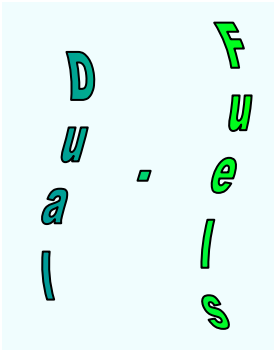
HDDF07 – Draft HDDF report to GFV

as amended further in the GFV meeting

Brussels 10 May 2011

110510 GFV – suggested HDDF terminology



- Terminology: "HDDF i X"
- Digit i: category of HDDF, depending on the gas ratio
  - 1 for GR > 90%
  - 2 for 10% < GR < 90%
  - 3 for GR < 10%
- Character X: possible operating modes in the category
  - A for engines only operating in Dual Fuel mode
  - B for engines capable of operating either in Dual Fuel or in Diesel mode

- Note:
  - old Type 1 becomes HDDF Type 1A;
  - old Type 1+ becomes HDDF Type 1B
  - old Type 2 becomes HDDF Type 2A;
  - old Type 2+ becomes HDDF Type 2B
  - old Type 3 becomes HDDF Type 3 (whatever the possible operating modes)

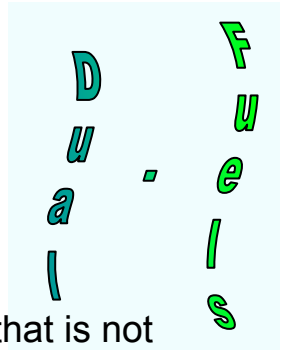
110510 GFV – proposed definitions (1)

- "Dual-Fuel engine"
  means an engine that uses simultaneously 2 different types of fuels supplied from separate storage systems and where the consumed amount of one of the fuels versus the other one may vary depending on the operation.
- "Dual-Fuel vehicle"
  means a vehicle that is powered by a Dual-Fuel engine and that supplies the fuels used by the engine from separate on-board storage systems.

- "Dual fuel mode"
  means the operating mode of a dual-fuel engine where the engine uses simultaneously 2 different types of fuels
- "Diesel mode"
  means, when applicable, the operating mode of a dual-fuel engine where the engine uses exclusively Diesel fuel
- "Service mode"
  means a Diesel mode of a dual-fuel engine activated for the purpose of moving the vehicle off the traffic when the Dual-fuel mode is not possible (for example in case of an empty gas tank).

- "Gas Ratio"
  means the ratio of the energy content of the gas fuel over the energy content of the total fuel (Diesel + gas).

110510 GFV – proposed definitions (2)



- "Heavy-Duty Dual-Fuel (HDDF) Type 1A engine or vehicle"
  means a Diesel-gas Dual-fuel engine or vehicle operating with an average Gas Ratio that is not lower than 90% (GR ≥ 90%)[1].
- "Heavy-Duty Dual-Fuel (HDDF) Type 1B engine or vehicle"
  means a Diesel-gas Dual-fuel engine or vehicle operating with an average Gas Ratio that is not lower than 90% (GR ≥ 90%)[1] where the engine also has been type approved to operate as a Diesel fuel engine according to this Regulation.

- "Heavy-Duty Dual-Fuel (HDDF) Type 2A engine or vehicle"
  means a Diesel-gas Dual-fuel engine or vehicle that typically is operating with a Gas ratio varying between 10% and 90% (90% > Gas Ratio > 10%).
- "Heavy-Duty Dual-Fuel (HDDF) Type 2B engine or vehicle"
  means a Diesel-gas Dual-fuel engine or vehicle that typically is operating with a Gas ratio varying between 10% and 90% (90% > Gas Ratio > 10%) where the engine also has been type approved to operate as a Diesel fuel engine according to this Regulation.

- "Heavy-Duty Dual-Fuel (HDDF) Type 3 engine or vehicle"
  means a Diesel-gas Dual-fuel engine or vehicle operating with an average Gas Ratio that does not exceed 10% (GR ≤ 10%).

[1] An engine that can operate or idle solely on diesel fuel does not meet this definition. It would then be an HDDF Type 2A or HDDF Type 2B as appropriate

110510 GFV – HDDF type

- HDDF Type 1A and cold start
  - As an exception it shall be allowed that HDDF Type 1A may start and warm-up on idle on 100% diesel until the engine coolant reaches a certain temperature.
  - The exception shall not apply to HDDF Type 1B (because they are able to warm-up on the Diesel mode).

- Verification of the HDDF type
  - The verification shall be part of the demonstration at type-approval
  - Demonstration test: hot part of WHTC (EURO VI) or ETC (EURO V)
  - In absence of demonstration (e.g. due to measurement difficulties of LPG-LNG consumption, lack of accuracy of the LPG-LNG consumption, etc…): HDDF type 2A or HDDF type 2B

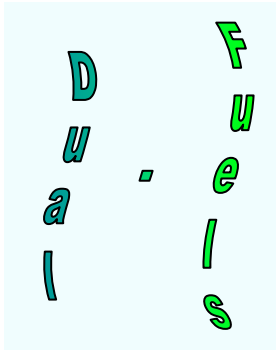
- Additional demonstration test in case of HDDF Type 1A engines: demonstration of dual fuel operation at idle. Test to be agreed w/ the Approval authority and described in the report.

110510 GFV – Torque and Power

- Dedicated HDDF phone conference on 04 April 2011
  - Draft amendments to R85 (informal GRPE document) will be prepared by HDDF, subject to final approval by GFV on 110607
  - GFV is requested to validate the principles of these amendments (see separate document)

- HDDF06 agreed on principles regarding the torque/ power retrievable in the ECU
  - GFV is requested to validate these principles

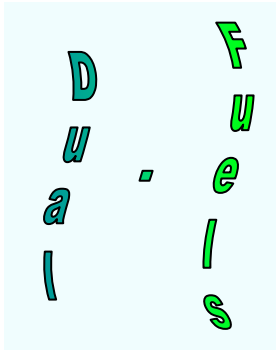
110510 GFV – Amendments to R85 Principles



- The declared power and torque are those obtained in the Dual Fuel mode (HDDF Type 1B; HDDF Type 2B; HDDF Type 3)

- Same reference fuels as the ones for the emission test

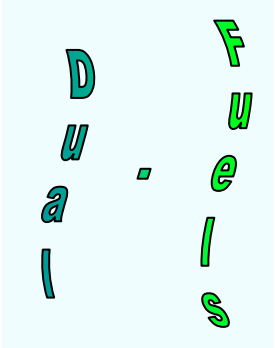
110510 GFV – EURO VI
streamed / broadcasted power / torque data



- When the engine operates in the DF mode,
  - the reference torque curve retrievable with the EURO VI Communication Standards shall be the one obtained when the engine operates in the DF mode
  - the recorded actual torques (indicated torque and friction torque) shall be the result of the DF combustion and not the result from solely the Diesel combustion

- when the engine operates in the Diesel mode,
  - the reference torque curve retrievable with the EURO VI Communication Standards shall be the one obtained when the engine operates in the Diesel mode

110510 GFV – EURO VI
NOx control measures



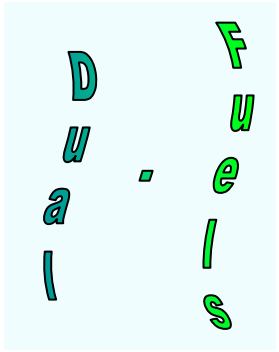
- EURO VI NOx control measures shall apply "mutatis mutandis" to HDDF engines
  - the torque considered to apply the low level inducement in case of HDDF Type 1B and HDDF Type 2B shall be the lowest of the torques obtained in the Diesel mode and on the DF mode.
  - It shall be allowed in case of a "NOx control issue" in the DF mode to switch to the pure Diesel mode (for HDDF Type 1B and HDDF Type 2B)

110510 GFV – HDDF indicators

- HDDF mode indicator
  - Would indicate DF, service or Diesel mode (in case of HDDF Type 1B and HDDF Type 2B)
  - HDDF mode indicator is set on service mode as soon as the service mode is activated (i.e. before it becomes actually active)
  - HDDF mode indicator is mandatory, but the type of indicator is left to the manufacturer (icon, message, etc…). Indication between DF, Diesel, and Service mode shall be clearly differentiated.
  - Continuous indication when operating in DF or Diesel mode is not required. If not continuous, in case of HDDF Type 1B and HDDF Type 2B :
    - Indication required at each change of mode [during at least 1min]
    - Indication required at key-on [during at least 1min]
    - [Indication upon driver's request]
  - Mandatory continuous indication when operating in the service mode or (in case of HDDF Type1A) on Diesel for warming-up. Indication in case of warm-up to be reviewed by HDDF08 (could also concern Type 2A)

- Empty gas tank warning
  - Empty gas tank warning indicator is mandatory, but the type of indicator is left to the manufacturer (icon, message, etc…)
  - Shall be activated as long as the amount of gas is below a certain level (value left to the manufacturer)

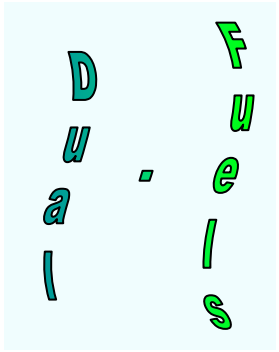
110510 GFV – EURO VI
Lack of gas availability



- Level of the operability restriction
  - Same level as the "severe inducement" of Annex XIII (i.e. 20km/h)

- Activation scheme
  - Operability restriction activated as soon as a lack of gas supply is detected
    - Possibility for HDDF Type 1B and HDDF Type 2B to switch to the Diesel mode
  - Active either 30 minutes after activation or after the next time the vehicle is stationary, whatever the earliest in case of a malfunction of the gas supply system – resetting mechanism to be introduced
  - Active immediately in case of an empty tank (the driver has been warned)

110510 GFV – EURO VI HDDF OBD

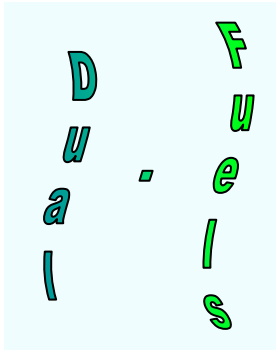


- Full EURO VI compression ignition engines OBD
- Gas supply system subject to component monitoring
- Gas consumption monitoring – subject to confirmation by HDDF08

Note:

There is an issue with the scope of R49 and that of EURO VI ("Gas engines" vs "positive ignition engines"). This should be resolved when discussing the transposition of EURO VI into R49 (rev6)

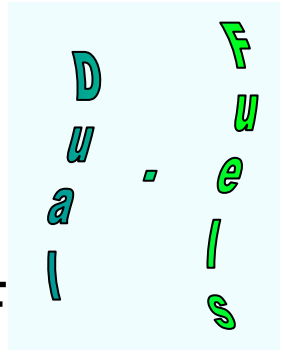
110510 GFV – EURO V HDDF OBD



- HDDF proposal
  - EURO V Diesel OBD rules shall apply
  - Electrical failures of the DF system as well as major functional failures of the specific catalysts of the DF system (in the sense of stage 1 OBD) shall be monitored when the engine is on DF mode.
  - The EURO IV / V derogation clause shall apply when operated in a DF mode.
  - It will be allowed in case of a failure in the DF mode to switch to the pure Diesel mode (for HDDF Type 1B and HDDF Type 2B engines)
  - The torque signal(s) may correspond to the torque(s) resulting from the DF combustion and/or from the Diesel combustion when the engine is operated on the DF mode.

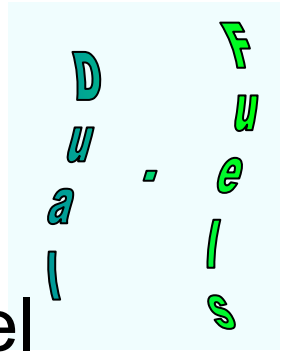
- Rationale
  - Most of the EURO V HDDF are resulting from a modification of a Diesel engine without re-design or re-calibration of the original engine ECU (incl. the OBD system.)

110510 GFV – EURO VI - PEMS test at certification



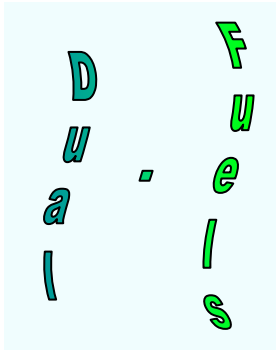
- Proposed test in case of a HDDF Type 1A or HDDF Type 2A
  - Perform a PEMS test at certification according to Annex VI, but on the dual fuel mode
  - the resulting NOx level shall be lower or equal to (1.5 * NOx emission limit)
  - Concerning other pollutants: to be further discussed in HDDF08
- Proposed test process in case of a HDDF Type 1B or HDDF Type 2B
  - Perform a PEMS test on the Diesel mode according to Annex VI and conclude
  - Perform a PEMS test on the DF mode and conclude as for HDDF Type 1A and HDDF Type 2A engines
  - Conclude to pass if both the PEMS test on DF mode and the PEMS test on Diesel modes have concluded to pass
- It will be allowed to repeat the PEMS tests and to average the final emission value per pollutant resulting from each of the individual PEMS tests.

110510 GFV – EURO V and VI – ISC



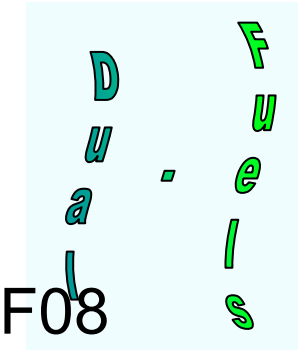
- ISC tests shall be performed in the Dual Fuel mode
- In case of HDDF Type 1B or HDDF Type 2B the tests will be also performed in the pure Diesel mode on the same engine. Pass would mean pass both in Diesel mode and in DF mode
- ISC tests shall be performed as appropriate as specified for Diesel mono-fuel engines in EURO VI Comitology (Annexes II and XVI) or EURO V Directives

110510 GFV – CH4 correlation factor



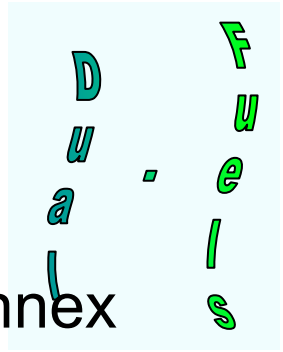
- GFV group could come with a recommendation
  - Jeff S. to circulate a HDDF document within GFV on the basis of the Westport presentation
  - JFR to request ACEA / OICA input (as much as available) on mono fuel gas engines
  - CAP to check the correlation for type 2 engines
  - The issue will be presented in the next GFV meeting
- The Commission will check the way to address the issue (if feasible)
- The issue shall be addressed at one of the next GFV meetings

110510 GFV – EURO V specific issues



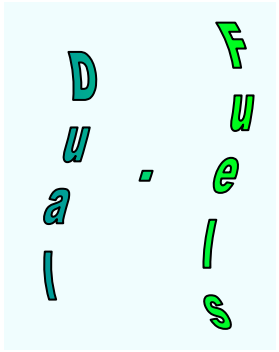
- PEMS test at certification to be addressed by HDDF08
- EURO V HDDF Type 2A present substantial difficulties:
  - What should be the inducement
  - What should be the operability restriction
  - What should be the OBD requirements
- EURO V HDDF Type 2A engines will not be included and can not be EU Type-approved
  - May be addressed at a later stage upon request of a Contracting Party

110510 GFV – Calculation formulae



- Calculation formulae may have to be changed in Annex 4B and possibly the GTR. Otherwise
  - changes would have to be included in the EURO VI R49 HDDF Annex (either in the core of the Annex or as an appendix) and the EURO V R49 HDDF Annex would have to refer to it, or
  - a new Annex 4D or an appendix to 4B may be developed for the formulae dedicated to gas engines
- HDDF considers that some correction may also be useful for mono-fuel gas engines.
- HDDF agreed to have an HDDF meeting that will be dedicated to calculation after eventual GRPE guidance
  - PA and JFR to inform by end of April the appropriate experts and OICA on calculation through an intermediate status document (cf John's one).
  - Input / Advice / expertise requested for the dedicated meeting

110510 GFV – EURO VI - LNG tanks



- GRSG chairman has not yet provided any comment.
  - The issue will be directly presented to GRSG by AR
  - HDDF recommends there should be a call for experts in view of amending R110 within the given time-frame (acceptance by WP29 in Nov 2012)

- The "LNG tank" dedicated meeting scheduled on 04 April has been postponed to 16 May
  - ISO has been invited to give input
  - R110 should not be blocked because of ISO concerns