

**BRITISH STANDARD FOR
METHYLENE BLUE
PARTICULATE TEST FOR
RESPIRATOR
CANISTERS**

B.S. 2577 : 1955

THIS BRITISH STANDARD, having been approved by the Personal Safety Equipment Standards Committee, was published under the authority of the General Council on 31st March, 1955.

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 2500, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook,

This standard makes reference to the following British Standards:

B.S. 796 Rubber hose with cotton braided reinforcement.

B.S. 924 Rubber hose with woven fabric reinforcement.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following B.S.I. references relate to the work on this standard:—
Committee reference PSM/11 Draft for comment CR(PSM) 9298

CO-OPERATING ORGANIZATIONS

The Personal Safety Equipment Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:—

Associated Portland Cement Manufacturers
 Association of British Chemical Manufacturers
 British Chemical Plant Manufacturers' Association
 British Leather Manufacturers' Research Association
 British Iron and Steel Federation
 British Ironfounders' Association
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 Combustion Engineering Association
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 *Federation of British Rubber Manufacturers' Associations
 Federation of Civil Engineering Contractors
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 National Paint Federation
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The scientific and industrial organization marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:—

Association of British Insecticide Manufacturers
 British Agricultural Contractors' Association
 British Mechanical Rubber Manufacturers' Association
 British Plastics Federation
 Fungicide and Insecticide Research Co-ordination Service
 Manufacturers of Protective Equipment
 Ministry of Agriculture and Fisheries
 Ministry of Labour and National Service
 Ministry of Supply
 National Farmers Union
 Society of Chemical Industry

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FOREWORD

This British Standard is based on Porton Specification No. 1141 prepared by the Chemical Defence Experimental Establishment of the Ministry of Supply. Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to use Porton Specification No. 1141 and Crown copyright is reserved in the drawings which are reproduced with the permission of the Controller, H.M.S.O.

According to this British Standard a particulate test cloud of methylene blue is generated continuously and is passed through the respirator canister and a filter paper in series. Particles of dye penetrating the canister are retained on the paper, the blue stain produced is developed to its maximum intensity and compared with a series of standard stains which enables an estimate to be made of the percentage of particles penetrating the canister.

SCOPE

1. This British Standard specifies the methylene blue particulate test which permits the assessment of the protection afforded by respirator canisters against particulate clouds. It includes the method of test, preparation of standard stains, description of the apparatus required and notes on its maintenance.

DEFINITION

2. *Canister.* For the purpose of this British Standard the canister is that part of the respirator containing the filtering medium.

DESCRIPTION OF APPARATUS

3. The apparatus is shown diagrammatically in Fig. 1. It comprises the following main sections:—

a. Test cloud generator. This comprises the atomizer A, needle valve V_1 , pressure gauge D, compressed air flow meter M_1 and evaporation tube E.

b. Control cock C.

c. Test circuit. This comprises the canister holder R, test paper holder F, flow meter M_2 and control valve V_2 .

d. By-pass circuit. This comprises the filter G, flow meter M_3 and control valve V_3 .

e. Filter paper clamp S. This is for sampling the test cloud with a hand sampling pump.

A source of compressed air, a rotary suction pump, an air drier and steam are also required.

DESCRIPTION OF METHOD

4. The atomizer, working under a constant pressure and flow of compressed air, disperses a solution of methylene blue into a mist at a uniform rate. The mist passes into the evaporation tube E where it is diluted to a total volume of 30 litres per minute by dry air entering at B. The droplets of solution evaporate before reaching the cock C, leaving a residue of solid particles of methylene blue. When the cock C is in the 'Test' position, the test cloud passes to the test circuit which contains the canister under test and the filter paper.

When the control cock is turned to the central or 'Air' position, the cloud is diverted to the by-pass circuit and at the same time air is drawn through the 'Test' circuit. In the OFF position of the control cock the cloud remains diverted to the by-pass circuit, but there is no flow through the 'Test' circuit. The rates of flow in the two circuits are adjusted to 30 litres per minute by means of the air valves V_2 and V_3 respectively.

To test a canister the control cock is first turned to OFF and the canister and filter paper are inserted into their respective holders. The test cloud is then passed to the canister for a predetermined time, following which air is passed through for a further period of twenty seconds in order to sweep out the residual cloud from the test circuit. The cock is then turned to OFF and the filter paper removed. Finally, the test stain is developed with steam and the penetration is assessed by comparing the stain with the standard stains.

TEST

ASSEMBLY OF APPARATUS

5. *a. Layout.* (i) The apparatus shall be mounted on a table or bench approximately 4 ft long by 2 ft wide. A vertical panel approximately 1 ft high, extending the full length of the table and 15 in. from the front edge, shall be provided.

(ii) The general layout of the apparatus is illustrated in Figs. 1 and 2. The control cock, canister holder with filter paper clamp attached, and the test paper holder are mounted on the table, and the test circuit flow meter, by-pass circuit flow meter, air valves, pressure gauge, needle valve and compressed air flow meter are mounted on the panel as indicated in Fig. 2. The atomizer and evaporation tube shall be placed behind the panel.

(iii) The angles of inclination at which the flow meters are mounted shall be determined during the preliminary calibration of these components.

(iv) The air compressor and rotary suction pump may be placed in any convenient position near the main portion of the apparatus.

(v) Any variations from the above layout which may be made to suit individual requirements shall be approved by the inspecting authority.

b. Connections. (i) Unless otherwise stated, the following connections shall be made with $\frac{5}{8}$ in. rubber garden hose complying with B.S. 796* or B.S. 924.† The positions of the connections are shown in Fig. 2.

(ii) Outlet of evaporating tube to control cock, port 1.

(iii) Control cock, port 2, to filter.

(iv) Filter to lower end of by-pass circuit flow meter.

(v) Control cock, port 5, to inlet of canister holder.

(vi) Canister holder outlet to movable section of test paper holder. (This connection to be made with $\frac{5}{8}$ in. bore, $\frac{1}{8}$ in. wall, soft rubber tubing.)

(vii) Test paper holder to lower end of test circuit flow meter.

(viii) Valve of test circuit flow meter to control cock, port 3.

(ix) Centre of control cock to suction pump.

(x) Valve of by-pass circuit flow meter to suction pump.

(xi) The outlet of the atomizer and the cloud inlet to the evaporation tube are to be placed co-axially and in contact, and connection made with a short length of $\frac{5}{8}$ in. rubber garden hose complying with B.S. 796 or B.S. 924.

(xii) Air inlet of evaporation tube to air drier.

c. Compressed air system. (i) The following connections are to be made with $\frac{1}{4}$ in. compressed air hose complying with B.S. 796 or B.S. 924.

(ii) Needle valve outlet to lower end of compressed air flow meter.

(iii) Flow meter to 'T' junction.

(iv) Side arm of 'T' junction to pressure gauge.

(v) 'T' junction to atomizer.

(vi) Air compressor to needle valve.

d. The above connections shall be made with the minimum necessary length of tubing.

e. At no point shall the connecting tubing be bent sharply or kinked so as to cause any constriction of the bore.

f. Calibration of flow meters. (i) The flow meters shall be calibrated after assembly of the apparatus. The calibrations shall be carried out under working conditions as follows:—

(ii) *Test circuit flow meter.* Place a piece of card in the filter paper clamp mounted on the canister holder and close the clamp firmly in order

* B.S. 796, 'Rubber hose with cotton braided reinforcement'.

† B.S. 924, 'Rubber hose with woven fabric reinforcement'.

to prevent the entry of air into the inlet duct at this point. Disconnect the atomizer from the evaporation tube and block the cloud inlet of the latter. Remove the air drier and connect a standard flow meter to the evaporation tube air inlet. Place a strip of filter paper in position in the test paper holder.

After setting the suction pump in operation, turn the control cock to the 'Test' position and adjust the air valve in the test circuit until the standard meter indicates a flow of 30 litres per minute. Mark the position of the ball in the sight tube of the test circuit flow meter.

(iii) *By-pass circuit flow meter.* With connections as in (ii), turn the control cock to 'Air'. Adjust the valve in the by-pass circuit to give a flow of 30 litres per minute as shown by the standard flow meter. Mark the position of the ball in the sight tube of the by-pass circuit flow meter.

(iv) *Compressed air flow meter.* Assemble the atomizer with no liquid in the glass reservoir. Connect the outlet tube of the atomizer to the standard flow meter. Turn on the compressed air and adjust the needle valve until a pressure of 30 lb/sq. in. is shown on the pressure gauge. If the jets of the atomizer are not blocked or otherwise damaged the flow will now be between 8 and 8.5 litres of free air per minute. Examine the standard flow meter and verify that the flow is within the above limits. Mark the position of the ball in the sight tube of the compressed air flow meter. If the standard flow meter does not at first show the air flow to be between 8 and 8.5 litres per minute, the atomizer shall be examined for blocked jets, leaking connections, or other faults. During subsequent operation of the apparatus, the flow of compressed air shall remain constant at the value for which the meter was set. Any deviation from this value will indicate faults as described above, and the fault shall be remedied.

OPERATION OF APPARATUS

6. a. Preliminary. (i) Fill the atomizer with the appropriate methylene blue solution up to a level $\frac{1}{4}$ in. below that of the spray orifice. Approximately 500 ml of solution are required. See Appendix Ba.

(ii) If necessary, renew the pad in the by-pass circuit filter.

(iii) *In the following, the filter paper clamp mounted on the canister holder will be assumed to be closed as described in 5 f (ii) unless otherwise stated.*

b. Procedure in starting apparatus. (i) Turn control cock to OFF position.
(ii) Switch on the suction pump.
(iii) Insert a canister into the canister holder, and filter paper into the test paper holder.

(iv) Turn control cock to 'Test' position. Adjust air valve to give a flow of 30 litres per minute through the test circuit.

(v) Turn control cock to 'Air' position. Adjust second valve to give a flow of 30 litres per minute through the by-pass circuit.

- (vi) Turn control cock OFF.
 - (vii) Switch on compressor.
 - (viii) When air pressure in receiver has built up to its maximum value, i.e. 35 lb/sq. in., turn on compressed air to atomizer and adjust needle valve until pressure gauge shows pressure of 30 lb/sq. in.
 - (ix) The ball in the compressed air flow meter should now come up to the calibration mark. If the air flow is insufficient, turn off compressed air and clean the jets of the atomizer, then proceed as at (viii).
 - (x) Check the concentration of the test cloud by taking a sample of five strokes with the hand pump as described in Clause 7.
- c. Testing of canisters.** (i) With the control cock OFF, insert canister into holder and place clean paper in the test paper holder.
- (ii) Turn control cock to 'Test' position and start stop-clock. Leave in this position for required time (see Clause 8).
- (iii) After this period in 'Test' position, turn control cock to 'Air' for further period of twenty seconds.
- (iv) Turn control cock OFF. Change canister and filter paper and commence test of new canister as at (i).
- d.** During the testing of canisters, the air valves shall be adjusted as necessary to maintain the correct rates of flow through the apparatus.
- e.** It is convenient to include the stains of from six to eight canisters on one strip of filter paper of size 6 in. by $\frac{7}{8}$ in.
- f. Development of test stains.** (i) On the completion of a test strip of filter paper, the stains from the various canisters are developed by exposing the paper to a jet of steam.
- (ii) The steam shall be directed on to the side of paper which bears the stains.
- (iii) The steaming shall be continued until the intensities of the stains have reached their maximum values.
- g. Estimation of percentage penetration.** (i) The percentage penetration of the canisters is estimated by comparing the test stains with a series of standardized stains whose intensities represent known penetrations. The standard stain of intensity most nearly equal to that of the test stain is determined by visual examination, and the penetration noted. Intermediate values between two consecutive standard stains may be estimated.
- (ii) The standard stains are to be prepared as described in Clause 7.
- (iii) In making the comparison, the standard strip and the strip of paper bearing the test stains shall be placed side by side in such a manner that they receive equal illumination.

SAMPLING OF TEST CLOUD AND PREPARATION OF STANDARD STAINS

7. a. General. (i) The concentration of the test cloud is measured by drawing a known volume of the cloud through a $\frac{1}{2}$ in. diameter circle of filter paper by means of a hand pump. The paper is held in the clamp S,

Figs. 1 and 2. The adaptor to this clamp opens into the main inlet pipe of the canister holder.

(ii) If the apparatus is functioning correctly, the test cloud will remain constant from day to day.

b. Procedure. (i) Pass the test cloud to the canister by turning the control cock to 'Test'. Adjust the apparatus as described in Clause 6 *b*.

(ii) Connect the appropriate hand sampling pump (see Clause 8) to the filter paper clamp by a minimum length of $\frac{1}{4}$ in. rubber tubing.

Insert a strip of filter paper into the clamp.

(iii) Take a sample of the test cloud through the filter paper by means of five strokes of the pump.

(iv) Move the filter paper into a new position and repeat (iii).

(v) Develop the stains, and verify that the cloud concentration is normal.

c. Preparation of standard stains. (i) Proceed as in *b* (i) and (ii) above.

(ii) Fill the dead volume of the filter paper clamp and adaptor with cloud by taking a preliminary one stroke sample of the cloud as in (iii) above.

(iii) Prepare a series of stains by drawing samples of 1 stroke, 2 strokes, etc., to 10 strokes of test cloud through the filter paper. The strip of paper is moved on by $\frac{5}{8}$ in. after the completion of each stain.

(iv) Develop the stains as described in Clause 6 *g*.

(v) When comparison is made with the test stain, the standard stain obtained by sampling n strokes, each of volume v , of the test cloud will represent a penetration of

$$\frac{nv}{30,000t} \times 100 = \frac{nv}{300t} \text{ per cent,}$$

where t is the time of test in minutes.

The series of standard stains therefore represent penetrations of $\frac{v}{300t}$ per cent, $\frac{2v}{300t}$ per cent . . . $\frac{10v}{300t}$ per cent respectively.

TESTING OF CANISTERS

8. a. Testing canisters with penetrations up to 4 per cent. Proceed as described in Clauses 6 and 7, using a standard nozzle, a 1 per cent methylene blue solution and a 12 cu. cm hand sampling pump.

Then for a two-minute test, $\frac{v}{300t} = \frac{12}{600} = 0.02$ per cent and the standard stains will correspond to penetrations of 0.02, 0.04, 0.06 . . . 0.2 per cent respectively.

Similarly for a test of six seconds' duration $\frac{v}{300t} = \frac{12}{30} = 0.4$ per cent, and the standard covers a range of 0.4 per cent to 4 per cent.

A standard stain corresponding to a penetration of 0.01 per cent in a two-minute test may be prepared as follows:—

Adjust the apparatus as described in Clause 6 for the testing of canisters. Place a canister of known penetration, say 0.04 per cent (determined by a previous test), in the holder, and insert the paper which is to bear the 0.01 per cent standard stain into the test paper holder. Pass the cloud to the test circuit for $2 \times \frac{0.01}{0.04} = \frac{1}{2}$ minute.

The resulting stain will then correspond to 0.01 per cent penetration in a normal two minutes' test.

b. Testing of canisters with penetrations from less than 4 per cent to 20 per cent. In this case a standard nozzle with two of the liquid feed holes closed and a $\frac{1}{2}$ per cent methylene blue solution will be used. This will so reduce the concentration of the methylene blue cloud without significantly altering its size distribution that a sufficiently long testing time is needed for the high penetration canisters. A hand sampling pump of 80 cu. cm capacity will also be required.

Proceed as described in Clauses 6 and 7. Then for a test of 1 minute 20 seconds, $\frac{v}{300t} = \frac{80 \times 60}{300 \times 80} = 0.2$ per cent and the standard stains will correspond to penetrations of 0.2, 0.4, 0.6 . . . 2 per cent respectively.

Similarly for a testing time of 8 seconds, $\frac{v}{300t} = \frac{80 \times 60}{300 \times 8} = 2.0$ per cent, giving a range for the standard stains of 2.0 per cent to 20 per cent

It may be found convenient to take the standard stains with a 40 cu. cm. hand sampling pump, in which case the number of pump strokes for each stain density will have to be doubled.

APPENDIX A

DETAILS OF APPARATUS REQUIRED

a. Components. All components shall comply with this British Standard. No component shall be built up or repaired in any way not covered by this standard except with the approval of the inspecting authority.

No alternatives to, or variations from, the method of construction and materials specified in this standard shall be made without the approval of the inspecting authority.

The components detailed in Table 1 are required.

TABLE 1. LIST OF COMPONENTS

Component	Quantity	Component	Quantity
Atomizer	One	Canister holder	One
Control cock	One	Hand sampling pumps	Two
Test paper holder	One	Filter paper clamp	
Flow meter and air valve	Two	and adaptors	One
Compressed air flow meter	One	Air drier	One
Pressure gauge	One	Clock	One
Needle valve	One	Water heater	One
Evaporation tube	One	Sundries	
Filter	One	Accessory apparatus	
		Expendable materials	

b. Atomizer. (i) The atomizer shall conform to Fig. 3 and shall be assembled in the manner indicated in the drawing from component parts detailed in Table 2.

TABLE 2. COMPONENTS OF ATOMIZER

Component	Quantity	Component	Quantity
Atomizer head	One	Wing nut	One
Sleeve	One	Glass reservoir	One
Nozzle (3 jet)	One	Locking ring	One
Compressed air connection	One	Rubber washer	One
Nozzle (3 jet) with one liquid feed hole	One		

(ii) One nozzle of each type, and one glass reservoir with rubber washer, locking ring and lid should be provided as spares.

NOTE. A 2 lb size pressure jar, of the type having locking ring, rubber washer and lid, makes a suitable glass reservoir.

c. Control cock. (i) The control cock shall conform to Fig. 4 and shall be assembled in the manner indicated in the drawing from the component parts detailed in Table 3.

TABLE 3. COMPONENTS OF CONTROL COCK

Component	Quantity	Component	Quantity
Body	One	Screwed plug	One
Plug	One	Tube	Six
Nipple	Five	Backnut	One
Elbow	Five	Operating handle	One

(ii) *Body*. The body shall be made of gunmetal or brass and shall be machined to the form and dimensions indicated on the drawing. The metal shall be sound and free from blow holes or other defects.

(iii) *Plug*. The plug shall be made of gunmetal or brass and machined to the form and dimensions indicated on the drawing. The metal shall be sound and free from blow holes or other defects. The taper shall be machined to ensure a gas-tight fit between the ports on assembly.

(iv) *Screw threads*. All screw threads shall comply with the corresponding British Standard and all screwed connections shall be made air-tight on assembly.

d. Test paper holder. (i) The test paper holder shall conform to Fig. 5.

(ii) The surfaces between which the paper is clamped shall be machined flat and square with the thread to ensure a substantially air-tight seating when the clamp is closed.

(iii) The bore of the clamp shall be reamed out to $\frac{1}{2}$ in. diameter as indicated on Fig. 5.

e. Flow meter and air valve. (i) The flow meters shall be of the inclined tube and ball type, and shall be fitted with air regulating valves. The flow meters and air valves shall conform to Fig. 6.

(ii) All screw threads shall be a good fit and rubber connections shall be made air-tight.

(iii) The flow meters shall be calibrated for a flow of 30 litres of free air per minute at their working pressures. A final calibration shall be carried out after the complete assembly of the apparatus.

f. Compressed air flow meter. (i) One compressed air flow meter, of the ball and curved tube type, to measure a flow of 8 litres of free air per minute at a pressure of 30 lb/sq. in. is required. The flow meter shall conform to Fig. 6.

(ii) The ball of the flow meter shall run freely in the sight tube.

g. Pressure gauge. The pressure gauge shall be of the Bourdon type, reading up to 40 lb/sq. in., with 4 in. dial.

h. Needle valve. The needle valve shall be suitable for controlling an air flow of 8 litres of free air per minute at a pressure of 30 lb/sq. in. It should be adapted for panel mounting.

j. Evaporation tube. The evaporation tube shall conform to Fig. 3.