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Retrofit Emission Control Devices (REC)

Draft new Regulation on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery (NRMM) equipped with Compression Ignition engines.

Submitted by the expert from []

The text reproduced below was prepared by the expert from [] as a result of the discussion of the informal group on retrofit emission control devices (REC) regarding a proposal for a new Regulation on REC.

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[Values], [dates], [provisions] and [parameter] not fixed yet are indicated in [square brackets], and [highlighted in yellow].

I. Proposal

Draft new Regulation on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery (NRMM) equipped with Compression Ignition engines.

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1. Purpose

This regulation provides a harmonized method for the classification, evaluation and approval of retrofit emission control systems (REC) for particulate matter oxides of nitrogen (NO_x), or for both PM and NO_x, and for the determination of the levels of emissions from compression-ignition (C.I.) engines used in applications within the scope indicated in paragraph 2.

The regulation provides a framework for approval of RECs for different applications with corresponding environmental performance levels.

2. Scope

This Regulation applies to retrofit emission control systems (REC) to be installed:

- 2.1. on category M₂, M₃ and N vehicles¹ and their C.I. engines, excluding those vehicles approved according to UN Regulation N°83,
- 2.2. on C.I. engines having a net power higher than 18 kW but not more than 560 kW installed in non-road mobile machinery¹, operated under variable speed,
- 2.3. on C.I. engines having a net power higher than 18 kW but not more than 560 kW installed in non-road mobile machinery¹, operated under constant speed,
- 2.4. on C.I. engines having a net power higher than 18 kW but not more than 560 kW installed in category T vehicles.

3. Definitions

For the purpose of this Regulation:

- 3.1. "*Active regeneration*" means any additional measure to initiate regeneration either on a periodic or continuously regenerating REC.
- 3.2. "*Adjustment factors*" means additive upward adjustment factor and downward adjustment factor or multiplicative factors to be considered during periodic regeneration;
- 3.3. "*Application range*" means the range of vehicles to which a retrofit emission control device (REC) approved according to this regulation can be applied;
- 3.4. "*Continuous regeneration*" means the regeneration process of an exhaust after-treatment system that occurs either permanently or at least once per applicable test cycle;
- 3.5. "*deNO_x system*" means an exhaust after-treatment system designed to reduce emissions of oxides of nitrogen (NO_x) (for example, passive and active lean

¹ As defined in Annex 7 to the Consolidated Resolution on the Construction of Vehicles (R.E.3), (document TRANS/WP.29/78/Rev.1/Amend.2, as last amended by Amend.4).

- NO_x catalysts, NO_x adsorbers, and selective catalytic reduction (SCR) systems);
- 3.6. "Emission control monitoring system" means the system that monitors the operation of the emission control measures implemented in the engine and/or REC system in accordance with the requirements of paragraph [---];
- 3.7. "Engine baseline emission" means the emissions of a given engine or engine system without any retrofit emission control device. For engines without after-treatment the engine baseline emissions are equal to the engine out raw emissions. For engines with after-treatment the engine baseline emissions are equal to the tailpipe emissions downstream of the after-treatment system;
- 3.8. "Engine family" means an engine manufacturer's grouping of engine systems which, through their design as defined in Paragraph 7 of Regulation 49 or Paragraph 7 of Regulation 96 as appropriate, have similar exhaust emission characteristics; all members of the family shall comply with the applicable emission limit values;
- 3.9. "engine system" means the engine, the emission control system and the communication interface (hardware and messages) between the engine system electronic control unit(s) (ECU) and any other powertrain or vehicle control unit;
- 3.10. "ESC" means a test cycle consisting of 13 steady state modes to be applied in accordance with the relevant series of amendments to UN Regulation No.49;
- 3.11. "ETC" means a test cycle consisting of 1800 second-by-second transient modes defined in, and to be applied in accordance with the relevant series of amendments to UN Regulation No.49;
- 3.12. "Load condition" means the loading of particulate matter being stored at any moment in a particulate reduction system (such as a filter) expressed as a proportion of the maximum loading of particulate matter that may be stored in the system under specific driving conditions without external regeneration measures being initiated;
- 3.13. "Gaseous pollutants" means carbon monoxide, hydrocarbons (assuming a ratio of CH_{1.85} for diesel), oxides of nitrogen (NO_x expressed as NO₂ equivalent) and nitrogen dioxide (NO₂);
- 3.14. "NO_x-reduction REC" means a REC that has a NO_x mass emission reduction efficiency which qualifies it to be certified as meeting the classification type as defined in this Regulation;
- 3.15. "NO_x reduction REC family" means a family of NO_x reduction systems that are technically identical with respect to their functioning in accordance with paragraph number 15;
- 3.16. "NRSC" means a test cycle consisting of steady state modes defined in, and to be applied in accordance with, the relevant series of amendments to UN Regulation No.96;
- 3.17. "NRTC" means a test cycle consisting of 1173 second-by-second transient modes defined in, and to be applied in accordance with, the relevant series of amendments to UN Regulation No.96;

Comment [JMY1]: Correct reference to be discussed with GRPE secretariat.

Comment [JMY2]: Correct reference to be discussed with GRPE secretariat.

Comment [JMY3]: Correct reference to be discussed with GRPE secretariat.

Comment [JMY4]: Correct reference to be discussed with GRPE secretariat.

- 3.18. “*Particulate matter (PM)*” means the mass of any material collected on a specified filter medium which is defined in the relevant series of amendments to UN Regulations No.49 or 96;
- 3.19. “*Particulate reduction REC*” means a REC that has a particulate mass or number emission reduction efficiency which qualifies it to be certified as meeting the classification type as defined in this Regulation. The regeneration system and strategy are part of the particulate reduction REC;
- 3.20. “*Particulate reduction REC family*” means a family of particulate reduction systems that are technically identical with respect to their functioning in accordance with paragraph number 14;
- 3.21. “*Periodic regeneration*” means the regeneration process of an emission control device that occurs periodically in typically less than 100 hours of normal engine operation. During cycles where regeneration occurs, emission standards can be exceeded;
- 3.22. “*PM number*” means the number of particles which is defined in the relevant series of amendments to UN Regulation No.49 (this definition is not used in the current provisions)...
- 3.23. “*Reagent*” means any medium that is stored on-board the vehicle in a tank and provided to the exhaust after-treatment system (if required) upon request of the emission control system;
- 3.24. “*Reduction efficiency*” means the ratio between the emissions downstream of the REC system (E_{REC}) and the engine baseline emissions (E_{Base}) and both measured in accordance with the procedures defined in this Regulation and calculated as defined in paragraph 8.3.4;
- 3.25. “*Reduction level*” means a reduction efficiency in percent to be met by the retrofit emission control device (REC) in order to be certified as meeting the reduction level specified in paragraph 8.3;
- 3.26. “*Retrofit emission control device (REC)*” means any particulate reduction system, NO_x -reduction system or combination of both which is used for retrofit purposes. This includes any sensors and software essential to the operation of the device. Systems that only modify the existing engine system controls are not considered to be RECs;
- 3.27. “*Type I retrofit emission control device (REC)*” means a retrofit emission control device which is intended to control particulate matter emissions only, and which does not increase the direct NO_2 emissions;
- 3.28. “*Type II retrofit emission control device (REC)*” means a retrofit emission control device which is intended to control particulate matter emissions only, and which does not increase the direct NO_2 emissions by more than the percentage specified in paragraph 8.4.2 based on the engine baseline emission NO_2 level;
- 3.29. “*Type III retrofit emission control device (REC)*” means a retrofit emission control device which is intended to control NO_x emissions only;
- 3.30. “*Type IV retrofit emission control device (REC)*” means a retrofit emission control device which is intended to control both particulate matter emissions and NO_x emissions, and thus NO_2 emissions;

Comment [JM5]: Correct reference to be discussed with GRPE secretariat.

- 3.31. "WHSC" means a test cycle consisting of 13 steady state modes defined in, and to be applied in accordance with the relevant series of amendments to UN Regulation No.49;
- 3.32. "WHTC" means a test cycle consisting of 1800 second-by-second transient modes defined in, and to be applied in accordance with the relevant series of amendments to UN Regulation No.49;

4 Application for approval

- 4.1. The application for approval of an REC shall be submitted by the manufacturer or by his duly accredited representative,
- 4.2. Each REC shall be accompanied by the following information:
- (a) the manufacturer's name or trade mark;
 - (b) the make and identifying part number of the REC as recorded in the information document issued in accordance with the model set out in Annex 1;
 - (c) the Application Range (as defined in paragraph 10) including year of manufacture, for which the REC is approved, including, where applicable, a marking to identify if the REC is suitable for fitting to a vehicle that is equipped with an on-board diagnostic (OBD) system;
 - (d) the instruction manual for the retrofit installation;
 - (e) the end-user service manual including maintenance instructions.
- 4.3. The applicant shall provide sample(s) of the REC to be tested and to be retained by the Technical Service.

5. Markings

- 5.1. All REC shall be marked with the trade name or mark of the retrofit manufacturer as indicated in Annex 1, and the identifying part number as recorded in the information document issued in accordance with the model set out in Annex 1.
- 5.2. All REC shall be identified by a **plate label**, in which the approval mark including the type and reduction level, as set out in Annex 3 shall be placed. This **plate label** has to be permanently fixed to the REC, ~~shall be indelible,~~ and shall be clearly readable after installation of the REC,
- 5.2.1 **Label Properties**
Labels shall be durable for the useful life of the engine. Labels shall be clearly legible and their letters and figures shall be indelible. Additionally, labels shall be attached in such a manner that their fixing is durable for the useful life of the engine, and the labels cannot be removed without destroying or defacing them.
- 5.3. REC samples for approval testing have to be clearly identified with at least the applicant's name and the **reference of the** application.
- 5.4. An international approval mark shall be affixed to ~~the~~ a REC **conforming to a type approved under this Regulation** as indicated in Annex 3, ~~conforming to a type approved under this Regulation,~~ in addition to the mark prescribed in

paragraphs 5.1. and 5.2. This approval mark shall consist of:

- 5.4.1. A circle surrounding the letter "E" followed by the distinguishing number of the country which has granted the approval².
- 5.4.2. The number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle as defined Annex 3. The approval number appears in the communication form for this type (see paragraph 6.2. and annex 2) preceded by two figures indicating the latest series of amendments to this Regulation.
- 5.4.3 The Type and Reduction Level of the REC.

Comment [JMY6]: To be confirmed with UN secretariat that it is permissible to include the Reduction Level in the mark

6. Approval

- 6.1. Type approval shall be granted if the REC meets the requirements of this Regulation.
- 6.2. An approval number shall be assigned to each REC approved. Its first two digits (at present 00 according to the Regulation in its original form) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same type approval number shall not be assigned to another REC.
- 6.3. Notice of approval or of refusal or of extension of approval of a REC pursuant to this Regulation shall be communicated to the Parties to the Agreement applying this Regulation, by means of a Communication conforming to the model in Annex 2 to this Regulation.

7. General requirements

- 7.1. The REC shall be designed, constructed and capable of being mounted so as to enable the application to comply with the rules set out in this Regulation throughout the normal life of the REC under normal conditions of use.

² /

1 for Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Serbia and Montenegro, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for Russian Federation, 23 for Greece, 24 for Ireland, 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32 for Latvia, 33 (vacant), 34 for Bulgaria, 35 (vacant), 36 for Lithuania, 37 for Turkey, 38 (vacant), 39 for Azerbaijan, 40 for The former Yugoslav Republic of Macedonia, 41 (vacant), 42 for the European Community (Approvals are granted by its Member States using their respective ECE symbol), 43 for Japan, 44 (vacant), 45 for Australia, 46 for Ukraine, 47 for South Africa and 48 for New Zealand. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify the Agreement Concerning the Adoption for 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 Approval Granted on the Basis of these Prescriptions, and the numbers, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement. To be updated as necessary by GRPE secretariat.

- 7.2. The REC shall be durable. That is, it shall be designed, constructed and capable of being mounted so that reasonable resistance is obtained to phenomena such as the corrosion, oxidation, vibration and mechanical stress to which it will be exposed under normal conditions of use. Specific durability requirements are in paragraph 9.
- 7.3. For REC requiring a reagent **or additive**, each separate **reagent storage** tank installed on a vehicle or machine shall include means for taking a sample of any fluid inside the tank. The sampling point shall be easily accessible without the use of any specialised tool or device.
- 7.4. Where a REC requires the use of a reagent **or additive**, the driver or machine operator shall be informed of the level of reagent **or additive** in the **reagent storage** tank on the vehicle or machine through a specific mechanical or electronic indication. This indication shall include a specific warning (such as a warning lamp or clear mechanical indication) when the level of reagent goes either:
- (a) Below 10 per cent of the tank or a higher percentage at the choice of the manufacturer, or;
- (b) Below a level corresponding to 12 hours of usage of the vehicle or machine under average conditions of operation.
- The reagent level indicator and the warning indicator shall both be placed in close proximity to the fuel level indicator.
- 7.5. Devices that by-pass or reduce the efficiency of the REC are not permitted.
- 7.6. NOx control: Reagent quality and dosing requirements; freezing protection.

Comment [JMY7]: OICA/Euromot to be inserted when available

8. Performance requirements

- 8.1. REC approved under this regulation shall meet ~~both~~ **all** of the following criteria
- the emission limit values as specified in paragraph 8.2.
 - the reduction levels as specified in paragraph 8.3.
 - **the NO₂ emission requirements specified in paragraph 8.4.**
 - **the secondary emissions requirements specified in paragraph 8.6.**
- 8.2. Limit values
- The retrofitted engine system shall meet at least the limits of the next more stringent emission stage for the relevant pollutants (NO_x ~~and~~ or PM, **or both as appropriate for the REC Type**) with respect to the limits of Regulation No. 49 and No. 96 based on the engine baseline emissions, as measured using the test procedure(s) associated with the limit values to be achieved. **The retrofitted engine system shall meet at least the limits for the stage to which the base engine was approved for each of the other controlled pollutants relevant to that stage.**
- 8.2.1. The requirements for each type of REC **in terms of meeting the limits of the next more stringent emission stage** are illustrated in the tables ~~below~~.

Comment [S8]: The editorial group suggests moving these tables into an Annex [9] to improve clarity.

Table 8.1: Equivalence REC matrix for Regulation No.49 - Standard series

Emissions limits in g/kWh.

Baseline*	Component	Type I/II To the standard of				Type III To the standard of			Type IV To the standard of				
		A	B1	B2	C	A	B1	B2	A	B1	B2	C	
Before A	NO _x	(ESC)	-	-	-	-	5.0	3.5	2.0	5.0	3.5	2.0	2.0
		(ETC)	-	-	-	-	5.0	3.5	2.0	5.0	3.5	2.0	2.0
	PM	(ESC)	0.10 ⁽¹⁾	0.02	0.02	0.02	-	-	-	0.10 ⁽¹⁾	0.02	0.02	0.02
		(ETC)	0.16 ⁽²⁾	0.03	0.03	0.02	-	-	-	0.16 ⁽²⁾	0.03	0.03	0.02

(1) 0.13 g /kWh for engines having a swept volume of less than 0.75 dm³ per cylinder and a rated power speed of more than 3,000 min⁻¹(2) 0.21 g /kWh for engines having a swept volume of less than 0.75 dm³ per cylinder and a rated power speed of more than 3,000 min⁻¹

Baseline*	Component	Type I/II To the standard of				Type III To the standard of			Type IV To the standard of				
		B1	B2	C		B1	B2	C	B1	B2	C		
A	NO _x	(ESC)	-	-	-		3.5	2.0	2.0	3.5	2.0	2.0	
		(ETC)	-	-	-		3.5	2.0	2.0	3.5	2.0	2.0	
	PM	(ESC)	0.02	0.02	0.02		-	-	-	0.02	0.02	0.02	
		(ETC)	0.03	0.03	0.02		-	-	-	0.03	0.03	0.02	

Baseline*	Component	Type I/II To the standard of				Type III To the standard of			Type IV To the standard of				
		B2	C	D		B2	C	D	B2	C	D		
B1	NO _x	(ESC)	-	-	-		2.0	2.0		2.0	2.0	-	
		(ETC)	-	-	-		2.0	2.0		2.0	2.0	-	
		(WHSC)	-	-	-		-	-	0.4	-	-	0.4	
		(WHTC)	-	-	-		-	-	0.46	-	-	0.46	
	PM	(ESC)	0.02	0.02	-		-	-	-	0.02	0.02	-	
		(ETC)	0.03	0.02	-		-	-	-	0.03	0.02	-	
		(WHSC)	-	-	0.01		-	-	-	-	-	0.01	
		(WHTC)	-	-	0.01		-	-	-	-	-	0.01	

Baseline *	Component	Type I/II To the standard of				Type III To the standard of				Type IV To the standard of				
		C	D			C	D			C	D			
B2	NO _x	(ESC)	-	-			2.0	-			2.0	-		
		(ETC)	-	-			2.0	-			2.0	-		
		(WHSC)	-	-			-	0.4			-	0.4		
		(WHTC)	-	-			-	0.46			-	0.46		
	PM	(ESC)	0.02	-			-	-			0.02	-		
		(ETC)	0.02	-			-	-			0.02	-		
		(WHSC)	-	0.01			-	-			-	0.01		
		(WHTC)	-	0.01			-	-			-	0.01		

* where the baseline corresponds to that in Tables 1 and 2 of the 05 series of amendments to UN Regulation No. 49.

* Where A, B1, B2 and C correspond to the limit values in Tables 1 and 2 of the 05 series of amendments to UN Regulation No. 49 and D corresponds to the limit values in the 06 series of amendments to UN Regulation 49.

Note: The table shows emission limits in g/kWh that would have to be met in order to achieve equivalence to the standard shown from each baseline. The efficiency requirements detailed in paragraph 8.3 may require that the measured emissions are lower than these limit values.

Table 8.2:

REC Equivalence Matrix for Regulation No. 96 / REC Type I / II

Baseline	net. Power	Component g / kWh	Type I / II									
			H	I	J	K	L	M	N	P	Q	R
E	$130 \leq P \leq 560$	PM	-	-	-	-	0,025	-	-	-	0,025	-
F	$75 \leq P \leq 130$	PM	-	-	-	-	-	0,025	-	-	-	0,025
G	$37 \leq P \leq 75$	PM	-	-	-	-	-	-	0,025 ⁽¹⁾	-	-	0,025 ⁽¹⁾
D	$18 \leq P \leq 37$	PM	-	-	-	0,6 ⁽²⁾	-	-	-	-	-	-
H	$130 \leq P \leq 560$	PM	-	-	-	-	0,025	-	-	-	0,025	-
I	$75 \leq P \leq 130$	PM	-	-	-	-	-	0,025	-	-	-	0,025
J	$37 \leq P \leq 75$	PM	-	-	-	-	-	-	0,025 ⁽¹⁾	-	-	0,025 ⁽¹⁾
K	$19 \leq P \leq 37$	PM	-	-	-	-	-	-	-	-	-	-
L	$130 \leq P \leq 560$	PM	-	-	-	-	-	-	-	-	-	-
M	$75 \leq P \leq 130$	PM	-	-	-	-	-	-	-	-	-	-
N	$56 \leq P \leq 75$	PM	-	-	-	-	-	-	-	-	-	-
P	$37 \leq P \leq 56$	PM	-	-	-	-	-	-	-	-	-	-

(1) only for engines with net power > 56 kW

(2) only for engines with net power > 19 kW

where the baseline corresponds to that in Regulation No.96 revision n.

Comment [JMY9]: Correct reference be checked with GRPE secretariat.

Table 8.3:

REC Equivalence Matrix for Regulation No. 96 / REC Type III

Baseline	net. Power	Component g / kWh	Type III										
			H	I	J	K	L	M	N	P	Q	R	
E	$130 \leq P \leq 560$	NOx	4,0 ⁽³⁾	-	-	-	-	2.0	-	-	-	0.4	-
F	$75 \leq P \leq 130$	NOx	-	4,0 ⁽³⁾	-	-	-	-	3.3	-	-	-	0,4 ⁽¹⁾
G	$37 \leq P \leq 75$	NOx	-	-	4,7 ⁽³⁾	-	-	-	-	3,3 ⁽¹⁾	-	-	-
D	$18 \leq P \leq 37$	NOx	-	-	-	7,5 ⁽²⁾	-	-	-	-	-	-	-
H	$130 \leq P \leq 560$	NOx ⁽³⁾	-	-	-	-	-	2.0	-	-	-	0.4	-
I	$75 \leq P \leq 130$	NOx ⁽³⁾	-	-	-	-	-	-	3.3	-	-	-	0,4 ⁽¹⁾
J	$37 \leq P \leq 75$	NOx ⁽³⁾	-	-	-	-	-	-	-	3,3 ⁽¹⁾	-	-	0,4 ⁽¹⁾
K	$19 \leq P \leq 37$	NOx ⁽³⁾	-	-	-	-	-	-	-	-	-	-	-
L	$130 \leq P \leq 560$	NOx	-	-	-	-	-	-	-	-	-	0.4	-
M	$75 \leq P \leq 130$	NOx	-	-	-	-	-	-	-	-	-	-	0.4
N	$56 \leq P \leq 75$	NOx	-	-	-	-	-	-	-	-	-	-	0.4
P	$37 \leq P \leq 56$	NOx	-	-	-	-	-	-	-	-	-	-	-

(1) only for engines with net power > 56 kW

(2) only for engines with net power > 19 kW

(3) sum of hydrocarbons and oxides of nitrogen

where the baseline corresponds to that in Regulation No.96 revision n.

Comment [JMY10]: Correct referen
to be checked with GRPE secretariat

Table 8.4:
REC Equivalence Matrix for Regulation No. 96 / REC Type IV

Baseline	net. Power	Component	Type IV										
			H	I	J	K	L	M	N	P	Q	R	
E	130 ≤ P ≤ 560	PM	-	-	-	-	0,025	-	-	-	-	0,025	-
		NOx	4,0 ⁽³⁾	-	-	-	2,0	-	-	-	-	0,4	-
F	75 ≤ P ≤ 130	PM	-	-	-	-	-	0,025	-	-	-	-	0,025
		NOx	-	4,0 ⁽³⁾	-	-	-	3,3	-	-	-	-	0,4 ⁽¹⁾
G	37 ≤ P ≤ 75	PM	-	-	-	-	-	-	0,025 ⁽¹⁾	-	-	-	0,025 ⁽¹⁾
		NOx	-	-	4,7 ⁽³⁾	-	-	-	3,3 ⁽¹⁾	-	-	-	-
D	18 ≤ P ≤ 37	PM	-	-	-	0,6 ⁽²⁾	-	-	-	-	-	-	-
		NOx	-	-	-	7,5 ⁽²⁾	-	-	-	-	-	-	-
H	130 ≤ P ≤ 560	PM	-	-	-	-	0,025	-	-	-	-	0,025	-
		NOx ⁽³⁾	-	-	-	-	2,0	-	-	-	-	0,4	-
I	75 ≤ P ≤ 130	PM	-	-	-	-	-	0,025	-	-	-	-	0,025
		NOx ⁽³⁾	-	-	-	-	-	3,3	-	-	-	-	0,4 ⁽¹⁾
J	37 ≤ P ≤ 75	PM	-	-	-	-	-	-	0,025 ⁽¹⁾	-	-	-	0,025 ⁽¹⁾
		NOx ⁽³⁾	-	-	-	-	-	-	3,3 ⁽¹⁾	-	-	-	0,4 ⁽¹⁾
K	19 ≤ P ≤ 37	PM	-	-	-	-	-	-	-	-	-	-	-
		NOx ⁽³⁾	-	-	-	-	-	-	-	-	-	-	-
L	130 ≤ P ≤ 560	PM	-	-	-	-	-	-	-	-	-	-	-
		NOx	-	-	-	-	-	-	-	-	-	0,4	-
M	75 ≤ P ≤ 130	PM	-	-	-	-	-	-	-	-	-	-	-
		NOx	-	-	-	-	-	-	-	-	-	-	0,4
N	56 ≤ P ≤ 75	PM	-	-	-	-	-	-	-	-	-	-	-
		NOx	-	-	-	-	-	-	-	-	-	-	0,4
P	37 ≤ P ≤ 56	PM	-	-	-	-	-	-	-	-	-	-	-
		NOx	-	-	-	-	-	-	-	-	-	-	-

(1) only for engines with net power > 56 kW

(2) only for engines with net power > 19 kW

(3) sum of hydrocarbons and oxides of nitrogen

where the baseline corresponds to that in Regulation No.96 revision n.

Comment [JMY11]: Correct referen
to be checked with GRPE secretariat

8.3. Reduction levels

8.3.1 The reduction level of a REC system is characterised by means of its reduction efficiency as specified in Table 8.5:

Table 8.5:

Reduction levels

	Minimum reduction efficiency (%)	
	PM mass	NOx
Reduction level 1	50	[50]

- 8.3.2. The reduction efficiency shall be determined by comparison of the emissions measured over the WHTC for RECs to be applied to heavy-duty engines or over the NRTC for RECs to be applied to NRMM or Tractor engines. The reduction efficiency shall be calculated as defined in 8.3.4.
- 8.3.3. For the purpose of this regulation the reduction efficiency for NO_x shall be applicable to systems which are intended to reduce NO_x, and the PM reduction level to systems intended to reduce PM. For Type IV REC the reduction levels for both NO_x and PM shown in Table 8.5 of this Regulation must be met.
- 8.3.4. The reduction efficiency shall be calculated from the measured emissions of the relevant pollutant downstream of the REC system (E_{REC}) and the engine system emissions measured before fitment of the REC (E_{Base}) for that pollutant, both measured in accordance with the procedures defined in this Regulation.

$$\text{reduction efficiency (\%)} = (1 - (E_{REC} \div E_{Base})) \times 100.$$

- 8.4. NO₂ emissions requirements
- 8.4.1. For a Type I REC, there shall be no incremental increase in NO₂ emissions above the NO₂ baseline emissions, measured as defined in Annex 5.
- 8.4.2. For a Type II REC, the NO₂ incremental increase shall not be more than 30 percentage points greater than the level recorded when no REC is fitted (baseline). As an example, if baseline NO₂ is 10% of NO_x, the maximum permitted NO₂ emission with the REC is 40% of NO_x measured as defined in Annex 5.
- 8.4.3. For Type III RECs, there should be no increase of NO₂ emissions measured in g/kWh and as defined in Annex 6.
- 8.4.4. For Type IV RECs, there should be no increase of NO₂ emissions measured in g/kWh and as defined in Annex 7.
- 8.5. [This paragraph is reserved for future use.]
- 8.6. ~~Other~~ Secondary emissions requirements
- 8.6.1. Emissions of ammonia shall not exceed a mean value of 25 ppm when measured using the procedures defined in the [06] series of amendments to Regulation 49.
- 8.6.2. The manufacturer of the REC system shall provide documentary evidence to show that materials and processes used in the REC do not present any additional hazard to health and the environment.
- 8.6.2.1. The REC shall not increase secondary emissions to concentrations known to be hazardous to health. For the purposes of this Regulation secondary emissions produced at concentrations not significantly higher than the concentrations produced by emission control systems fitted as original equipment on engines type-approved in accordance with the requirements of Regulation 96 or Regulation 49, as appropriate, shall be considered not to be hazardous to health.
- 8.6.2.2. The applicant for approval shall provide the approval authority with an assessment of the performance of the REC with respect to secondary emissions. The assessment shall address all likely secondary emissions from the REC having regard to its working principle, its design, its method of construction, and the materials employed.

- 8.6.2.3 The assessment shall, in particular,
- a) in cases where the REC contains copper or copper compounds, address the possible formation of dioxins.
 - b) in cases where the REC makes use of a fuel-borne catalyst, consider the impact upon the production of secondary emissions of
 - i) the absence of that catalyst and
 - ii) its presence at up to twice the recommended or intended concentration.
- 8.6.2.4 The assessment shall name each of the species of secondary emissions considered.
- 8.6.2.5 The assessment may be based upon sound engineering analysis and judgement, upon the results of tests or simulations, upon the results of analysis or tests of similar systems or technologies, or upon any combination of these elements.
- 8.6.3. The applicant may be required to perform tests for secondary emissions as a prerequisite for approval in cases where the assessment of the performance of the REC with respect to secondary emissions produces a reasonable expectation that the requirements of paragraph 8.6.2 will not be met, but not otherwise.

9. Durability requirements

- 9.1. The applicant shall declare that the REC system when used and maintained according to the manufacturer's instructions will comply with the applicable provisions during normal operation over a useful life of:
- a) for category M₂ and M₃ and N vehicles, a mileage of 200 000 km or a service life of 6 years, whichever occurs first,
 - b) for all other applications, 4 000 operating hours or a service life of 6 years, whichever occurs first.
- 9.2. The applicant shall conduct a 1 000 hours durability test on an engine and REC combination. This test shall be either a field test in a typical vehicle or machine application agreed between the Type Approval Authority and the applicant or a test [using an appropriate duty cycle] on an engine test bed. The engine for the durability run may be different from the test engine used for tests to establish the reduction level of the REC, but must be an engine within the declared application range of the particular REC.
- 9.3. The content of the test is as follows:
- 1 000 hours ~~durability run~~ service accumulation of the REC with recording of all relevant operating data of the engine concerned including continuous second-by-second data logging of exhaust temperature before the REC and pressure loss over the REC, type and consumption of fuel and lubricating oil. In the case of a field test the REC must be sealed by the Technical Service and the data-logging shall be carried out by the REC manufacturer or by the operator of the vehicle or machine on which the endurance test is performed.
 - In the case of REC that operate with additives or makes use of a reagent, verification of the correct dosing rate shall additionally be performed at the

beginning of the field test, after 500 hours of operation and after 1 000 hours of operation.

- 9.4. After completion of the durability run the REC system used to demonstrate durability shall be used for any further evaluation testing with the original test engine.

In the event that the original test engine is no longer functional, an engine of the same type may be used with the prior agreement of the approval authority.

- 9.5. ~~After completion of the durability run, the REC system needs to fulfil the appropriate requirements.~~ The REC system must meet the requirements of section 8 when tested in accordance with section 9.4 after completion of the service accumulation.

10. Application range

The application range describes the range of engines or engine systems to which the REC family may be applied. The applicant shall provide detailed information about the application range to the Type Approval Authority / Technical Service as specified in Annex 4.

The application range is defined by the engine family to which the test engine as defined in paragraph 12 belongs.

The application range may be extended to

- a) other engines produced by the same engine manufacturer, and
- b) engines of other engine manufacturers

if the applicant can demonstrate that the following ~~criteria~~ features of the engines concerned are the same as those in the test engine:

- (i) individual cylinder displacement within [$\pm 20\%$] of the test engine
- (ii) method of aspiration (turbocharged or normally-aspirated engine)
- (iii) with or without EGR
- (iv) whether a constant speed or a variable speed engine³
- (v) engine baseline emission stage and
- (vi) with or without an aftertreatment system.

11. Modifications to engine baseline emissions

- 11.1. Any engine operation parameter specified by the original engine manufacturer, such as maximum allowable exhaust gas back pressure or limits set for impact of external devices upon the electrical or data handling systems, ~~[to be completed]~~ shall not be affected by the REC. ~~Back pressure modifications can be allowed by~~ Modifications to any of the parameters specified by the original engine manufacturer that result in them failing to meet the engine manufacturer's specification are allowed with the written permission of the original engine manufacturer.

³ An engine approved to Regulation 49 will be considered a variable speed engine for this purpose.

Comment [DB12]: Mr Schulte will propose some additional wording to clarify 'application range'

- 11.2. In cases where additional measures with respect to emission-relevant components and / or system components, such as modifications to the exhaust gas recirculation (EGR) control, are necessary in order to ensure proper functioning of the engine and exhaust after-treatment systems in conjunction with the REC, the applicant shall provide a detailed description of the design modification along with an explanation of how the modification will change the operation and performance of the emission control strategy. To support its claims, the applicant shall submit additional test data, engineering justification and analysis, or any other information deemed necessary by the Type Approval Authority or Technical Service to address the differences between the modified and original designs.
- 11.3. The emission control system of the original engine manufacturer shall not be modified, except for:
- a) modifications allowed by written permission of the original engine manufacturer or
 - b) in the case of a Type I or Type II REC, replacement of an existing diesel oxidation catalyst providing that
 - i) the requirements of paragraph 8.4 are met and that
 - ii) the retrofitted engine system meets at least the limits for the stage to which the base engine was approved for each of the other controlled pollutants relevant to that stage.
- 11.4. Notwithstanding the requirements of paragraphs 11.1. to 11.3, no ~~Any~~ modification upstream of an original de-NOx system is ~~not~~ allowed.
- 11.5. ~~Subject to the requirements of paragraph 11.1. being met, modifications downstream of an original aftertreatment system are allowed~~ ~~permissible if the above mentioned parameters defined by the original engine manufacturer are not affected.~~
- 11.6. The performance of any On-Board Diagnostics (OBD) system and NOx control system of the original engine system shall not be compromised by the REC.

Comment [JMY13]: For discussion

12. Choice of the test engines and REC combination

- 12.1. The test engines shall originate from an engine family corresponding to the subsequent application range of the REC. The emissions performance of the test engine shall be measured and ~~shall~~ meet the limits for the applicable baseline emission stage.
- 12.2. The test engine and REC combination for the selected application range shall meet the following criteria:
- a) the engine shall have a nominal power output between 100% and 60% of the maximum power of the parent engine in the particular family when assessed in accordance with the procedures of UN Regulation 49 ~~and/~~ or Regulation 96 ~~as appropriate~~;
 - b) ~~when combined with the selected test engine~~ the REC shall have the highest space velocity within the application range of the REC ~~family combined with the selected test engine~~;
 - c) the REC shall have the minimum ~~total-charge~~ ~~volumetric concentration~~ of catalytically active materials specified by the manufacturer for the REC family.

When the requirements of sub-paragraph b) and sub-paragraph c), above, are mutually incompatible, the requirements of sub-paragraph b) shall take priority.

- 12.3. For REC intended to be used on engines type-approved in accordance with Regulation No.96, testing on one test engine for each power category for which the REC is intended is mandatory.
- 12.4. The selected test engine must comply in both series production condition and in retrofitted condition with all of the pollutant emissions limits associated with the stage or standard to which it was originally type-approved. Where vehicles or machines are fitted with on-board diagnostic systems those systems shall not be affected with respect to their monitoring function after the retrofit system has been installed. The characteristics of the electronic engine control unit (as regards, for example, injection timing, air-mass flow metering, or exhaust emissions reduction strategies) shall not be altered by the retrofitting. Any modification of the test engine that changes the original emission behaviour (e.g. alternation of the injection timing) is not permitted.

13. Specifications concerning emissions measurement

- 13.1. The gaseous and particulate components emitted by the engine or engine system in combination with the REC submitted for testing shall be measured by the methods described in the applicable annexes of Regulation 49 and Regulation 96.
- 13.2. If a heated chemiluminescent detector (CLD) is used for the determination of NO₂ in accordance with paragraph 8.4, two parallel measuring chambers to determine NO_x and NO simultaneously shall be used. Two CLDs in parallel are permitted providing that they both comply with the requirements of Regulation 49 or Regulation 96 as appropriate, and the absolute converter efficiencies are shown to be within 3% of each other.

14. Particulate reduction REC family

- 14.1. The approval of a particulate reduction REC will continue to be valid for a nominally similar system in a different configuration or application provided that it does not deviate from the tested system with respect to the following features:
- a) Type of retention of the active element (for example, adhesive or mechanical fixing), and functioning
 - b) Working principle of the ~~reduction material~~ active element (for example, ~~adhesive or mechanical fixing~~, metallic or ceramic material, barrier filtration or aerodynamic separation);
 - c) Design and characteristics of the filter or other active material (for example, whether it consists of sheets or plates, or is braided or wound, the cell, material, or non-woven density, the porosity and pore diameter of barrier filter media, the number of pockets, blades or balls in aerodynamic separators, the surface roughness of critical components, and the diameters of wires, balls, or fibres);

- d) Minimum ~~total charge~~ volumetric concentration of catalytically active materials of the particulate reduction system including upstream catalysts (if fitted) (grams/m³);
- e) Maximum ~~total charge~~ volumetric concentration of catalytically active materials of the particulate reduction system including upstream catalysts (if fitted) (grams/m³);
- f) The design characteristics of the canning or packaging (for example, the storage or retention of the carrier of the active elements);
- g) Volume of each active component (e.g. DOC, filter substrate) which must be within $\pm 40\%$ of the volume of the tested device;
- h) Type of regeneration (whether periodic or continuous);
- i) Regeneration principle (for example, catalytic, thermal, or electrothermal) and regeneration strategy (for example passive, active, forced);
- j) Method and control strategy for introducing additives or reagents (if used);
- k) Type of additive or reagent (if used);
- l) Installation conditions (max. + 0.5 m introduction difference between the turbocharger outlet (turbine) and the inlet of the particulate reduction REC);
- m) Type of any catalytically active material;
- n) With or without an upstream oxidation catalyst.
- o) Where the tested device was tested in association with other pollution control devices, the retention of the same arrangement of devices for the REC under consideration [and the other pollution control devices being similar in design and principle of operation to those used during testing];

- 14.2. When testing the particulate reduction REC on the engine test bed, the REC must be fitted so that there is a distance of at least 2 metres to the REC inlet from the outlet of the turbocharger (turbine) or the outlet plane of the exhaust manifold where no turbocharger is fitted. If the applicant can show that a distance shorter than the minimum distance specified here will be used in all subsequent applications of the REC, the length of the pipe used in the test cell may be correspondingly reduced. Insulation or similar means of maintaining the exhaust temperature are permissible only if they will also be used in the subsequent installation of the REC on the vehicle or machine.

15. NO_x reduction REC family

- 15.1. The approval of a NO_x reduction REC will continue to be valid for a nominally similar system (employing the same NO_x reduction technology) in a different configuration or application provided that it does not deviate from the tested system with respect to the following features:
- a) Critical dimensions of the active elements of the device (such as the size of valves or ducts, or the volume of a catalytic element, and including any reagent mixing device) must be the same as those on the tested device, or must not differ from those dimensions in the tested device by an amount greater than can be justified as insignificant by relevant tests or robust

Comment [JMY14]: Copy of proposed wording for section 15.1 c). REC-10 proposed addition of this to section 14.

engineering analysis. The active volume, for instance, of a catalytic element must be within $\pm 40\%$ of the active volume of the tested device;

b) Any temperature control method employed (for example, catalytic, thermal, or electrothermal heating);

c) Where the tested device was tested in association with other pollution control devices, the retention of the same arrangement of devices being retained for the device-REC under consideration [and the other pollution control devices being similar in design and principle of operation to those used during testing];

d) The catalyst substrate material and the mechanical design of the substrate (for example a coated monolith or an extruded monolith, sheets or plates) and the shape, cross-sectional area, and density of the exhaust gas channels formed in it;

e) The same catalytically active material, washcoat, loading and catalyst distribution over the substrate as the Type Approved system, within reasonable production tolerances;

f) Type of reagent or additive (if used);

g) Any control strategy employed, including features of the implementation of that strategy such as delay periods, dosing rates for reagents, the positioning and characteristics of sensors, and the time constants and flow characteristics associated with valves. If different reagents and/or strategies are used for different climatic conditions the strategy with the lowest total dosing during the test shall be tested;

h) The reagent introduction location and conditions. This condition will be considered to have been met if the introduction point is at least the same distance from inlet of the catalyst as the tested device and the means of reagent introduction (e.g. for example, air assisted or not) and any the same mixing device (if any) are also the same.

- 15.2. When testing the NO_x reduction REC in an engine test cell, the REC must be fitted so that there is a distance of at least 2 metres from the outlet of the turbocharger (turbine), or the exit flange of the exhaust manifold in the case of an engine not fitted with a turbocharger, to the REC inlet. If the applicant can show that a distance shorter than the minimum distance specified here will be used in all subsequent applications of the REC, the length of the pipe used in the test cell may be correspondingly reduced. Insulation or similar means of maintaining the exhaust temperature are permissible only if they will also be used in the subsequent installation of the REC on the vehicle or machine.

16. NO_x and PM reduction REC family

The approval of a NO_x and PM REC system will continue to be valid for a nominally similar system in a different configuration or application provided that it does not deviate from the tested system with respect to the following features:

a) The PM reduction elements of the REC are in conformance with the requirements of paragraph 14 of this Regulation.

b) The NO_x reduction elements of the REC are in conformance with the requirements of paragraph 15 of this Regulation.

c) The location of the PM and NO_x reduction REC-elements of the REC device relative to each other is the same as the relationship between these elements in the tested device (for example the PM REC upstream of the NO_x REC).

Devices where PM and NO_x reduction are performed on the same substrate may not be considered to be in the same family as devices where the two activities are performed on separate substrates.

17. Fuel and fuel consumption

17.1. The testing of the REC shall be conducted with commercially available fuel representative of that generally used for the type of vehicle or machine to which the REC will be fitted.

17.2. The REC manufacturer may, as an alternative to using market fuel, apply to the Approval Authority for permission to perform the tests on the REC using a reference fuel. The reference fuel to be used in this case will be the appropriate fuel specified in either Regulation No. 49 or Regulation No. 96. ~~for testing of engines for type approval to the standard indicated in paragraph 4 that the vehicle or machine is intended to achieve after the REC under test has been fitted.~~

17.3. The specific fuel consumption of the engine fitted with the ~~PM REC and/or NO_x REC~~ during the applicable test cycles (annex 5, para. 6.5 & 6.6) shall be not more than 4% greater in the retrofitted condition than the mean specific consumption in the non-retrofitted condition.

[17.3 The specific fuel consumption of the engine fitted with the REC during the applicable test cycles shall be measured, and the percentage change in the specific fuel consumption between the retrofitted condition and the non-retrofitted condition shall be recorded in the information document if it is greater than [1%].

The measurements for determining the fuel consumption may be carried out in parallel with the measurements carried out in accordance with paragraph [---] for continuously regenerating systems or carried out in accordance with paragraph [---] for periodically regenerating systems. If the fuel consumption measurements (for technical or other reasons) are not carried out in parallel with the measurements to establish the reduction level of the REC, then they must be carried out using an identical procedure to that specified for those measurements.

Comment [JMY15]:

FOR DISCUSSION

A possible alternative version of 17.3 which is a bit less prescriptive.

Comment [JMY16]:

For discussion: Are fuel consumption measurements required?

Comment [JMY17]: Final version of wording proposed by Simon Davies & P Williams 18/05/2012

18. Operating behaviour and safety hazard

18.1. The REC shall be so designed that it can be used in its intended applications, when fitted in accordance with the supplied instructions, without exposing operators or bystanders to safety hazard either directly or as result of modifications to the vehicle or machine or its operating characteristics.

18.2. The REC shall be so designed that it can be used in its intended applications, when fitted in accordance with the supplied instructions, without impairment of the operating behaviour of the vehicle or machine unless

a) the impairment does not cause a safety hazard.

b) the impairment does not increase the fuel consumption beyond the level set in paragraph 17.

c) the nature and extent of the impairment is clearly stated in the instructions and information that will be passed to the retrofitter and to the operator and owner.

18.3 In order to ensure that the requirements of Section 20 and Annex 10 with respect to installation and the provision of information are properly complied with, the REC manufacturer shall make an assessment of the safety hazards that might arise from installation of the REC on the vehicle or machine. In performing this assessment he shall take as the baseline the level of safety provided by the vehicle or machine when it was first placed on the market.

~~No impairment of the operating behaviour of the vehicle or machine, and no additional safety hazard (increased surface temperature etc.) associated with the vehicle or machine shall arise as a result of the installation of the REC.~~

~~The operator is responsible for the operation of the vehicle or machine equipped with the REC.~~

19. Noise Emissions

The applicant shall provide evidence that the retrofitting of a REC in accordance with the supplied fitting instructions will not lead to an increase of the vehicle's noise emissions. Evidence that the REC is intended only to be fitted in addition to the original equipment manufacturer's standard production silencer system on a road vehicle⁴ will be considered to fulfil this requirement.

~~The applicant shall prove that the retrofitting of a REC will not lead to an increase of the vehicle's noise emissions. This may be omitted in the case of REC fitted in addition to the original equipment manufacturer's standard production silencer system.~~

20. Installation of a REC

20.1. The REC manufacturer must provide written installation guidelines and operation and maintenance instructions in accordance with the requirements of Annex 10.

20.2. The attention of the REC manufacturer is drawn, in particular, to the requirement in Annex 10 for the guidelines and instructions,

a) to be written in the language of the country in which the REC is sold or in which the REC is expected to be used, and to be in clear language appropriate to the intended readership.

b) to remind the installer of his or her potential legal responsibilities.

Comment [JMY18]: To be deleted if fuel consumption deleted from Section 1

Comment [JMY19]: Final version of wording proposed by Simon Davies & P Williams 18/05/2012

Comment [JMY20]: Final version of wording proposed by Simon Davies & P Williams 18/05/2012

⁴ Road vehicles, for this purpose, are category M2, M3 and N vehicles as defined in Annex 7 to the Consolidated Resolution on the Construction of Vehicles (R.E.3), (document TRANS/WP.29/78/Rev.1/Amend.2, as last amended by Amend.4), excluding those vehicles approved according to UN Regulation N°83.

c) to indicate to the end user any requirements for the proper maintenance of the REC, including, where relevant, the use of consumable reagents or additives.

d) to indicate any requirements or limitations on the use of the vehicle or machine that are necessary in order to ensure safety and correct functioning of the REC.

e) to specify whether any reagents need to be refilled by the vehicle or machine operator between normal maintenance intervals, and to indicate a likely rate of reagent consumption.

f) to specify the type and quality of any consumable reagents or additives used.

g) to remind the owner and operator of the vehicle or machine that, where the fitting of the REC is a condition for its operation in a particular country or area, or where fitting of the REC entitles the vehicle or machine owner to incentives or privileges, the failure to maintain the REC in proper working order (including the failure to ensure a proper supply of any reagent or additive), may be a breach of contract or constitute a criminal offence.

- ~~1. Retrofitting with a REC must be performed in accordance with the installation instructions provided by the REC manufacturer. Any additional instructions provided by the vehicle or machine manufacturer, authorities and other parties must also be taken into consideration.~~
- ~~2. The vehicle or machine to be retrofitted must be in a properly maintained condition. Defects that could prevent achievement of the emission reduction level for which the REC is approved, or could adversely affect its endurance are to be rectified as necessary before the retrofitting.~~
- ~~3. The REC manufacturer must provide installation guidelines. The REC manufacturer shall supply, with each REC delivered, written instructions that shall state that the proper installation and maintenance of the REC is essential to its correct functioning.~~
- ~~4. The instructions must indicate requirements for the proper maintenance of the REC, including, where relevant, the use of consumable reagents or additives. They must indicate any requirements or limitations on the use of the vehicle or machine that are necessary in order to ensure correct functioning of the REC.~~
- ~~5. The instructions shall be written in clear and non-technical language, and be suitable for passing to the owner or operator of the vehicle or machine to which the REC will be fitted. The instructions shall be in the language of the country in which the REC is sold or in which the REC is expected to be used.~~
- ~~6. Where the REC uses consumable reagents or additives, the instructions shall specify whether those reagents need to be refilled by the vehicle or machine operator between normal maintenance intervals, and shall indicate a likely rate of reagent consumption. The instructions shall specify the type and quality of the consumable reagents or additives used.~~
- ~~7. The instructions shall state that, where the fitting of the REC is a condition for operation of the vehicle or machine in a particular country or area, or where fitting of the REC entitles the vehicle or machine owner to incentives or privileges, the failure to maintain the REC in proper working order~~

~~(including the failure to ensure a proper supply of any reagent or additive), may be a criminal offence or constitute a breach of contract.~~

21. Conformity of production

The conformity of production procedures shall comply with those set out in the 1958 Agreement, appendix 2 (E/ECE/324 - E/ECE/TRANS/505/Rev.2).

...

Comment [JMY21]: Henk Baarbé w
propose additional text

22. Modification and extension of approval of a REC

22.1. Every modification relevant in the context of this Regulation of the REC shall be notified to the authority, which granted the REC type approval. The authority ~~may then either~~ will then assess whether or not the REC still complies with the requirements for inclusion in the appropriate REC family.

~~22.1.1. Consider that the modifications made are unlikely to have an appreciably adverse effect and that in any case the REC still complies with the requirements, or~~

~~22.1.2. The authority may require a further test report from the technical service responsible for conducting the tests in order to assist in its assessment.~~

~~22.2. In both cases described in paragraphs 22.1.1. and 22.1.2. above, the authority shall be presented in the updated installation manual.~~

22.2. Where the type-approval authority approves the modification, a reference to the formal notification of that approval shall be included in the installation manual for the REC.

22.3. Confirmation or refusal of approval, specifying the alteration, shall be communicated by the procedure specified in **paragraph [...]** above to the Parties to the 1958 Agreement applying this Regulation.

22.4. The competent authority issuing the extension of approval shall assign a series number for such an extension and inform ~~thereof~~ the other Parties to the 1958 Agreement applying to this Regulation ~~of that number~~ by means of the Communication specified in Annex 2 to this Regulation.

23. Penalties for non-conformity of production

23.1. The approval granted in respect of a type of REC pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 21 & 22 above are not complied with.

23.2. If a Party to the Agreement applying this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation, by means of the Communication specified in Annex 2 to this Regulation.

24. Production definitely discontinued

If the holder of the approval completely ceases to manufacture a type of retrofit system approved in accordance with this Regulation, he shall so

inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Parties to the 1958 Agreement applying this Regulation by means of the Communication specified in Annex 2 to this Regulation.

**25. Names and addresses of technical services
conducting approval tests and of Administrative
departments**

The Parties to the Agreement applying this Regulation shall communicate to the United Nations Secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval and to which forms certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

Annex 1.

Information document

INFORMATION DOCUMENT NO..... RELATING TO THE TYPEAPPROVAL OF RETROFIT EMISSION CONTROL DEVICES (REC) FOR HEAVY DUTY VEHICLES, AGRICULTURAL TRACTORS AND NON-ROAD MOBILE MACHINERY (NRMM) EQUIPPED WITH COMPRESSION IGNITION ENGINES.

Any drawings must be supplied in appropriate scale and sufficient detail on size A4 or on a folder of A4 format. Photographs, if any, must show sufficient detail.

If the system, components or separate technical units have electronic controls, information concerning their performance must be supplied.

1. GENERAL

1.1. Make (trade name of manufacturer):

~~1.2. Type:~~

~~1.5.2. Name and address of manufacturer:~~

~~1.7.3. In the case of components and separate technical units, location and method of affixing of the ECE approval mark:~~

~~1.8.4. Address(es) of assembly plant(s):~~

2. DESCRIPTION OF THE DEVICE

2.1. Make, ~~and type~~ and identifying part number of the REC:

~~2.2. Description and drawings of the REC:~~

~~2.3. Engine type or types for which the REC is intended (application range):~~

~~2.4. Number(s) and/or symbol(s) characterising the engine baseline emission(s):~~

~~2.5. Number(s) and/or symbol(s) characterising the achieved engine emission(s):~~

~~2.6. Reduction level of the REC as defined in 8.3:~~

~~2.3.2. 2.7. Is the REC intended to be compatible with OBD requirements: Yes / No (Strike out what does not apply).~~

~~2.4. 2.8. Description and drawings showing the position of the REC device relative to the engine exhaust manifold(s):~~

3. PARTICULATE REDUCTION REC

3.1. Dimensions, shape ~~capacity~~ and active volume of the particulate trap:

3.2. Design of the particulate trap

~~3.2.1. Type of retention and functioning of reduction material~~

~~3.2.2. Design and characteristics of the filter [or other active] material:.....~~

~~3.2.1. Type of retention of the active element (for example, adhesive or mechanical fixing),~~

~~3.2.2. Working principle of the active element (for example metallic or ceramic material, barrier filtration or aerodynamic separation);~~

~~As defined in Paragraph 8.2 of this Regulation.~~

Comment [DB22]: Proposed revision from Hungary. Further changes proposed by the editorial group are highlighted in blue

Comment [JMY23]: Needs to include Part No. as this is specified in 5.1

Comment [DB24]: Specify what this means (cf. annex 4 'Type Approval'; Ty I, II, III & IV..., or manufacturer's description of type)

- 3.2.3. Minimum **total-charge volumetric concentration** of catalytically active materials of the particulate reduction system including upstream catalysts (if fitted) (grams/m³):.....
- 3.2.4. Maximum **total-charge volumetric** concentration of catalytically active materials of the particulate reduction system including upstream catalysts (if fitted) (grams/m³):.....
- 3.2.5. The design characteristics of the canning or packaging:.....
- 3.2.6. Volume of each active component:.....
- 3.3. Method or system of regeneration (description and/or drawing)
- 3.3.1. Type of regeneration (periodic / continuous)
- 3.3.2. Regeneration principle and regeneration strategy:.....
- 3.3.3. Method and control strategy for introducing additives or reagents (if used);
- 3.4. Type of additive or reagent (if used):.....
- 3.5. Type of catalytically active material(s):.....
- 3.6. Upstream oxidation catalyst (yes / no).
- 3.7. Location (**reference distance in the exhaust line distance to the REC inlet from the outlet of the turbocharger (turbine) or the outlet plane of the exhaust manifold where no turbocharger is fitted.**):
.....
- 3.8. Normal operating temperature: (K) and pressure range (KPa)
- 3.9. In the case of periodic regeneration
- 3.9.1. Number of ETC (if applicable) test cycles between 2 regenerations (n1):
- 3.9.2. Number of ETC (if applicable) cycles during regeneration (n2):
- 3.9.3. Number of WHTC (if applicable) test cycles without regeneration (n):.....
- 3.9.4. Number of WHTC (if applicable) test cycles with regeneration (nR):**
- 3.9.1. Number of NRSC (if applicable) test cycles between 2 regenerations (n1):
- 3.9.2. Number of NRSC (if applicable) cycles during regeneration (n2):
- 3.9.3. Number of NRTC (if applicable) test cycles without regeneration (n):.....**
- 3.9.4. Number of NRTC (if applicable) test cycles with regeneration (nR):**

- 4. NO_x REDUCTION REC
To be completed later

- 5. NO_x AND PM REDUCTION REC
To be completed later
- 2.2. ~~Drawings of the REC, identifying in particular all the characteristics referred to in items 2.3. to 2.3.2. of this appendix:~~
- 2.3. ~~Description of the vehicle type or types for which the REC is intended:~~
- 2.3.1. ~~Number(s) and/or symbol(s) characterising the engine and vehicle type(s):~~

- 3. ~~APPLICATION RANGE & REDUCTION LEVEL TO BE ADDED~~

Comment [JMY25]: Items in **green** highlight is to be discussed.

Annex 2.

Communication

Comment [JMY26]: Proposed revision from Hungary. Not yet fully reviewed by Editorial group.

(maximum format: A4 (210 x 297 mm))

issued by: Name of administration
.....
.....
.....



1/

issued by: Name of administration:
.....
.....
.....

concerning: 2/

- APPROVAL GRANTED
APPROVAL EXTENDED
APPROVAL REFUSED
APPROVAL WITHDRAWN
PRODUCTION DEFINITELY DISCONTINUED

of a Retrofit Emission Control Device (REC) pursuant to Regulation No. [nnn]

Approval No.

Extension No.

Reason for extension:

- 1. Applicant's name and address:.
2. Manufacturer's name and address:
3. Manufacturer's trade name or mark:
4. Type and Commercial designation of the REC device:
5. Means of identification of type, if marked:
5.1. Location of that marking:
6. Vehicle-Engine type(s) for which the device type qualifies as an REC:
7. Type(s) of vehicle(s)engine on which the REC has been tested:
7.1 Has the REC demonstrated compatibility with OBD requirements: Yes / No 2/
8. Location and method of affixing of the approval mark:

1 Distinguishing number of the country which has granted/extended/refused/withdrawn approval (see approval provisions in the Regulation).

2 Strike out what does not apply.

9. Submitted for approval on:
10. Technical Service responsible for approval tests:
- 10.1. Date of test report:
- 10.2. Number of test report:
11. Approval granted / extended / refused / withdrawn ^{2/}
12. Reason(s) of extension (if applicable);
13. Engine type or types for which the REC is intended (application range) based on test results:
14. REC Type I. / II. / III. / IV. 2/ and reduction efficiency:
15. Annexed to this communication is a list of documents in the approval file deposited at the administrative services having delivered the approval and which can be obtained upon request [?]
16. The following documents, bearing the approval number shown above, are annexed to this communication:
 - 16.1. Verification of the engine baseline emissions.
 - 16.2. Determination of emissions with the REC fitted
 - 16.3. Results of the reduction efficiency.
 - 16.4. Performance of an endurance run.
 - 16.5. Determination of the NO₂ emissions and of emissions of the other regulated pollutants.
 - 16.6. Declaration on noise emission.
 - 16.7. Approved application range.
17. Place:
18. Date:
19. Signature:

Annex 4A – Addendum (for discussion only)

ADDENDUM TO THE COMMUNICATION CONCERNING A TYPE OF RETROFIT EMISSION CONTROL DEVICE PURSUANT TO REGULATION No. 000

(Approval No. Extension No.)

1. Engines on which the retrofit emission control device has been tested:
shall completed later

Engine No.	1	2	n
Make:			
Type:			
Engine:			
Power:			
Category:			

2. Test results:

3. Engine type(s) for which the REC device is qualified (application range):
shall completed later (see current Annex 4)

Engine No.	1	2	n
Make:			
Type:			
Model year from/to:			
Capacity / cylinder:			

1/ Strike out what does not apply.

Annex 3.

Arrangement of the REC System type approval mark

Comment [JMY27]: Proposed revision from Hungary. Not yet reviewed by Editorial group.

Model A
(See paragraph 5.4. of this Regulation)



a = 8 mm min

The above example approval mark affixed to a Retrofit Emission Control device (REC) shows that the type concerned has been approved in the Netherlands (E 4), pursuant to Regulation No. [nnn] under approval No. 001234. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No. [nnn] in its original form. The approval mark shall also show the Type of REC (I, II, III or IV) and bears the marking Level 1.

Comment [JMY28]: REC-10 had decided that the Level marking should be kept if compatible with UN rules.

The diagram shows a rectangular plate with rounded corners. At the top left is a circle with 'E 7'. To its right is '[nnn] R - 001234'. Below this are several fields for technical information:

- NAME OR TRADE MARK:
- TYPE I./II./III./IV. DATE:
- MODEL YEAR:
- ENGINE TYPE:
- BASELINE EMISSION:
- ACHIEVED EMISSION (PM):
- ACHIEVED EMISSION (NO_x):
-
-

The above plate, with approval mark and some technical information on the retrofit system, has to be fixed permanently on the body of the vehicle.

Annex 4**Application range (example)**

Comment [DB29]: Hungary will look into Annex

Number	Model year from/to	Engine type	Capacity / cylinder (cm ³)	Capacity V _H (cm ³)	engine net power kW with min ⁻¹	Engine Baseline emissions	Silencer replaced	Type identification of the REC	REC Type and Reduction Level
1	1996 - 2006		1994	12000	185 KW 220 KW 260 KW	Stage A	yes		Type II Level 1
2	1996 - 2006		1994	12000	185 KW 220 KW 260 KW	Stage B	yes		Type II Level 1
3	1996 - 2006		1994	1200	185 KW 220 KW 260 KW	Stage II	no		Type II Level 1

Annex 5

Test of a particulate reduction REC

Comment [JMY30]: This section needs to be reviewed in detail because of the changes to the regulation structure.

1. Testing of a particulate reduction REC is performed in a series of stages as follows;
 - i) Verification of the engine baseline emissions.
 - ii) Determination of emissions with the REC fitted
 - iii) Determination of the reduction level.
 - iv) Performance of an endurance run.
 - v) Determination of whether the REC regenerates periodically or continuously.
 - vi) Test of the regeneration characteristic (if appropriate).
 - vii) Establishment of the regeneration adjustment factor (if appropriate).
 - viii) Determination of the NO₂ emissions and of emissions of the other regulated pollutants.

In Annex 8 a flow chart outlines the test sequence for particulate reduction REC.

2. The engine baseline emissions are established by performance of an emissions test procedure on the engine system without the REC in accordance with the requirements of Regulation No.49 or Regulation No.96, as appropriate to the Type Approval level of the base engine.
3. The particulate emissions are determined by performance of an emissions test procedure on the engine system in accordance with the requirements of Regulation No.49 or Regulation No.96, as appropriate to the intended emission level of the candidate system, with the REC fitted in accordance with the requirements of this Regulation.
4. The reduction efficiency is determined by measurement of the emissions before and then after fitment of the REC. Emissions are measured over the WHTC for RECs to be applied to heavy-duty engines or over the NRTC for RECs to be applied to NRMM or Tractor engines.
5. The ~~endurance–durability~~ run shall be performed in accordance with the requirements of Section 9 of this Regulation.
6. The regeneration strategy and the regeneration characteristics are established by use of the following procedure. [The emissions of NO₂ and of the regulated pollutants are determined by measurements taken immediately after the tests to establish the regeneration characteristics.]
 - 6.1. In order to assess the regeneration performance of a REC at least 25 ETC or WHTC test cycles or 25 NRTC cycles, must be carried out. The test cycle used must be a cycle appropriate to the emissions stage or standard that the REC system is intended to permit the vehicle or machine to meet.

The gaseous emissions and the particulate mass, and the particulate number when appropriate, must be measured during at least each fifth test cycle. A separate test of the particulate reduction system is carried out for each family or application range defined in the type approval procedure for the engine with which the REC system is intended to be used. That is, one system test takes place for each application area.

If the applicant can prove that a particulate reduction system that has been tested for vehicles of category M2 and N vehicles^{1/} is designed for use in the same manner [and will work effectively] on C.I. engines for use in non-road mobile machinery, and the family of test engines used in accordance with the requirements of paragraph [12] is representative for such applications and meets the family criteria of paragraph [14], then the application range for which the system is approved may be extended to C.I. engines for use in non-road mobile machinery. Extending the range of a particulate reduction system that has been approved for use with C.I. engines in non-road mobile machinery to cover on-road applications in the way described in this paragraph is not permitted.

- 6.2. A particulate reduction REC is considered to have been proved to have a continuously operating regeneration process if a suitable assessment variable can be regarded as constant over at least 25 applicable test cycles. The particulate emission and the exhaust gas backpressure are regarded as suitable assessment variables for this purpose.

If an applicant wishes to use one or more different assessment variables, he must present a robust technical case to the approval authority in support of his request to do so.

Where a continuously regenerating system as defined above also contains provision for active regeneration, then the assessment criteria defined in paragraph [6.6?] shall be applied.

The PM mass emission and the exhaust gas backpressure are considered constant within the meaning of this regulation where there is a coefficient of variance of less than 15% over 25 test cycles. The exhaust gas backpressure is measured continuously for the purposes of this assessment and the particulate emissions are measured during at least every fifth test cycle.

The coefficient of variance (CoV) is calculated as follows.

$$\text{Coefficient of Variance} = \frac{\text{Standard deviation } X(n)}{\text{Average value } X(n)}$$

with:

$$\text{Standard deviation} = \sqrt{\frac{n \sum x^2 - (\sum x)^2}{n(n-1)}}$$

~~Standard deviation~~ $\sqrt{\frac{n \sum x^2 - (\sum x)^2}{n-1}}$

and:

$$\text{Average value} = (x_1 + x_2 + \dots + x_n) / n$$

where:

- n = number of measured values
- x = respective single measured value

- 6.3. If an REC manufacturer intends to apply for approval for an REC that can reduce emissions of particulate mass by two subsequent emission stages, then additional verification becomes necessary.

This additional verification required in this case is performed in accordance with the procedure set out in paragraph number 13.2 and paragraph number 15.6 on a test engine selected in accordance with the procedure set out in

Comment [JMY31]: To be reviewed
Mike Galey

Comment [JMY32]: Original cross-references need to be checked to determine new paragraphs.

paragraph 12 on the basis of the final emission level to be achieved by the retrofitted engine.

It will be considered sufficient to perform the additional testing on only one engine family member representative of the application range. For that reason it is permissible to transfer the emission category extension that has been gained by this additional testing to other engine families in the same application range.

The REC used in the additional verification procedure required in order to extend the approval to a further (subsequent) emission category must be from the application range of the basic REC for which the approval was issued. It must not be a REC which has been approved by extension of the original approval. If the REC is not from the application range of the basic REC for which the approval was issued and the system is not identical, then a full test for a new type in accordance with this regulation is necessary.

If the scope of application is widened, then the applicant must additionally certify in the letter of application for approval that the REC is also designed and suitable for higher raw emission burdens when used on lower emission level engines.

6.4. Test of the regeneration characteristic of a particulate reduction REC

This testing is carried out by loading the system with particulate matter until a constant exhaust gas backpressure is reached or over a time period of a maximum of 100 hours if no constant value for the backpressure has been achieved before that time. The exhaust gas backpressure is considered constant if, when measured after a period of at least 50 hours, the exhaust gas backpressure does not vary by more than plus or minus 4 mbar within a period of 30 min. The test points of the cycle used for loading the system are to be selected so that a maximum exhaust gas temperature of 180°C at the inlet of the particulate reduction system is not exceeded. The loading of the system with particulate matter is preferably carried out by running the test engine at a constant speed of between 50% and 75% of its rated speed.

After the REC has been loaded with particulate matter until the backpressure is constant, or after a maximum of 100 hours of running to load the system as defined above, regeneration is activated. This can, for example, be activated by running the engine at a higher load mode step so as to increase the exhaust temperature. After completion of the regeneration, exhaust gas measurements are to be taken during at least three appropriate test cycles (That is, three ESC cycles, ETC cycles, WHSC cycles, WHTC cycles, NRSC cycles, or NRTC cycles.) The measured exhaust gas pollutant values shall not deviate from the measured exhaust gas pollutant values before the REC loading procedure by more than 15% for the gaseous emissions or more than 20% for the particulate mass or particulate number emissions.

The manufacturer shall confirm in writing that the maximum temperatures occurring during the regeneration process will not damage or significantly shorten the effective life of the REC.

As an alternative to using the loading procedure described above, the manufacturer may provide a particulate reduction REC already loaded to the limit for the regeneration test.

6.5. Assessment criteria for continuously regenerating particulate reduction REC

The REC system test of the particulate reduction REC is considered satisfactory if the particulate emissions measured as defined in paragraph number 3 are met.

6.5.1. Regulated pollutants

The emissions of the regulated pollutants (CO, HC, PM and NO_x) in the initial condition and in the retrofitted condition shall be within the limit values for the emissions stage or standard for which the engine was originally type-approved. The NO₂ to NO_x ratio for the initial condition and the retrofitted condition is to be recorded and shown in the test report.

The determination of the NO₂ and NO_x mass emissions is to be determined by simultaneous measurement in accordance with section 1.7

6.6. Assessment criteria for periodically regenerating particulate reduction REC

This provision only applies to RECs which utilise active regeneration.

The emissions shall be measured during at least three appropriate hot-start test cycles (That is, three hot-start ESC cycles, ETC cycles, WHSC cycles, WHTC cycles, NRSC cycles, or NRTC cycles.) One of the cycles from which measurements are taken should include a regeneration event on a stabilized REC system. The other two cycles from which measurements are taken should be cycles in which regeneration does not occur. If regeneration takes longer than one test cycle, consecutive test cycles shall be run until regeneration is complete.

The REC manufacturer shall declare the conditions under which the regeneration process normally occurs (the particulate loading, temperature, exhaust back-pressure, or other relevant parameters.). The manufacturer shall also provide the frequency of the regeneration event in terms of the fraction of tests during which the regeneration occurs. The exact procedure used to determine this fraction shall be agreed with the manufacturer by the type approval authority on the basis of good engineering judgement. (This frequency fraction is the factor *F* in the procedure for calculation of nominal particulate emissions set out below.)

For a regeneration test, the manufacturer shall provide a particulate reduction REC system that has been loaded with particulate matter. As an option, the manufacturer may run consecutive test cycles as set out in paragraph 10.4 until the particulate reduction REC is loaded. Emissions measurement is not required on cycles run for the purposes of loading the REC with particulate matter.

Average emissions between regeneration phases shall be determined from the arithmetic mean of several tests approximately equidistant in terms of the number of unmeasured test cycles between them. As a minimum, at least one test cycle as close as possible prior to a regeneration test and one test cycle immediately after a regeneration test shall be included in the calculation of the arithmetic mean.

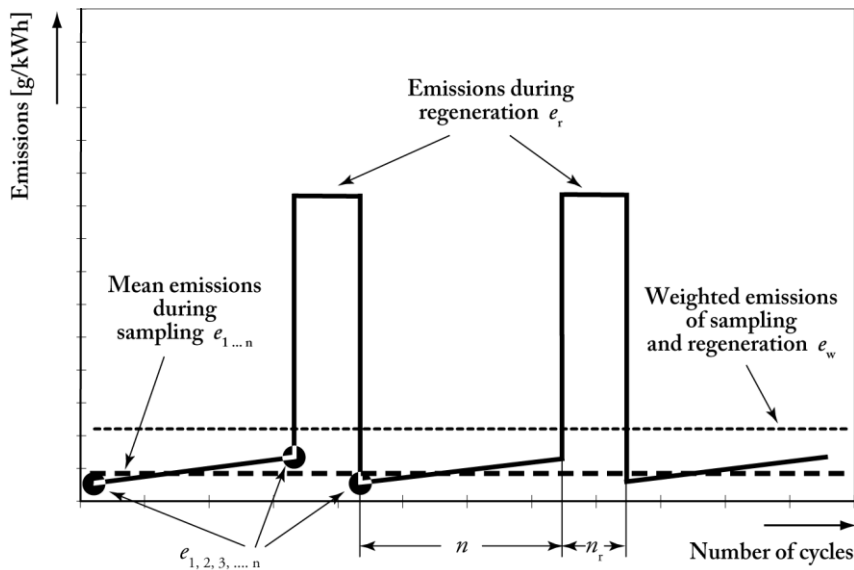
During the regeneration test, all the data needed to detect regeneration shall be recorded (CO or NO_x emissions, temperature before and after the REC, exhaust back pressure, and any other relevant parameters). It is permissible for the applicable emission limits to be exceeded during the regeneration process. The test procedure is shown schematically in figure 1.1.

Figure 1.1:

Comment [DB33]: Is this the right word?

Comment [DB34]: Check the referen

Scheme of periodic regeneration



The system test of a periodically regenerating particulate reduction REC is considered passed if the [nominal] particulate emissions calculated using the procedure set out below are within the limit set for the reduction level for which the applicant wishes the REC to be approved.

The particulate emissions PM mass (g/kWh) for periodically regenerating systems are determined as follows.

$$\text{PM mass} = \text{PM mass}_r \times F + (1-F) \times \text{PT}_{\text{wor}}$$

Where:

F = frequency of the regeneration event in terms of fraction of tests during which the regeneration occurs [-]

$\text{PM mass}_{\text{wor}}$ = average specific emission from a test in which the regeneration does not occur [g/kWh]

PM mass_r = average specific emission from a test in which the regeneration occurs [g/kWh]

The manufacturer may choose, on the basis of good engineering analysis, to calculate either a multiplicative or an additive regeneration adjustment factor k_r , expressing the average emission rate, as follows:

$$k_r = \text{PM mass} / \text{PM mass}_{\text{wor}} \quad (\text{multiplicative adjustment factor})$$

or

$$k_{Ur} = \text{PM mass} - \text{PM mass}_{\text{wor}} \quad (\text{upward adjustment factor})$$

or

$$k_{Dr} = \text{PM mass} - \text{PM mass}_r \quad (\text{downward adjustment factor})$$

If more than two measurements between the regeneration phases are used to determine the emissions, these further measurements must be taken at equal intervals and an arithmetical average taken.

6.6.1. Regulated pollutants

The emissions of regulated pollutants (CO, HC, PM and NO_x) shall be within the limit values for the standard to which the engine was originally type approved, both in the initial condition and in the retrofitted condition. The NO₂/NO_x ratio for both the initial condition and the retrofitted condition are to be recorded and shown in the test report.

The determination of the NO₂ - and NO_x- mass emissions is to be determined by simultaneous measurement in accordance with section 6.7.2 of this annex (and paragraph 13?).

6.6.2. Weighted gaseous emissions

The emission of gaseous components M_{gas} (g/kWh) for periodically regenerating systems is determined as follows.

$$M_{gas} = M_{gas_r} \times F + (1-F) \times M_{gas_{wor}}$$

where:

F = frequency of the regeneration event in terms of the fraction of tests during which the regeneration occurs [-]

M_{gas_{wor}} = average specific emission from a test in which the regeneration does not occur [g/kWh]

M_{gas_r} = average specific emission from a test in which the regeneration occurs [g/kWh]

The manufacturer may choose, on the basis of good engineering analysis, to calculate either a multiplicative or an additive the regeneration adjustment factor k_r, expressing the average emission rate, as follows:

$$k_r = M_{gas} / M_{gas_{wor}} \text{ (multiplicative adjustment factor)}$$

or

$$k_{Ur} = M_{gas} - M_{gas_{wor}} \text{ (upward adjustment factor)}$$

or

$$k_{Dr} = M_{gas} - M_{gas_r} \text{ (downward adjustment factor)}$$

6.7. Determination of NO₂ emissions

The testing shall be performed on the test engine selected by the criteria described in paragraph 112).

6.7.1. Selection of the particulate reduction REC for NO₂ determination.

The particulate reduction REC to be tested shall be

- a particulate reduction REC with the largest active volume and, if a diesel oxidation catalyst (DOC) is used upstream, the catalytic converter with the largest active surface area and

Comment [DB35]: Check reference

- the particulate reduction REC containing the maximum total charge of catalytically active materials and maximum platinum charge of the particulate reduction REC within the defined REC family.

The chosen particulate reduction REC shall be fitted in such a way that the shortest distance between the engine and the particulate reduction REC, as specified in the application range for the particulate reduction REC, is achieved.

The particulate reduction REC shall be unloaded and shall not have been run in for longer than 50 hours.

[For particulate reduction REC with zone coatings, the properties of the coated zone of the particulate reduction REC which has the maximum loading of precious metals shall not deviate from those of the other particulate reduction REC within the REC family.]

6.7.2. Determination of NO₂ emissions

Three successive test cycles shall be conducted. The emissions shall be determined over all three cycles and averaged. The coefficient of variance shall not exceed 15%.

The calculation of the NO_x and NO₂ emissions shall be determined for C.I. engines used in vehicles of category M² and N² over the complete WHTC cycle.

For C.I. engines used in non-road mobile machinery ^{1/} having an installed net power higher than 18 kW, but not more than 560 kW the calculation of the NO_x and NO₂ emissions shall be determined over the complete NRTC cycle.

7. Test Cycles.

7.1. In cases where the approval of the engine with which the REC is to be used is an on-road approval (performed in accordance with Regulation No.49) the test cycle to be used for approval of the REC must be the test cycle associated with the emissions stage in Regulation No.49 for which approval of the REC is being sought.

7.2. Where the engine is being used in an on-road application and has an approval issued in accordance with the requirements of Regulation No.49, the test cycle to be used for the establishment of the base emissions of the engine must be the test cycle associated with the emissions stage in Regulation No.49 for which the engine has an approval.

7.3. Where the engine is being used in an on-road application but does not have an approval issued in accordance with the requirements of Regulation No.49, the test cycle to be used for the establishment of the base emissions of the engine must meet one of the following requirements;

a) It is the test cycle associated with the emissions stage in Regulation No.49 for which approval of the REC is being sought, or with a later emissions stage;

7.5. In cases where the approval of the engine with which the REC is to be used is a non-road approval (performed in accordance with Regulation No.96) the test cycle to be used for approval of the REC must be the test cycle associated with the emissions stage in Regulation No.96 for which approval of the REC is being sought.

Comment [DB36]: Mr Eberhardt to check with UBA if § can be deleted.

Comment [DB37]: Is this meaningful with only 3 tests? Look at Reg.49 for this

- 7.6. Where the engine is being used in a non-road application and has an approval issued in accordance with the requirements of Regulation No.96, the test cycle to be used for the establishment of the base emissions of the engine must be the test cycle associated with the emissions stage in Regulation No.96 for which the engine has an approval.
- 7.7. Where the engine is being used in a non-road application but does not have an approval issued in accordance with the requirements of Regulation No.96, the test cycle to be used for the establishment of the base emissions of the engine must be the test cycle associated with the emissions stage in Regulation No.96 for which approval of the REC is being sought, or with a later emissions stage.
- 7.8. For the purposes of establishing the emissions of NO₂ during tests of a Type I or Type II REC, the specific test cycle defined in paragraph 6.7.2 of this Annex shall be used.

Annex 6**Test of a NO_x reduction REC**

1. Testing of a NO_x reduction REC is performed in a series of stages as follows;
 - i) Establishment of the engine baseline emissions.
 - ii) Determination of the reduction level.
 - iii) Performance of an endurance run.
 - iv) Determination of the NO₂ emissions and of emissions of the other regulated pollutants.

In Annex [8] a flow chart outlines the test sequence for NO_x reduction REC.

2. The engine baseline emissions are established by performance of an emissions test procedure on the engine system without the REC in accordance with the requirements of Regulation No.49 or Regulation No.96, as appropriate.
3. An endurance run is performed in accordance with the requirements of Section 9 of this Regulation.
The gaseous emissions must be measured during at least each fifth test cycle during the endurance run.
4. The reduction level is determined by performance of an emissions test procedure on the engine system in accordance with the requirements of [Annex 7 or Annex 8 of Section 8?] this Regulation, as appropriate.
5. A separate test of the NO_x reduction system is carried out for each family or application range defined in the type-approval procedure for the engine with which the REC is intended to be used. That is, one system test takes place for each application area.
6. If the applicant can prove that a NO_x reduction system that has been tested for vehicles of Category M < 3.5 t or Category N, is designed for use in the same manner and will work effectively on C.I. engines for use in non-road mobile machinery, and the family of test engines used in accordance with the requirements of paragraph [5A] is representative for such applications and meets the compliance criteria of [paragraph 11], then the application range for which the system is approved may be extended to C.I. engines for use in non-road mobile machinery.

Extending the range of a NO_x reduction system that has been approved for use with C.I. engines in non-road mobile machinery to cover on-road applications in the way described in this paragraph is not permitted.
7. Regulated pollutants

In the case of an engine type-approved in accordance with the requirements of Regulation No. 49 or Regulation No. 96, the emissions of each of the regulated pollutants (CO, HC, NO_x, and PM) in the initial condition and in the retrofitted condition shall be within the limit values for the emissions stage or standard for which the engine was originally type-approved. The NO₂ to NO_x ratio for the initial condition and the retrofitted condition is to be recorded and shown in the test report.

- In the case of an engine not type-approved in accordance with the requirements of either Regulation No. 49 or Regulation No. 96, the emissions of each of the regulated pollutants (CO, HC, NO_x, and PM) in the initial condition and in the retrofitted condition shall be either,
- a) within the limit values for the emissions stage or standard immediately below that for which certification of the REC is sought, or,
 - b) where certification of the REC is being sought for the lowest emissions stage or standard, within the limit values for that emissions stage or standard.
8. Determination of emissions of the regulated pollutants and of NO₂.
- In order to determine the emissions of the regulated pollutants and NO₂, three successive test cycles as defined in this paragraph shall be conducted. The emissions shall be determined over all three cycles and averaged. The standard deviation shall not exceed 15%.
- In the case of a REC intended for an on-road application, calculation of the regulated pollutants and NO₂ emissions shall be determined over the complete WHTC cycle. For C.I. engines used in non-road mobile machinery having an installed net power higher than 18 kW, but not more than 560 kW the calculation of the regulated pollutant and NO₂ emissions shall be determined over the complete NRTC cycle.
9. Test cycles.
- 9.1. In cases where the approval of the engine with which the REC is to be used is an on-road approval (performed in accordance with Regulation No.49) the test cycles to be used for approval of the REC must be the test cycle associated with the emissions stage in Regulation No.49 for which approval of the REC is being sought. The REC must, in addition, be shown to achieve the reduction level and the emission limit value associated with the emissions stage in Regulation No.49 for which approval of the REC is being sought when it is tested on either,
- a) the WHSC or
 - b) the WHDC or
 - c) a test cycle consisting of [5] urban elements of the ETC.
- 9.2. Where the engine is being used in an on-road application and has an approval issued in accordance with the requirements of Regulation No.49, the test cycle to be used for the establishment of the base emissions of the engine must be the test cycle associated with the emissions stage in Regulation No.49 for which the engine has an approval.
- 9.3. Where the engine is being used in an on-road application but does not have an approval issued in accordance with the requirements of Regulation No.49, the test cycle to be used for the establishment of the base emissions of the engine must meet one of the following requirements;
- a) It is the test cycle associated with the emissions stage in Regulation No.49 for which approval of the REC is being sought, or with a later emissions stage;
 - b) It is the WHSC
 - c) It is the WHDC.
 - d) It is a test cycle consisting of [5] urban elements of the ETC.

-
- 9.5. In cases where the approval of the engine with which the REC is to be used is a non-road approval (performed in accordance with Regulation No.96) the test cycle to be used for approval of the REC must be the test cycle associated with the emissions stage in Regulation No.96 for which approval of the REC is being sought.
- 9.6. Where the engine is being used in a non-road application and has an approval issued in accordance with the requirements of Regulation No.96, the test cycle to be used for the establishment of the base emissions of the engine must be the test cycle associated with the emissions stage in Regulation No.96 for which the engine has an approval.
- 9.7. Where the engine is being used in a non-road application but does not have an approval issued in accordance with the requirements of Regulation No.96, the test cycle to be used for the establishment of the base emissions of the engine must be the test cycle associated with the emissions stage in Regulation No.96 for which approval of the REC is being sought, or with a later emissions stage.

Annex 7**Tests of a PM and NO_x reduction REC**

1. Tests of a PM and NO_x reduction REC shall meet the requirements for testing for each of the pollutants set out in [section 45 and section 45A] above.
2. Regulated pollutants

In the case of an engine type-approved in accordance with the requirements of Regulation No. 49 or Regulation No. 96, the emissions of each of the regulated pollutants (CO, HC, NO_x, and PM) in the initial condition and in the retrofitted condition shall be within the limit values for the emissions stage or standard for which the engine was originally type-approved. The NO₂ to NO_x ratio for the initial condition and the retrofitted condition is to be recorded and shown in the test report.

In the case of an engine not type-approved in accordance with the requirements of either Regulation No. 49 or Regulation No. 96, the emissions of each of the regulated pollutants (CO, HC, NO_x, and PM) in the initial condition and in the retrofitted condition shall be either,

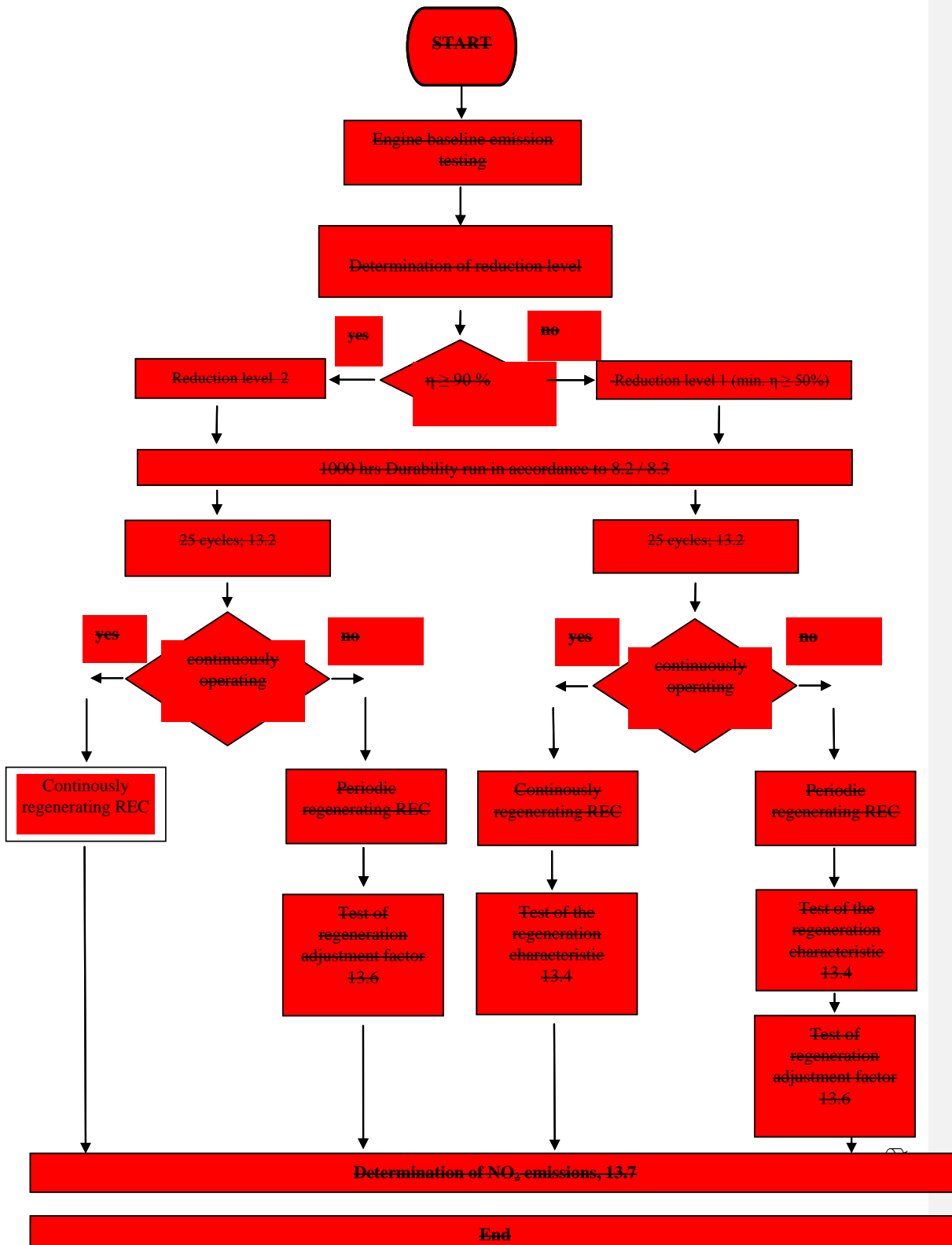
 - a) within the limit values for the emissions stage or standard immediately below that for which certification of the REC is sought, or,
 - b) where certification of the REC is being sought for the lowest emissions stage or standard, within the limit values for that emissions stage or standard.
3. Test cycles.
- 3.1. Tests of PM and NO_x reduction REC must be undertaken using test cycles that meet all of the requirements of Annex 5 and Annex 6 of this Regulation.

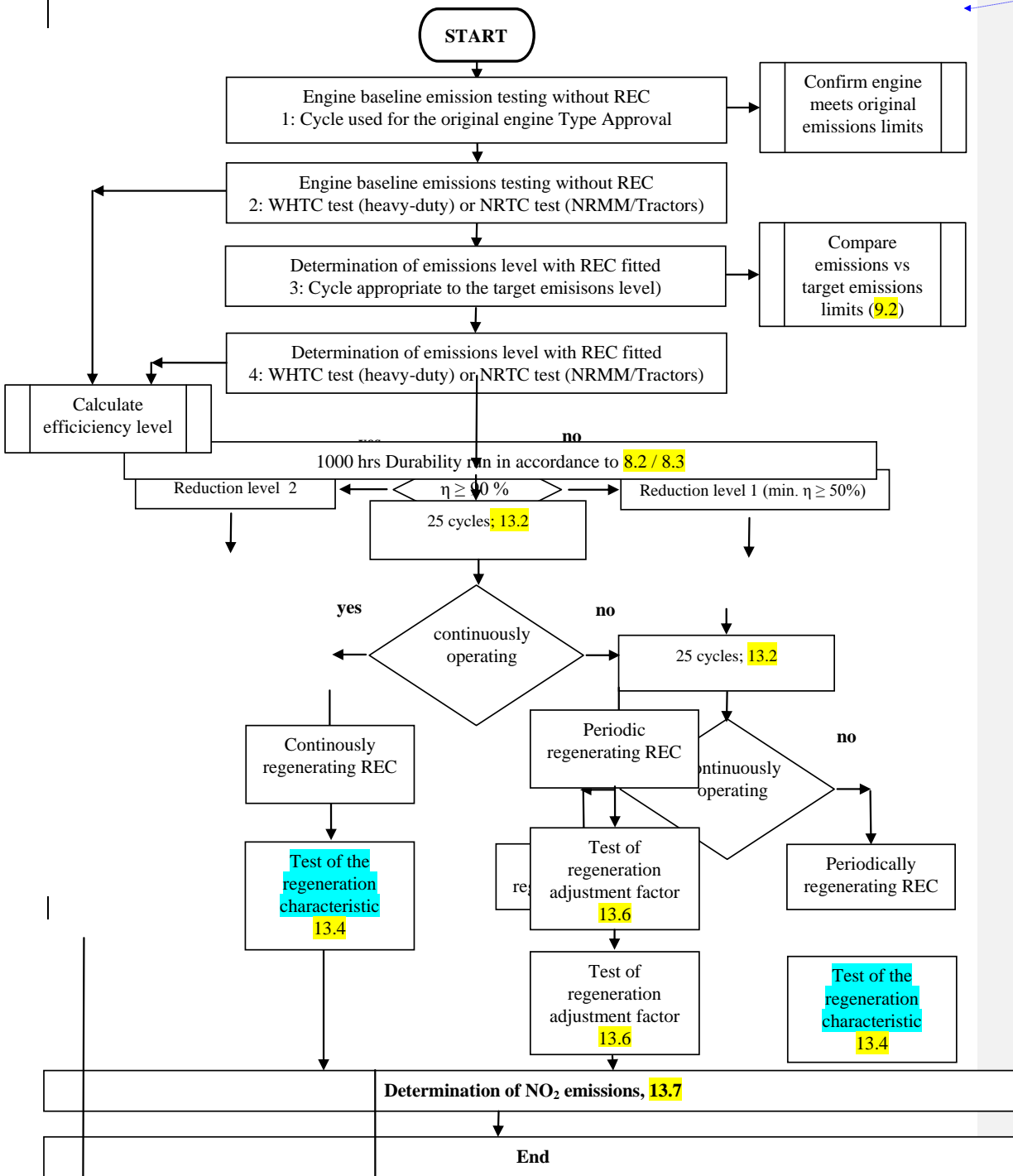
Comment [JMY39]: To be reworded after completion of Annexes 5 & 6

Annex 8

Test sequence for **particulate reduction-REC**

Comment [JMY40]: Can PM & NO_x reduction be combined in 1 flowchart? Chart to be reviewed when rest of document finalised.





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Annex 9

Limit value equivalence tables

Comment [JMY41]: Proposal from Editorial Group to relocate tables from Section 8 into this appendix.

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Annex 10**Installation instructions**

1. The REC manufacturer must provide written information and installation instructions for use by retrofitters, and operation and maintenance instructions for use by owners and operators. These instructions must
 - a) address the safety hazards identified in the course of the assessment undertaken in accordance with paragraph 18.3 so that, to the greatest extent possible, fitting of the REC in accordance with the instructions will eliminate those hazards and will
 - i) maintain the level of safety provided by the vehicle or machine when it was first placed on the market,
 - ii) maintain the vehicle or machine in a state of conformity with all legal health and safety requirements,
 - b) explicitly list and describe any identified safety hazards that will not be fully eliminated by following the fitting instructions and that will have to be addressed by the application of appropriate skills and good engineering judgement on the part of the retrofitter.
 - c) clearly address each of the points in paragraphs 3 and 4 of this annex.
2. Preparation and demonstration requirements
 - 2.1 The instructions and guidelines must be written in the language of the country in which the REC is sold or in which the REC is expected to be used, and must be in clear language appropriate to the intended readership.
 - 2.2 The REC manufacturer must be able to demonstrate to the type-approval authority where each of the relevant points in this annex is addressed, but may address these points in any way that meets the requirement for clarity. There is no requirement for the wording or layout of this annex to be reproduced.
 - 2.3 Technical or legal language should not be used in documents intended for readers, such as end users, who are unlikely to be familiar with it. Where the use of such language is considered essential in such documents, it should be accompanied by a clear explanation of its intent.
 - 2.3 The REC manufacturer is encouraged to consider, in the interests of clarity, the use of local idioms and usages where a language is used in more than one country or region, and the use of industry-specific terms where a REC is intended for use on vehicles or machines specific to that industry.
3. Instructions for the retrofitter
 - 3.1 The instructions for the retrofitter should include,
 - a) specific instructions related to any specific vehicle or machine application for which the REC is intended,
 - b) general instructions and guidelines, when appropriate, which will permit the REC to be properly fitted to any vehicle or machine in the range for which it is approved,
 - c) a clear indication of the range of applications for which the REC is approved, and of the range of vehicle or machine applications for which it may be safely used if that is different,

Comment [JMY42]: Final version of proposal from Paul Williams and Simon Davies. Not yet reviewed by Editorial group.

- d) an indication of the level of skill and education required in order to perform the fitting operation,
 - e) a level of detail at least sufficient to permit an appropriately skilled and educated person to perform the work.
- 3.2 The instructions shall state that retrofitting with a REC must be performed in accordance with the installation instructions provided by the REC manufacturer, and that any additional instructions provided by the vehicle or machine manufacturer, public authorities, or other competent parties must also be taken into consideration.
- 3.3. The instructions shall state that the vehicle or machine to be retrofitted must be in a properly maintained condition, and that defects that could prevent achievement of the emission reduction level for which the REC is approved, or could adversely affect its endurance are to be rectified as necessary before the retrofitting.
- 3.4 The instructions shall state that all necessary care must be taken in order to ensure that the safety in use of the vehicle or machine is not impaired by the fitting of the REC, and that it remains conformant with local laws and regulations. The instructions shall, in particular,
- a) draw attention to any additional safety hazards to operators or bystanders, such as high surface temperatures or electrical voltages, that are associated with the REC, and propose measures for reducing the risks associated with them.
 - b) warn against the installation of the REC, or any systems associated with it, in such a way as to interfere with the field of vision of the operator of a vehicle or machine, or with the visibility of any gauges or indicators, or with access to any controls.
 - c) warn that the extent of the liability of the person or company fitting the REC for any subsequent accident or failure will depend upon local laws and customs, and may extend beyond liability for failures of or directly attributable to the REC.
- 3.5 The instructions shall draw attention to the fact that any modification made to an engine enclosure or access panel may increase the noise emitted by the vehicle or machine, that increases in noise may be forbidden by local laws, and that increases in noise may have implications for the health and safety of operators and bystanders.
4. Instructions for the owner and operator
- 4.1 The instructions for the owner and operator should include both specific instructions related to any vehicle or machine application for which the REC is intended and, when appropriate, general instructions related to its use with any vehicle or machine in the range for which it is approved..
- 4.2 The instructions shall indicate any requirements or limitations on the use of the vehicle or machine that are necessary in order to ensure correct functioning of the REC.
- 4.3 The instructions shall specify whether any reagents or additives need to be refilled by the vehicle or machine operator between normal maintenance intervals, and to indicate a likely rate of reagent consumption.
- 4.4 The instructions shall specify the type and quality of any consumable reagents or additives used.

- 4.5 The instructions shall remind the owner and operator of the vehicle or machine that, where the fitting of the REC is a condition for its operation in a particular country or area, or where fitting of the REC entitles the vehicle or machine owner to incentives or privileges, the failure to maintain the REC in proper working order (including the failure to ensure a proper supply of any reagent or additive), may constitute a breach of contract or be a criminal offence.