IEC 60332-3-10 Test for Vertical Flame Spread of Vertically-Mounted Bunched Wires or Cables – Apparatus

Description

5 Test apparatus
The test apparatus consists of the following:
5.1 Test chamber
The test rig (see Figures 1a and 1b) shall comprise a vertical test chamber having a width of (1000 ± 100) mm, a depth of (2000 ± 100) mm and a height of (4000 ± 100) mm; the floor of the chamber shall be raised above ground level. The test chamber shall be nominally airtight along its sides, air being admitted at the base of the test chamber through an aperture of (800 ± 20) mm × (400 ± 10) mm situated (150 ± 10) mm from the front wall of the test chamber (see figure 1).
An outlet (300 ± 30) mm x (1000 ± 100) mm shall be made at the rear edge of the top of the test chamber. The back and sides of the test chamber shall be thermally insulated to give a coefficient of heat transfer of approximately 0,7 W·m–2·K–1. For example, a steel plate 1,5 mm to 2,0 mm thick covered with 65 mm of mineral wool with a suitable external cladding is satisfactory (see figure 2). The distance between the ladder and the rear wall of the chamber is (150 ± 10) mm, and between the bottom rung of the ladder and the floor (400 ± 5) mm. The clearance between the lowest point of the test piece and the floor is approximately 100 mm (see figure 3).

5.2 Air supply
A means of supplying a controlled air flow through the chamber shall be fitted. Air shall be introduced into the test chamber through a box fitted directly underneath, and of approximately the same dimensions as, the air inlet aperture. Air shall be blown into the box from a suitable fan through a straight section of duct which shall enter from the rear of the test chamber and be parallel to the floor and along the burner centre line as shown in Figure 1b. The duct shall be arranged to allow air into the box through an opening in the longest side.
NOTE 1 A grille may be placed over the air inlet aperture to facilitate accessing the test chamber but should neither restrict the airflow nor modify its direction.
NOTE 2 A duct of constant cross-section of approximately 240 cm2 and minimum length of 60 cm is recommended.
Prior to burner ignition, the air flow shall be adjusted to a rate of (5 000 ± 500) l/min at a constant controlled temperature of (20 ± 10) °C and at atmospheric pressure and measured at the inlet side before the test commences. This air flow rate shall be maintained throughout the test until cable burning or glowing has ceased or for a maximum time of 1 h from completion of the test flame application period, after which period the flame or glowing shall be extinguished.
NOTE 3 In order to remove noxious gases, it is recommended to maintain the air flow for some minutes after the end of the test, before entering the test chamber.

5.3 Ladder types

There are two types of tubular steel ladder: a standard ladder of (500 ± 5) mm width and a wide ladder of (800 ± 10) mm width. Details of the types of ladder are given in figures 4a and 4b.

5.4 Effluent cleaning attachment

Legal requirements may make it necessary for equipment for collecting and washing the effluent to be fitted to the test chamber. This equipment shall not cause a change in the air flow rate through the test chamber.

6 Ignition source

6.1 Type

As required by the test procedure the ignition source shall be one or two ribbon-type propane gas burners complete with venturi mixer, and their own set of flowmeters. The propane gas shall be technical grade propane of nominal 95 % purity. The flame-producing surface of the burner(s) shall consist of a flat metal plate through which 242 holes of 1,32 mm in diameter are drilled on 3,2 mm centres in three staggered rows of 81, 80 and 81 holes each to form an array having the nominal dimensions 257 mm × 4,5 mm. As the burner plate may be drilled without the use of a drilling jig, the spacing of the holes may vary slightly. Additionally, a row of small holes may be milled on each side of the burner plate to serve as pilot holes with the function of keeping the flame burning.

The burners are shown in figures 5a and 5b, and the placement of the holes in figure 6.

NOTE 1 To ensure reproducibility between results from different testing stations, a burner, which is readily
available, is recommended for use. For details, see annex A.

Each burner shall be individually fitted with an accurate means of controlling the propane gas and air input flow rates, either by means of a rotameter-type flowmeter or mass flowmeter.

NOTE 2 Mass flowmeters are recommended for ease of use.

Figure 7 shows an example of a rotameter-type system.

SAFETY NOTE – The following precautions are recommended to ensure safe operation of the ignition source:

– the gas supply system should be equipped with flashback arresters;

– a flame failure protection device should be used;

– safe sequencing of the propane and air supply should be employed during ignition and extinguishing.

The calibration of the propane gas and air rotameter-type flowmeters shall be checked after installation to ensure that the pipework and venturi mixer have not affected the calibration. Corrections for the variations in temperature and pressure from that specified on the propane gas and air rotameter-type flowmeters shall be applied when necessary, see annex B. Propane gas and air rotameter-type flowmeters shall be calibrated according to the following reference conditions.

Reference temperature and pressure are 20 °C and 1 bar (100 kPa).

For the purpose of this test, the air shall have a dew-point not higher than 0 °C.

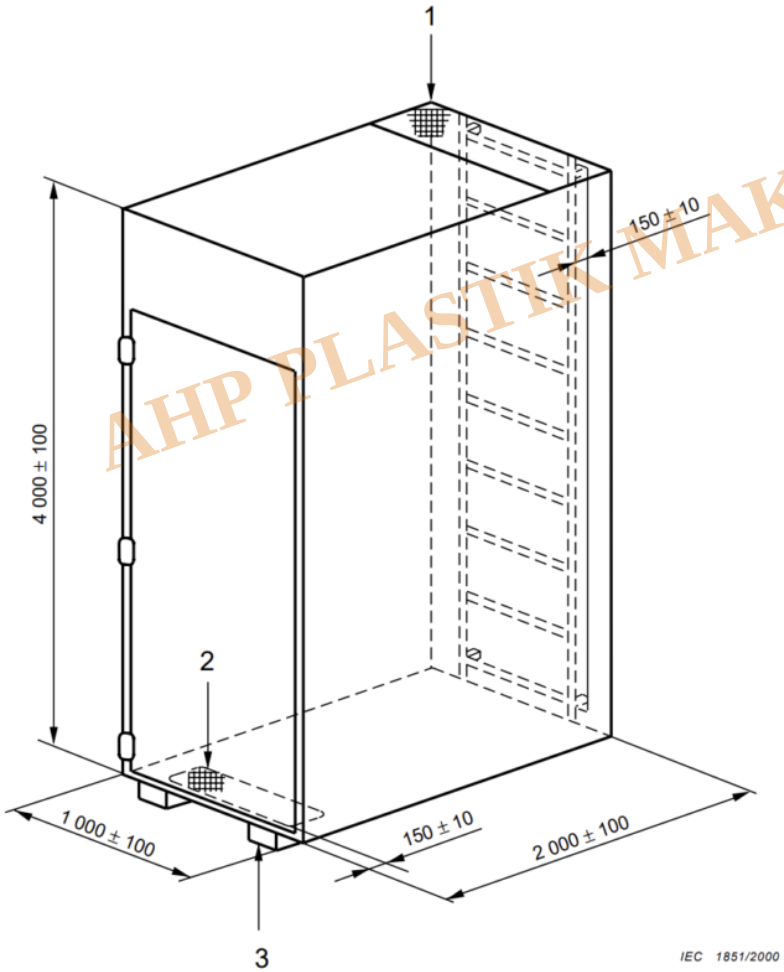
The flow rates for the test shall be as follows:

Air (77,7 ± 4,8) l/min at reference conditions (1 bar and 20 °C) or (1 550 ± 140) mg/s Propane (13,5 ± 0,5) l/min at reference conditions (1 bar and 20 °C) or (442 ± 10) mg/s to provide a nominal (73,7 ±

1,68) × 106 J/h ((70 000 ± 1 600) Btu/h). 1)
NOTE 3 A net heat of combustion of 46,4 kJ/g is used to calculate the propane flow rate.

6.2 Positioning

For the test, the burner shall be arranged horizontally at a distance of (75 ± 5) mm from the front surface of the cable sample, (600 ± 5) mm above the floor of the test chamber and approximately symmetrical with the axis of the ladder. The point of application of the burner flame shall lie between two cross-bars on the ladder (see Figure 2 and Figure 3).
Adjustment of air and gas flows prior to the test may be carried out away from the test position. Where two burners are used in combination with the wide ladder, they shall be arranged so as to be approximately symmetrical with the axis of the ladder, as shown in figure 5b. The burner system shall be positioned such that the centre line of the burner system is approximately coincident with the centre of the ladder.

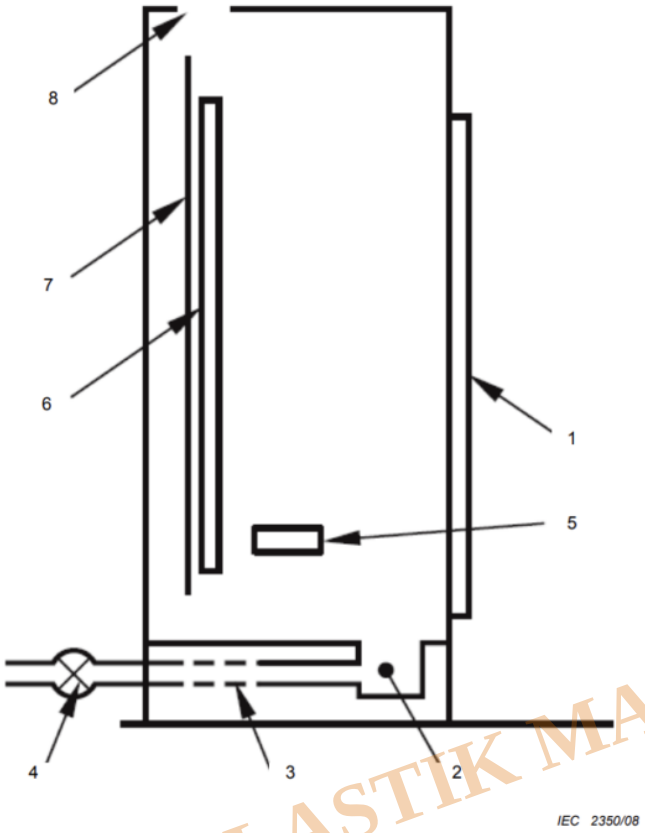


Key

1 Smoke outlet (300 ± 30) × (1 000 ± 100)
2 Air inlet (800 ± 20) × (400 ± 10)
3 Rig raised above ground level

Dimensions in millimetres

Figure 1a – Test chamber

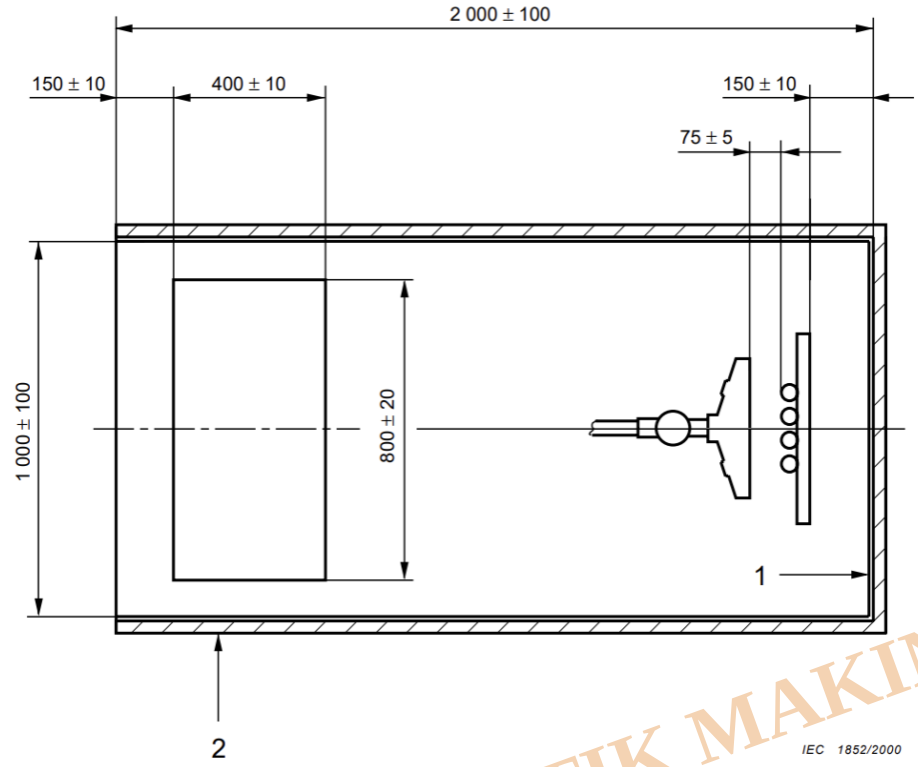


Key

1	door	5	burner
2	air inlet box	6	cables tested
3	air inlet duct	7	ladder
4	fan (illustrative position)	8	smoke outlet

Figure 1b – Schematic side elevation of test chamber and air inlet arrangement

Figure 1 – Test chamber



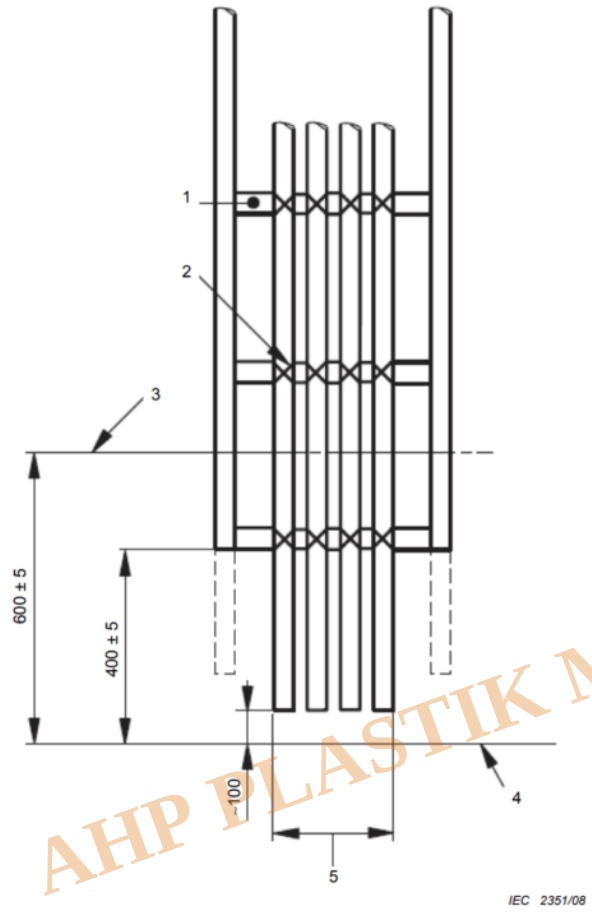
Key

1 Steel plate, 1,5 mm to 2 mm thick
2 Thermal insulation of mineral wool approximately 65 mm thick with suitable external cladding to give a coefficient of heat transfer of approximately 0,7 W × m^{-2} × K^{-1}

Dimensions in millimetres

Figure 2 – Thermal insulation of back and sides of the test chamber

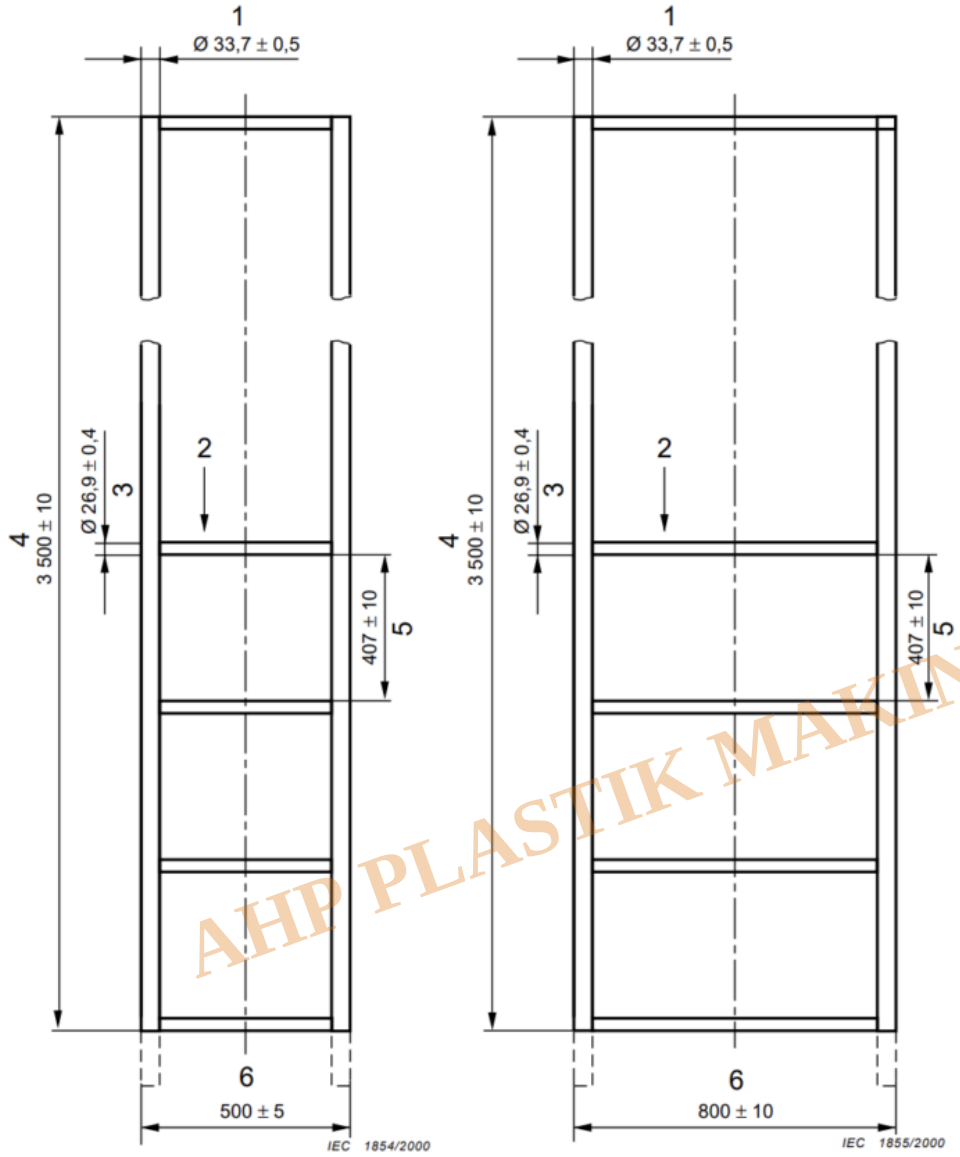
Dimensions in millimetres



Key

1 round steel rungs
2 metal wire ties
3 centre line of burner
4 floor
5 maximum width (according to test category)

Figure 3 – Positioning of burner and typical arrangement of test sample on ladder



Key

1 Diameter of upright
2 Number rungs = 9
3 Diameter of rungs
4 Total height of ladder
5 Distance between rungs
6 Width

Dimensions in millimetres

Figure 4a – Standard ladder

Figure 4b – Wide ladder

Figure 4 – Tubular steel ladders for cable test

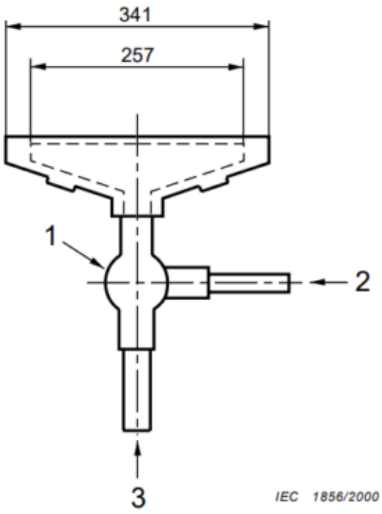


Figure 5a – Single burner for use with standard ladder

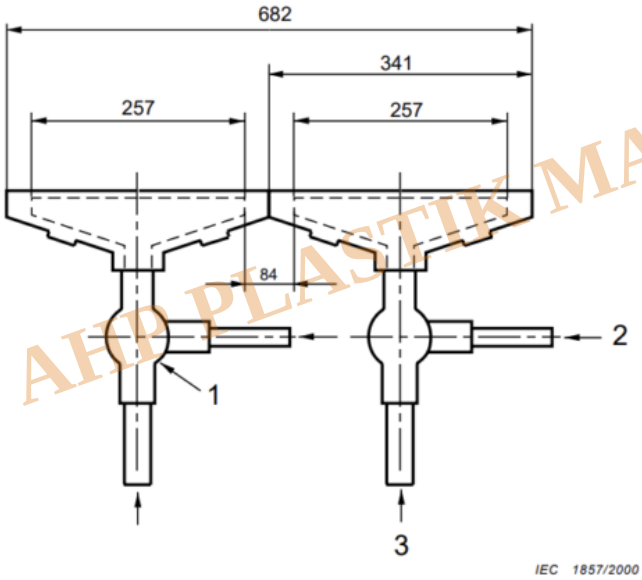


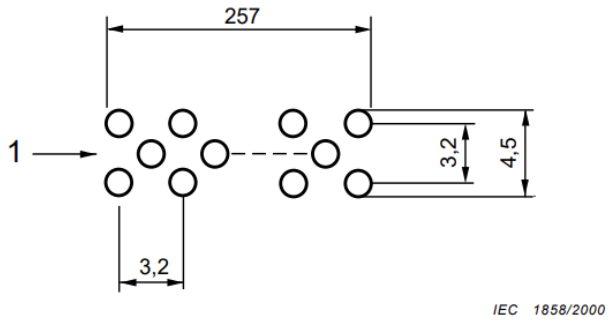
Figure 5b — Two burners in combination for use with the wide ladder

Key

1 Venturi air-gas mixer
2 Propane gas entry
3 Compressed air entry

Dimensions in millimetres

Figure 5 – Burner configurations

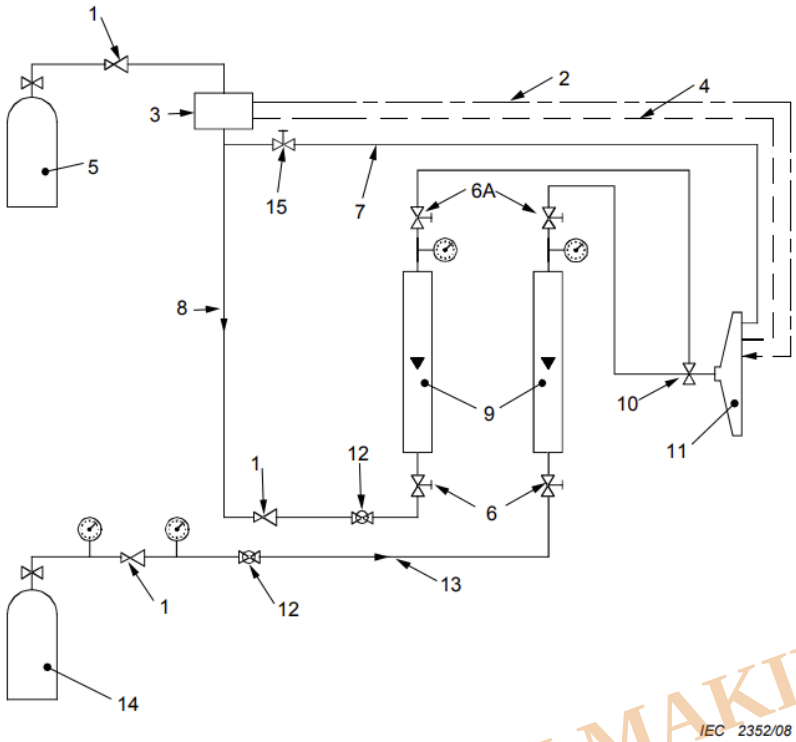


Key

1 242 round holes, 1,32 mm in diameter on 3,2 mm centres, staggered in three rows of 81, 80 and 81 holes, centred on the face of the burner

Dimensions in millimetres (approximate values)

Figure 6 – Arrangement of holes for burners



Key

1	regulator	9	flowmeters
2	piezoelectric igniter	10	venturi mixer
3	flame failure device	11	burner
4	control thermocouples	12	ball valve
5	propane cylinder	13	air flow
6	screw valve (6a = alternative position)	14	compressed air cylinder
7	pilot feed	15	screw valve on pilot feed
8	gas flow		

Figure 7 – Schematic diagram of an example of a burner control system using rotameters

Annex B
(informative)
Flowmeter calibration correction factors

B.1 General

When using the rotameter type flowmeters to monitor the supply rate of the gases, two factors need to be considered in order to use them correctly. It is important

a) to know what the flowmeter is indicating when used under the actual operating conditions;

b) to know under what conditions of temperature and gas pressure the flowmeter was calibrated, and at what conditions it was designed to operate.

Considering point a), most flowmeters are designed to indicate the volumetric flow rate at atmospheric temperature and pressure, i.e. 20 °C and 1 bar. However, considering point b), not all flowmeters are calibrated and designed to work at the same temperature and pressure, and care should be taken to

ensure that the temperature and pressure of the gas flowing through a flowmeter are correct for that particular meter. Working the flowmeter at temperatures and pressures different from these conditions requires application of a correction factor such as provided hereinafter.

B.2 Example

B.2.1 General

Assume that air flow rate of 77,7 l/min at 1 bar and 20 °C is required at the burner.

Flowmeter 1 is calibrated to operate at 2,4 bar absolute and 15 °C, but to indicate l/min at 1 bar and 15°C.

Flowmeter 2 is calibrated to operate at 1 bar absolute and 20 °C, but to indicate l/min at 1 bar and 20 °C.

Assume that the air supply pressure up to and including the flowmeters is alternatively at 1 bar (see B.2.2) or at 2,4 bar (see B.2.3) and 20 °C.

The calibration correction factor is given as follows:

$$C = \sqrt{\frac{P_1}{P_2} \times \frac{T_2}{T_1}}$$

where

T is the absolute temperature, in kelvins (K);

P is the absolute pressure, in bars (bar);

P_1, T_1 are the calibration conditions;

P_2, T_2 are the operating conditions.

B.2.2 Air supplied at 1 bar

Flowmeter 1

This will require a correction factor to be used since the meter is operating in conditions removed from its designed operating conditions.

P_1 = 2,4 bar $\qquad$ T_1 = 15 °C = 288 K

P_2 = 1 bar $\qquad$ T_2 = 20 °C = 293 K

Substituting these values:

$$C = \sqrt{\frac{2,4}{1} \times \frac{293}{288}} = 1,56$$

Thus, to set a flow rate of 77,7 l/min at reference conditions, a reading on this flowmeter of 121,2 l/min (77,7 × 1,56) is required.

Flowmeter 2

Since this meter is operating under its design conditions, the required flow rate of 77,7 l/min can be read directly from the meter with no correction factor necessary.

B.2.3 Air supplied at 2,4 bar

Flowmeter 1

This will require a correction factor for temperature, but not for pressure since the meter is operating at

its design pressure.

P_1 = 2,4 bar T_1 = 15 °C = 288 K

P_2 = 2,4 bar T_2 = 20 °C = 293 K

Substituting these values:

$$C = \sqrt{\frac{2,4}{2,4} \times \frac{293}{288}} = 1,01$$

Thus, to set a flow rate of 77,7 l/min at reference conditions, a reading of 78,5 l/min (77,7 × 1,01) on this flowmeter is required.

Flowmeter 2
This will also require a correction factor since it is operating in conditions removed from its design conditions.

P_1 = 1 bar T_1 = 20 °C = 293 K

P_2 = 2,4 bar T_2 = 20 °C = 293 K

Substituting these values:

$$C = \sqrt{\frac{1}{2,4} \times \frac{293}{293}} = 0,65$$

Thus, to set a flow rate of 77,7 l/min at reference conditions, a reading of 50,5 l/min (77,7 × 0,65) on this flowmeter is required.

Fire Testing Cabin According to IEC 60332-3-10

- AHP test chamber with sample holder, hood, collector, measuring tube, gas installation, burner, air supply and sensors (as per customer request)
- Double-walled test chamber, stainless steel with mineral wool insulation, opening for air supply at the bottom, opening for smoke extraction, rail guides on the back wall for easy mounting of sample holders, winch assembly, stainless steel door
- Cable winch , ramp and option for easier transport of the sample holder
- Exhaust gas fan
- Modules for data acquisition and control of all processes (As per customer reuquest)
- Extensive options and accessories for enhancing the exhaust system and for calibrating the test unit
- Stainless steel extraction hood and collector for protection against aggressive gases
- Ribbon propane burner with venturi mixer, piezoelectric igniter, flame detector, stainless steel protective cover
- Gas installation with gas flow controller, pressure controller and solenoid valves
- Supply air process fan with frequency inverter and digital control module
- Exhaust air process fan with frequency converter and digital control module
- **The basic model includes the sample cabin and the gas and air control systems, burner (single), ladder(500mm). Other functions like gas analysis, smoke density measurement, Double burner, wide ladder (800mm) .... will be quoted as per customer request.**

Test Method

The cable is exposed to the flames in a closed chamber for 20 minutes. The cables are mounted in a vertical tube furnace on a ladder and the flame is ignited with a propane gas ribbon burner. The time of ignition provides information for evaluating the combustion behaviour.

Test Setup

The cables to be tested are evenly distributed on the conductor. During the fire test, the conductor with the cable samples facing inwards is placed vertically against a wall in a combustion chamber. The burner is placed in front of the conductor at a distance of 7.5 cm from the samples.

Measurement

The spread of the flame and the burning droplets/particles are observed and the length of the fire damage is measured at the end of the test. The flue gases produced during combustion are discharged via an exhaust air duct, where the speed of the air flow, the O_2 and CO_2 content as well as the light absorption and temperature are measured. (All functions will be as per the customer request)

Category

1. Equipment for Standards
2. Standards