PART X – SUB PART (B): DETAILS OF STANDARDS OF VISIBLE AND GASEOUS POLLUTANTS FROM DIESEL ENGINES FOR CONSTRUCTION EQUIPMENT VEHICLES

Scope

This part applies to the emission of visible pollutants and gaseous pollutants from compression ignition (C.I.) engined construction equipment vehicle's Engines effective from 1st Oct. 2007, 1st Oct. 2008 & 1st April 2011 as per Central Motor Vehicle Rules 115 A and enforced as per the Government of India, Ministry of Shipping, Road Transport and Highways, Notification no. G.S.R 276 (E) dated 10th April 2007.

2. Type Approval

2.1 For the purpose of type approval and conformity of production certification, manufacturer's engine range shall be divided into model families, consisting of parent engine model and its variant and application for Type Approval shall be made in the proforma prescribed in AIS 007 Rev. 03 Table 15 & Annexure- I of Table 15, as amended by time to time.

2.2 The determination of an engine family and the decision regarding parent engine shall be based on Annexure - I to this Part. For the purpose of identification, the manufacturer shall designate the families as F1, F2, F3 ….. Fn.

2.3 The Testing agency shall decide the family, the parent model and its variants depending on the information provided by the manufacturer.

2.4 Testing of the parent model, shall, normally, be sufficient for type approval of the family. The Testing agency has the option to carry out the testing of more than one model in the family to satisfy itself, subject to parent engine-concept as per Annexure I.

2.5 At later stage if the manufacturer submits the application for type approval of a model, the Testing agency shall ascertain whether the model can be classified as belonging to a family of model(s) already certified.

If the model does not belong to a family already certified, the Testing agency shall proceed with the testing of the model for type approval.

If the model belongs to a family already certified, the Testing agency shall decide whether the specific testing of the model is required. In case the specific testing of the model is not required, the type approval certificate for the family may be extended to include the model.

2.6 The Testing agency shall intimate its decision to the applicant within a fortnight of receipt of the application, indicating need and plan (schedule) of testing for type approval.

2.7 MODIFICATIONS IN THE ENGINE MODEL

2.7.1 Every modification in the characteristics or parameters of the engine model, which has been declared by the manufacturer as per AIS 007 Rev. 03 Table 15 & Annexure I of Table 15, shall be intimated by the manufacturer to the Testing agency, which is responsible for carrying out TA & COP for that Model. The Testing agency may either

Consider that the engine with the modifications made may still comply with the requirements. In this case, the Testing agency shall extend the type approval covering the modified specifications.

or

Consider that the engine with the modifications made require a further test to ensure compliance. In this case, if the engine with the modifications complies with the requirements on testing as per part X of this document, the Testing agency shall extend the type approval.

2.8 The manufacturer shall submit an engine for testing, as intimated by the Testing agency.

2.9 Every manufacturer of construction equipment vehicle's Engine shall meet the following requirements for the model before granting the type approval.

2.9.3 Construction equipment vehicle's Engine shall comply with the standards for visible pollutants (smoke) emitted by it when tested as per the procedure described in Indian Standards IS: 12062 – 1987 and shall not exceed the limit values of 3.25 m-1 light absorption co-efficient (75 H.S.U.) when tested on engine dynamometer at 80% load at six equally spaced speeds between 55% of maximum power speed as declared by the manufacturer or 1000 rpm whichever is higher And Maximum Power speed as declared by the manufacturer.

2.9.4 The gross power of the engine i.e. without fan shall be tested as per procedure given in Part IV of MoRTH/CMVR/TAP-115/116 Issue No.3 on engine dynamometer.

When tested on engine dynamometer at steady speeds over the full load curve, may differ from the power declared by the manufacturer as follows:

For Type Approval:

For single cylinder engines, ±10% at maximum power speed including all other measured speeds.

For all other engines, ±5% at maximum power speed and all other measured speeds.

For Conformity of Production:

At maximum power speed by ±10% for single cylinder engines and +8% / -5% for all other engines.

2.9.3 Every diesel driven Construction equipment vehicle's Engine (type or family) shall be so manufactured and produced by its manufacturer that it complies with the following mass emission standards mentioned in table below, in addition to those of visible pollutants as mentioned above at clause 2.9.1 when tested as per the procedures described in ISO-8178 Part-4(1996) 'C1' 8 mode cycle for variable speed engines & ISO-8178 Part-4(1996) 'D2' 5-Mode cycle for constant speed engines.

Bharat Stage II (CEV)	Applicable with effect from	CO	HC	NOx	PM
Category		g/kWh			
KW < 8	1-Oct-2008	8.00	1.30	9.20	1.0
8 ≤ kW < 19	1-Oct-2008	6.60	1.30	9.20	0.85
19 ≤ kW < 37	1-Oct-2007	6.50	1.30	9.20	0.85

37 ≤ kW < 75	1-Oct-2007	6.50	1.30	9.20	0.85
75≤ kW < 130	1-Oct-2007	5.0	1.30	9.20	0.70
130≤ kW ≤ 560	1-Oct-2007	5.0	1.30	9.20	0.54

Bharat Stage* III (CEV)	Applicable with effect from	CO	HC + NOx	PM
Category		g/kWh		
kW < 8	1-Apr-2011	8.0	7.5	0.80
8 ≤ kW < 19	1-Apr-2011	6.60	7.5	0.80
19 ≤ kW < 37	1-Apr-2011	5.50	7.50	0.60
37 ≤ kW < 75	1-Apr-2011	5.0	4.70	0.40
75 ≤ kW < 130	1-Apr-2011	5.0	4.0	0.30
130≤ kW ≤ 560	1-Apr-2011	3.50	4.0	0.20

* *The limit values shall include deterioration-calculated in accordance with Annexure III.*

2.10 For mass emission test, procedure will be followed as per Part X of MoRTH/CMVR/TAP-115/116 except the following clauses:

(1) Engine will be subjected to mass emission in gross condition i.e. w/o fan but inclusive of intake and exhaust system or equivalent in test cells to simulate AID (Air Intake depression) & EBP (Exhaust Back Pressure) as specified by Engine manufacturer.

If the engine is equipped with an exhaust after-treatment device, the exhaust pipe shall have the same diameter as found in-use for at least four pipe diameters upstream to the inlet of the beginning of the expansion section containing the after-treatment device. The distance from the exhaust manifold flange or turbocharger outlet to the exhaust after-treatment device shall be the same as in the machine configuration or within the distance specifications of the manufacturer. The exhaust backpressure or restriction shall follow the same criteria as above, and may be set with a valve.

CEV Manufacturer & Engine Manufacturer shall declare Air Intake depression & Exhaust Back Pressure jointly for all vehicle models with same engine family. At the time of approval of vehicle model, AID & EBP shall be confirmed by Test Agency that they are within the declared specifications.

(2) Cycle will be as per ISO 8178 (1996) Part-4 ‘C1’ – 8 modes for variable speed engines & ISO-8178 (1996) Part-4 ‘D2’ 5 Modes for constant speed engines.

(3) Each mode-duration will be 10 min.

(4) Particulate may be collected by single filter or by multi filter methods.

(5) One Engine family covers more than one power band, the emission values of the parent engine (TA & COP) and of all engine types within the same family (TA & 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.

(6) Periodicity of COP:
For equipment with annual production upto 200 nos., it shall be once in two years per family.
For equipment with annual production exceeding 200 nos., it shall be once in every year per family.

(7) Test fuel shall be reference fuel as per B.S.-II (enclosed as Annexure- II (a)) (with sulphur content of less than 500 ppm) for Bharat Stage II (CEV) and as per B.S. – III (enclosed as Annexure-II(b)) (with sulphur content of less than 300 ppm) for Bharat Stage III (CEV)

3 Conformity of Production:

3.3 Every produced vehicle's Engine of the model approved under this rule shall conform with regard to components affecting the emission of gaseous pollutants by the engine to the vehicle model type approved. The procedure for carrying out conformity of production test is given in Part VI of this document.

3.4 For verifying the conformity of the engine in a test, the following procedure is adopted: -

3.2.1 An engine is taken from the series is subjected to the mass emission test.

3.2.1.1 If the engine taken from the series does not satisfy the requirements of Paragraph 2.9.1 &2.9.2 above, two more engines are tested in the same way and if the Gross Power figure does not fulfill the requirements of 2.9.1 & 2.9.2, the production shall be considered not to conform the requirements of regulations.

3.2.1.2 If the engine taken from the series does not satisfy the requirements of Paragraph 2.9.3 above, the manufacturer may ask for measurements to be performed on a sample of engines taken from the series and including the engine originally taken. The Manufacturer shall specify the size n of the sample subject to n being minimum 2 and maximum 10, including the engine originally taken. The engines other than originally-tested shall be subjected to a test. The arithmetical mean ($\overline{x}$) of the results obtained from the sample shall be determined for each pollutant .The production of the series shall then be deemed to conform if the following condition is met: -

$$\overline{X} + k*S \leq L$$

Where: -

$S^2 = \sum (x_i - x)^2 / (n-1)$

S = Standard Deviation

x_i = any one of the individual results obtained with the sample n.

L = the limit value laid down in Paragraph 2.9.3 for each gaseous pollutant considered and

k = 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

ANNEXURE I

PARAMETERS DEFINING THE ENGINE FAMILY

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:

Combustion cycle:
- 2 cycle
- 4 cycle

Cooling medium:
- air
- water
- oil

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

Method of air aspiration:
- naturally aspirated
- pressure charged

Combustion chamber type/design:
- pre-chamber
- swirl chamber
- open chamber

Valve and porting - configuration, size and number:
- cylinder head
- cylinder wall
- crankcase

Fuel system:
- pump-line-injector
- in-line pump
- distributor pump
- single element
- unit injector
- common rail direct injection

Miscellaneous features:
- exhaust gas recirculation

- water injection/emulsion
- air injection
- charge cooling system

Exhaust after-treatment

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

CHOICE OF THE PARENT ENGINE

Gaseous & Particulate Emission test data of every engine type may be provided by manufacturer & based on the test results & also the following guidelines test agency shall decide parent engine.

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 criterion, 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 engine for test, based upon following additional features

k) An engine whose injection control is not dependent on speed;
l) An engine whose injection control is not dependent on load;
m) An engine with the lowest maximum injection pressure.
n) An engine with the highest charge air temperature at the inlet to the cylinder;
o) An engine with lowest charge air pressure at the inlet to the cylinder;
p) An engine with the least number of cylinders;
q) An engine with lowest rated power at rated speed;
r) An engine with lowest rated speed;
s) An engine with the lowest low idle speed;
t) An engine with the least number of injection points.

Which indicate that it may have the highest emission levels of the engines within that family.

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.

ANNEXURE II(A)

DIESEL FUEL SPECIFICATIONS for BSII (CEV)

	Minimum	Maximum	Test Method
Cetane Number	49	53	ISO 5165
Density at 15°C (kg/m^3)	835	845	ISO 3675 ASTM D 4052
Distillation : in °C			
50% point	245		ISO 3405
90% point	320	340	
Final boiling point	--	370	
Flash point (°C)	55		ISO 2719
CFPP (°C)	--	(-) 5	EN116(CEN)
Viscosity at 40°C	2.5 mm²/s	3.5 mm²/s	ISO 3104
Sulphur Content (% mass)	to be reported	0.05	ISO 8754, EN24260
Copper Corrosion at 50°C		1	ISO 2160
Conradson carbon residue 10% DR) (% mass)		0.2	ISO 10370
Ash Content % mass		0.01	ASTM D 482
Water Content % mass		0.05	ASTM D95 / D1744
Neutralisation (strong acid) No.		0.2 mg/koh/g	---
Oxidation Stability (mg/100 ml)		2.5	ASTM D2274

ANNEXURE II(B)

DIESEL FUEL SPECIFICATIONS for BSIII (CEV)

	Minimum	Maximum	Test Method
Cetane Number	52	54	EN-ISO 5165
Density at 15°C (kg/m^3)	833	837	EN-ISO 3675
Distillation : in °C			
50% point (°C)	245	---	EN-ISO 3405
95% point (°C)	345	350	
Final boiling point (°C)	--	370	
Flash point (°C)	55	---	EN 22719
CFPP (°C)	--	(-) 5	EN 116
Viscosity at 40°C (mm^2/s)	2.5	3.5	EN-ISO 3104
Polycyclic aromatic hydrocarbons (% m/m)	3.0	6.0	IP 391
Sulphur Content (mg/kg)	---	300	ASTM D 5453
Copper Corrosion	---	Class 1	EN-ISO 2160
Conradson carbon residue (10% DR) (% m/m)	---	0.2	EN-ISO 10370
Ash Content (% m/m)	---	0.01	EN-ISO 6245
Water Content (% m/m)	---	0.05	EN-ISO 12937
Neutralisation (strong acid) No. (mg KOH/g)	---	0.02	ASTM D 974
Oxidation Stability (mg/ml)	---	0.025	EN-ISO 12205

ANNEXURE III

DURABILITY REQUIREMENTS

1. **EMISSION DURABILITY PERIOD AND DETERIORATION FACTORS**.

This appendix shall apply to CI engines Bharat Stage III (CEV) only.

1.1. Manufacturers shall determine a Deterioration Factor (DF) value for each regulated pollutant for all Stage III engine families. Such DFs shall be used for type approval and Conformity Of Production Testing.

1.1.1. Test to establish DFs shall be conducted as follows:

1.1.1.1. The manufacturer shall conduct durability tests to accumulate engine operating hours according to a test schedule that is selected on the basis of good engineering judgement to be representative of in-use engine operation in respect to characterising emission performance deterioration. The durability test period should typically represent the equivalent of at least one quarter of the Emission Durability Period (EDP).

Service accumulation operating hours may be acquired through running engines on a dynamometer test bed or from actual in-field machine operation. Accelerated durability tests can be applied whereby the service accumulation test schedule is performed at a higher load factor than typically experienced in the field. The acceleration factor relating the number of engine durability test hours to the equivalent number of EDP hours shall be determined by the engine manufacturer based on good engineering judgement. During the period of the durability test, no emission sensitive components can be serviced or replaced other than to the routine service schedule recommended by the manufacturer.

The test engine, subsystems, or components to be used to determine exhaust emission DFs for an engine family, or for engine families of equivalent emission control system technology, shall be selected by the engine manufacturer on the basis of good engineering judgement. The criterion is that the test engine should represent the emission deterioration characteristic of the engine families that will apply the resulting DF values for certification approval. Engines of different bore and stroke, different configuration, different air management systems, different fuel systems can be considered as equivalent in respect to emissions deterioration characteristics if there is a reasonable technical basis for such determination.

DF values from another manufacturer can be applied if there is a reasonable basis for considering technology equivalence with respect to emissions deterioration, and evidence that the tests have been carried according to the specified requirements.

Emissions testing will be performed according to the procedures defined in this Document for the test engine after initial run-in but before any service accumulation, and at the completion of the durability. Emission tests can also be performed at intervals during the service accumulation test period, and applied in determining the deterioration trend.

1.1.1.2 The service accumulation tests or the emissions tests performed to determine deterioration must not be witnessed by the Test Agency.

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1.1.1.3. Determination of DF values from durability tests An additive DF is defined as the value obtained by subtraction of the emission value determine at the beginning of the EDP, from the emissions value determined to represent the emission performance at the end of the EDP.

A multiplicative DF is defined as the emission level determined for the end of the EDP divided by the emission value recorded at the beginning of the EDP.

Separate DF values shall be established for each of the pollutants covered by the legislation. In the case of establishing a DF value relative to the NOx + HC standard, for an additive DF, this is determined based on the sum of the pollutants notwithstanding that a negative deterioration for one pollutant may not offset deterioration for the other. For a multiplicative NOx+HC DF, separate HC and NOx DFs shall be determined and applied separately when calculating the deteriorated emission levels from an emissions test result before combining the resultant deteriorated NOx and HC values to establish compliance with the standard.

In cases where the testing is not conducted for the full EDP, the emission values at the end of the EDP are determined by extrapolation of the emission deterioration trend established for the test period, to the full EDP.

When emissions test results have been recorded periodically during the service accumulation durability-testing, standard statistical processing techniques based on good practice shall be applied to determine the emission levels at the end of the EDP; statistical significance testing can be applied in the determination of the final emissions values.

If the calculation results in a value of less than 1,00 for a multiplicative DF, or less than 0,00 for an additive DF, then the DF shall be 1,0 or 0,00, respectively.

1.1.1.4 A manufacturer may, with the approval of the type Test Agency, use DF values established from results of durability tests conducted to obtain DF values for certification of on-road HD CI engines. This will be allowed if there is technological equivalency between the test on-road engine and the non-road engine families applying the DF values for certification. The DF values derived from on-road engine emission durability test results must be calculated on the basis of EDP values defined in clause 2.

1.1.1.5.In the case where an engine family uses established technology, an analysis based on good engineering practices may be used in lieu of testing to determine a deterioration factor for that engine family subject to approval of the type Test Agency.

1.2. DF information in approval applications

1.2.1. Additive DFs shall be specified for each pollutant in an engine family certification application for CI engines not using any after-treatment device.

1.2.2. Multiplicative DFs shall be specified for each pollutant in an engine family certification application for CI engines using an after-treatment device.

1.2.3. The manufacture shall furnish the type-approval agency on request with information to support the DF values.

This would typically include emission test results, service accumulation test schedule, and maintenance procedures together with information to support engineering judgments of technological equivalency, if applicable.

2. EMISSION DURABILITY PERIODS FOR BHARAT STAGE III (CEV) ENGINES.

2.1. Manufacturers shall use the EDP in Table 1 of this section.
Table 1: EDP categories for CI Bharat Stage III (CEV) (hours)

Category (power band)	Useful life (hours)
	(EDP)
<=19 kW	3 000*
19< kW <=37 (Constant speed)	3 000
19< kW <=37 (Variable speed)	5 000
> 37 kW	8 000

*** In this case, if EDP declared by the manufacturer is less than 3000 hrs, whatever declared shall be considered for evaluation & the same shall be mentioned in the manufacturer's Sales & Service Manual.**

2.2 As an alternative to using a service accumulation schedule to determine deterioration factors, engine manufacturers may choose to use the following deterioration factors:

CO	HC	NOx	PM
1.1	1.05	1.05	1.1