



# DECISION OF THE ENDURANCE COMMITTEE



To:  Team  Manufacturers

Decision N°: 31

Date: 24.12./2013

Re:

## Mission concerned

Article:...Appendix B.....

- 2014 FIA World Endurance Championship Sporting Regulations
- 2014 Technical Regulations for Prototypes - LMP1
- 2014 Technical Regulations for Prototypes – LMP2
- 2014 Technical Regulations for Le Mans Grand Touring Cars - LM GTE Pro & LM GTE Am
- Internal Regulations of the FIA Endurance Commission

## Decision

### INTRODUCTION

This document clarifies how the FIA and ACO will apply the Technical Regulation to rule the LMP1 category.

- The 2014 LMP1 regulations allow a large diversity of technologies: It has been agreed by manufacturers that a process of Equivalence of Technology (EOT) as proposed by FIA/ACO is necessary to manage this situation.
- The EOT is defined as an equivalence of BSFC: no ICE technology (diesel or gasoline) should get an advantage from the regulations. More particularly the following factors used in Appendix B of the technical regulations are under the scope of EOT:
  - Fuel Technology Factor (FTF)
  - K Technology Factor (KTF)
  - ERS Incentive
- EOT is an equivalence based on « best in class » ICE (see definitions in the document below)
- After le Mans 2014, the EOT will be reviewed through a regular process (once a year) from after Le Mans year n to after Le Mans year n+1
  - FIA will fix the parameters of EOT from Le Mans data and manufacturers data
  - The new EOT will be published end July of year n, valid one year
  - On the long run, this guarantees a fair competition between various fuel technologies even if one technology has a quicker rate of progress than another
  - It gives an incentive to technology progress: a competitor can get the fruit of a yearly development, because the EOT is reviewed after Le Mans
- For the first year of application of new LMP1 regulations (i.e. two first races of 2014 + Le Mans 2014 included) the EOT will be defined as follows:

- Based on data delivered to FIA by manufacturers
  - First set of data sent by manufacturers to FIA in December 2013
  - Review of Appendix B on this basis in January 2014
  - Final set of data sent by manufacturers to FIA in February 2014
  - Final Review of Appendix B on this basis in March 2014
  - The values of BSFC (and weights necessary for KTF and ERS incentive eventual adjustments) would be confidential but disclosed to the other manufacturers
  - Dissuasive penalty to be applied at Le Mans in case one of the manufacturers has declared data too far from reality
  - Cross-checking of the FIA's data against that of the manufacturers will be carried out during the first two events and official testing sessions before the Le Mans 2014
  - If the results are considered to be correct, they will be maintained until Le Mans
  - In case of abnormal results from data measurement or expertise of FIA, an emergency meeting can be held with the manufacturers concerned
- EOT will be a transparent process:
    - Models used described with disclosed formulas
    - Accelerations sectors information made officially available for competitors

## A. Parameters List

A list of engine, ERS and chassis parameters are asked to Manufacturers in order to:

- Compute FTF and KTF
- Rescale torque meter
- Post process race data



2013-10-04 LMP1  
2014 Parameters List

## B. Sensor List

A list of sensors must be installed on the LMP1s so that FIA can check they comply with the regulation.



List\_sensors+CAN\_  
WEC\_P1\_2014\_V5

## C. Fuel Flow Meter Management Process

The fuel flow will be measured by Fuel Flow Sensors.



WEC\_Fuel\_Flow\_Met  
ering\_FIA V02

## D. Torque Meter Management Process

The torque metering is compulsory for manufacturer's cars and must be able to be fitted on any other car. The document below explains how FIA will manage the torque meter installation, measurement and calibration.



FIA Torque Meter  
Control Process V03

## E. Fuel Technology Factor (FTF)

### 1. Definition

FTF balances gasoline and fuel engine efficiencies. FTF is computed in 2 different ways whether it is used for allocated energy computation (FTF average) or maximum flow computation (FTF max):

$$FTF_{average} = \frac{BSFC_{Gasoline\ Average}}{BSFC_{Diesel\ Average}} * \frac{ED_{Gasoline}}{ED_{Diesel}}$$

$$FTF_{max} = \frac{BSFC_{Gasoline\ @Pmax}}{BSFC_{Diesel\ @Pmax}} * \frac{ED_{Gasoline}}{ED_{Diesel}}$$

With :

- *BSFC Average* is the “Best-in-Class” Average Brake Specific Fuel Consumption on one single lap [g/kWh]. “Best-in-Class” Average BSFC is the best average BSFC on one lap whatever the appendix B column considered.
- *BSFC@Pmax* is the Brake Specific Fuel Consumption at maximum power [g/kwh]
- *ED* is the Energy Density [MJ/kg]

*BSFC Average* is computed this way:

$$BSFC_{Average} = \frac{\int_0^{LT} C(t)dt}{\int_0^{LT} P_{Corr}(t)dt}$$

- *P Corr(t)* is the corrected power [kW]
- *C(t)* is the instantaneous Fuel Consumption given by the fuel flow meter [g/s]
- Both integrals will be computed when *P Corr(t)* is positive and outside braking zones
- *LT* is lap time [s]

### 2. Measurement

To check and compare average Power and average Consumption during events, FIA uses:

- Fuel flow meter delivering the “C(t)” signal (instantaneous fuel flow)
- Torque meter delivering the T(t) signal (instantaneous ICE torque)
- Engine rotational speed w(t)
- Corrected torque  $T_{corr}(t)$  : Torque meter signal corrected by the effect of EGRS (see paragraph c.)

Instantaneous corrected Power is computed this way:

$$P_{corr}(t) = T_{corr}(t) * \omega(t)$$

### 3. Effect of Exhaust Gas Recovery System:

Measurement of average true BSFC can be altered by Exhaust Gas Recovery Systems which increase counter pressure at exhaust and thus decrease the efficiency of the engine. This phenomenon is taken into account by FIA by computing an instantaneous corrected torque (see paragraph b.)

$$T_{corr}(t) = T(t) + T_{loss}(t)$$

With :

- $T_{corr}(t)$  = Corrected instantaneous torque
- $T(t)$  = Torque meter signal
- $T_{loss}(t)$  = estimated torque loss from recovery. Torque loss model to be defined.

## F. K Technology Factor (KTF)

### 1. Definition

KTF balances fuel and gasoline engine weights. The heaviest technology is handicapped because it does not allow embedding the same amount of ERS as the lightest technology.

$$KTF = \frac{E_{Gasoline}/FTF}{E_{Gasoline}/FTF + E_{Additional}}$$

$$E_{Additional} = (W_{Best Diesel} - W_{Best Gasoline}) * \frac{\rho_{ERS-Diesel}}{x_{Diesel on lap time}} \text{ if } W_{Best Diesel} > W_{Best Gasoline}$$

$$E_{Additional} = (W_{Best Diesel} - W_{Best Gasoline}) * \frac{\rho_{ERS-Gasoline}}{x_{Diesel on lap time}} \text{ if } W_{Best Gasoline} > W_{Best Diesel}$$

With

- $E_{Gasoline}$  is the allocated Gasoline Energy in Appendix B [MJ]
- $FTF$  the fuel Technology Factor defined in paragraph 1 [-]
- $E_{Additional}$  is the additional allocated Diesel Energy due to technology differences. It can be negative [MJ]
- $W_{Best Diesel}$  is the weight of the Diesel ICE with the best average BSFC whatever the appendix B column considered [kg]
- $W_{Best Gasoline}$  is the weight of the Gasoline ICE with the best average BSFC whatever the appendix B column considered [kg]
- $\rho_{ERS-Diesel}$  is the best-in-class ERS density among diesel cars only [s/kg]
- $\rho_{ERS-Gasoline}$  is the best-in-class ERS density among gasoline cars only [s/kg]
- $x_{Fuel on lap time}$  is the effect of additional Fuel on lap time [s/MJ]

Note that KTF can vary from one Appendix B column to another.

### 2. Measurement and computation

- Each engine and ERS component will be weighed through the process defined in the file below:



## LMP1\_PTrain\_ERS\_Weight\_Perimeter\_iss4

- Amount of energy boosted by ERS system will be measured thanks to official FIA sensors.
- ERS Weight, amount of energy and simulations will give the ERS density
- Effect of fuel on lap time will be computed thanks to simulation with a standard FIA LMP1 car
- Effect of energy boosted and energy boosted strategy on lap time will be computed with simulation by applying the ERS system and strategy on a standard FIA LMP1 car :



### EoT- ERS Density V03

## G. ERS incentive

### 1. Definition

Appendix B has been computed based on the Committee recommendations, in order to conserve an incentive for big ERS system. Simulated theoretical incentive in Appendix B is:

**~-0.5s/lap/MJ hybrid**

Appendix B is currently based on Manufacturers data given in 2012, but theoretical hierarchy between columns could be wrong in case of discrepancies between 2012 and 2014 data (e.g. significant increase of chassis weight without ICE). In 2014, after having weighed every car, system and component, Commission will decide or not to change the Appendix B in order to conserve the hierarchy.

The Committee decision will be based on comparison of the optimum Hybrid LMP1 car weight and the minimum regulatory LMP1-H weight (870kg).

The optimum Hybrid LMP1 car weight will be estimated by FIA this way:

$$W_{Optimum} = W_{Best\ Chassis} + W_{Best\ ICE} + W_{Best\ 8MJ\ ERS}$$

Where:

- $W_{Optimum}$  is the optimum Hybrid LMP1 car weight
- $W_{Best\ Chassis}$  is the weight of the lightest chassis whatever the column or the technology (Diesel or Gasoline) considered [kg]
- $W_{Best\ ICE}$  is the weight of the lightest ICE whatever the column or the technology (Diesel or Gasoline) considered [kg]
- $W_{Best\ 8MJ\ ERS}$  is the weight of 8MJ system computed with the best ERS density [MJ/kg] whatever the column or the technology (Diesel or Gasoline) considered [kg]

### 2. Process

In case Commission would decide to change Appendix B to conserve incentive, FIA/ACO will proceed this way:

- Theoretical Gap between columns would be computed thanks to simulation.
- This gap defined by the commission would be defined for Le Mans only.
- Columns could be adjusted with: **Allowed Fossil Energy and/or Maximum Fuel Flow and/or Fuel Capacity carried on board.**

- FIA/ACO will compare this weight with minimum regulatory LMP1-H car weight (870kg)

## H. Race Control

Fuel consumption and flow will be checked during the races. The complete method of control is described in appendixes 1 and 2 of the “WEC\_Fuel\_Flow\_Metering\_FIA” document (see paragraph C).

## I. Dissuasive Penalty

The following principles will be applied for the 2014 Le Mans 24 Hours:

- If the FIA notices during the race that a car has an average or instantaneous (P max) BSFC exceeding what was announced in February by more than 2% (estimation of the maximum error of the sensors), and to the advantage of this car, the technical delegate shall inform the stewards, after which there will be an open debate with the competitor in order to **propose to him** a minimum stop and go penalty of 60 seconds (which can be extended at the discretion of the stewards according to the duration of the infringement noted, i.e. the time during which the competitor ran while exceeding the authorised values). The duration will be recorded on the basis of the on-board sensors (fuel flow meter and torque meter), information which will be available to the competitor.
- If the competitor accepts the penalty, official notification will be issued to the competitor and penalty will be applied. If the competitor then returns, until the end of the race, to the BSFC/KTF which he had announced, there will be no exclusion penalty; however, a fine could be imposed after the race on a manufacturer who has intentionally provided incorrect values in order to bias the EOT process.
- If the competitor refuses the penalty, the final classification will be published subject to further investigations, with possible exclusion following the race, further to detailed analysis between the FIA and the competitor: “dissuasive penalty”. The detailed post-race analysis could involve tests and inspections with the competitor or elsewhere (calibration sensor check), and will include an analysis of the other data at the disposal of the FIA (reverse engineering).
- If the FIA does not notice anything during the race, the “dissuasive penalty” cannot be applied after the race, except in the event of a serious sensor failure, noted during or after the race, and where the other data available to the FIA demonstrates that the car was running with an abnormal BSFC.

### Nota Bene:

- It should be noted that the penalty can apply only to the car(s) which have committed the infringement, and not to all of the competitor’s cars.
- The precision of 2% above is, for the time being, subject to tests on the sensors at the beginning of 2014. This value could be definitively fixed after Spa and communicated to all competitors.
- If we do not have a fuel flow meter (back-up plan), we consider that for the average BSFC, the precision goes to approximately 3%, and that we cannot do anything with the instantaneous BSFC.

For the first two races of the season and the preliminary tests at Le Mans, we propose to monitor the BSFC and to “streamline” our methods, but without applying penalties (except in the case of a significant breach of the values established beforehand).

Our results will be communicated to the competitors for joint recalibration.

## Period of validity/application of the decision

This decision comes into effect:

- with immediate application
- from:
- from the following event :

And is applicable:

- until further notice
- for the above-mentioned event(s) only

## Committee Members



Denis CHEVRIER



Vincent BEAUMESNIL

**Any decision taken by the Endurance Committee is not subject to appeal, in accordance with Article 88 B of the WEC Sporting Regulations.**

This decision is available on the following websites:

- [www.fia.com](http://www.fia.com)
- <http://sport.lemans.org/login.php>