

**INFORMAL GROUP ON GASEOUS FUEL VEHICLES**  
**Within the UN GRPE (WP29)**  
**PROPOSED AMENDMENT GFV-02-04**

**Name of Organisation submitting Amendment/Work Item:**

Expert from Poland to GRPE

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**Regulation name and reference number:** Regulation 115

**Name of Amendment/Work Item:**

Proposals for Draft Amendment and Comments to Regulation 115

**Specific language for Amendment/Work Item:** English

**Rationale: (Why is it important/required?)**

Experiences with the application of Regulation 115 in Poland (several type approvals granted) have proved that it has many defects and needs amending. It is required, in particular:

- to clarify the scope of application,
- to delete the concept of “non-intrusive” retrofit systems,
- to adapt to technical progress and to correct provisions for vehicles of M2, M3, N2, N3 categories,
- to correct a huge number of errors, unclear provisions etc. leading to misinterpretation.

This document contains some proposals for draft amendments or at least comments indicating defects of particular provisions. They are limited to LPG retrofit systems.

Additionally, it is desirable to decide if Regulation 115 should apply to retrofit systems intended for dual fuel vehicles. In theory, it is applicable to systems intended for vehicles of M2, M3, N2, N3 categories, but type approvals are not possible as no test procedure is specified. No proposals are given for such systems in this document as Poland has not been interested in such a technology so far.

The proposed amendments are in red. Emphasis is placed on errors affecting the substance. Some errors of purely editorial nature are also corrected when found.

**Analysis/testing or data requirements to support the Amendment/Work item**

(could be anticipated or existing supporting documentation)

**1. Clarification of the scope of application**

When Regulation 115 was amended in 2006 (Amendment 2 and Amendment 2 – Corrigendum 1), the intention of GRPE was to limit its scope of application to Euro 3, Euro 4 and later vehicles.

According to paragraph 1.4, Regulation 115 applies to retrofit systems intended to be fitted to all M and N vehicles in service with the exception of those type approved pursuant to Regulations 83 and 49, listed in (a) to (e). The first problem is that the majority of vehicles in service in Contracting Parties applying Regulation 115 are not approved under Regulations 83 and 49, but under Directives 70/220/EEC and 88/77/EEC. Consequently, this Regulation applies not only to Euro 3 and later vehicles, but also to pre-Euro, Euro 1, Euro 2 vehicles type-approved pursuant to the above Directives because they are not excepted. There are also vehicles, for instance new or second-hand ones imported from USA, Canada, China etc., which are not approved either under Regulations 83 and 49 or under Directives 70/220/EEC and 88/77/EEC. This Regulation applies to such vehicles irrespective of their emission level. All the above is contradictory to the intention. The next problem is that there are vehicles, for instance new or second-hand imported from USA, Canada, China etc., for which the limit values are not known. In this connection it is not possible to determine if they comply with Regulation 115. To correct these shortcomings it is proposed to amend paragraph 1.4 of Regulation 115 in the following way:

**Paragraph 1.4, amend to read:**

- „1.4. This Regulation applies to retrofit systems intended to be fitted on vehicles of categories M and N, **type approved pursuant to Regulation 83 or 49, or equivalent UE Directives** with the exception of:
- .....
- .....
- (f) **vehicles type-approved pursuant to Directive 70/220/EEC and Directives amending this Directive, earlier than Directive 98/69/EC,**
  - (g) **vehicles equipped with diesel engines type-approved pursuant to Directive 98/69/EEC and later Directives amending Directive 70/220/EEC,**
  - (h) **vehicles others than M1 and N1 categories type-approved pursuant to Directive 98/69/EEC and later Directives amending Directive 70/220/EEC,**
  - (i) **vehicles type-approved pursuant to EU Directive 88/77/EEC and Directives amending this Directive, earlier than Directive 1999/96/EC.”**

**2. Deletion of the splitting of retrofit systems into “intrusive” and “non-intrusive”**

The splitting of retrofit systems into 2 groups: “intrusive” and “non-intrusive” systems was introduced in Regulation 115 in 2006 (Amendment 2). Its main purpose was to reduce the number of tests (“non-intrusive” systems are not subjected to the type 1 test with reference petrol (paragraph 6.1.2.5.1.4); the number of emission tests of “non-intrusive” systems with LPG/CNG may be reduced in the specified conditions (paragraph 6.1.2.5.1.4.2)). However, experiences with the application of Regulation 115 have proved that the concept of “non-intrusive” systems does not serve a purpose and is not justified for the following reasons.

(i). According to the definition in paragraph 2.1.5 of Regulation 115 ““Non intrusive system” means a retrofit system in which the LPG or CNG fuelling system does not change the original air and petrol feed system to the engine.” The description of the petrol feed system and air system are given respectively in paragraphs 4.2.4.3 and 4.2.7.3 of Annex 1 to Regulation 83. By virtue of the above definition all gas injection systems may be regarded as “non-intrusive”. However, what matters is not the change in the original air and petrol feed

system, but the change in the engine operation. Compliance with the definition does not necessarily ensure that the operation of the engine fuelled with petrol is not affected after the retrofit.

(ii). In several cases, the installation of a “non-intrusive” system affects, sometimes seriously, the engine operation, in particular the air-fuel ratio with petrol which, in turns, affects the emission. As a result the change of the pollutant emission in the order of 20% or even more may be found.

Table 1 shows the test results of a Euro 3 vehicle equipped with the LPG retrofit system of the IV generation, measured before the retrofit and after the retrofit in LPG mode over the type 1 test. In LPG mode the switch over from petrol to LPG occurred after 133 s.

**Table 1**

Pollutant	Emission [g]		Percentage of the first 133 s in the total emission in the urban cycle [%]
	First 133 s	Total urban cycle	
<b>before the retrofit</b>			
CO	5.28	5.89	90
NOx	0.02	0.17	13
HC	0.54	0.55	98
<b>after the retrofit in LPG mode</b>			
CO	8.32	8.79	95
NOx	0.02	0.42	5
HC	0.73	0.76	97

Source: Environmental Protection Division, Motor Transport Institute, Warsaw, Poland

The approved retrofit system was qualified as “non-intrusive” as it met the requirement of the definition in paragraph 2.1.5, but the emission of CO and HC in the first 133 s in LPG mode (petrol operation) was by respectively 57% and 34% higher than that before the retrofit.

(iii) For “non-intrusive” systems the values of the petrol CO<sub>2</sub> emission and fuel consumption required for the calculation of the ratios of CO<sub>2</sub> emissions and fuel consumption ( $K_{CO_2}$ ,  $K_{cons}$ ) may be the values determined during the type-approval of the original vehicle (paragraph 6.1.2.5.3.4). Some values of  $K_{CO_2}$ ,  $K_{cons}$  determined in this way for some retrofit systems type-approved pursuant to Regulation 115 are listed in Table 2 below.

**Table 2**

System/vehicle	1	2	3	4	5	6
$K_{CO_2}$	0,94	<b>1,08!</b>	0,98	0,95	<b>1,04!</b>	0,92
$K_{cons}$	1,41	<b>1,58!</b>	1,44	1,35	<b>1,50!</b>	1,35

Source: Environmental Protection Division, Motor Transport Institute, Warsaw, Poland

The theoretical  $K_{CO_2}$  value is about 0,88. The method of  $K_{CO_2}$ ,  $K_{cons}$  calculation specified for “non-intrusive” systems in paragraph 6.1.2.5.3.4. of Regulation 115 “falsifies” the type-approval results. In several cases the values of  $K_{CO_2}$ ,  $K_{cons}$  obtained are wrong and worthless.

(iv) The provisions in paragraph 6.1.2.5.1.4.2 making it possible to reduce the number of type 1 tests (from 3 tests to 1 or 2 tests) for “non-intrusive” systems do not serve a purpose

as 3 type 1 tests must be anyway conducted to collect the data for CO2 emission and fuel consumption (paragraph 6.1.2.5.3.1).

(v) The “official” values of the CO2 emission, fuel consumption and net power required for the calculation of  $K_{CO_2}$ ,  $K_{cons}$ ,  $K_{power}$  for “non-intrusive” system are not available for some vehicles in service, in particular in some non-EU member countries. In those countries the type-approval with regard to the CO2 emission, fuel consumption and power is often not required for the holistic type-approval of a vehicle type. In such a case  $K_{CO_2}$ ,  $K_{cons}$  can not be calculated as the type 1 test with petrol is not allowed (paragraph 6.1.2.5.1.4 “Notwithstanding the provisions of paragraphs 6.1.2.5.1.1. to 6.1.2.5.1.3., for non intrusive retrofit system as defined in paragraph 2.1.5., the type I test **shall be carried out only with each LPG reference fuel.**”). However, there are no provisions forbidding the power test.

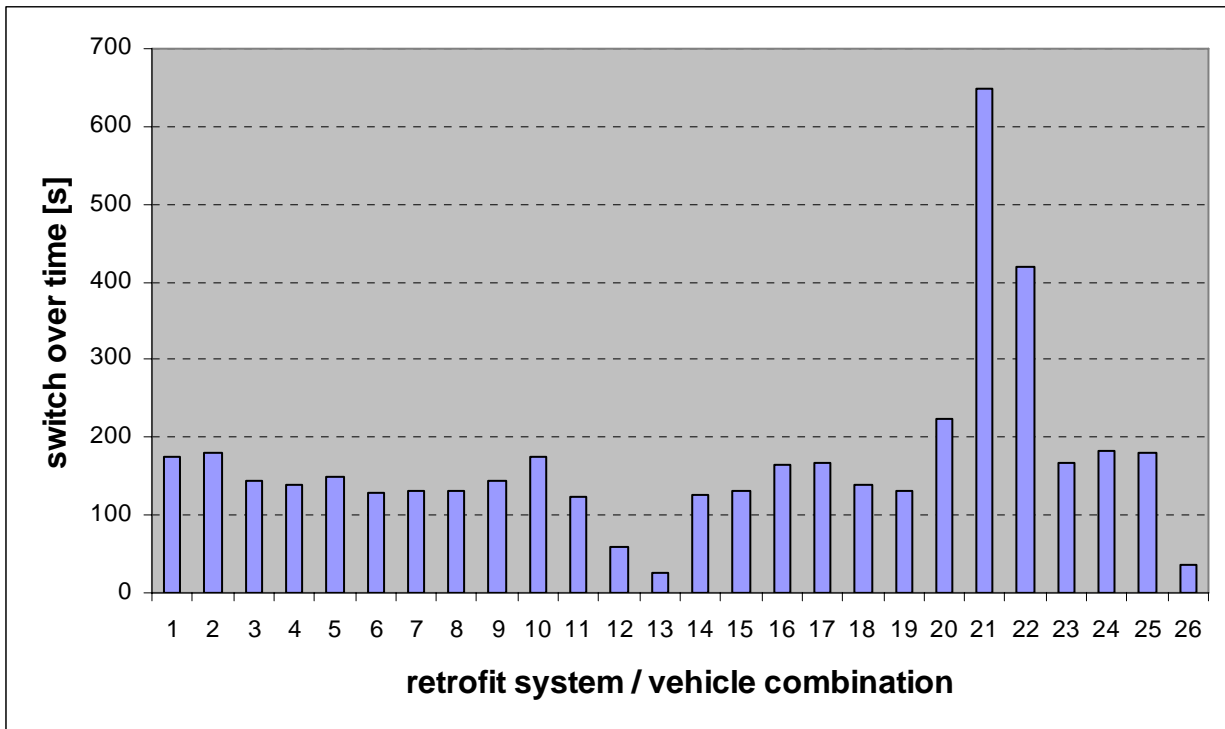
(vi) The introduction of the “non-intrusive” concept leads to the situation that the emission limit values for the “intrusive” and “non-intrusive” systems are different which should not be acceptable. Consequently, the limit values are not performance-oriented, but are design-oriented. The difference between the emission limit values for “intrusive” and “non-intrusive” systems is shown in Table 3 below.

**Table 3**

<b>Value of the emission with petrol, S</b>	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.99
<b>Limit value for “intrusive” system with LPG</b>	0.65	0.74	0.82	0.91	0.99	1	1	1
<b>Limit value for “non-intrusive” system with LPG</b>	1	1	1	1	1	1	1	1
<b>Difference,%</b>	53	35	21	10	0.5	0	0	0

Note. Relative values. The limit value applied during the type approval of the vehicle is assumed to be 1.

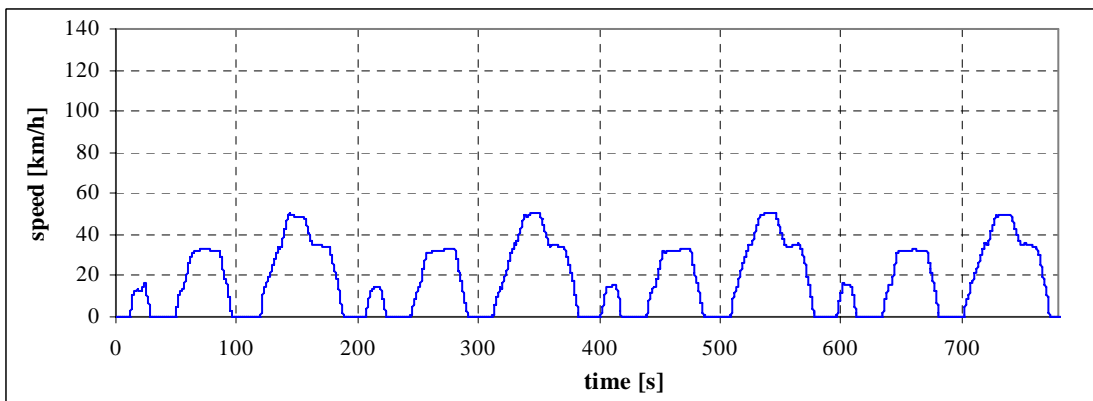
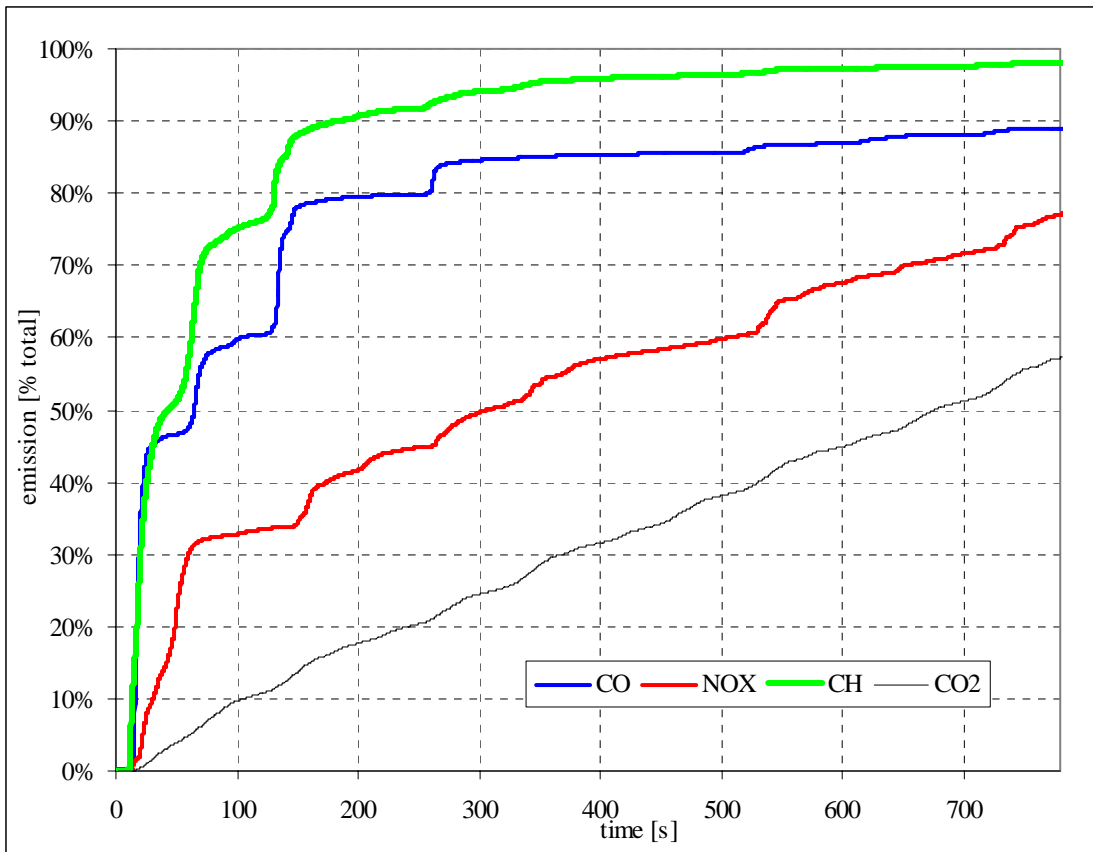
(vii) In LPG mode the switch over from petrol fuelling to LPG fuelling in the type 1 test occurs after some time. The switch over time of some retrofit system/vehicle combinations submitted for the type-approval in Poland is shown in Figure 1.



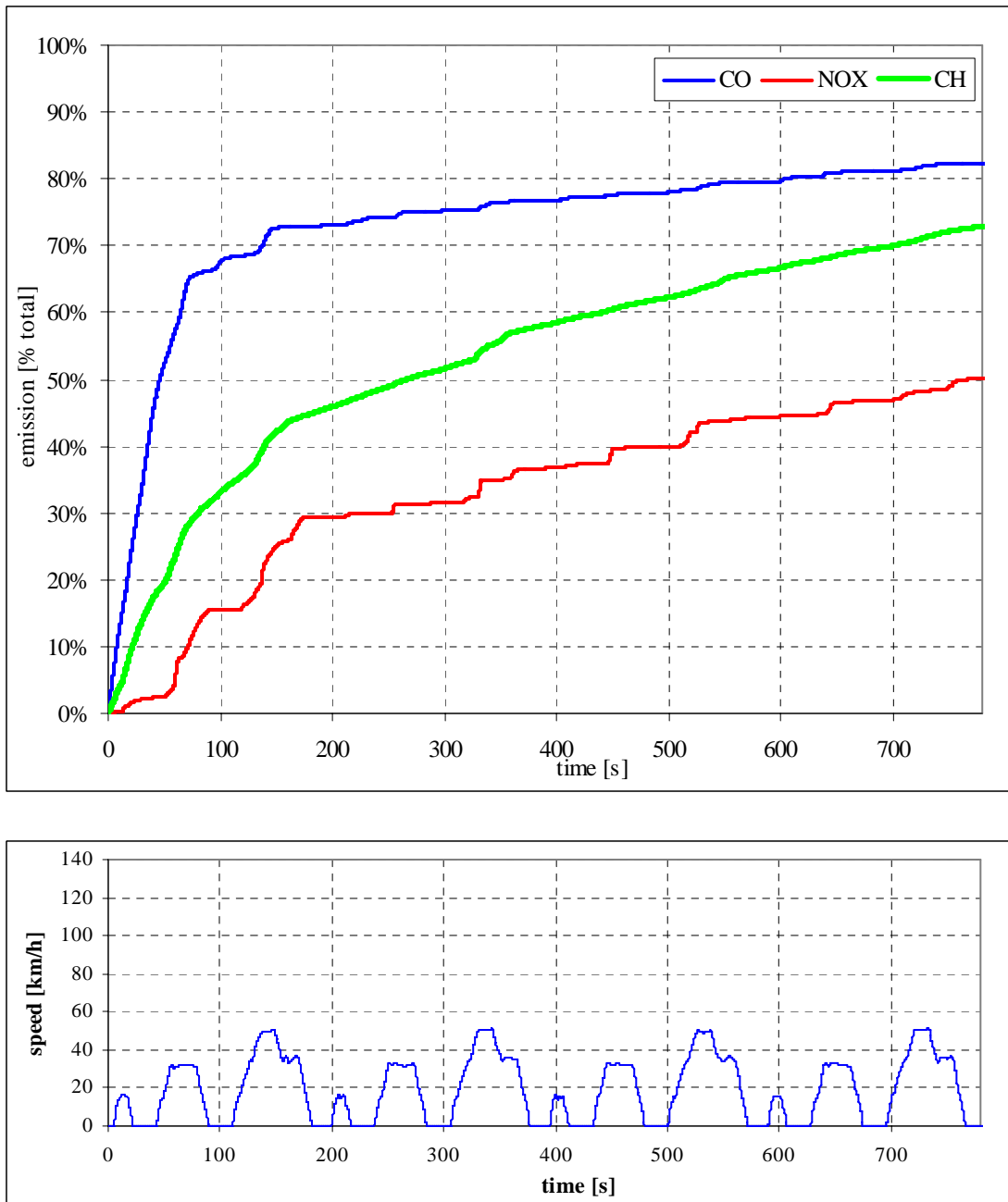
**Fig. 1. Switch over time for some retrofit system/vehicle combinations**  
 (Source: Environmental Protection Division, Motor Transport Institute, Warsaw, Poland)

This switch over time varies from 25 s to 648 s. It seems that this time in some retrofit systems is made longer than required to reduce the emission in LPG mode in the type 1 test and consequently to make it possible to comply with the requirements in force.

Figures 2 and 3 show the relative emission in the urban cycle (the total value measured over the whole type 1 test = 100%) versus time for 2 vehicles converted to LPG. Such curves are typical for Euro 3 and Euro 4 vehicles.



**Fig. 2. Relative emission versus time for vehicle A in the urban part of the type 1 test**  
 (Source: Environmental Protection Division, Motor Transport Institute, Warsaw, Poland)



**Fig. 3. Relative emission versus time for vehicle B in the urban part of the type 1 test** (Source: Environmental Protection Division, Motor Transport Institute, Warsaw, Poland) Based on Figures 2 and 3

the ratio of the emission with LPG in LPG mode determined on the assumption that the total emission in the type 1 test is equal to the limit divided by the emission with petrol in petrol mode in the period equivalent to the operation with LPG in LPG mode (referred to as "LPG/petrol emission ratio" hereinafter)

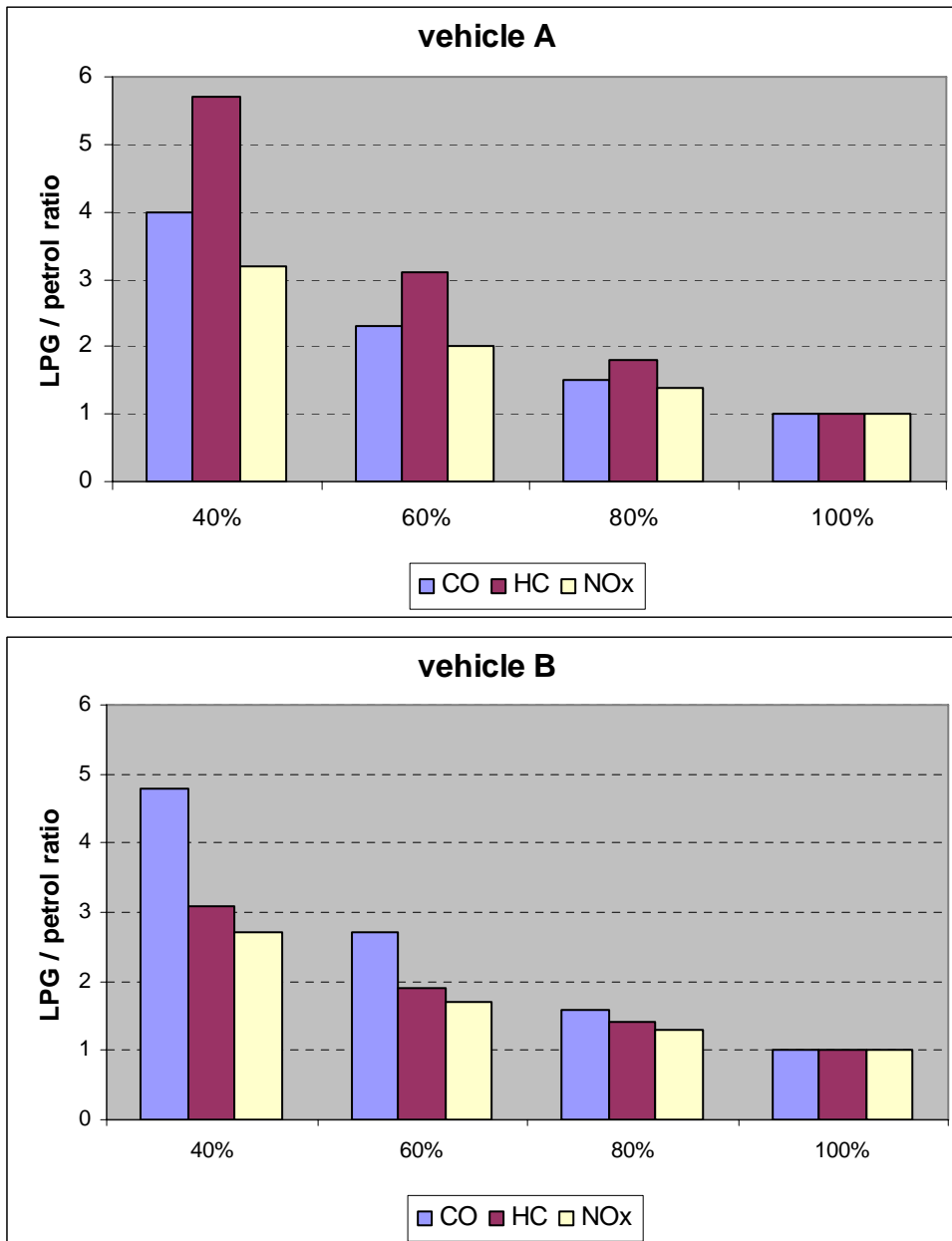
is calculated for each pollutant for "non-intrusive" retrofit systems. The following assumptions are applied:

(a) The retrofit system is truly, not apparently, "non-intrusive", i.e. the emission with petrol before the retrofit is identical to that with petrol in LPG mode or in petrol mode after the retrofit.

(b) The switch over time is equal to 60 s. This time is selected because the EU draft comitology Regulation for LDV specifies that “During the type 1 test the vehicle shall use only petrol for a maximum of 60 s when operating in gas mode”.

(c) The ratio of the emission measured over the type 1 test to the emission limit is equal to 40%, 60%, 80%, 100%.

The LPG/petrol emission ratio is shown in Figure 4.

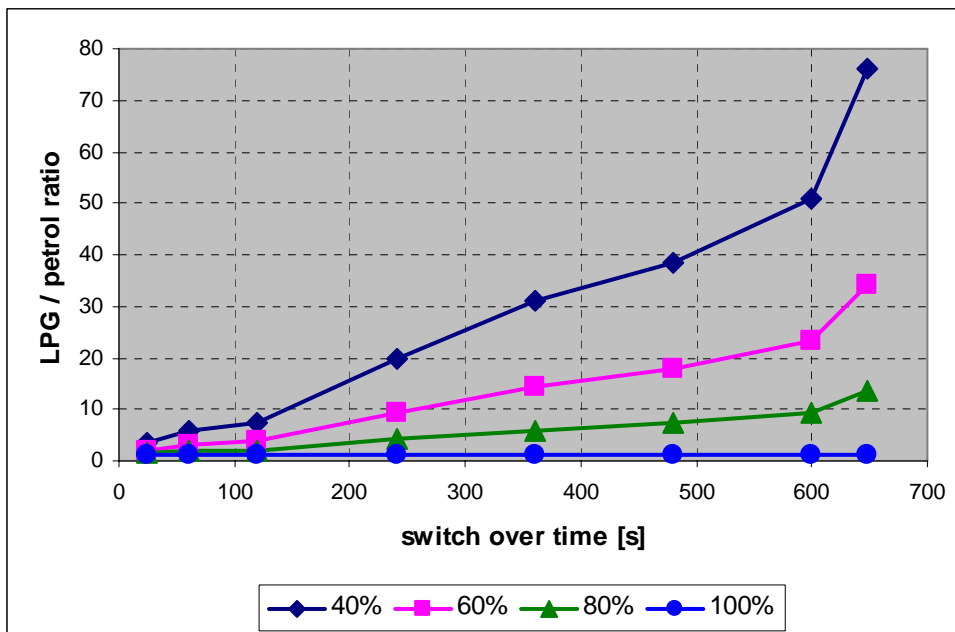


**Fig. 4. LPG/petrol emission ratio for different ratio of actual emission with petrol to limit (40%, 60% 80%, 100%) for “non-intrusive” retrofit system**

The ratio of the actual emission to the limit value is usually in the order of 40% - 60% for Euro 3 and Euro 4 vehicles. If it is equal to 40%, the relative emission versus time curve is similar to those shown in Figures 2 and 3 and the switch over time is 60 s, the emission with LPG may be even about 5 times higher than that with petrol and the vehicle is deemed to comply with the requirements of Regulation 115 for “non-intrusive” retrofit systems.

Figure 5 shows the effect of the switch over time on the LPG/petrol emission ratio for HC (vehicle A).





**Fig. 5. LPG/petrol emission ration versus switch over time for different ratio of actual emission with petrol to limit (40%, 60% 80%, 100%) for “non-intrusive” retrofit system (HC, vehicle A)**

In Figure 5 the switch over time varies from 25 s (the shortest time in Figure 1) to 648 s (the longest time in Figure 1). If the ratio of the actual emission to the limit value is 40 %, the switch over time is 648 s and the relative emission versus time curve is similar to that shown in Figures 2, **the emission with LPG may be even 70 times higher than that with petrol and the vehicle is deemed to comply with the requirements of Regulation 115 for “non-intrusive” retrofit systems.** Even when the switch over time is 25 s, the emission with LPG may be 3 times higher.

To straighten out these shortcomings of Regulation 115, it is proposed to amend it as follows.

A Regulation concerning retrofit gas systems serves a purpose only if it ensures, among other things, that the vehicle after the retrofit is at least as clean as the original vehicle. Regulation 115 does not seem to meet this precondition. This is its main defect and the main problem to be solved. The proposed amendments are a minimum. They will not solved the above problem, but only they will patch it up.

LPG is believed to be a “clean” fuel. It has several features that can contribute to the reduction of emission. However they are not taken advantage of in the current Regulation 115. The emission with LPG may be several, in extreme case even more than 70, times higher than that with petrol (Figure 5) and the system passes the tests.

#### **Proposed amendments:**

(i) The following paragraphs should be deleted:

- 2.1.5,
- 3.2.5,
- 5.2,
- 6.1.2.2,
- 6.1.2.5.1.4,
- 6.1.2.5.1.4.1,
- 6.1.2.5.1.4.2,
- 6.1.2.5.3.4,

- 6.1.3.4,
- Annex 1A, item 11.1, the second line,
- Annex 3A, item 2.4.

(ii) Paragraph 6.1.2.5.1.2, amend to read:

see item 4 below.

(iv) Paragraph 6.1.3.1, amend to read:

see item 4 below.

### 3. Adaptation to technical progress and correction of provisions for M2, M3, N2, N3 vehicles

It is proposed to amend provisions for M2, M3, N2, N3 vehicles in the following way. A13-mode test does not apply to Euro 3 and later vehicles.

This proposal refers only to the conversion of diesel engines to SI gas engines. It does not refer to dual-fuel engines.

#### Paragraph 6.1.2.6, amend to read:

“6.1.2.6. Exhaust emissions (M2, M3, N2 and N3 categories of vehicles)

The parent engine(s) are submitted to the tests indicated in Regulation No. 49 5/ as follows:

Measurements of emissions in the ~~13-mode cycle~~ ESC test for the engine type approved pursuant to Regulation 49 or Directive 88/77/EEC row A or  
Measurements of emissions in the ~~13-mode cycle~~ ETC test for the engine type approved pursuant to Regulation 49 or Directive 88/77/EEC row B1, B2, C

with each fuel:

- (i) reference diesel fuel,
- ~~(ii) commercial LPG.~~
- (ii) reference LPG A,
- (iii) reference LPG B.

The emissions of CO, HC and NOx ~~and particulates~~ are calculated according to Regulation No. 49 5/.

~~The parent engine(s) shall be tested with the reference diesel fuel before the retrofit. The total engine operation time between the tests before and after retrofit shall not exceed [20] hours. The test parent engine(s) with the reference diesel fuel shall comply with the limit values according to the type approval of the engine(s) applied during the type approval.~~

The requirements regarding emissions of the engine(s) equipped with the retrofit system, and with the LPG, shall be deemed to be fulfilled if the results meet for each regulated pollutant (CO, HC and NOx ~~and particulates~~) the following conditions:

$$\text{(1) } M < 0.85S + 0.4G$$

~~(2)  $M < G$~~

~~M: value of the emissions of one pollutant obtained from the 13-mode test with the retrofit system and with LPG,~~

~~S: value of the emissions of one pollutant obtained from the 13-mode test with the reference diesel fuel,~~

~~G: limit value of the emissions of one pollutant according to the type approval of the engine(s).~~

(1)  $(MA + MB)/2 < 0.85S + 0.4G$

(2)  $MA \text{ and } MB < G$

where:

MA: value of the emissions of one pollutant  $(CO/HC/NO_x)_{4/}$  obtained from the ESC or ETC test with the retrofit system and with LPG A,

MB: value of the emissions of one pollutant  $(CO/HC/NO_x)_{4/}$  obtained from the ESC or ETC test with the retrofit system and with LPG B,

S: mean value of the emissions of one pollutant  $(CO/HC/NO_x)_{4/}$  obtained from the ESC or ETC test with the reference petrol,

G: limit value of the emissions of one pollutant  $(CO/HC/NO_x)_{4/}$  according to the type approval of the engine in the ESC or ETC test.”

#### 4. Correction of errors, unclear provisions etc.

##### Paragraphs 2.1.1 and 2.1.2, amend to read:

“2.1.1. Specific LPG retrofit system of an approved type may consist of several components as classified and approved according to Regulation No. 67, 01 series of amendments, Part I, ~~and~~ the specific vehicle ~~instruction installation~~ manual ~~and end-user manual.~~”

“2.1.2. Specific CNG retrofit system of an approved type may consist of several components as classified and approved according to Regulation No. 110, Part I, ~~and~~ the specific vehicle ~~instruction installation~~ manual ~~and end-user manual.~~”

##### Insert new paragraphs 2.xx, to read:

“2.xx. “Safety device” means a pressure relief valve or fusible plug (fuse) or a combination of these two devices, as defined in Regulation 67, 01 series of amendments.”

Comment. Is it correct?. Shut-off valve, gas-tube pressure relief valve etc., should also be included?

“2.xx. “Original vehicle/engine” means a vehicle/engine before the installation of the retrofit system”

“2.xx. “Gas injection device” means .....?”

Justification.

The terms “safety device”, “original vehicle”, “gas injection device” are used in some paragraphs of Regulation 115, for instance paragraphs 2.5, 3.2.3, Annex 2A, Annex 2B, but they are not defined either in Regulation 115 or Regulation 67. It is necessary to define the difference between “gas injection device” and “injector.”

### Paragraph 2.2 needs correcting and clarifying:

- “2.2.            "Specific LPG or CNG retrofit system of an approved type" means systems, which do not differ in such respect as:
- 2.2.1.           retrofit system manufacturer (responsible for retrofit approval application);
  - 2.2.2.           pressure regulator/vaporiser type ~~by the same manufacturer~~ (only the type with which the parent vehicle(s)/engine(s) is(are) fitted can be used; different versions in respect of the maximum gas delivery are permitted);
  - 2.2.3.           gas fuelling system type ~~by the same manufacturer~~ (i.e. induction mixer or gas injection device or injector device, vapour or liquid, single or multi-point injection system, direct or indirect injection; for the gas injection device or injector only the type with which the parent vehicle(s)/engine(s) is(are) fitted can be used, different versions in respect of the maximum gas delivery are permitted);
  - 2.2.4.           sensors and actuators set types;
  - 2.2.5.           the fuel container type (i.e. ~~as amended by TRANS/WP.29/GRPE/2005/8~~ liquid take off/ vapour pressure, vapour take off, liquid take off / pressurized by pump), the safety devices and fuel container accessories, as required by Regulation No. 67, 01 series of amendments, or Regulation No. 110, where applicable. ~~(i.e. relief valve, ...);~~");
  - 2.2.6.           fuel container fitting devices;
  - 2.2.7.           ECU (Electronic Control Unit) type ~~by the same manufacturer~~ (only the type with which the parent vehicle(s)/engine(s) is(are) fitted can be used; versions for different cylinder number/configuration are permitted);
  - 2.2.8.           the same ~~basic~~ software ~~principles~~ and control strategy which are used in the parent vehicle(s)/engine(s) (software versions for different cylinder number/configuration are permitted);
  - 2.2.9.           installation manual (see para. 7);
  - 2.2.10.          end-user manual (see para. 7).

Note: With respect to paragraphs 2.2.4., 2.2.5. and 2.2.6., the manufacturer of the retrofit system can insert in his installation manual other components, included in the approval, as interchangeable items (see para. 7).”

Justification and comments.

- (i) It is not clear what the term “type” means in current paragraphs 2.2.2, 2.2.4, 2.2.7. The term “type” is clearly defined in paragraphs 2.2.3, 2.2.5.
- (ii). The term “safety device” is neither defined nor used in Regulation 67. It is not defined in Regulation 115 either. It needs defining.
- (iii) The term “fuel container fitting devices” is neither defined nor used in Regulation 67. It is not defined in Regulation 115 either. Nobody knows what it means.
- (iv) “~~Basic~~ software ~~principles~~ and control strategy” is not included in the description in Annex 3A, but should be included.
- (v) Gas injection devices and injectors, as we understand them, have different characteristics and can not fall into the same retrofit system type.
- (vi) In my view paragraphs 2.2.4, 2.2.6 and the wording in paragraph 2.2.5 “the safety devices and fuel container accessories, as required by Regulation No. 67, 01 series of amendments, or Regulation No. 110, where applicable” are redundant and may be deleted.
- (vii) “the same manufacturer” (used in paragraphs 2.2.2, 2.2.3, 2.2.7) is not a criterion which can decide that retrofit systems fall into the same type.

## Paragraphs 2.5.1 and 2.5.1.1 need correcting and clarifying:

“2.5.1. According to this Regulation, "a member of the family" is a vehicle equipped with retrofit system type of which type approval is requested and sharing the following essential characteristics with its parent one:”

Comment.

(i) According to our interpretation this definition refers to a vehicle after the retrofit (“...a vehicle equipped with retrofit system type...”), but according to some technical services this definition refers to the situation before the retrofit, to the original vehicle. This problem should be clarified.

(ii) The definition in the current paragraph 2.5.1.1 should apply only to M1 and N1 vehicles. It is not suitable for M2, M3, N2, N3 vehicles. According to Regulation 49, an engine type-approved under Regulation 49 can be used in any vehicle, irrespective of its manufacturer and category. It is not justified that Regulation 115 should be more restrictive than Regulation 49. That is why it is proposed to introduce separate definition for M2, M3, N2, N3 vehicles. Comment (i) above applies also to the proposed definition for M2, M3, N2, N3 vehicles.

### 2.5.1.1. For M1 and N1 vehicles:

(a) It is produced by the same vehicle manufacturer.

Comment. FIAT, Lancia, Alfa Romeo – the same family?  
VW, Skoda, Audi, Seat – the same family?  
Vauxhall, Opel – the same family?

(b) It is classified in the same category M<sub>1</sub> ~~or M<sub>2</sub> or M<sub>3</sub>~~ or N<sub>1</sub> ~~or N<sub>2</sub> or N<sub>3</sub>~~.  
Vehicles of category M<sub>1</sub> and N<sub>1</sub> class I may belong to the same family.

Comment. It is not clear if it refers to the situation before or after the retrofit.

(c) It is subject to the same emission limits or those specified in earlier series of amendments of the applicable Regulation.

Comment. It is not clear if this provision refers to the limits before or after the retrofit. According to paragraph 6.1.2.5.1.3 vehicles fuelled with LPG should meet the requirements the original vehicle had to comply with at the date of its approval. All these provisions are not coherent.

(d) If the gas fuelling system has a central metering for the whole engine: it has an approved **maximum net** power output between 0.7 and 1.15 times that of the engine of the parent vehicle. If the gas fuelling system has an individual metering per cylinder: it has an approved **maximum net** power output per cylinder between 0.7 and 1.15 times that of the engine of the parent vehicle.

(e) Fuel feed and combustion process (injection: direct or indirect, single-point or multi-point).

Comment. It is not clear if it refers to petrol feed (original vehicle) or gas feed (after the retrofit). In paragraph 2.2.3 the single-point or multi-point injection is specified as a criterion for the retrofit system type. Does subparagraph (e) refer to the petrol feed?

(f) It has the same pollution control system:  
- same type of catalyst if fitted (three-way, oxidation, de NO<sub>x</sub>),  
- air injection (with or without),

- exhaust gas recirculation (EGR) (with or without).  
If the ~~tested parent~~ vehicle was not equipped with air-injection or EGR, ~~engines- vehicles~~ with these devices are allowed."

**Insert a new paragraph 2.5.1.x, to read:**

"2.5.1.x. For M2, M3, N2, N3 vehicles:

- (a) Its engine is produced by the same manufacturer.
- (b) It is subject to the same emission limits or those specified in earlier series of amendments of the applicable Regulation.
- (c) If the gas fuelling system has a central metering for the whole engine: it has an approved maximum net power output between 0.7 and 1.15 times that of the engine of the parent vehicle. If the gas fuelling system has an individual metering per cylinder: it has an approved maximum net power output per cylinder between 0.7 and 1.15 times that of the engine of the parent vehicle.
- (d) Fuel feed and combustion process (injection: direct or indirect, single-point or multi-point).
- (e) It has the same pollution control system:
  - same type of catalyst if fitted (three-way, oxidation, de NO<sub>x</sub>),
  - air injection (with or without),
  - exhaust gas recirculation (EGR) (with or without).

If the parent vehicle was not equipped with air-injection or EGR, vehicles with these devices are allowed."

**Paragraph 2.5.1.2, this paragraph needs clarifying:**

"2.5.1.2. With regard to the requirement of paragraph 2.5.1.1.(a), the vehicle family can also cover vehicles produced by other vehicle manufacturers if it can be demonstrated to the type approval authority that the same engine type and emission strategy is used."

Comment. How can a technical service verify that the same strategy is used? What are criteria?

**Paragraph 2.5.1.3, amend to read:**

"2.5.1.3. With regard to requirement of paragraph 2.5.1.1.(d) and 2.5.1.x (c):

- in the case of a central metering for the whole vehicle where a demonstration shows that two gas fuelled vehicles could be members of the same family with the exception of their approved maximum net power output, respectively P1 and P2 ( $P1 < P2$ ), and both are tested as if they were parent vehicles, the family relation will be considered valid for any vehicle with an approved maximum net power output between  $0.7 \cdot P1$  and  $1.15 \cdot P2$ ;
- in the case of an individual metering per cylinder where a demonstration shows two gas fuelled vehicles could be members of the same family with the exception of their approved maximum net power output per cylinder, respectively P1 and P2 ( $P1 < P2$ ), and both are tested as if they were

parent vehicles, the family relation will be considered valid for any vehicle with an approved **maximum net** power output **per cylinder** between  $0.7 \cdot P1$  and  $1.15 \cdot P2$ ."

Justification. Self-evident.

**Chapter 3, amend to read:**

3. APPLICATION FOR APPROVAL

- 3.1. The application for approval of a specific retrofit system shall be submitted by **its** manufacturer or by his duly accredited representative.
- 3.2. It shall be accompanied by the under-mentioned documents in triplicate and by the following details:
  - 3.2.1. Description of the retrofit system comprising all the relevant details, included the approval numbers of each component, referred to in **item 2 of Annex 3A** to this Regulation for LPG system and Annex 3B to this Regulation for CNG system.
  - 3.2.2. Description of the parent vehicle(s) on which the requirements of this Regulation are going to be tested **and the vehicles for which the retrofit system is proposed to be qualified, comprising all the relevant details referred to in item 1 of Annex 3A to this Regulation for LPG system and Annex 3B to this Regulation for CNG system.**
  - 3.2.3. Description of all modifications applied to the original parent vehicle. **, only in case of bi-fuel configuration**
  - ~~3.2.4. Verification of compliance with the specifications prescribed in paragraph 6 of this Regulation;~~
  - 3.2.4. Installation manual(s) for the retrofit system installation on the parent vehicle(s).
  - 3.2.5. End-user manual.
  - 3.2.6. If needed for the purpose of paragraph 5.3., notice of approval of the retrofit system for a parent vehicle which is different from those the approval is applied for, certifying that the retrofit system has been approved as a "master-slave" system, as defined in paragraph 2.1.6.
  - 3.2.x. **A list of vehicle type(s) for which the retrofit system is qualified, containing all the details specified in item 3 of Addendum to Annex 1A to this Regulation for LPG system or Annex 1B to this Regulation for CNG system.**
- 3.3. A sample of the specific retrofit system, properly installed in the parent vehicle(s) **shall be submitted to the technical service."**

**Paragraph 5.3, amend to read:**

- "5.3. Notice of approval or of refusal ~~or of extension~~ of approval of a retrofit system type/~~part~~ pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a form conforming to the model in annexes 1A and 1B to this Regulation."

Justification. Chapter 5 refers to the approval. Chapter 8 refers to the extension. Notice of extension – see paragraph 8.3.

**Paragraph 6.1.1.3, amend to read:**

“6.1.1.3. The LPG retrofit system installed in the vehicle, in a proper way as defined in the above installation manual, shall comply with the installation requirements of Regulation No. 67, 01 series of amendments. Concerning the fixation of the **cylindrical** fuel container, the requirements of Regulation No. 67, 01 series of amendments shall be deemed to be met if the requirements of annex 5 to the present Regulation are satisfied.”

**Paragraph 6.1.2, amend to read:**

“6.1.2. Pollutants emissions and CO<sub>2</sub> emissions ~~(for category M<sub>4</sub> and N1 vehicles only)~~ “

**Paragraph 6.1.2.4, amend to read:**

“6.1.2.4. "Pollutants" means:  
(i) carbon monoxide  
(ii) hydrocarbons assuming a ratio:  
CH<sub>1,85</sub> for petrol,  
CH<sub>1,86</sub> for diesel fuel,  
~~CH<sub>2,52</sub>~~ CH<sub>2,55</sub> for LPG for vehicles of M1 and N1 categories, CH<sub>2,57</sub> for  
LPG for vehicles of M2, M3, N2 and N3 categories,  
CH (to be defined) for dual fuel;  
(iii) oxides of nitrogen, the latter being expressed in nitrogen dioxide (NO<sub>2</sub>)  
equivalent.  
(iv) particulates, ~~etc.~~”

Justification. See the separate document “Regulations 49 and 83 – LPG reference fuel” related to the correction of LPG density in Regulations 49, 83, 101, 115, already transmitted to GFV.

**Paragraph 6.1.2.5.1.1, amend to read:**

“6.1.2.5.1.1. Three measurements of tailpipe emissions shall be performed after a cold start with each fuel:  
(i) reference petrol,  
(ii) reference LPG A,  
(iii) reference LPG B.

**The reference mass of the parent vehicle equipped with the retrofit system and tested with petrol shall be equal to that of the original vehicle. The reference mass of the parent vehicle equipped with the retrofit system and tested with LPG shall be determined according to the provision of Regulation 83.**

The emissions of CO, HC, NO<sub>x</sub> ~~and HC + NO<sub>x</sub>~~ are calculated according Regulation No. 83. 4/ “



Justification.

(i) The reference mass of a vehicle equipped with the retrofit system differs from that of the original vehicle. A question arises how to test vehicles after the retrofit.

(ii) The sum HC + NO<sub>x</sub> is subject to limitation only for diesel vehicles of M1 and N1 category. Regulation 115 does not apply to such vehicles.

**Paragraph 6.1.2.5.1.2, amend to read:**

“6.1.2.5.1.2. The test vehicle(s) equipped with the retrofit system, and with the reference petrol, shall comply with the limit values according to the type approval of the vehicle(s) including the deterioration factors applied during the type approval of the vehicle(s).

This condition is deemed to be met if the emissions values for each pollutant ~~or combination of pollutants~~ obtained in each test with reference petrol are less than the limit ~~divided by the deterioration factor~~.

~~Notwithstanding the provision of the first indent, the mono-fuel vehicle may be tested with the reference petrol before the retrofit if tests after the installation of the retrofit system are not possible or may result in false results. The total vehicle mileage between the tests before and after retrofit shall not exceed [200] km. “~~

**Paragraph 6.1.2.5.1.3, amend to read:**

“6.1.2.5.1.3. The requirements regarding emissions of the vehicle(s) equipped with the retrofit system, and with the two reference gases, shall be deemed to be fulfilled if the results meet the following conditions for each regulated pollutant ~~(CO, HC + NO<sub>x</sub>) or~~ (CO, HC, NO<sub>x</sub>) according to the requirements the petrol parent vehicle had to comply with at the date of its approval:

(1)  $(MA + MB)/2 < 0.85S + 0.4G$

(2)  $MA \text{ and } MB < G$

where:

MA: mean value of the emissions of one pollutant (CO/HC/NO<sub>x</sub>) ~~4/ or the sum of two pollutants (HC + NO<sub>x</sub>)~~ obtained from the three Type I tests with the retrofit system and with LPG A,

MB: mean value of the emissions of one pollutant (CO/HC/NO<sub>x</sub>) ~~4/ of the sum of two pollutants (HC + NO<sub>x</sub>)~~ obtained from the three Type I tests with the retrofit system and with LPG B,

S: mean value of the emissions of one pollutant (CO/HC/NO<sub>x</sub>) ~~4/ or the sum of two pollutants (HC + NO<sub>x</sub>)~~ obtained from the three Type I tests with the reference petrol,

G: limit value of the emissions of one pollutant (CO/HC/NO<sub>x</sub>) ~~4/ or the sum of two pollutants (HC + NO<sub>x</sub>)~~ according to the type approval of the vehicle(s) divided by the deterioration factors.”

**Paragraphs from 6.1.2.5.2 to 6.1.2.5.2.2 should be deleted.**

Justification. Regulation 115 is supposed to be applicable to Euro 3 and later vehicles. The CO limit value at idle for vehicles having a maximum mass exceeding 3500 kg is 3.5% vol. Such vehicles can hardly be regarded as Euro 3.

**Paragraph 6.1.2.5.3.2 and 6.1.2.5.3.3**

Comment. The calculation of fuel consumption does seem to be really required.  $K_{cons}$  is not specified in Annex 1.

**Paragraph 6.1.3.1, amend to read:**

"6.1.3.1. One LPG retrofit system sample as described in paragraph 2 of this Regulation, installed in the parent vehicle(s) or on the parent engine(s) shall be submitted to the test procedures of paragraph 6.1.3.2. or 6.1.3.3. The measured maximum power with LPG shall be lower than that measured with petrol + 5 per cent.  
Notwithstanding the provision of the first indent, mono-fuel vehicles of M1 and N1 categories may be tested with the reference petrol before the retrofit if tests after the installation of the retrofit system are not possible or may result in false results. The total vehicle mileage between the tests before and after the retrofit shall not exceed [200] km."  
Notwithstanding the provision of the first indent, vehicles of M2, M3, N2, N3 categories or their engines shall be tested with the reference diesel fuel before the retrofit. The total vehicle mileage between the tests before and after the retrofit shall not exceed [500] km. The total engine operation time between the tests before and after the retrofit shall not exceed [20] h.  
....."

Justification. Self-evident.

**Paragraph 6.1.3.2, amend to read:**

"6.1.3.2. Chassis dynamometer method:  
  
The maximum power at the wheels roller is measured on a chassis dynamometer on each parent vehicle with the following fuels:  
  
(i) reference petrol or diesel fuel,  
(ii) reference LPG A or B.  
....."

Justification and comment.

- (i) Paragraph 6.1.3.2 applies also to M2, M3, N2, N3 vehicles.
- (ii) This paragraph needs complementing, for instance:
  - two measurement methods on a chassis dynamometer may be used; constant speed method and acceleration method; which is supposed to be used in this case?
  - measurement conditions,
  - how many measurements have to be conducted?
  - correction to standard ambient conditions etc.

**Paragraph 6.1.3.3, amend to read:**

"6.1.3.3. Engine dynamometer method:

The maximum power at the crankshaft is measured on an engine dynamometer according to Regulation No. 85 for each parent vehicle(s) with the following fuels:

- (i) ~~commercial~~ reference petrol or diesel fuel,
- ~~(ii) commercial LPG,~~
- (ii) reference LPG A or B.

The mean of power measurements shall be calculated as follows:

.....  
 .....

where:

- n - number of parent vehicles/engines (i = 1 to n),
- Power<sub>petrol</sub> - mean value of maximum power measured with petrol, kW,
- Power<sub>LPG</sub> - mean value of maximum power measured with LPG A or B, kW.

.....”

**Paragraphs 8.1, amend to read:**

8.1. Every modification of the installation of the specific ~~equipment~~ retrofit system for the use of LPG and compressed natural gas in the propulsion system of the vehicle shall be notified to the authority, which granted the retrofit system type approval. The authority may then either:

**Annex 1A, item 11 and 11.1**

It is not clear what information should be given in these 2 items. A list of vehicle types for which the retrofit system is qualified and emission requirements for each of them? A list of vehicle types is given in item 3 of Addendum. As regards the emission requirements the following information are desirable:

“11.1. Emission requirements:

~~Has the retrofit system demonstrated to be "non-intrusive": yes/no-2/~~  
 Regulation 83, .....series of amendments, level A (2000), B (2005),  
 Directive 70/220/EEC as amended by Directive ....., level A (2000), B (2005),  
 Regulation 49, .....series of amendments, row A (2000), B1 (2005), B2 (2008), C (EEV),  
 Directive 88/77/EEC as amended by Directive ....., row A (2000), B1 (2005), B2 (2008), C (EEV).”

Comment. These 2 items seem to be redundant. The emission requirements (item 11.1) may be specified in item 3 of Addendum.

**Annex 1A, Addendum, item 1 needs correcting and clarifying:**

"1. Vehicles/engines on which the retrofit equipment has been tested:

Vehicle/engine No.	1	2	n
Make:			
Type:			
Category, class:			

Emission limits *:			
Maximum net power:			
Pollution control system type**:			

\* according to the type-approval of the original vehicle ?

\*\* type of catalyst if fitted (three-way, oxidation, de NO<sub>x</sub>),

air injection (with or without),

exhaust gas recirculation (EGR) (with or without).

Justification and comment.

It is not clear – category, class, emission limits, power for the original vehicle or after the retrofit?

Engines not vehicles are tested for M2, M3, N2, N3 categories.

“Class” is required – see paragraph 2.5.1.1.

### Annex 1A, Addendum, item 3, amend to read:

"3. Vehicles type(s) for which the retrofit ~~equipment~~ system type is qualified:

Fuel		Petrol (or diesel) 1/					LPG				
Vehicle type	Engine type	Power 4/ (kW)	CO 3/ (g/km)	HC 3/ (g/km)	NO <sub>x</sub> 3/ (g/km)	CO <sub>2</sub> 2/ (g/km)	Power 4/ (kW)	CO 3/ (g/km)	HC 3/ (g/km)	NO <sub>x</sub> 3/ (g/km)	CO <sub>2</sub> 2/ (g/km)

1/ Strike out what does not apply.

2/ Applicable to vehicles of category M1 and N1 only. Type-approval values of the original vehicle multiplied by K<sub>CO2</sub> shall be specified for each vehicle type.

3/ Applicable only to parent vehicle(s). The mean test results shall be specified.

4/ Type-approval values of the original vehicle multiplied by K<sub>power</sub> shall be specified for each vehicle type.

Justification. Footnotes clarify how to complete item 3.

### Annex 2A

Comment.

(i). Some approval authorities assign wrong approval numbers to the approved retrofit system. The assigned number is:

115R - 02xxxx

instead of:

115R – 00xxxx.

(ii). Nobody knows what technical information should be placed on the plate:

- names of all the components of the retrofit systems, or
- names of all the components of the retrofit systems and their manufacturer (points.....), or
- names of all the components of the retrofit systems and their make and type (points.....).

This problem needs clarifying.

### Annex 3A, item 1, amend to read:

1. Description of the parent vehicle/engine and vehicle/engine for which the retrofit system is qualified <sup>1)</sup>

<sup>1)</sup> Specify for each parent vehicle/engine and each vehicle/engine for which the retrofit system is qualified

1.1. Name and address of the manufacturer.....

1.2. Category, class and identification type.....

1.3. Chassis identification number .....

1.4. Certification number .....

Comment. It is understood that the number of the “holistic” type-approval should be specified. In the ECE system, there is no “holistic” type-approval. What number should be specified:

- for M1 – the number of EU “holistic” type-approval, Russian, Ukrainian certification etc?
- for M2, M3, N1, N2, N3 - the number of German, French, Polish etc. national type-approval?

1.x. Mass of the vehicle in running order (for M1, N1 vehicle).....

Comment. For the original vehicle or after the retrofit, depending on the decision of GFV.

1.x. Maximum mass of the vehicle

1.x. Emission requirements

- for M1, N1 vehicle: Regulation 83, .....series of amendments, level A (2000), B (2005); Directive 70/220/EEC as amended by Directive ..... level A (2000), B (2005),

-for M2, M3, N2, N3 vehicle: Regulation 49, .....series of amendments, row A (2000), B1 (2005), B2 (2008), C (EEV); Directive 88/77/EEC as amended by Directive ....., row A (2000), B1 (2005), B2 (2008), C (EEV).

1.5. Internal combustion engine identification type.....

1.5.1. Working principle and thermodynamic cycle: positive ignition/ compression ignition, four-stroke/two-stroke.....

1.5.2. Naturally aspirated or pressure charged .....

Comment. Is it really required?

~~1.5.3. Engine displacement .....~~

1.5.x. Engine maximum net power.....

Comment. Original vehicle or after the retrofit depending on the decision of GFV

1.5.x. Fuel feed and combustion process (single-point or multipoint or direct injection).

Comment. For the original vehicle (petrol feed) or after the retrofit (LPG feed) depending on the decision of GFV.

1.5.4. Catalyst system type.....

1.5.x. Air injection (with or without).....

1.5.x. Exhaust gas recirculation (with or without).....

~~4.5.5. Ignition system type~~ .....

Justification. In item 1 all particulars listed in paragraph 2.5.1 should be specified for all parent vehicles/engines and member of the family. As regards M2, M3, N2, N3 categories, those particulars should be specified for:

- parent engine(s),
- all members of the engine family,
- all vehicles for which the system is qualified.

**Annex 3A, item 2, amend to read:**

“2. Description of the LPG retrofit system <sup>2)</sup>  
.....”

<sup>2)</sup> Specify also for all alternative components, if applicable.

**Annex 3A, insert a new item to read:**

“2.19.x. Software and system strategy, all the settings included.”

Justification. See paragraph 2.2.6.

**Title page of document E/ECE/324, E/ECE/TRANS/505 Rev.2 Add. 114/Amend. 1/Corr. 1**

E/ECE/324	}	Rev.2/Add.114/Amend.1/Corr.1
E/ECE/TRANS/505		
6 March 2006		

**AGREEMENT  
CONCERNING THE ADOPTION OF UNIFORM TECHNICAL PRESCRIPTIONS FOR  
WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN BE FITTED AND/OR BE  
USED ON WHEELED VEHICLES AND THE CONDITIONS FOR RECIPROCAL  
RECOGNITION OF APPROVALS GRANTED ON THE BASIS OF THESE**

**PRESCRIPTIONS \*/**

(Revision 2, including the amendments which entered into force on 16 October 1995)

**Addendum 114: Regulation No. 115**

**Amendment 1 2 - Corrigendum 1**

Corrigendum 1 to Supplement 1 2 to the original version of the Regulation, subject of  
Depositary Notification C.N.1276.2005.TREATIES-3 dated 21 December 2005

**Please submit comments to e-mail: stanislaw.radzimirski@its.waw.pl  
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