

CHAPTER 3 : TEST PROCEDURE FOR MEASUREMENT OF GASEOUS & PARTICULATE POLLUTANTS FROM DIESEL ENGINES

1 Scope : This chapter describes the method of determining emissions of gaseous pollutants and the particulates from the engine to be tested, as defined in para 5.2 of Chapter 1 of this Part.

2 Measurement Principle : The test shall be carried out with the engine mounted on a test bench and connected to a dynamometer. The gaseous & particulate emissions from the exhaust of the engine include hydrocarbons, carbon monoxide and oxides of nitrogen and particulates. During a prescribed sequence of warmed up engine operating conditions the amounts of the above pollutants in the exhaust shall be examined continuously. The prescribed sequence of operations consist of a number of speed and power modes which span the typical operating range of diesel engines. During each mode the concentration of each pollutant, exhaust flow and power output shall be determined and the measured values weighted and used to calculate the grammes of each pollutant emitted per kilowatt hour, as described in this part.

3 Equipment :

3.1 Dynamometer and Engine Equipment

The following equipment shall be used for emission tests of engines on engine dynamometers:

3.1.1 An engine dynamometer with adequate characteristics to perform the test cycle described in Paragraph 4.1 below.

3.1.2 Measuring instruments for speed, torque, fuel consumption, air consumption, temperature of coolant and lubricant, exhaust gas pressure and section flow resistance, air inlet temperature, atmospheric pressure, fuel temperature and humidity. The accuracy of these instruments shall satisfy the method of measuring the power of the internal combustion engines of road vehicles, given in Chapter 6 of Part IV of this Rule. Other instruments shall have an accuracy which satisfies the following requirements.

3.1.2.1 Temperatures :

Exhaust gas temperature shall be measured with an accuracy of $\pm 5K$ ($5^{\circ}C$), other temperatures with an accuracy of $\pm 1.5K$ ($1.5^{\circ}C$).

3.1.2.2 Absolute humidity :

The absolute humidity (H) shall be determined to an accuracy of $\pm 5\%$.

- 3.1.3 An engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures for the duration of the prescribed engine tests;

Where there is a risk of an appreciable effect on the engine power, or when the manufacturer request so, the complete exhaust system shall be fitted as provided for the intended application, non insulated and uncooled, extending at least 0.5m past the point where the raw exhaust sample probes are located.

- 3.1.4 In other cases, an equivalent system may be installed provided the pressure measurement at the exit of the engine exhaust system does not differ by more than 1000 Pa from that specified by the manufacturer.

The exit from the engine exhaust system is defined as a point 150 mm down stream from the termination of the part of the exhaust system mounted on the engine.

Where there is a risk of an appreciable effect on the engine power, or where the manufacturer request so, the complete intake system shall be fitted as provided for the intended application.

- 3.1.5 In other cases, an equivalent system may be used and a check should be made to ascertain that the intake pressure does not differ by more than 100 Pa from the limit prescribed by the manufacturer for a clean air filter.

When an engine is tested for exhaust emissions, the complete engine shall be tested with all standard accessories which might reasonably be expected to influence emissions to the atmosphere installed and functioning as listed in Chapter 6 of Part IV of this regulation.

- 3.2 Exhaust Gas Sampling System :
Chapter 4 of this part describes the analytical system for gaseous and particulate pollutants in current use. Other systems or analysers which have proved to give equivalent results, may be used.

- 3.2.1 The exhaust gas sampling system shall be designed to enable the measurement of the true mass emissions of the exhaust.

- 3.2.2 The probe shall extract a true sample of the exhaust gases.

- 3.2.3 The system should be free of gas leaks. The design and materials shall be such that the system does not influence the pollutant concentration in the diluted exhaust gas. Should any component (heat exchanger, blower, etc.) change the concentration of any pollutant gas in the diluted gas, then the sampling for that pollutant shall be carried out before that component, if the problem cannot be corrected.

3.2.4 The various valves used to direct the exhaust gases shall be of a quick-adjustment, quick-acting type.

3.3 Analytical Equipment :

3.3.1 Pollutant gases shall be analysed with the following instruments

3.3.1.1 Carbon monoxide (CO) and carbon dioxide (CO₂) analysis.

The carbon monoxide and carbon dioxide analysers shall be of the NON-DISPERSIVE INFRA RED (NDIR) absorption type.

3.3.1.2 Hydrocarbon (HC) analysis

The Hydrocarbon analyser shall be of the Heated Flame Ionisation type (HFID) with the whole FID system maintained at a temperature between 453 K to 473 K (180°C to 200°C). It shall be calibrated with propane gas of equivalent to carbon atoms (C₁).

3.3.1.3 Oxides of nitrogen (NO_x) Analysis.

The nitrogen oxide analyser shall be of the heated Chemiluminescent (HCLA) type with an NO_x-NO converter or equivalent .

3.3.1.4 Carbon dioxide (CO₂) Analysis for checking dilution ratio.

The carbon dioxide analyser shall be of the non-dispersive infra red (NDIR) absorption type.

3.3.1.5 Accuracy

The analysers shall have a measuring range compatible with the accuracy required to measure the concentrations of the exhaust gas sample pollutants. Measurement errors shall not exceed ± 2.5 % of the full scale deflection or better disregarding the true value of the calibration gases. For concentrations of less than 100 ppm the measurement error shall not exceed ± 3 ppm. The ambient air sample shall be measured on the same analyser and range as the corresponding diluted exhaust sample.

3.3.1.6 Gas Drying :

Optional gas drying devices shall have no effect on the pollutant content of the gas stream.

3.3.1.7 Sampling :

A heated sample line for continuous HC analysis with the flame ionisation detector (HFID), including recorder (R) shall be used, through out the test, the temperature of complete sampling system shall be maintained at the temperature of 453 to 473 K (180°C to 200°C). The heated sampling line shall be fitted with a heated filter (F) (99% efficient with particles $\geq 0.3 \mu\text{m}$) to extract any solid particles from the continuous flow of gas required for analysis. A second heated line for NO_x analysis is to be used when appropriate. The temperature of this line shall be controlled at 368 to 473 K (95°C to 200°C). The sample line for CO and CO₂ analysis may be heated or unheated.

3.3.1.8 Determination of the particulates :

The determination of the particulates requires a dilution system capable of maintaining the temperature of the diluted exhaust gas at or below 325 K (52°C) and preventing water condensation, a particulate sampling system, specified particulate sampling filters and a micro gram balance which shall be placed in an air conditioned weighing chamber. Dilution may be accomplished by a full flow dilution or a partial flow dilution system. Chapter 4 of this part describes the analytical system in current use. Other systems which have proved to give equivalent results may be used.

3.4 Gases

3.4.1 The following pure gases shall be available when necessary, for calibration and operation :

Purified nitrogen (purity $\leq 1\text{ppm C}$, $\leq 1\text{ppm CO}$, $\leq 400\text{ppm CO}_2$, $\leq 0.1\text{ppm NO}$);

Purified synthetic air (purity $< 1\text{ppm C}$, $< 1\text{ppm CO}$, $< 400\text{ppm CO}_2$, $< 0.1\text{ppm NO}$); Oxygen content between 18 and 21 percent vol.;

Purified oxygen (purity > 99.5 percent Vol. O₂) ;

Hydrogen mixture (40 \pm 2% hydrogen, balance helium)
(Purity $\leq 1\text{ppm C}$, $\leq 400 \text{ ppm CO}_2$);

3.4.2 Calibration and span gases :

Gases having the following chemical compositions shall be available C₃ H₈ and purified synthetic air (see paragraph 3.4.1 above); CO and purified nitrogen; CO₂ and purified nitrogen; NO and purified nitrogen (the amount of NO₂ contained in this calibration gas must not exceed 5 percent of the NO content)

The true concentration of a calibration and span gas shall be within $\pm 2\%$ of the nominal value. All concentrations of calibration gases shall be given on volume basis (volume % or volume ppm)

The gases used for calibration and span must be obtained by means of a gas divider, diluting with purified nitrogen or with purified synthetic air. The accuracy of the mixing device shall be such that the concentrations of the diluted calibration and span gases may be determined within $\pm 2\%$.

4 Test Procedure :

4.1 Test Cycle :

The following 13-mode cycle in case of automotive engines for example, shall be followed in dynamometer operation on the test engine:-

Mode No.	Engine Speed	% Load
1	Idle	----
2	Intermediate	10
3	”””	25
4	”””	50
5	”””	75
6	”””	100
7	Idle	----
8	Rated	100
9	”””	75
10	”””	50
11	”””	25
12	”””	10
13	Idle	-----

4.2 Measurement of Exhaust Gas Flow :

For calculation of the emission it is necessary to know the exhaust flow, as given in Para 4.3.1.1. below. For determination of exhaust flow either of the following methods may be used. The volumetric flow rates V'_{EXH} and V''_{EXH} are defined at $T = 273$ and $P = 101.315$ kPa

4.2.1 Direct measurement of the exhaust flow by flow nozzle or equivalent metering system.

4.2.2 Measurement of the air flow and the fuel flow by suitable metering systems and calculation of the exhaust flow by the following equations :

4.2.2.1 In the case of C.I. Engines

$$G_{EXH} = G_{AIR} + G_{FUEL}$$

or

$$V'_{EXH} = V_{AIR} - 0.75 G_{FUEL} \text{ (dry exhaust volume)}$$

Or

$$V''_{EXH} = V_{AIR} + 0.77 G_{FUEL} \text{ (wet exhaust volume)}$$

4.2.2.2 In the case of NG Engines

$$G_{EXH} = G_{AIR} + G_{FUEL}$$

or

$$V'_{EXH} = V'_{AIR} - 1.35 G_{FUEL} \text{ (dry exhaust volume)}$$

or

$$V''_{EXH} = V''_{AIR} + 1.36 G_{FUEL} \text{ (wet exhaust volume)}$$

The accuracy of exhaust flow determination shall be $\pm 2.5\%$ or better.

4.2.2.3 In case of LPG fueled engines :

$$G_{EXH} = G_{AIR} + G_{FUEL}$$

or

$$V'_{EXH} = V'_{AIR} - G_{FUEL} \text{ (dry exhaust volume)}$$

or

$$V''_{EXH} = V''_{AIR} + G_{FUEL} \text{ (wet exhaust volume)}$$

4.2.3 The accuracy of exhaust flow determination shall be $\pm 2.5\%$ or better.

4.2.4 The concentration of carbon monoxide and nitric oxide are measured in the dry exhaust. For this reason the CO and NOx emissions shall be calculated using the dry exhaust gas volume V'_{EXH} . If the exhaust mass flow rate (G_{EXH}) is used in the calculation the CO and NOx concentrations shall be related to the wet exhaust. Calculation of the HC emission shall include G_{EXH} and V''_{EXH} according to the measuring method used.

4.3 Operating and Calibrating Procedure for Analysers and Sampling System :

The operating procedure for analysers shall follow the startup and operating instructions of the instrument manufacturer. The following minimum requirements shall be included.

4.3.1 Calibration Procedure

4.3.1.1 The calibration procedure shall be carried out within one month preceding the emission test. The instrument assembly shall be calibrated and calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust.

4.3.1.1.1 A minimum of two hours shall be allowed for warming up the analysers.

4.3.1.1.2 A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyzer pump shall be switched on. After an initial stabilization period all flow meters and pressure gauges should read zero. If not, the sampling line(s) shall be checked and the fault corrected.

4.3.1.1.3 The NDIR analyzer shall be tuned, where appropriate, and the flame combustion of the HFID analyzer optimized.

4.3.1.1.4 Using purified dry air (or nitrogen), the CO (CO₂ if used) and NO_x analysers shall be set at zero; dry air must be used for the HC analyzer. Using appropriate calibration gases, the analysers shall be reset.

4.1.1.1.5 The zero setting shall be rechecked and the procedure described in Paragraph 4.1.4 above repeated, if necessary.

4.3.1.1.6 Gas meters or flow instrumentation used to determine flow through the particulate filters and to calculate the dilution ratio are calibrated with a standard air flow measurement device upstream of the instrument. This device must conform to the regulations of the National Bureau of Standards of the respective country. The points on the calibration curves relative to the calibration device measurements must be within +/- 1.0% of the maximum operating range +/-2% of the point, whichever is smaller.

4.3.1.1.7 When using a partial-flow-dilution system with isokinetic probe, the dilution ratio is checked with the engine running using either the CO₂ or NO_x concentrations in the raw and diluted exhaust.

4.3.1.1.8 When using a full-flow-dilution system, the total flow is verified by means of a propane check. The gravimetric mass of propane injected into the

system is subtracted from the mass measured with the full-flow-dilution system and then divided by the gravimetric mass. Any discrepancy greater than +/- 3% must be corrected.

4.3.2 Establishment of Calibration Curve

4.3.2.1 Each normally used operating range shall be calibrated in accordance with the following procedure :

4.3.2.2 The analyser calibration curve shall be established by at least five calibration points, spaced as uniformly as possible. The nominal concentration of the calibration gas of the highest concentration shall be at least equal to 90% of the full scale.

4.3.2.3 The calibration curve is calculated by the least square method. If the degree of the polynomial resulting from the curve is greater than 3, the number of calibration points shall be at least equal to this polynomial degree plus 2.

4.3.2.4 The calibration curve shall not differ by more than $\pm 2\%$ from the nominal value of calibration gas.

4.3.2.5 Trace of the Calibration curves.

From the trace of the calibration curve and the calibration points, it is possible to verify that the calibration has been carried out correctly. The different characteristic parameters of the analyzer must be indicated, particularly:

the scale

the sensitivity

the zero point

the date of carrying out the calibration

4.3.2.6 It can be shown to the satisfaction of the technical service that alternative technology (e.g. computer, electronically controlled range switch, etc.) can give equivalent accuracy, then these alternatives may be used.

4.3.3 Verification of Calibration

4.3.3.1 Each normally used operating range shall be checked prior to each analysis in accordance with the following:

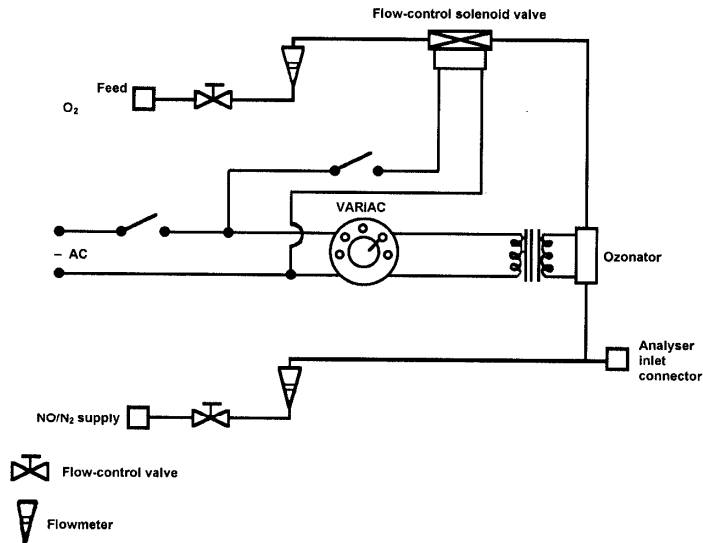
4.3.3.2 The calibration is checked by using a zero gas and a span gas whose nominal value is near to the supposed value to be analysed.

4.3.3.3 If, for the two points considered, the value found does not differ by more than +/-5% of the full scale from the theoretical value, the adjustment parameters may be modified. Should this not be the case, a new calibration curve shall be established in accordance with Paragraph 4.3.2 of this appendix.

- 4.3.3.4 After testing, zero gas and the same span gas will be used for rechecking. The analysis will be considered acceptable if the difference between the two measuring results is less than 2%.
- 4.3.4 Efficiency test of the NO_x Converter
- 4.3.4.1 The efficiency of the converter used for the conversion of NO₂ into NO is tested as follows :
- 4.3.4.2 Using the test set up as shown at the end of this annex and the procedure below, the efficiency of converters can be tested by means of an ozonator.
- 4.3.4.3 Calibrate the CLA in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which must amount to about 80% of the operating range and the NO₂ concentration of the gas mixture to less than 5% of the NO concentration). The NO_x analyzer must be in the NO mode so that the span gas does not pass through the converter. Record the indicated concentration.
- 4.3.4.4 Via a T fitting, oxygen is added continuously to the span gas flow until the concentration indicated is about 10% less than the indicated calibration concentration given in Paragraph 4.3.4.3. Record the indicated concentration (c). The ozonator is kept deactivated throughout the process.
- 4.3.4.5 The ozonator is now activated to generate enough ozone to bring the NO concentration down to 20% (minimum 10%) of the calibration concentration given in Paragraph 4.3.4.3. Record the indicated concentration (d).
- 4.3.4.6 The NO analyzer is then switched to the NO_x mode which means that the gas mixture (consisting of NO, NO₂, O₂ and N₂) now passes through the converter. Record the indicated concentration (a).
- 4.3.4.7 The ozonator is now deactivated. The mixture of gases described in Paragraph 4.4.4 passes through the converter into the detector. Record the indicated concentration (b).
- 4.3.4.8 With the ozonator deactivated, the flow of oxygen or synthetic air is also shut off. The NO reading of the analyzer must then be no more than 5% above the figure given in Paragraph 4.3.4.3.
- 4.3.4.9 The efficiency of the NO_x converter is calculated as follows :

$$\text{Efficiency}(\%) = 1 + \frac{a-b}{c-d} \cdot 100$$

4.3.4.10 The efficiency of the converter must be tested prior to each calibration of the NO_x analyzer.



Schematic of NO_x converter efficiency device

Figure 1 : Schematic of Nox Converter Efficiency Device

4.3.4.11 The efficiency of the converter must not be less than 95%.

NOTE : If the analyzer operating range is above the highest range that the NO_x converter can operate to give a reduction from 80 to 20%, then the highest range the NO_x converter will operate on will be used.

4.3.5 Pre-test Checks

4.3.5.1 A minimum of two hours shall be allowed for warming up the infra-red NDIR analyser, but it is preferable that power be left on continuously in the analysers. The chopper motors may be turned off when not in use.

4.3.5.2 Each normally used operating range shall be checked prior to each analysis.

4.3.5.3 Using purified dry air (or nitrogen), the CO and NOx analysers shall be set at zero; dry air shall be purified for the HC analyser.

4.3.5.4 Span gas having a concentration of the constituent that will give a 75-95% full-scale deflection or span gas where nominal value is near to the supposed value to be analysed shall be introduced and the gain set to match the calibration

curve. The same flow rate shall be used for calibration, span and exhaust sampling to avoid correction for sample cell pressure.

4.3.5.5 The nominal value of the span calibration gas used shall remain with $\pm 2\%$ of the calibration curve.

4.3.5.6 If it does not, but it remains within $\pm 5\%$ of the calibration curve, the system parameters such as gain of the amplifier, tuning of NDIR analysers, optimisation of FID analysers etc. may be adjusted to bring within $\pm 2\%$.

4.3.5.7 If the system does not meet the requirement of 4.3.5.5 and 4.3.5.6 above, the system should be checked, fault, if any corrected and a new calibration curve should be obtained.

4.3.5.8 Zero shall be checked and the procedures described in para 4.3.3.3 and 4.3.3.4 above repeated, if required.

4.4 System Leak Test :

A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilisation period all flow meters and pressure gauges should read zero. If not, the sampling line(s) shall be checked and the fault corrected.

4.5 Checking for FID Hydrocarbon Response :

Detector response optimisation

The FID must be adjusted, as specified by the instrument manufacturer. Propane in air should be used, to optimise the response, on the most common operating range.

Calibration of the HC analyser.

The analyser should be calibrated using propane (C_3H_8) in air and purified synthetic air. See paragraph 3.4.2 of this Appendix (calibration-and span gases).

Establish a calibration curve as described in Paragraphs 4.3.2 to 4.3.3 of this Appendix.

Response Factors of Different Hydrocarbons and Recommended Limits.

The response factor (Rf), for a particular hydrocarbon species is the ratio of the FID C1 reading to the gas cylinder concentration, expressed as ppm C1.

The concentration of the test gas must be at a level to give a response of approximately 80% of full scale deflection, for the operating range. The concentration must be known, to an accuracy of $\pm 2\%$ in reference to a gravimetric standard expressed in volume. In addition the gas cylinder must be pre-conditioned for 24 hours at a temperature between 20°C and 30°C.

Response factors should be determined when introducing an analyser into service and thereafter at major service intervals. The test gases to be used and the recommended response factors are, relative to a response factor (Rf) of 1.00 for propane and purified air:

Methane and purified air	$1.00 \leq Rf \leq 1.15$
Propylene and purified air	$0.90 \leq Rf \leq 1.00$
Toluene and purified air	$0.90 \leq Rf \leq 1.00$

Oxygen Interference Check and Recommended Limits.

The response factor should be determined as described in above paragraph The test gas to be used and recommended response factor range are:

Propane and nitrogen	$0.95 \leq Rf \leq 1.05$
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- 4.6 Gas meters or flow instruments used to determine flow through the particulate filters and to calculate the dilution ratio shall be calibrated with a standard air flow measurement device upstream of the instrument. This device must conform to the regulations of the National Bureau of Standards of the respective country. The points on the calibration curve relative to the calibration device measurements must be within $\pm 1.0\%$ of the maximum operating range or $\pm 2.0\%$ of the point, whichever is smaller.
- 4.7 When using a partial flow dilution system with isokinetic probe, the dilution ratio is checked with the engine running using either the CO₂ or Knox concentration in the raw and diluted exhaust.
- 4.8 When using a full flow dilution system, the total flow is verified by means of a propane check. The gravimetric mass of propane injected into the system is subtracted from the mass measured with the full flow dilution system and then divided by the gravimetric mass. Any discrepancy greater than $\pm 3\%$ must be corrected.
- 4.9 Fuel :
 - 4.9.1 The fuel shall be the reference fuel as specified in the applicable gazette notification.

4.10 Engine test conditions :

4.10.1 The absolute temperature (T) of the engine air at the inlet to the engine expressed in Kelvin, and the dry atmospheric pressure (PS), expressed in kilopascals, shall be measured and the parameter F shall be determined according to the following provisions :

4.10.2 Naturally Aspirated and Mechanically Supercharged Engines:

4.10.2.1 C.I. Engines

$$F=(99/PS) * (T/298) ^ 0.7$$

4.10.2.2 Spark-ignition engines

$$F=(99/PS)^{1.2} * (T/298) ^ 0.6$$

4.10.3 Turbo-Charged Engines With or Without Cooling of Inlet Air:

4.10.3.1 C.I. Engines

$$F=(99/PS)^{0.7} * (T/298) ^ 1.5$$

4.10.3.2 Spark-ignition Engines

$$F=(99/PS)^{1.2} * (T/298) ^ 0.6$$

4.10.4 For a test to be recognised as valid, the parameter F shall be between 0.98 and 1.02 for CI engines as per the notification issued by MOST from 1/4/96.

For a test to be recognised as valid, the parameter F shall be between 0.93 and 1.07 for SI engines as per IS-14599 - 1999.

4.11 Test Run

4.11.1 At least two hours before the test each filter for measurement of the emission of particulate pollutants shall be placed in a closed but unsealed petri dish and placed in the weighing chamber for stabilisation. At the end of the stabilisation period each filter is weighed and the tare weight recorded. The filter is then stored in the petri dish which must remain in the weighing chamber, or a sealed

filter holder until needed for testing. If the filter is not used within one hour of its removal from the weighing chamber, it must be re-weighed before use.

- 4.11.2 During each mode of the test cycle, the specified speed shall be held to within ± 50 rpm and the specified torque shall be held to within $\pm 2\%$ of the maximum torque at the test speed. The fuel temperature at the injection pump inlet shall be $311 \pm 5\text{K}$ ($33^\circ\text{C} - 43^\circ\text{C}$). The governor and fuel system shall be adjusted as established by the manufacturer's sales and service literature. The following steps shall be taken for each test :-
- 4.11.3 In the case of NG engines, the fuel temperature and the pressure at pressure regulator final stage shall be within the range specified by the manufacturer; the speed limiting device and fuel system must be adjusted as established by the manufacturer's sales and service literature. The following steps are taken for each test :
- 4.11.4 Instrumentation and sample probes shall be installed as required. When using a full-flow-dilution system for exhaust gas dilution, the tailpipe is connected to the system, and the settings of inlet restriction and exhaust gas back pressure re-adjusted accordingly. The total flow must be set so as to keep the temperature of the diluted exhaust at or below 325 K (52°C) immediately before the particulate filters at the mode with the maximum heat flow as determined from exhaust flow and/or temperatures;
- 4.11.5 The cooling system and the full flow dilution system, or partial flow dilution system, respectively, are started;
- 4.11.6 The engine shall be started and warmed up until all temperatures and pressures have reached equilibrium;
- 4.11.7 The torque curve at full load shall be determined by experimentation to calculate the torque values for the specified test modes and to check the conformity of the tested engine performance with manufacturer's specifications. The corrected performance shall not differ by more than $\pm 2\%$ for maximum net power and $\pm 4\%$ for maximum net torque from the values declared by the manufacturer. The maximum permissible power absorbed by engine-driven equipment, declared by the manufacturer to be applicable to the engine type, is taken into account. The dynamometer setting for each engine speed and load are calculated using the formula:

$$S = P_{\min} \times \frac{L}{100} + P_{\text{aux}}$$

Where

S = dynamometer setting

P_{\min} = minimum net engine power as indicated in Line (e) in the table

of AIS 007
L = per cent load as indicated in Paragraph 4.1 of this Annex.
P_{aux} = total permissible power absorbed by engine driven equipment
minus the power of any such equipment actually driven by the
engine: AIS 007

4.11.8 The emission analysers shall be set at zero and spanned. The particulate sampling system is started. When using a partial-flow-dilution-system, the dilution ratio must be set so as to keep the temperature of the diluted exhaust at or below 325 K (52°C) immediately before the particulate filters at the mode with the maximum heat flow as determined from exhaust flow and/or temperature;

The range of the exhaust gas velocity and the pressure oscillations is checked and adjusted according to the requirements of Annex 4, Appendix 4, if applicable.

4.11.9 The test sequence as given in para 4.1 above shall be started. The engine shall be operated for six minutes in each mode, completing engine speed and load changes in the first minute. The responses of the analysers shall be recorded on a strip chart recorder for the full six minutes with exhaust gas flowing through the analysers at least during the last three minutes for particulate sampling, one pair of filters (primary and back up filters, refer chapter ... of this part) is used for the complete test procedure. With a partial flow dilution system, the product of dilution ratio and exhaust gas flow for each mode shall be within $\pm 7\%$ of the average of all modes. With the full flow dilution system, the total mass flow rate shall be within $\pm 7\%$ of the average of all modes. The sample mass drawn through the particulate filters (M_{SAM}) must be adjusted at each mode to take account of total modal weighing factor and the exhaust or fuel mass flow rate (Refer Chapter 4). A sampling time of at least 20 seconds is used. Sampling shall be conducted as late as possible within each mode. The engine speed and load, intake air temperature and vacuum exhaust back pressure, fuel flow and air or exhaust flow shall be recorded during the last five minutes of each mode, with the speed and load requirements being met during the time of particulate sampling, but in any case during the last minute of each mode.

4.11.10 Any additional data required for calculation shall be read and recorded. (See para 4.12 below)

4.11.11 The zero and span settings of the emission analysers shall be checked and reset, as required, at least at the end of the test. The test shall be considered satisfactory if the adjustment necessary after the test does not exceed the accuracy of the analysers prescribed in Paragraph 3.3.1.5 above.

4.12 Chart Reading and Data Evaluation

4.12.1 At the completion of testing, the total sample mass through the filters (M_{SAM}) shall be recorded. The filters shall be returned to the weighing chamber and conditioned for at least two hours, but not more than 36 hours, and then shall be

weighed. The gross weight of the filters shall be recorded. The particulate mass (Pf) is the sum of the particulate mass collected on the primary and back up filters.

- 4.12.2 For the evaluation of the gaseous emissions chart recording, the last 60 seconds of each mode shall be located, and the average chart reading for HC, CO and NOx during each mode shall be determined from the average chart readings and the corresponding calibration data. However, a different type of registration can be used if it ensures as equivalent data acquisition.