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Amend

No. 893—1940.

British Standards Institution

Incorporated by Royal Charter.

BRITISH STANDARD
FOR
THE METHOD OF TESTING
DUST EXTRACTION PLANT
AND
THE EMISSION OF SOLIDS FROM CHIMNEYS
OF
ELECTRIC POWER STATIONS.

April, 1940.



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Amendment No. I. September, 1942

to

B.S. 893—1940 Method of Testing Dust Extraction Plant, etc.

Corrigendum

Page 25, line 32.—The first sentence of this paragraph to be amended to read :—

“ In any type of apparatus where a pressure reading is taken inside the nozzle itself it is necessary to ensure that the Reynolds Number for the gas flow in the nozzle is either below 2000 or above 3000, thus avoiding the unstable range where unreliable results would be obtained.”

[B.S. 893—1940, p. 25.]

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CO-OPERATING ORGANISATIONS.

The Mechanical Industry Committee under whose supervision this British Standard was prepared consists of representatives from the following Government Departments and Scientific and Industrial Organisations :—

Admiralty.	British Marine Oil Engine Manufacturers' Association.
Crown Agents for the Colonies.	Engineering Insurance Companies.
*Department of Scientific and Industrial Research.	Institute of Petroleum.
High Commissioner for India.	Institution of Automobile Engineers.
H.M. Office of Works.	Institution of Civil Engineers.
Home Office.	Institution of Gas Engineers.
Ministry of Transport.	Institution of Heating and Ventilating Engineers.
War Office.	Institution of Marine Engineers.
Agricultural and Road Machinery Manufacturers' Association.	*Institution of Mechanical Engineers.
Association of Consulting Engineers (Incorporated).	Institution of Production Engineers.
British Chemical Plant Manufacturers' Association.	Locomotive Manufacturers' Association.
British Electrical and Allied Manufacturers' Association.	Machine Tool Trades Association.
*British Engineer's Association.	Railway Companies of Great Britain.
British Iron and Steel Federation.	

The Government Departments and Scientific and Industrial Organisations 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 :—

Ministry of Health.
 British Coal Utilisation Research Association.
 Combustion Appliance Makers' Association.
 Electricity Commissioners.
 Incorporated Association of Electric Power Companies.
 Incorporated Municipal Electrical Association.
 Institute of Fuel.
 Institution of Electrical Engineers.
 Provincial Electric Supply Association.

FOREWORD.

The Technical Committee on the Testing of Dust Extraction Plant was appointed at the meeting of the Mechanical Industry Committee held on May 17th, 1934, in response to representation made by the Electricity Commissioners for the setting up of a standard method of testing dust extraction plant and of grading dust particles from the chimneys of electric power stations.

One of the major difficulties which the Committee had to face in commencing the work was the variable flow of gases at the point of testing. In an endeavour to arrive at a solution, a comprehensive programme of tests was carried out at the National Physical Laboratory. The results, however, were not such as to enable the Committee to put forward any practical solution at the present time. Some notes on this problem have been included in Appendix D and the Committee would welcome any information with regard to results obtained when adopting the recommendations set out therein.

The question of a suitable sampling apparatus has also engaged the Committee's attention. Details of a number of sampling devices which are considered satisfactory and conditions of use are given in Appendix A (page 23). The Committee carried out a limited number of tests on these devices but it was not practicable to make comprehensive tests to cover all the varying conditions which were met with in practice.

The Committee propose to review these recommendations at an early date, and to assist them in such work they would welcome any information as to the practical experience obtained in working to this Standard.

This Method of Test requires reference to the following British Standards :—

No. 10, Part 1. Tables of Pipe Flanges (for Land Use)—

Working Gas Pressures up to 30 lb.
per sq. inch.

Working Water Pressures up to 175 lb.
per sq. inch.

No. 707. Testing of Mine Fans.

No. 848. Testing of Fans for General Purposes. (Excluding Mine Fans).

In order to keep abreast of progress in the Industries concerned, the British Standards are subject to periodical review.

Suggestions for improvements, addressed to the British Standards Institution, 28, Victoria Street, London, S.W.1, will be welcomed at all times. They will be recorded, and in due course brought to the notice of the Committee charged with the revision of the publications to which they refer.

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BRITISH STANDARD
FOR
THE METHOD OF TESTING
DUST EXTRACTION PLANT
AND
THE EMISSION OF SOLIDS FROM CHIMNEYS
OF
ELECTRIC POWER STATIONS.

PART 1.

METHOD OF TESTING.

NOTE.—The attention of Users of this Standard is called to the Foreword.

Scope.

1. Dust Extraction Plant and the exit gases from chimneys of electric power stations shall be tested for emission of solids as 15 herein laid down.

The emission of solids shall be stated in terms of the solids in the flue gases leaving the plant expressed as grains per cubic foot of dry gas at N.T.P. and also in lb. per hour.

Where it is desired to make a size grading of the solids this 20 shall be carried out by the method described in Part 3 (page 15).

NOTE.—It is considered that accurate sampling of the gases entering a dust extractor would in most cases be subject to many difficulties, and it has been agreed, therefore, that tests need only be made for the dust content of the gases leaving the plant and passing into the atmosphere. 25

Should efficiency figures be desired, they may be obtained by measuring the amount of dust collected by the extractor during the period of sampling and making the necessary calculation.

Sampling.

2. The total dust concentration in the flue gases shall be 30 determined by withdrawing and filtering a representative sample of the flue gases. The procedure adopted shall be in accordance with the method described in Part 2 (page 9).

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Boiler Conditions.

3. For the whole of the period during which the flue gases are being sampled all the boiler conditions shall be kept as constant as practicable.

Soot Blowing.

4. Unless otherwise agreed, no soot blowing shall be carried out during the period of test.

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PART 2.**METHOD OF SAMPLING FLUE GASES.****Method of Sampling.**

5. The method of obtaining a sample of flue gas shall be as follows :—

5

A properly designed sampling tube shall be inserted into the gas stream at a sampling point selected as specified below so that its nose faces the direction of flow. A sample of the gas shall be withdrawn for a given time, after which the tube shall be moved with the minimum delay to a second 10 sampling point and a further sample of flue gas withdrawn for the same length of time. This process shall be repeated until the required number of gas samples has been withdrawn from points over the whole cross section of the gas stream. Should the pressure-drop through the apparatus become 15 excessive during the process a fresh filter must be used.

A description of suitable designs of sampling tube and details of the methods of their operation are given in Appendix A (page 23). These embody the use of the following filtering media :—

- (a) A scrubber containing sodium carbonate solution, 20
- (b) Alundum thimble,
- (c) Paper thimble.

The last two are suitable for use only when testing pulverised fuel installations in which the flue gases at the point of sampling are above the dewpoint taking sulphur trioxide (SO_3) into 25 account.

If it is desired to determine the dewpoint this shall be ascertained by an agreed method.*

It is essential that the method used to collect the sample shall conform in every detail to the conditions specified below, including 30 the position of sampling, the number of sampling points, the duration and the rate of sampling at each sampling point and the total weight of sample collected in a given filter.

A number of tubes may be used simultaneously if desired.

Point of Test.

35

6. The sampling shall be carried out at any agreed position, not necessarily in the chimney, where the gas flow is known to be reasonably uniform. Methods by means of which uniform flow may be secured are outlined in Appendix D (page 43).

* An instrument for determining the dewpoint is described in a 40 paper by Robey & Harlow. Proceedings of the Institution of Mechanical Engineers, vol. 125, pp. 237 to 247.

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Where a position in the chimney is selected, such position shall be not less than $D + 5$ ft. above the top of the flue through which the flue gases enter, where D is the internal diameter of the chimney at the top of the flue opening.

This distance is an absolute minimum and should be considerably increased, wherever practicable, particularly in those cases where no steps have been taken to secure unidirectional and reasonably uniform gas flow.

Number of Gas Sampling Points.

7. The total number of sampling points shall be at least 24 and shall be taken from points over the cross section which correspond to the centres of equal areas. For chimneys and flues of circular and rectangular cross section the positions are as shown in Figs. 1, 2 and 3.

Sampling Holes in Chimneys.

8. Where sampling is carried out in chimneys the following number of holes, 10 in. in diameter, shall be provided to enable the necessary flue gas samples to be taken :—

In steel chimneys ... 3 holes.

In brick or concrete chimneys 15 ft. and under in external diameter ... 3 holes.

In brick or concrete chimneys over 15 ft. in external diameter ... 8 holes
(See Fig. 13)

The holes shall be equally spaced round the periphery of the chimney in the same horizontal plane and shall be fitted on the outside with a flange or blank door. In brick or concrete chimneys the holes shall be formed using cast-iron pipe 10 inches in internal diameter provided with a flange on the end at the outside of the chimney. The flanges shall conform to the requirements of B.S. 10, Part 1, Table A, as follows :—

Diameter of flange ... 16 in.

Diameter of bolt circle ... 14 in.

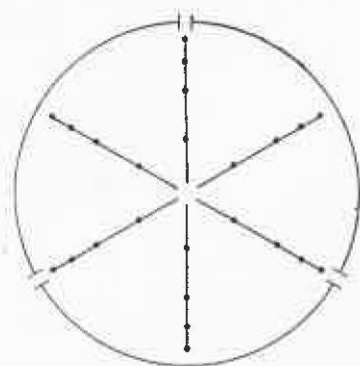
Number of bolts ... 8

Diameter of bolts ... $\frac{3}{4}$ in.

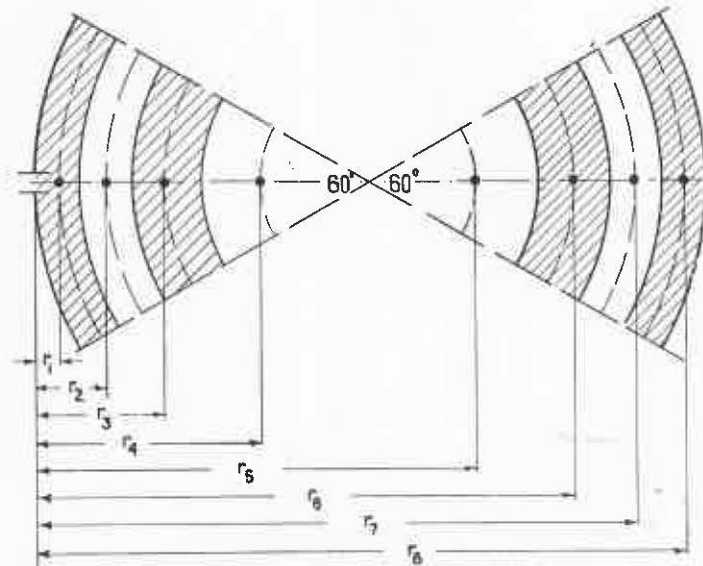
Thickness of flange ... $1\frac{5}{16}$ in.

Sampling Tube and Filter.

9. The sampling tube and filter shall be of suitable design (see Appendix A, page 23).



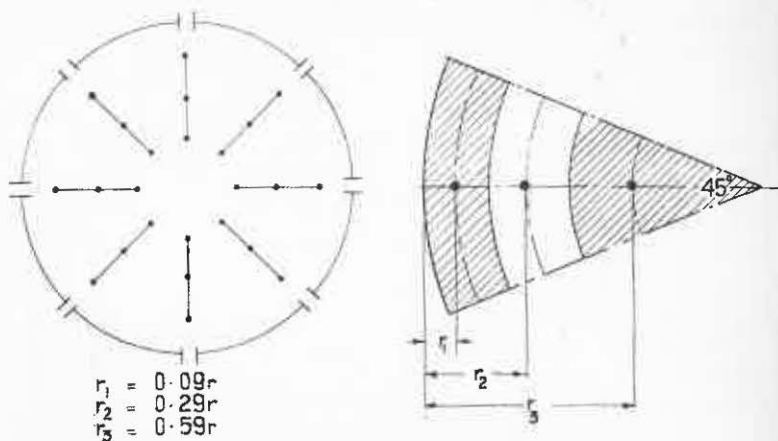
r_1	=	0.07 r
r_2	=	0.21 r
r_3	=	0.39 r
r_4	=	0.65 r
r_5	=	1.35 r
r_6	=	1.61 r
r_7	=	1.79 r
r_8	=	1.94 r



NOTE.— r = radius of circle corresponding to the cross section of chimney or flue.
The points are at the centres of equal areas.

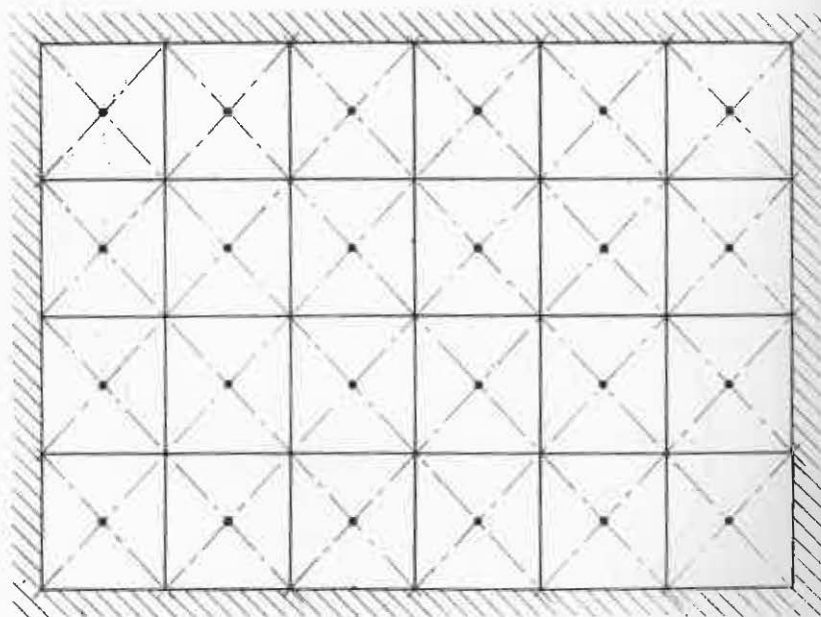
Fig. 1. 24-point sampling from 3 holes in circular chimneys or flues.

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NOTE.— r = radius of circle corresponding to the cross section of chimney or flue.
The points are at the centres of equal areas.

Fig. 2. 24-point sampling from 8 holes in circular chimneys or flues.



NOTE.—The points are at the centres of equal areas.

Fig. 3. 24-point sampling in rectangular chimneys or flues.



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Freedom from Leaks.

10. Strict precautions shall be taken to ensure that there are no leaks in any part of the apparatus at any time during the whole period of test when it is subjected to the maximum difference in pressure that will be experienced during testing. Where an alundum or a paper thimble filter is used steps shall also be taken to ensure that the joint at the base of the filter remains gas-tight throughout the test. 5

Angle of Yaw.

11. At no time during the period of sampling shall any sampling or Pitot tube be maintained in such a position that the central axis of the nozzle of the tube is inclined to the axis of the chimney or flue at more than 10° .

Rate of Sampling.

12. The rate of sampling shall be such that the velocity of the flue gas in the sampling tube shall not vary by more than plus or minus 10 per cent from the velocity of the flue gas at the specified point of sampling. The flue gas velocity shall be determined by readings with Pitot tubes, such readings being made either at the time of sampling, using Pitot tubes† incorporated in the design of sampling tube, or by a preliminary exploration of the gas stream immediately prior to the test. The rate of sampling shall be determined by means of an orifice plate or by any suitable form of continuously indicating flowmeter. 15 20

Where the sampling tube is of a design which incorporates 25 Pitot tubes, the accuracy of the Pitot tube readings shall, both at the beginning and at the end of the period of test, be checked by means of a clean and separate Pitot tube. If it is necessary to dismantle the sampling tube during the period of test a check shall also be made before dismantling and after re-assembling. 30

Gas Velocity in the Chimney or Flue at the Sampling Position.

13. During the period of test the velocity of the flue gases at any given sampling point should preferably be not less than 15 ft. per second.

Duration of Sampling.

14. The duration of sampling shall be the same for each sampling point and shall in no case be less than 10 minutes. 35

Weight of Sample Collected.

15. The total dry weight of dust collected in any test shall be not less than that specified for the particular sampling apparatus used (see Table 2, p. 30). 40

Where elutriation tests are to be made the amount required is indicated in Part 3, page 15.

† Details of Pitot tubes are given in B.S. 707 and B.S. 818.

Volume of Gas Sample.

16. The total volume of the flue gas sampled shall be measured by any suitable means, such as by an orifice plate, Venturi meter, or a gas meter, provided that under the conditions of test the error does not exceed 5 per cent. The measuring device shall be placed between the sampling apparatus and the exhauster unless it can be shown that there is no leakage at the exhauster. Frequent readings shall be recorded and shall be corrected for temperature, pressure and humidity. 5

Rate of Filtering.

10

17. The size of the filter used shall be such that the maximum velocity at which the gases pass through the filtering medium does not exceed 15 ft. per minute. In the case of Model A (see Fig. 6) the calculation is made on the internal cross sectional area of the bottle. 15

Expression of Dust Concentration.

18. The dust concentration of the gases leaving the dust extraction plant shall be taken as the total weight of dust collected by the filter and sampling apparatus divided by the total volume of the gas sample reduced to N.T.P. dry gas. (0°C. and 760 mm. 20 of mercury.)

Total Volume.

19. The calculation of total volume of the gases at N.T.P. dry gas passing up the chimney should preferably be made from the analysis of the flue gas at the point of test, the analysis of the coal, 25 the carbon in the ash, and the rate of coal consumption. Alternatively, the calculation may be made from Pitot tube readings taken at the point of test, provided an adequate number is obtained.

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PART 3.**METHOD FOR THE AIR ELUTRIATION OF FLUE DUST.****General.**

20. The method and apparatus described below are suitable for obtaining an approximate size grading of flue dust within the range of 5-50 microns. Owing to the fact that flue dust is a mixture of particles which differ widely in shape and in apparent density it is only possible to grade the dust satisfactorily according to its terminal velocity. It is recommended therefore that the grading of flue dust should be expressed in terms of the terminal velocity only, and that it should be carried out at one or more of the following air velocities :—

0.6 cm./sec.	
2.5 " "	
10.0 " "	15

Apparatus.

21. The design and dimensions of a suitable air elutriator, together with the general layout of the necessary apparatus, are shown in Figs. 4, 5, 6 and 7.

Care must be taken that the various joints are truly air-tight, and the inner surfaces of the elutriator tubes must be highly polished.

Preparing the Apparatus.

22. Before a test the inner surfaces of :—

- (1) The elutriator tubes (A),
- (2) The cone (B),
- (3) The dust container (C)

should first be washed with petroleum ether to remove all traces of grease, and then polished with a soft cloth. Care should be taken to see that the elutriator tubes (A) are vertical.

Selection of Size of Elutriator Tube.

23. The elutriator is provided with three tubes of different diameters, and the size of tube selected should be in accordance with the following table :—

Diameter of tube.	Range of terminal velocities.	35
in.		
5½	Up to 0.7 cm./sec.	
2¾	0.7 cm./sec. to 7.0 cm./sec.	
1¾	7.0 cm./sec. to 20.0 cm./sec.	