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*Draft Indian Standard*

# PLASTICS — METHODS OF TESTING
# PART 6 THERMAL PROPERTIES
# SECTION 9 DETERMINATION OF DENSITY OF SMOKE FROM THE BURNING OR DECOMPOSITION OF PLASTICS

**(**First Revision of IS 13360 (Part 6/Sec 9)**)**

(ICS No. 83.080.01)

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| Methods of Sampling and Test for Plastics Sectional Committee, PCD 27 | Last date for receipt of comment is **30 December 2023** |

**FOREWORD**
(*Formal clauses to be added later*)

This Indian Standard was originally published in 2001. This revision has been undertaken to update the standard with the latest technological advancements. Clause 3.1.3.3, 3.1.4.3, 3.1.4.4, 3.1.5, 4, 6, 7.2 and 7.3 of the document have been modified.

Tests made on a material under conditions prescribed in this standard can be of considerable value in comparing the relative smoke obscuration characteristics of plastics. The test method prescribed in this standard serves to determine the extent to which plastic materials are likely to smoke under conditions of active burning and decomposition in the presence of flame.

The usefulness of this test procedure is in its ability to measure the amount of smoke obscuration produced in a simple, direct, and meaningful manner under the specified conditions. The degree of obscuration of vision by smoke generated by combustibles can be substantially affected by changes in quantity and form of material, humidity, draft, temperature, and oxygen supply.

While preparing this standard, assistance has been derived from ASTM D 2843 'Standard test method for Density of Smoke from the Burning or Decomposition of Plastics' issued by American Society for Testing and Materials (ASTM), USA.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'.

## 1 SCOPE

This standard (Part 6/Sec 9) prescribes a test method which covers a laboratory procedure for measuring and observing the relative amounts of smoke obscuration produced by the burning or decomposition of plastics. It is intended to be used for measuring the smoke-producing characteristics of plastics under controlled conditions of combustion or decomposition. Correlation with other fire conditions is not implied. The measurements are made in terms of the loss of light transmission through a collected volume of smoke produced under controlled, standardized conditions. The apparatus is constructed so that the flame and smoke can be observed during the test.

CAUTION — During the course of combustion, gases or vapours, or both, are evolved that may be hazardous to personnel. Adequate precautions shall be taken to protect the operator.

## 2 SUMMARY OF TEST METHOD

**2.1** The test specimen is exposed to flame for the duration of the test, and the smoke is substantially trapped in the chamber in which combustion occurs. A 25 mm × 25 mm × 6 mm specimen is placed on supporting metal screen and burned in a laboratory test chamber (*see* Fig. 1) under active flame conditions using a propane burner operating at a pressure of 276 kPa. The 300 mm × 300 mm × 790 mm test chamber is instrumented with a light source, photoelectric cell, and meter to measure light absorption horizontally across the 300 mm light beam path. The chamber is closed during the 4 min test period except for the 25 mm high ventilation openings around the bottom.

**2.2** The light absorption data are plotted versus time. A typical plot is shown in Fig. 2. Two indexes are used to rate the material: the maximum smoke produced and the smoke density rating.

## 3 APPARATUS

**3.1** The smoke chamber shall be constructed essentially as shown in Fig. 1.

**3.1.1** *Chamber*

**3.1.1.1** The chamber shall consist of a 300 mm × 300 mm × 790 mm aluminium box to which is hinged a heat resistant glass glazed door. This box shall be mounted on a 350 mm × 400 mm × 57 mm base which houses the controls. Dependent upon the materials tested, the metal may require protection from corrosion.

**3.1.1.2** The chamber shall be sealed except for 25 mm × 230 mm openings on the four sides of the bottom of the chamber. A 1 700 litres/min blower shall be mounted on one side of the chamber. The inlet duct to the blower shall be equipped with a close-fitting damper. The outlet of the blower shall be connected through a duct to the laboratory exhaust system. If the chamber is in a ventilated hood, no connection to the lab exhaust system through a duct is needed.

**3.1.1.3** The two sides adjacent to the door shall be fitted with 70 mm diameter smoke-tight glazed areas centred 480 mm above the base. At these locations and outside the chamber, boxes containing the optical equipment and additional controls shall be attached.

**3.1.1.4** A removable white plastics plate shall be attached to the back of the chamber. There shall be a 90 mm **x** 150 mm clear area centred about 480 mm above the bottom of the chamber through which is seen an illuminated white-on-red exit sign. The white background permits observation of the flame, smoke, and burning characteristics of the material. The viewing of the exit sign helps to correlate visibility and measured values.

**3.1.2** *Specimen Holder*

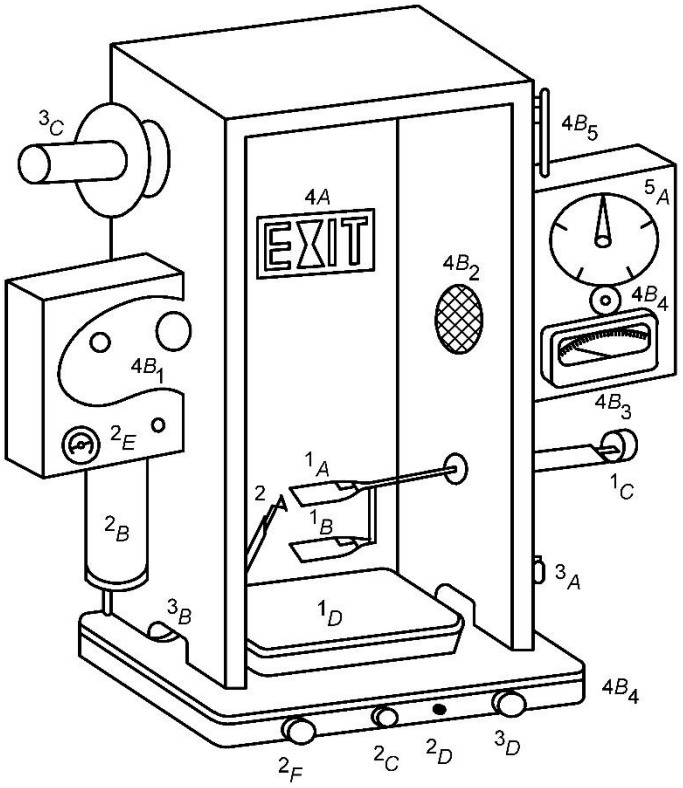
The specimen shall be supported on a square of 6 mm × 6 mm, 0.9 mm gauge stainless steel wire cloth 220 mm above the base and equidistant from all sides of the chamber. This screen shall lie in a stainless steel bezel supported by a rod through the right side of the chamber. From the same rod, a similar bezel shall be located 76 mm below, and it shall support a square of asbestos paper which catches any particles that may drip from the specimen during the test. By rotating the specimen holder rod, the burning specimen can be quenched in a shallow pan of water positioned below the specimen holder.

**3.1.3** *Ignition System*

**3.1.3.1** The specimen shall be ignited by a propane flame from a burner operating at a pressure of 276 kpa. The fuel (*see* Note 1) shall be mixed with air which has been propelled through the burner by the venturi effect of the propane as it passes from a 0.13 mm diameter orifice (*see* Note 2), and the burner shall be assembled as shown in the exploded view of the burner in Fig. 3. The burner must be designed to provide adequate outside air.

NOTES

1. Commercial grade 85 percent minimum, gross heating value 23000 cal/litre propane meets the requirements.
2. Since the orifice provides the metering effect proportionate to the supply pressure, care shall be taken that the orifice is the only means of fuel egress.




| | |
|---|---|
| **1.** Specimen Holder | **4.** Photometer |
| **A** Stainless steel screen | **A** Visual system (exit sign) |
| **B** Asbestos sheet | **B** Measuring system |
| **C** Adjusting knob | **1** Light source and adjusting transformer |
| **D** Quench pan | **2** Photronic cell and grid (to block stray light) |
| **2.** Ignition | **3** Meter (indicating percent of light absorbed) |
| **A** Burner | **4** Temperature compensation |
| **B** Propane tank | **5** Photocell temperature monitor |
| **C** Gas shut-off valve | **6** Range change |
| **D** Pressure regulator adjustment | **5.** Timer |
| **E** Pressure indicator | **A** Indicator, 0 to 5 min (friction reset) |
| **F** Burner-positioning knob | |
| **3.** Cabinet (shown without door) | |
| **A** Hinges (door gasketed three sides) | |
| **B** Vents [25mm (1-in) high opening four sides] | |
| **C** Blower (damper on mounting side) | |
| **D** Control (blower on when damper is open) | |

FIG. 1 SCHEMATIC DIAGRAM OF SMOKE CHAMBER

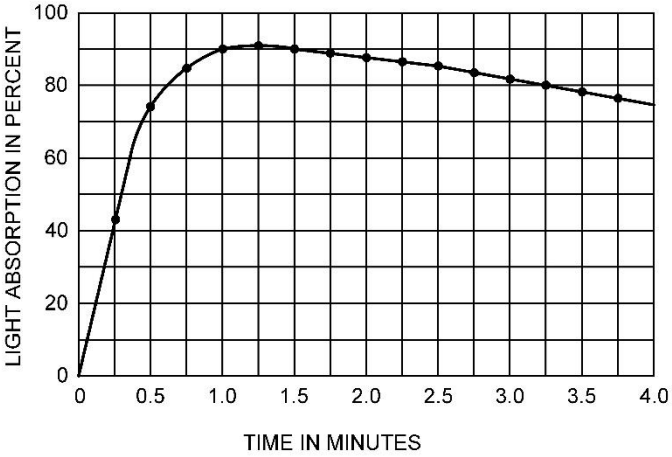



FIG. 2 LIGHT ABSORPTION VERSUS TIME

**3.1.3.2** The burner shall be capable of being positioned quickly under the specimen so that the axis of the burner falls on a line passing through a point 8 mm above the base at one back corner of the chamber extending diagonally across the chamber and sloping upward at 45° with the base. The exit opening of the burner shall be 260 mm from the reference point at the rear of the chamber.

**3.1.3.3** A duct having at least 150 mm diameter outside of the chamber shall provide the air piped to the burner.

**3.1.3.4** Propane pressure shall be adjustable and preferably automatically regulated. Propane pressure shall be indicated by means of a Bourdon tube gage.

**3.1.4** *Photometric System*

**3.1.4.1**. A light source, a barrier layer photoelectric cell, and a temperature compensated meter shall be used to measure the proportion of a light beam which penetrates a 300 mm path through the smoke. The light path shall be arranged horizontally as shown in Fig. 4.

**3.1.4.2** The light source shall be mounted in a box (4 B1 in Fig. 1) extending from the left side of the chamber at the mean height of 480 mm above the base. The light source shall be a compact filament microscope operated at 5.8 V and a spherical reflector, with power supplied by a voltage regulating transformer. A 60 to 65 mm focal length lens shall focus a spot of light on the photocell in the right instrument panel.

**3.1.4.3** Another box containing the photometer (4 B2 in Fig. 1) shall be attached to the right side of the chamber. The barrier layer photoelectric cell shall have standard observer spectral response. An egg crate grid in front of the photocell shall be used to protect the cell from stray light. The grid shall be finished in dull black and have openings at least twice as deep as they are wide. The current produced by the photocell is indicated in terms of percent light absorption. The photocell linearity decreases as the temperature increases; compensations shall therefore be made.

NOTE — Photocell manufacturers recommend operating the photocell at temperatures not exceeding 50 °C.

**3.1.4.4** The meter shall have two ranges. The range change shall be accomplished by shunting the meter to one tenth of its sensitivity. When smoke accumulates to absorb 90 percent of the light beam, the meter shall be set to its basic sensitivity. By doing this the meter scale will then read from 90 percent to 100 percent instead of 0 percent to 100 percent.

**3.1.5** *Timing Device*

A clock to indicate 15 s intervals shall be used. If the time intervals are audibly marked it will be convenient for the operator to record his observations. The timing device shall be reset at the start of test. The time device shall start measuring when the burner is swung into test position.

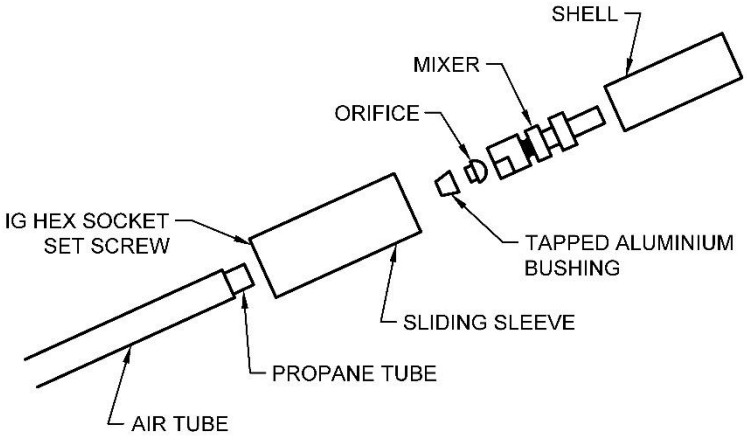
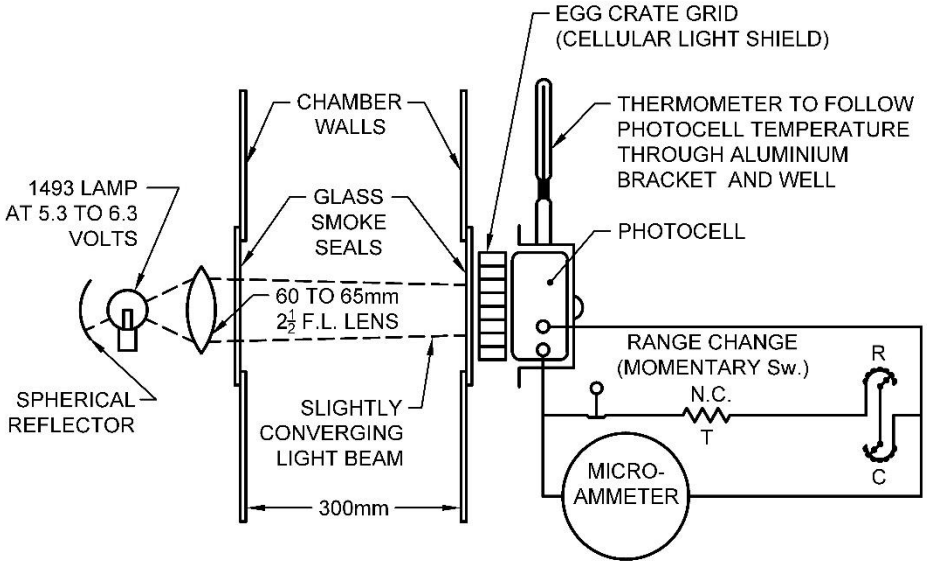



FIG. 3 EXPLODED VIEW OF BURNER




T = Temperature-sensitive winding in or on meter case to increase in resistance in proportion to increase in meter resistance with temperature.
R = Potentiometer with calibrated scale to reduce resistance in proportion to decrease in photocell output with rise in temperature.
C = Potentiometer to calibrate total resistance of shunt to change meter sensitivity exactly by 10:1 ratio.

FIG. 4 SMOKE DENSITY TEST CHAMBER PHOTOMETER

**3.1.6** *Planimeter*

A planimeter or other suitable means shall be used for measuring the area under the light absorption curve.

**4 TEST SPECIMEN**

**4.1** The standard specimen shall be (25.4 ± 0.3) mm × (25.4 ± 0.3) mm × (6.2 ± 0.3) mm. Material thinner than (6.2 ± 0.3) mm shall be tested by stacking and forming a composite specimen approximately (6.2 ± 0.3) mm thick. Material thicker than 6.2 mm shall be tested by machining the material down to a thickness of 6.2 mm.

**4.2** The specimens shall be sanded, machined, or die cut in a manner that produces a cut surface that is free from projecting fibres, chips and ridges.

**4.3** The test sample shall consist of three specimens.

## 5 CONDITIONING

### 5.1 Conditioning

Condition the test specimen at 27 °C ± 2 °C and (65 ± 5) percent relative humidity for not less than 40 h prior to test for those tests where conditioning is required. In cases of disagreement, the tolerances shall be ± 1°C and ± 2 percent relative humidity.

### 5.2 Test Conditions

Conduct tests in the standard laboratory atmosphere of 27 °C ± 2 °C and (65 ± 5) percent relative humidity, unless otherwise specified in this test method. In cases of disagreement, the tolerances shall be ± 1°C and ± 2 percent relative humidity.

**5.3** Tests shall be conducted in a hood that has a window for observing the test.

## 6 STANDARD PROCEDURE

**6.1** Turn on the photometer lamp, exit sign and exhaust blower.

**6.2** Turn on the propane, ignite the burner, and adjust the propane pressure to 276 kPa.

CAUTION — Do not fail to light the burner immediately**.**

**6.3** Set the temperature compensation.

**6.4** Adjust the lamp control to 100 percent light absorption (by blocking the light reaching the photocell with an opaque plate), if possible. Adjust the lamp control to zero percent light absorption.

**6.5** Lay the test specimen flat on the screen in such a position that the burner flame will be directly under the specimen when the burner is swung into position.

**6.6** Set the timer to zero.

**6.7** Shut off the exhaust blower, close the smoke chamber door, and immediately position the burner under the specimen and start the timer.

**6.8** If in a hood, shut off the hood fan and close the hood door to within 50 mm of the bottom of the hood.

**6.9** Record the percent light absorbed at 15 s intervals for 4 min.

**6.10** Record observations during the conduct of the test. Include the time it takes for the sample to burst into flame, the time for flame extinguishment or specimen consumption, the obscuration of the exit signs by smoke accumulation, and any general or unusual burning characteristics noted such as melting, dripping, foaming or charring.

**6.11** Upon completion of the test, turn on the exhaust blower to ventilate the combustion products from the chamber.

CAUTION — It shall be noted that for some materials the products of burning may be toxic and care shall be taken to guard the operator from the effects of these gases. The ventilating fan in the hood shall be turned on and the damper opened immediately after the test is completed before opening the hood door in order to remove any irritating products of the test. The exhaust fan is turned off and the hood damper closed during the test to prevent back draft**.**

**6.12** Open the door and clean the combustion deposits from the photometer, exit sign, and door glass with detergent and water. Burn off any material remaining on the screen or replace the screen and asbestos square for the next test.

**6.13** Run all tests in triplicate.

**6.14** At the beginning of each series or at least once a day, check the light absorption of the meter against a calibrated neutral filter of approximately 50 percent absorption. Check the 100 percent absorption point against an opaque plate.

**7 SPECIAL PROCEDURE**

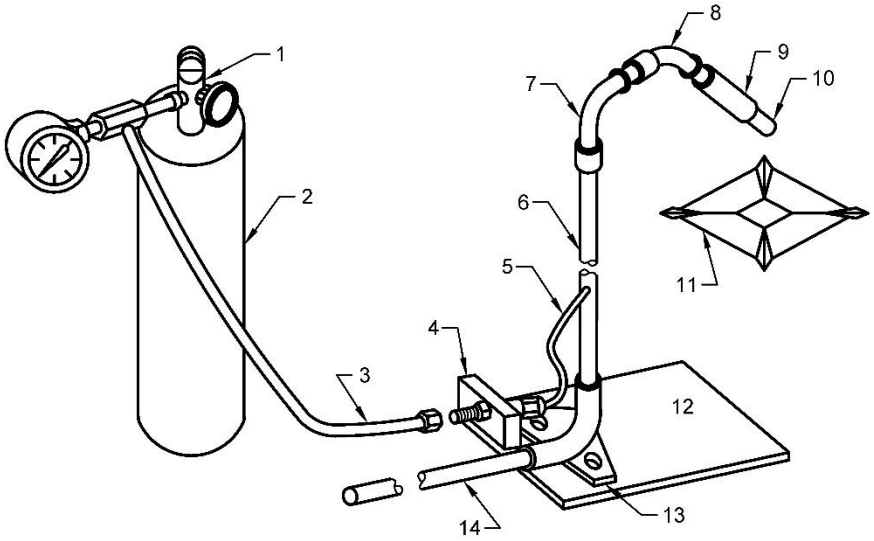
**7.1** For materials which drip excessively, a second or auxiliary burner (with separate propane gas supply) shall be introduced into the chamber. See Fig. 5 and auxiliary burner parts list.

**7.2** The auxiliary burner shall be ignited at the same time the standard burner is ignited. The auxiliary burner shall be operated at 138 kPa and it shall be positioned in such a manner that its flame is directed at the centre of the collector tray.

NOTE— It may be helpful to place a lightweight, about 1100 g on the aluminium mounting plate (Item 12, Fig. 5) to prevent movement of the burner during the test.

**7.4** To prevent movement of the burner during the test, place a lightweight, about 1 100 g, on the aluminium mounting plate (Item 12, Fig 5).

**7.4** In all other respects the procedures as specified in **6** shall be followed.




| | |
|---|---|
| **1.** low pressure propane gas regular (0 to 60psi gauge) | **8.** 90° extruded and expanded copper fitting (4 in from bend to end of burner head) |
| **2.** propane fuel tank | **9.** Sliding sleeve |
| **3.** Flexible gas line | **10.** Burner head (same as standard burner head) |
| **4.** Aluminium support bracket | **11.** S.S. collector tray 2½ by 2½ by ⅜ in deep with ½ in sq bottom). |
| **5.** ⅛ in O.D. copper tube (flexible). | **12.** Aluminium mounting plate (3 by 3½ in) |
| **6.** ½ in O.D. copper tube 8 in long. | **13.** 90° elbow and wall flange (copper). |
| **7.** 45° extruded and expanded copper fitting. | **14.** ½ in. diameter copper tube 8¾ in long |

FIG. 5 AUXILLIARY BURNER

## 8 OPTIONAL PROCEDURES

**8.1** The output of the photocell maybe recorded versus time on an appropriate graphic recorder.

**8.2** With a suitably sensitive meter, more than one-decade change may be used to separate readings in the very dense smoke range.

## 9 TREATMENT OF DATA

**9.1** Average the readings at 15 s intervals of light absorption for the three specimens in each group. Plot the average light absorption against time on linear paper. Figure 2 is a sample curve.

**9.2** Read the maximum smoke density as the highest point on the curve.

**9.3** Determine the total smoke produced by measuring the area under the curve. The smoke density rating represents the total amount of smoke present in the chamber for the 4 min time interval. Measure the total smoke produced by the area under the curve of light absorption versus time, divided by the total area of the graph, 0-4 min, 0-100 percent light absorption, times 100.

*Example* — In the light absorption time plot in Fig. 2, the plot has been made using 10 mm equal to 10 percent as the ordinate and 10 mm equal to 0.25 minutes as the abscissa. The graph area for 4 min is found to be 16 000 $mm^2$. The area under the curve is found to be 12 610 $mm^2$. The smoke density rating is then computed as follows:

$$\text{Smoke density rating, percent} = \frac{12610}{16000} \times 100 = 78.8$$

(dimensions in millimetres)

## 10 REPORT

The test report shall include the following information:

a) Identification of the material,
b) Dimensions of the specimen,
c) Readings of light absorption at 15-seconds interval for each test and average,
d) Plots of average light absorption versus time,
e) Maximum smoke density in percent light absorption,
f) Area in percent under the light absorption time curve (smoke density rating),
g) Observations on behaviour of material,
h) Observations on obscurement of exit sign, and
j) The details of any departure from the specifications of the method for testing.