

## SCHEDULE 1

Regulations 2(3), 6(1), 6(2), 9(1),  
11(1),11(9) and 13(1)(a)

(Annex 1 to Directive 97/68/EC)  
SCOPE, DEFINITIONS, SYMBOLS, ABBREVIATIONS, ENGINE  
MARKINGS, SPECIFICATIONS AND TESTS, SPECIFICATION OF  
CONFORMITY OF PRODUCTION ASSESSMENTS, PARAMETERS  
DEFINING THE ENGINE FAMILY, CHOICE OF THE PARENT ENGINE

1. This section is implemented by regulation 3.]

### DEFINITIONS, SYMBOLS AND ABBREVIATIONS

2. For the purposes of this Directive,

**2.1.** *compression ignition (C.I.) engine* shall mean an engine which works on the compression-ignition principle (eg diesel engine);

**2.2.** *gaseous pollutants* shall mean carbon monoxide, hydrocarbons (assuming a ratio of  $C_1:H_{1.35}$ ) and oxides of nitrogen, the last named being expressed in nitrogen dioxide (NO<sub>2</sub>) equivalent;

**2.3.** *particulate pollutants* shall mean any material collected on a specified filter medium after diluting C.I. engine exhaust gas with clean filtered air so that the temperature does not exceed 325 K (52°C);

**2.4.** *net power* shall mean the power in “EECKW” obtained on the test bench at the end of the crankshaft, or its equivalent, measured in accordance with the EEC method of measuring the power of internal combustion engines for road vehicles as set out in Directive 80/1269/EEC(1), except that the power of the engine cooling fan is excluded(2) and the test conditions and reference fuel specified in this Directive are adhered to;

**2.5.** *rated speed* shall mean the maximum full load speed allowed by the governor as specified by the manufacturer;

**2.6.** *per cent load* shall mean the fraction of the maximum available torque at an engine speed;

**2.7.** *maximum torque speed* shall mean the engine speed at which the maximum torque is obtained from the engine, as specified by the manufacturer;

**2.8.** *intermediate speed* shall mean that engine speed which meets one of the following requirements:

- for engines which are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be the declared maximum torque speed if it occurs between 60% and 75% of rated speed;
- if the declared maximum torque speed is less than 60% of rated speed, then the intermediate speed shall be 60% of the rated speed;
- if the declared maximum torque speed is greater than 75% of the rated speed then the intermediate speed shall be 75% of the rated speed.

### 2.9. Symbols and Abbreviations

#### 2.9.1. Symbols for test parameters

(1) OJ L 375, 31.12.1980, p. 46. Directive as last amended by Directive 89/491/EEC (OJ L 238, 15.8.1989, p.43).

(2) This means that, contrary to the requirements of section 5.1.1.1. of Annex 1 to Directive 80/1269/EEC, the engine cooling fan must not be installed during the test for the check of the engine net power; if on the contrary the manufacturer carries out the test with the fan installed on the engine, the power absorbed by the fan itself must be summed up to the power so measured.

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Symbol	Unit	Term
$A_P$	$m^2$	Cross sectional area of the isokinetic sampling probe
$A_T$	$m^2$	Cross sectional area of the exhaust pipe
aver		Weighted average values for:
	$m^3/h$	—volume flow
	kg/h	—mass flow
CI	–	Carbon 1 equivalent hydrocarbon
conc	ppm Vol%	Concentration (with suffix of the component nominating)
conc <sub>c</sub>	ppm Vol%	Background corrected concentration
conc <sub>d</sub>	ppm Vol%	Concentration of dilution air
DF	–	Dilution factor
$f_a$	–	Laboratory atmospheric factor
$F_{FH}$		Fuel specific factor used for the calculations of wet concentrations from dry concentrations hydrogen to carbon ratio
$G_{AIRW}$	kg/h	Intake air mass flow rate on wet basis
$G_{AIRD}$	kg/h	Intake air mass flow rate on dry basis
$G_{DILW}$	kg/h	Dilution air mass flow rate on wet basis
$G_{EDFW}$	kg/h	Equivalent diluted exhaust gas mass flow rate on wet basis
$G_{EXHW}$	kg/h	Exhaust gas mass flow rate on wet basis
$G_{FUEL}$	kg/h	Fuel mass flow rate
$G_{TOTW}$	kg/h	Diluted exhaust gas mass flow rate on wet basis
$H_{REF}$	g/kg	Reference value of absolute humidity 10.71 g/kg for calculation of NO <sub>x</sub> and particulate humidity correction factors
$H_a$	g/kg	Absolute humidity of the intake air

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Symbol	Unit	Term
$H_d$	g/kg	Absolute humidity of the dilution air
$i$	–	Subscript denoting an individual mode
$K_H$	–	Humidity correction factor for $NO_x$
$K_p$	–	Humidity correction factor for particulate
$K_{W,a}$	–	Dry to wet correction factor for the intake air
$K_{W,d}$	–	Dry to wet correction factor for the dilution air
$K_{W,e}$	–	Dry to wet correction factor for the diluted exhaust gas
$K_{W,r}$	–	Dry to wet correction factor for the raw exhaust gas
$L$	%	Percent torque related to the maximum torque for the test speed
mass	g/h	Subscript denoting emissions mass flow rate
$M_{DIL}$	kg	Mass of the dilution air sample passed through the particulate sampling filters
$M_{SAM}$	kg	Mass of the diluted exhaust sample passed through the particulate sampling filters
$M_d$	mg	Particulate sample mass of the dilution air collected
$M_f$	mg	Particulate sample mass collected
$P_a$	kPa	Saturation vapour pressure of the engine intake air (ISO 3046: $P_{sy} = PSY$ ; test ambient)
$P_B$	kPa	Total barometric pressure (ISO 3046: $P_x = PX$ Site ambient total pressure)

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Symbol	Unit	Term
		$P_y = P_Y$ Test ambient total pressure)
$P_d$	kPa	Saturation vapour pressure of the dilution air
$P_s$	kPa	Dry atmospheric pressure
$P$	kW	Power, brake uncorrected
$P_{AE}$	kW	Declared total power absorbed by auxiliaries fitted for the test which are not required by paragraph 2.4 of this Annex
$P_M$	kW	Maximum measured power at the test speed under test conditions (see Annex VI, Appendix 1)
$P_m$	kW	Power measured at the different test modes
$q$	–	Dilution ratio
$r$	–	Ratio of cross sectional areas of isokinetic probe and exhaust pipe
$R_a$	%	Relative humidity of the intake air
$R_d$	%	Relative humidity of the dilution air
$R_f$	–	FID response factor
$S$	kW	Dynamometer setting
$T_a$	K	Absolute temperature of the intake air
$T_D$	K	Absolute dewpoint temperature
$T_{ref}$	K	References temperature (of combustion air: 298 K)
$V_{AIRD}$	$m^3/h$	Intake air volume flow rate on dry basis
$V_{AIRW}$	$m^3/h$	Intake air volume flow rate on wet basis
$V_{DIL}$	$m^3$	Volume of the dilution air sample passed through the particulate sample filters
$V_{DILW}$	$m^3/h$	Dilution air volume flow rate on wet basis

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Symbol	Unit	Term
$V_{EDFW}$	$m^3/h$	Equivalent diluted exhaust gas volume flow rate on wet basis
$V_{EXHD}$	$m^3/h$	Exhaust gas volume flow rate on dry basis
$V_{EXHW}$	$m^3/h$	Exhaust gas volume flow rate on wet basis
$V_{SAM}$	$m^3$	Volume of sample through particulate sampling filters
$V_{TOTW}$	$m^3/h$	Diluted exhaust gas volume flow rate on wet basis
WF	–	Weighting factor
$WF_E$	–	Effective weighting factor

### 2.9.2 Symbols for the chemical components

CO	Carbon monoxide
CO <sub>2</sub>	Carbon dioxide
HC	Hydrocarbons
NO <sub>X</sub>	Oxides of nitrogen
NO	Nitric oxide
NO <sub>2</sub>	Nitrogen dioxide
O <sub>2</sub>	Oxygen
C <sub>2</sub> H <sub>6</sub>	Ethane
PT	Particulate
DOP	Di-octylphthalate
CH <sub>4</sub>	Methane
C <sub>3</sub> H <sub>8</sub>	Propane
H <sub>2</sub> O	Water
PTFE	Polytetrafluoroethylene

### 2.9.3 Abbreviations

FID	Flame ionization detector
HFID	Heated flame ionization detector
NDIR	Non-dispersive infrared analyser
CLD	Chemiluminescent detector
HCLD	Heated chemiluminescent detector

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PDP	Positive displacement pump
CFV	Critical flow venturi

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## ENGINE MARKINGS

### 3

**3.1** The engine approved as a technical unit must bear:

**3.1.1** the trade mark or trade name of the manufacturer of the engine;

**3.1.2** the engine type, engine family (if applicable), and a unique engine identification number;

**3.1.3** the EC type-approval number as described in Annex VII.

**3.2** These marks must be durable for the useful life of the engine and must be clearly legible and indelible. If labels or plates are used, they must be attached in such a manner that in addition the fixing is durable for the useful life of the engine, and the label/plates cannot be removed without destroying or defacing them.

**3.3** These marks must be secured to an engine part necessary for normal engine operation and not normally requiring replacement during engine life.

**3.3.1** These marks must be located so as to be readily visible to the average person after the engine has been completed with all the auxiliaries necessary for engine operation.

**3.3.2** Each engine must be provided with a supplementary movable plate in a durable material, which must bear all data indicated under section 3.1, to be positioned, if necessary, in order to make the marks referred to under section 3.1 readily visible to the average person and easily accessible when the engine is installed in a machine.

**3.4** The coding of the engines in context with the identification numbers must be such that it allows for the indubitable determination of the sequence of production.

**3.5** Before leaving the production line the engines must bear all markings.

**3.6** The exact location of the engine markings shall be declared in Annex VI, Section 1.

## SPECIFICATIONS AND TESTS

### 4

#### General

**4.1** The components liable to affect the emission of gaseous and particulate pollutants shall be so designed, constructed and assembled as to enable the engine, in normal use, despite the vibrations to which it may be subjected, to comply with the provisions of this Directive.

The technical measures taken by the manufacturer must be such as to ensure that the mentioned emissions are effectively limited, pursuant to this Directive, throughout the normal life of the engine and under normal conditions of use. These provisions are deemed to be met if the provisions of sections 4.2.1, 4.2.3 and 5.3.2.1 are respectively complied with.

If a catalytic converter and/or a particulate trap is used the manufacturer must prove by durability tests, which he himself may carry out in accordance with good engineering practice, and by corresponding records, that these after-treatment devices can be expected to function properly for the lifetime of the engine. The records must be produced in compliance with the requirements of section 5.2 and in particular with section 5.2.3. A corresponding warranty must be guaranteed to the customer. Systematic replacement of the device, after a certain

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running time of the engine, is permissible. Any adjustment, repair, disassembly, cleaning, or replacement of engine components or systems which is performed on a periodic basis to prevent malfunction of the engine in context with the after-treatment device, shall only be done to the extent that is technologically necessary to assure proper functioning of the emission control system. Accordingly scheduled maintenance requirements must be included in the customer's manual, and be covered by the warranty provisions mentioned above, and be approved before an approval is granted. The corresponding extract from the manual with respect to maintenance/replacements of the treatment device(s), and to the warranty conditions, must be included in the information document as set out in Annex II to this Directive.

### Specifications concerning the emissions of pollutants

**4.2.** The gaseous and particulate components emitted by the engine submitted for testing shall be measured by the methods described in Annex V.

Other systems or analysers may be accepted if they yield equivalent results to the following reference systems:

- for gaseous emissions measured in the raw exhaust, the system shown in Figure 2 of Annex V,
- for gaseous emissions measured in the dilute exhaust of a full flow dilution system, the system shown in Figure 3 of Annex V,
- for particulate emissions, the full flow dilution system, operating with a separate filter for each mode or with the single filter method, shown in Figure 13 of Annex V.

The determination of system equivalency shall be based upon a seven test cycle (or larger) correlation study between the system under consideration and one or more of the above reference systems.

The equivalency criterion is defined as a  $\pm 5\%$  agreement of the averages of the weighted cycle emissions values. The cycle to be used shall be that given in Annex III, section 3.6.1.

For introduction of a new system into the Directive the determination of equivalency shall be based upon the calculation of repeatability and reproducibility, as described in ISO 5725.

**4.2.1.** The emissions of the carbon monoxide, the emissions of hydrocarbons, the emissions of the oxides of nitrogen and the emissions of particulates obtained shall for stage I not exceed the amount shown in the table below:

Net power (P) (kW)	Carbon monoxide (CO) (g/kWh)	Hydrocabons (HC) (g/kWh)	Oxides of nitrogen (No <sub>x</sub> ) (g/kWh)	Particulates (PT) (g/kWh)
$130 \leq P \leq 560$	5.0	1.3	9.2	0.54
$75 \leq P < 130$	5.0	1.3	9.2	0.70
$37 \leq P < 75$	6.5	1.3	9.2	0.85

**4.2.2.** The emission limits given in paragraph 4.2.1 are engine-out limits and shall be achieved before any exhaust after-treatment device.

**4.2.3.** The emissions of the carbon monoxide, the emissions of hydrocarbons, the emissions of the oxides of nitrogen and the emissions of particulates obtained shall for stage II not exceed amounts shown in the table below:

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Net power (P) (kW)	Carbon monoxide (CO) (g/kWh)	Hydrocabons (HC) (g/kWh)	Oxides of nitrogen (No <sub>x</sub> ) (g/kWh)	Particulates (PT) (g/kWh)
130 ≤ P ≤ 560	3.5	1.0	6.0	0.2
75 ≤ P < 130	5.0	1.0	6.0	0.3
37 ≤ P < 75	5.0	1.3	7.0	0.4
18 ≤ P < 37	5.5	1.5	8.0	0.8

**4.2.4.** Where, as defined according to Section 6 in conjunction with Annex II, Appendix 2, one engine family covers more than one power band, the emission values of the parent engine (type approval) and of all engine types within the same family (COP) must meet the more stringent requirements of the higher power band. The applicant has the free choice to restrict the definition of engine families to single power bands, and to correspondingly apply for certification.

#### **Installation on the mobile machinery**

**4.3.** The engine installation on the mobile machinery shall comply with the restrictions set out in the scope of the type-approval. Additionally the following characteristics in respect to the approval of the engine always must be met:

**4.3.1.** intake depression shall not exceed that specified for the approved engine in Annex II, Appendix 1 or 3 respectively;

**4.3.2.** exhaust back pressure shall not exceed that specified for the approved engine in Annex II, Appendix 1 or 3 respectively.

### **SPECIFICATION OF CONFORMITY OF PRODUCTION ASSESSMENTS**

#### **5**

**5.1.** With regard to the verification of the existence of satisfactory arrangements and procedures for ensuring effective control of production conformity before granting type-approval, the approval authority must also accept the manufacturer's registration to harmonized standard EN 29002 (whose scope covers the engines concerned) or an equivalent accreditation standard as satisfying the requirements. The manufacturer must provide details of the registration and undertake to inform the approval authority of any revisions to its validity or scope. In order to verify that the requirements of section 4.2 are continuously met, suitable controls of the production shall be carried out.

**5.2.** The holder of the approval shall in particular:

**5.2.1.** ensure existence of procedures for the effective control of the quality of the product;

**5.2.2.** have access to the control equipment necessary for checking the conformity to each approved type;

**5.2.3.** ensure that data of test results are recorded and that annexed documents shall remain available for a period to be determined in accordance with the approval authority;

**5.2.4.** analyse the results of each type of test, in order to verify and ensure the stability of the engine characteristics, making allowance for variations in the industrial production process;

**5.2.5.** ensure that any sampling of engines or components giving evidence of non-conformity with the type of test considered shall give rise to another sampling and another test. All the necessary steps shall be taken to re-establish the conformity of the corresponding production.

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**5.3.** The competent authority which has granted type approval may at any time verify the conformity control methods applicable to each production unit.

**5.3.1.** In every inspection, the test books and production survey record shall be presented to the visiting inspector.

**5.3.2.** When the quality level appears unsatisfactory or when it seems necessary to verify the validity of the data presented in application of section 4.2, the following procedure is adopted:

**5.3.2.1.** an engine is taken from the series and subjected to the test described in Annex III. The emissions of the carbon monoxide, the emissions of the hydrocarbons, the emissions of the oxides of nitrogen and the emissions of particulates obtained shall not exceed the amounts shown in the table in section 4.2.1, subject to the requirements of section 4.2.2, or those shown in the table in section 4.2.3 respectively;

**5.3.2.2.** if the engine taken from the series does not satisfy the requirements of section 5.3.2.1 the manufacturer may ask for measurements to be performed on a sample of engines of the same specification taken from the series and including the engine originally taken. The manufacturer shall determine the size n of the sample in agreement with the technical service. Engines other than the engine originally taken shall be subjected to a test. The arithmetical mean (

$\bar{x}$

) of the results obtained with the sample shall then be determined for each pollutant. The production of the series shall then be deemed to confirm if the following condition is met:

$$\bar{x} + K \cdot S_t \leq L$$

(3)

where:

L is the limit value laid down in section 4.2.1/4.2.3 for each pollutant considered,

k is a statistical factor depending on n and given in the following table:

n	2	3	4	5	6	7	8	9	10
k	0.973	0.613	0.489	0.421	0.376	0.342	0.317	0.296	0.279
n	11	12	13	14	15	16	17	18	19
	0.265	0.253	0.242	0.233	0.224	0.216	0.210	0.203	0.198

$$\text{if } n \geq 20, k = \frac{0.860}{\sqrt{n}}$$

**5.3.3.** The approval authority or the technical service responsible for verifying the conformity of production shall carry out tests on engines which have been run-in partially or completely according to the manufacturer's specifications.

**5.3.4.** The normal frequency of inspections authorized by the competent authority shall be one per year. If the requirements of section 5.3.2 are not met, the competent authority shall ensure that all necessary steps are taken to re-establish the conformity of production as rapidly as possible.

(3) where x is any one of the individual results obtained with the sample n.

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## **PARAMETERS DEFINING THE ENGINE FAMILY**

6. The engine family may be defined by basic design parameters which must be common to engines within the family. In some cases there may be interaction of parameters. These effects must also be taken into consideration to ensure that only engines with similar exhaust emission characteristics are included within an engine family.

In order that engines may be considered to belong to the same engine family, the following list of basic parameters must be common:

**6.1. Combustion cycle:**

- 2 cycle
- 4 cycle

**6.2. Cooling medium:**

- air
- water
- oil

**6.3. Individual cylinder displacement:**

- engines to be within a total spread of 15%
- number of cylinders for engines with after-treatment device

**6.4. Method of air aspiration:**

- naturally aspirated
- pressure charged

**6.5. Combustion chamber type/design:**

- pre-chamber
- swirl chamber
- open chamber

**6.6 Valve and porting—configuration, size and number:**

- cylinder head
- cylinder wall
- crankcase

**6.7 Fuel system:**

- pump-line-injector
- in-line pump
- distributor pump
- single element
- unit injector

**6.8 Miscellaneous features:**

- exhaust gas recirculation
- water injection/emulsion
- air injection
- charge cooling system

#### **6.9 Exhaust after-treatment:**

- oxidation catalyst
- reduction catalyst
- thermal reactor
- particulates trap

### **7. CHOICE OF THE PARENT ENGINE**

**7.1** The parent engine of the family shall be selected using the primary criteria of the highest fuel delivery per stroke at the declared maximum torque speed. In the event that two or more engines share this primary criteria, the parent engine shall be selected using the secondary criteria of highest fuel delivery per stroke at rated speed. Under certain circumstances, the approval authority may conclude that the worst case emission rate of the family can best be characterized by testing a second engine. Thus, the approval authority may select an additional engine for test based upon features which indicate that it may have the highest emission levels of the engines within that family.

**7.2** If engines within the family incorporate other variable features which could be considered to affect exhaust emissions, these features must also be identified and taken into account in the selection of the parent engine.