
 - (d) Exhaust gas recirculation (i.e. with or without);
- OBD parts and functioning.
The methods of OBD functional monitoring malfunction detection and malfunction indication to the vehicle driver.

Annex 12 Granting of an ECE type approval for a vehicle fuelled by LPG or NG/biomethane

A "*family*" means a group of vehicle types fuelled by LPG, NG/biomethane identified by a parent vehicle.

A "*parent vehicle*" means a vehicle that is selected to act as the vehicle on which the self-adaptability of a fuelling system is going to be demonstrated, and to which the members of a family refer. It is possible to have more than one parent vehicle in a family.

2.2. Member of the family

2.2.1. A "*member of the family*" is a vehicle that shares the following essential characteristics with its parent(s):

- (a) It is produced by the same manufacturer;
- (b) It is subject to the same emission limits;
- (c) If the gas fuelling system has a central metering for the whole engine:
It has a certified power output between 0.7 and 1.15 times that of the parent vehicle.
If the gas fuelling system has an individual metering per cylinder:
It has a certified power output per cylinder between 0.7 and 1.15 times that of the parent vehicle.
- (d) If fitted with a catalyst, it has the same type of catalyst i.e. three way, oxidation, de-NO_x.
- (e) It has a gas fuelling system (including the pressure regulator) from the same system manufacturer and of the same type: induction, vapour injection (single point, multipoint), liquid injection (single point, multipoint).

- (f) This gas fuelling system is controlled by an ECU of the same type and technical specification, containing the same software principles and control strategy. The vehicle may have a second ECU compared to the parent vehicle, provided that the ECU is only used to control the injectors, additional shut-off valves and the data acquisition from additional sensors.

2.2.2. With regard to requirement (c): in the case where a demonstration shows two gas-fuelled vehicles could be members of the same family with the exception of their certified power output, respectively P1 and P2 ($P1 < P2$), and both are tested as if were parent vehicles the family relation will be considered valid for any vehicle with a certified power output between $0.7 P1$ and $1.15 P2$.

Annex 13 Emissions test procedure for a vehicle equipped with a periodically regenerating system

The procedure applies to vehicles equipped with a periodically regenerating system as defined in paragraph 2.20. of this Regulation. For the purpose of this annex vehicle family groups may be established. Accordingly, those vehicle types with regenerative systems, whose parameters described below are identical, or within the stated tolerances, shall be considered to belong to the same family with respect to measurements specific to the defined periodically regenerating systems.

2.1.1. Identical parameters are:

- Engine:
 - (a) Combustion process.

- Periodically regenerating system (i.e. catalyst, particulate trap):
 - (a) Construction (i.e. type of enclosure, type of precious metal, type of substrate, cell density);
 - (b) Type and working principle;
 - (c) Dosage and additive system;
 - (d) Volume ± 10 per cent;
 - (e) Location (temperature ± 50 °C at 120 km/h or 5 per cent difference of maximum temperature/pressure).

b) Definitions

2.1. "*Vehicle type*" means a group of vehicles that do not differ in the following respects:

2.1.1. The equivalent inertia determined in relation to the reference mass as prescribed in Annex 4a, Table 3; and

2.1.2. The engine and vehicle characteristics as defined in Annex 1;

2.17. "*Family of vehicles*" means a group of vehicle types identified by a parent vehicle for the purpose of Annex 12;

c)i) Modifications of the vehicle type

- 6.1. Every modification of the vehicle type shall be notified to the Technical Service that approved the vehicle type. The department may then either:
 - 6.1.1. Consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still complies with the requirement; or
 - 6.1.2. Require a further test report from the Technical Service responsible for conducting the tests.
- 6.2. Confirmation or refusal of approval, specifying the alterations, shall be communicated by the procedure specified in paragraph 4.3. above to the Parties to the Agreement which apply this Regulation.
- 6.3. The type Approval Authority issuing the extension of approval shall assign a series number to the extension and inform thereof the other Contracting Parties applying this Regulation by means of a communication form conforming to the model in Annex 2 to this Regulation.

c)ii) Extensions to type approvals

- 7.1. Extensions for tailpipe emissions (Type I, Type II and Type VI tests)
 - 7.1.1. Vehicles with different reference masses
 - 7.1.1.1. The type approval shall be extended only to vehicles with a reference mass requiring the use of the next two higher equivalent inertia or any lower equivalent inertia.
 - 7.1.1.2. For category N vehicles, the approval shall be extended only to vehicles with a lower reference mass, if the emissions of the vehicle already approved are within the limits prescribed for the vehicle for which extension of the approval is requested.
 - 7.1.2. Vehicles with different overall transmission ratios
 - 7.1.2.1. The type approval shall be extended to vehicles with different transmission ratios only under certain conditions.
 - 7.1.2.2. To determine whether type approval can be extended, for each of the transmission ratios used in the Type I and Type VI tests, the proportion,
$$E = |(V2 - V1)|/V1$$
shall be determined where, at an engine speed of 1,000 min⁻¹, V1 is the speed of the type of vehicle approved and V2 is the speed of the vehicle type for which extension of the approval is requested.

- 7.1.2.3. If, for each transmission ratio, $E \leq 8$ per cent, the extension shall be granted without repeating the Type I and Type VI tests.
- 7.1.2.4. If, for at least one transmission ratio, $E > 8$ per cent, and if, for each gear ratio, $E \leq 13$ per cent, the Type I and Type VI tests shall be repeated. The tests may be performed in a laboratory chosen by the manufacturer subject to the approval of the Technical Service. The report of the tests shall be sent to the Technical Service responsible for the type approval tests.
- 7.1.3. Vehicles with different reference masses and transmission ratios
The type approval shall be extended to vehicles with different reference masses and transmission ratios, provided that all the conditions prescribed in paragraphs 7.1.1. and 7.1.2. are fulfilled.
- 7.1.4. Vehicles with periodically regenerating systems
The type approval of a vehicle type equipped with a periodically regenerating system shall be extended to other vehicles with periodically regenerating systems, whose parameters described below are identical, or within the stated tolerances. The extension shall only relate to measurements specific to the defined periodically regenerating system.
- 7.1.4.1. Identical parameters for extending approval are:
- (a) Engine;
 - (b) Combustion process;
 - (c) Periodically regenerating system (i.e. catalyst, particulate trap);
 - (d) Construction (i.e. type of enclosure, type of precious metal, type of substrate, cell density);
 - (e) Type and working principle;
 - (f) Dosage and additive system;
 - (g) Volume ± 10 per cent;
 - (h) Location (temperature ± 50 °C at 120 km/h or 5 per cent difference of max. temperature/pressure).
- 7.1.4.2. Use of Ki factors for vehicles with different reference masses
The Ki factors developed by the procedures in paragraph 3. of Annex 13 of this Regulation for type approval of a vehicle type with a periodically regenerating system, may be used by other vehicles which meet the criteria referred to in paragraph 7.1.4.1. and have a reference mass within the next two higher equivalent inertia classes or any lower equivalent inertia.
- 7.1.5. Application of extensions to other vehicles
When an extension has been granted in accordance with paragraphs 7.1.1. to 7.1.4., such a type approval shall not be further extended to other vehicles.
- 7.2. Extensions for evaporative emissions (Type IV test)
- 7.2.1. The type approval shall be extended to vehicles equipped with a control system for evaporative emissions which meet the following conditions:
- 7.2.1.1. The basic principle of fuel/air metering (e.g. single point injection,) is the same.

- 7.2.1.2. The shape of the fuel tank and the material of the fuel tank and liquid fuel hoses is identical.
- 7.2.1.3. The worst-case vehicle with regard to the cross-paragraph and approximate hose length shall be tested. Whether non-identical vapour/liquid separators are acceptable is decided by the Technical Service responsible for the type approval tests.
- 7.2.1.4. The fuel tank volume is within a range of ± 10 per cent.
- 7.2.1.5. The setting of the fuel tank relief valve is identical.
- 7.2.1.6. The method of storage of the fuel vapour is identical, i.e. trap form and volume, storage medium, air cleaner (if used for evaporative emission control), etc.
- 7.2.1.7. The method of purging the stored vapour is identical (e.g. air flow, start point or purge volume over the preconditioning cycle).
- 7.2.1.8. The method of sealing and venting the fuel metering system is identical.
- 7.2.2. The type approval shall be extended to vehicles with:
 - 7.2.2.1. Different engine sizes;
 - 7.2.2.2. Different engine powers;
 - 7.2.2.3. Automatic and manual gearboxes;
 - 7.2.2.4. Two and four wheel transmissions;
 - 7.2.2.5. Different body styles; and
 - 7.2.2.6. Different wheel and tyre sizes.
- 7.3. Extensions for durability of pollution control devices (Type V test)
 - 7.3.1. The type approval shall be extended to different vehicle types, provided that the vehicle, engine or pollution control system parameters specified below are identical or remain within the prescribed tolerances:
 - 7.3.1.1. Vehicle:
 - Inertia category: the two inertia categories immediately above and any inertia category below.
 - Total road load at 80 km/h: +5 per cent above and any value below.
 - 7.3.1.2. Engine
 - (a) Engine cylinder capacity (± 15 per cent);
 - (b) Number and control of valves;
 - (c) Fuel system;
 - (d) Type of cooling system;
 - (e) Combustion process.
 - 7.3.1.3. Pollution control system parameters:
 - (a) Catalytic converters and particulate filters:
 - (i) Number of catalytic converters, filters and elements;
 - (ii) Size of catalytic converters and filters (volume of monolith ± 10 per cent);
 - (iii) Type of catalytic activity (oxidizing, three-way, lean NO_x trap, SCR, lean NO_x catalyst or other);
 - (iv) Precious metal load (identical or higher);
 - (v) Precious metal type and ratio (± 15 per cent);
 - (vi) Substrate (structure and material);

- (vii) Cell density;
- (viii) Temperature variation of no more than 50 K at the inlet of the catalytic converter or filter. This temperature variation shall be checked under stabilized conditions at a speed of 120 km/h and the load setting of the Type I test.

(b) Air injection:

- (i) With or without;
- (ii) Type (pulsair, air pumps, other(s)).

(c) EGR:

- (i) With or without;
- (ii) Type (cooled or non cooled, active or passive control, high pressure or low pressure).

7.3.1.4. The durability test may be carried out using a vehicle, which has a different body style, gear box (automatic or manual) and size of the wheels or tyres, from those of the vehicle type for which the type approval is sought.

7.4. Extensions for on-board diagnostics

7.4.1. The type approval shall be extended to different vehicles with identical engine and emission control systems as defined in Annex 11, Appendix 2.

The type approval shall be extended regardless of the following vehicle characteristics:

- (a) Engine accessories;
- (b) Tyres;
- (c) Equivalent inertia;
- (d) Cooling system;
- (e) Overall gear ratio;
- (f) Transmission type; and
- (g) Type of bodywork.