Computational Fluid Dynamics Workshop CFD sub-WG
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European Commission
DG GROW C.4 – Automotive and Mobility Industries
Bart Thedinga

CFD reference in EU emissions type approval legislation of LDV

Commission Regulation (EU) 2017/1151-2018/1832

- Annex XXI TYPE 1 EMISSIONS TEST PROCEDURES

- Sub Annex 7 Calculations (Combustion engines)

- 3. Mass emissions

- 3.2. Mass emissions calculation

  - 3.2.3. Fuel consumption and CO_2 calculations for individual vehicles in an interpolation family

  - 3.2.3.2. Fuel consumption and CO_2 emissions using the interpolation method

  - 3.2.3.2.2. Road load calculation for an individual vehicle

  - 3.2.3.2.2.3. <u>Aerodynamic drag of an individual vehicle</u>

Aerodynamic drag of an individual vehicle

3.2.3.2.2.3.1. Determination of aerodynamic influence of optional equipment

The aerodynamic drag shall be measured for each of the aerodynamic drag-influencing items of optional equipment and body shapes <u>in a wind tunnel</u> fulfilling the requirements of paragraph 3.2. of Sub-Annex 4 verified by the approval authority.

3.2.3.2.2.3.2. Alternative method for determination of aerodynamic influence of optional equipment

Determination of aerodynamic influence of optional equipment

At the request of the manufacturer and with approval of the approval authority, an alternative method may be used to determine $\Delta(C_D \times A_f)$ if the following criteria are fulfilled:

(a) The alternative method shall fulfil an accuracy for $\Delta(C_D \times A_f)$ of $\pm$ 0,015 m^2 and, additionally, in the case that simulation is used, *the **Computational Fluid Dynamics** method should be validated in detail such that the actual air flow patterns around the body, including magnitudes of flow velocities, forces, or pressures, are shown to match the validation test results;*

Determination of aerodynamic influence of optional equipment

(b) The alternative method shall be used only for those aerodynamic-influencing parts (e.g. wheels, body shapes, cooling system) <u>for which equivalency was demonstrated;</u>

(c) Evidence of equivalency shall be <u>shown in advance to the approval authority for each road load family</u> in the case that a mathematical method is used, or <u>every four years</u> in the case that a measurement method is used, and in any case shall be based on wind tunnel measurements fulfilling the criteria of this Annex;

Determination of aerodynamic influence of optional equipment

(d) If the $\Delta(C_D \times A_f)$ of a particular item of optional equipment is <u>more than double</u> the value of the optional equipment for which the evidence was given, aerodynamic drag shall not be determined by the alternative method; and

(e) In the case that a simulation model is changed, a revalidation shall be necessary.

General conditions required from virtual testing methods within TA

European Type Approval Framework Directive 2007/46/EC Annex XVI, Appendix 1

1. **Virtual test pattern**

The following scheme shall be used as basis structure for describing and conducting virtual testing:

- (a) purpose;
- (b) structure model;
- (c) boundary conditions;
- (d) load assumptions;
- (e) calculation;
- (f) assessment;
- (g) documentation.

General conditions required from virtual testing methods

2. Fundamentals of computer simulation and calculation

2.1. *Mathematical model*

The mathematical model shall be supplied by the manufacturer. It shall reflect the complexity of the structure of the vehicle, system and components to be tested in relation to the requirements of the regulatory act and its boundary conditions.

The same provisions shall apply *mutatis mutandis* for testing components or technical units independently from the vehicle.

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General conditions required from virtual testing methods

2.2. *Validation process of the mathematical model*

The mathematical model shall be validated in comparison with the actual test conditions.

To that effect a physical test shall be conducted for the purposes of comparing the results obtained when using the mathematical model with the results of a physical test. Comparability of the test results shall be proven. A validation report shall be drafted by the manufacturer or by the technical service and submitted to the approval authority.

General conditions required from virtual testing methods

Any change made to the mathematical model or to the software likely to invalidate the validation report shall be brought to the attention of the approval authority which may require that a new validation process is conducted.

2.3. Documentation

The data and auxiliary tools used for the simulation and calculation shall be made available by the manufacturer and be documented in a suitable way.

General conditions required from virtual testing methods

3. **Tools and support**

At the request of the technical service, the manufacturer shall supply or provide access to the necessary tools including appropriate software.

In addition he shall provide appropriate support to the technical service.

Providing access and support to a technical service does not remove any obligation of the technical service regarding the skills of its personnel, the payment of license rights and respect of confidentiality.

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Validation process