

CHAPTER IV : CONFORMITY OF PRODUCTION PROCEDURE FOR TESTING OF SMOKE METER.

1 Physical Check

It shall consist of checking -

- 1) Suitability and label on the instrument for the intended use.
- 2) Identification of the instrument consisting of model, serial number, name and address of the manufacturer, electrical power requirement, year and month of manufacture and operating voltage range specified in English language.
- 3) Scale, resolution, display.
- 4) Peak hold facility.
- 5) Heating facility.
- 6) Calibration facility.
- 7) Printout specifications, if provided with a printer.
- 8) Documentation.
- 9) Verification of the following specifications :
 - accessories provided
 - light source / detector / optical bench type & model no.
 - smoke tube dimensions
 - all printed circuits boards (model nos., sizes, quantity)
 - display : type, no. of digits
 - input/output connectors, cables
 - front panel controls
 - calibration filter value
 - software programme version
- 10) Oil temperature sensor probe
- 11) Engine speed sensor clamp / attachment.
- 12) Any other checks as found relevant

2.0 Linearity

1) Smoke measurement :

The linearity of smoke measurement shall be checked at minimum 4 points (5 points to include a full scale point, In case meter full scale corresponds to the total light cut-off) including the zero point. This will be checked by three different neutral density filters of known value within $\pm 0.05\text{m}^{-1}$ in the specified range given below, supplied by the smoke meter manufacturer or his representative along with Calibration Certificate from a reputed organisation. The neutral density filter shall have flat response (preferably within $\pm 2\%$ tolerance in absolute value) between the wavelength range 430 to 680 nm and the response at spot frequency between 550 to 570 nm as recommended by the manufacturer will be considered for linearity test. The test agency may decide to test the accuracy of the filter prior to the test.

one filter having $K \leq 1\text{ m}^{-1}$

one filter having K between 1.5 and 2.5 m^{-1}

one filter having $K \geq 3 \text{ m}^{-1}$.

2) Engine speed measurement :

The linearity of engine speed measurement shall be checked at minimum 4 points, which shall include at least one point, which is more than 80% of the required full scale range. The linearity shall be checked using engine speed measurement system with the accuracy of at least $\pm 3 \text{ rpm}$.

3) Oil temperature measurement:

The linearity of oil temperature measurement shall be checked at minimum 4 points, uniformly distributed over the full-scale range. The linearity shall be checked using temperature measurement system with the accuracy of at least $\pm 0.5^\circ\text{C}$.

3.0 Temperature Sensitivity

The smoke meter shall be maintained at 278 K and 323 K temperature. Span reading with neutral density filter having value between 1.5 to 2.5 m^{-1} at both these temperatures shall be within 0.1 m^{-1} from the reading obtained at the room temperature of $303 \pm 2 \text{ K}$.

Separate drift and repeatability tests are not included as these aspects will be partly verified during temperature tests.

4.0 CORRELATION TESTS

4.1 Full Load Test

The smoke meter under test and reference smoke meter shall be installed on an engine or a vehicle and full load test will be carried out. If it is not possible to install both the meters simultaneously, the testing will be carried out at first with reference smoke meter and subsequently with the meter under testing. The test shall be repeated to measure smoke of different 'K' values (minimum five points) approximately evenly spaced over the range 0 to 4 m^{-1} . If required the air system or the fuel system of the engine shall be adjusted to get smoke of different 'K' values. The difference in the reading shall be within percentage specified in the table below.

Mean value of test in K (m^{-1})	% Difference allowed
≤ 1	5
$>1, \leq 2$	7.5
$>2, \leq 3$	10
>3	12.5

or 0.1 m^{-1} whichever is higher

4.2 Free Acceleration Test

The test shall be carried out on at least five different diesel vehicles/engines as

below :

- a) one engine used for car/jeep application
- b) four different engines used for LCV/HCV application

The correlation tests shall be performed using either engines or complete vehicles. If the test is carried out on an engine mounted on test bench, the engine shall be decoupled from the dynamometer. If the test is carried out on a vehicle, the gear change control shall be set in the neutral position and the drive between engine and gearbox engaged. Test engines shall be warmed up to attain oil temperature of minimum 60°C. The test shall be carried out only after this engine condition is reached.

The free acceleration test shall be conducted as below: With the engine idling, the accelerator control shall be operated quickly, but not violently, so as to obtain maximum delivery from the injection pump. This position shall be maintained until maximum engine speed is reached and the speed governor comes into action. As soon as this speed is reached the accelerator shall be released until the engine resumes its idling speed and the smoke meter reverts to the corresponding conditions. Typically the maximum time for acceleration shall be 5s and for the stabilization at maximum no load speed shall be 2s. The time duration between the two free accelerations shall be between 5-20s.

The operation described above shall be repeated not less than six times in order to clear the exhaust system and to allow for any necessary adjustments of the apparatus. During this flushing cycle operation the sample probe shall not be inserted in to the vehicle exhaust system.

The operation described above shall then be carried out with sample probe inserted in to the vehicle exhaust system. The maximum no load rpm reached during this operation shall be within ± 500 rpm in respect of 3 wheeler vehicles and ± 300 rpm for all other categories of vehicles, of the average value obtained in the flushing cycle above. If for any reason the speed is not within the specified tolerance band the particular smoke reading shall be considered as invalid and shall be discarded. The above operation shall be repeated till the peak smoke values recorded in four successive accelerations are valid and are situated within a bandwidth of 25 % of the arithmetic mean (in m^{-1} unit) of these values or within a bandwidth of 0.25 K, whichever is higher and do not form a decreasing sequence. The absorption coefficient to be recorded shall be the arithmetic mean of these four valid readings.

Zero drift shall be checked after the test and if drift is greater than 0.2 m^{-1} this test shall be taken as invalid and repeated.

If the drift is 0.2 m^{-1} or less and positive, it shall be subtracted from the mean of the last valid reading.

A sequence of four free acceleration tests as per the procedure above shall be conducted with smoke meters as given below :

Test 1 With reference smoke meter.

Test 2 Subject meter installed on its own in the vehicle tailpipe and calibrated according to manufacturer's instructions using a neutral density filter.

Test 3 As per Test 2.

Test 4 As per Test 1.

Based on the mean of valid four readings in each test :

a) A test sequence is valid only if 'K' value of Test does not vary from Test 1 by more than 0.3 m^{-1} .

b) The percentage difference between the mean of the test 1 and 4 and the mean of test 2 and 3, for five vehicles, shall be less than figures given in the table below

Mean value of test 1 & 4 K (m^{-1})	% Difference allowed	
	(3 vehicles)	(2 vehicles)
≤ 1	5	10
$>1 \leq 2$	7.5	15
$>2, \leq 3$	10	20
>3	12.5	25

c) The result of Test 2 and 3 must lie within $\pm 10\%$ of the mean of the two tests.

d) In case correlation test does not meet the tolerances specified above in only one of the vehicles/engines, additional two correlation tests each consisting of five tests as mentioned above shall be carried out on different vehicles / engines (vehicles/engines other than used in the first series of correlation tests). The meter can be considered

satisfactory if it meets these additional correlation tests.

- 5.0 In addition to above conformity tests, the test agencies at their sole discretion may determine to carry out any other test, if found necessary.