
Methods for
Sampling and analysis of flue gases

Part 4. Miscellaneous analyses

Méthodes d'échantillonnage et d'analyse des gaz de fumée
Partie 4. Analyses diverses

Verfahren für die Probenahme und Analyse von Abgasen
Teil 4. Verschiedene Analysen

Contents

	Page		Page
Foreword		Inside front cover	
Cooperating organizations		Back cover	
Specification			
1. Scope	2	5. Filter tube for moisture or SO ₂ /SO ₃ determinations	7
2. References	2	6. Saturating tube for SO ₂ /SO ₃ determinations	7
3. Determination of moisture	2	7. Sulphur trioxide collecting vessel	7
4. Determination of oxides of sulphur: propan-2-ol (isopropanol) method	3	8. Suitable pump protection column for SO ₂ /SO ₃ determinations	7
5. Determination of oxides of sulphur: direct method	10	9. Suitable form of expansion chamber for SO ₂ /SO ₃ determinations	7
6. Determination of sulphuric acid dew point	15	10. Sampling train for the direct determination of sulphur trioxide and sulphur dioxide (diagrammatic)	11
7. Determination of carbon monoxide (< 0.5 %): macro iodine pentoxide method	16	11. Sulphur trioxide collector	12
8. Determination of carbon monoxide (< 0.5 %): micro iodine pentoxide method	21	12. Alternative forms of sulphur trioxide collector	12
9. Determination of oxides of nitrogen: modified Saltzman method	27	13. Apparatus for washing condensed sulphuric acid from collector	13
10. Determination of oxides of nitrogen: phenoldisulphonic acid method	28	14. Sulphuric acid dew point detector	15
		15. Probe for sulphuric acid dew point measurement	16
Tables		16. Temperature measuring and conductivity circuit for the dew point apparatus	16
1. Correction factors: saturated gas volume to dry volume at 0 °C and 1013.25 mbar	14	17. Compressed air filter for the dew point apparatus (diagrammatic)	17
2. Precision of analysis of carbon monoxide concentrations in test laboratories	21	18. General layout of the dew point apparatus (diagrammatic)	17
3. Selection of sample volume	26	19. Iodine pentoxide train for the macro determination of carbon monoxide	19
4. Vapour pressure of 40 % sodium dihydrogen phosphate solution	27	20. Multi-stage absorption bubbler	19
		21. Apparatus for the micro determination of carbon monoxide (diagrammatic)	22
Figures		22. Gas burette for the micro carbon monoxide apparatus	23
1. Typical absorption train for the determination of moisture in flue gases	3	23. Iodine pentoxide heater for the micro carbon monoxide apparatus	24
2. Midvale tube	3	24. Iodine absorption tube for the micro determination of carbon monoxide	24
3. Diagram of absorption apparatus for determination of sulphur trioxide and sulphur dioxide	5	25. Gas pipette for carbon monoxide determination	24
4. Sampling probe with water jacket for the determination of sulphur oxides	6		

Amendment No. 1
published and effective from 15 August 1993
to BS 1756 : Part 4 : 1977
Methods for sampling and analysis of flue gases
Part 4. Miscellaneous analyses

Revised text

AMD 7755
August 1993

Clause 4.4.5 Absorbent for sulphur oxides

Delete the text entirely.

AMD 7755
August 1993

Footnote to clause 4.4.5

Delete the text entirely.

AMD 7755
August 1993

Clause 4.5.3.6 Pump protection column (H) (optional)

Delete the text entirely.

AMD 7755
August 1993

Clause 8.4.9 Soda asbestos

Delete '*Soda asbestos*' and substitute '*Sodium hydroxide adsorbed onto synthetic silicate granules*'.

AMD 7755
August 1993

Clause 8.5.7 Trap tube

Delete the second sentence and substitute the following.

'The part of the tube containing sodium hydroxide adsorbed onto synthetic silicate granules shall be detachable so that the granules can be replaced without disconnecting the train.'

AMD 7755
August 1993

Clause 8.5.9 Bromac tube

In line 5, delete '*soda asbestos-silica gel*' and substitute '*sodium hydroxide adsorbed onto synthetic silicate granules-silica gel*'.

AMD 7755
August 1993

Clause 8.5.10 Soda asbestos-silica gel tube

In the title, delete '*Soda asbestos*' and substitute '*Sodium hydroxide adsorbed onto synthetic silicate granules*'.

In line 4, delete 'soda asbestos' and substitute 'sodium hydroxide adsorbed onto synthetic silicate granules'.

AMD 7755
August 1993

Clause 8.7 Assembly of apparatus

In paragraph 1, line 5, delete 'soda asbestos' and substitute 'sodium hydroxide adsorbed onto synthetic silicate granules'.

AMD 7755
August 1993

Figure 21. Apparatus for the micro determination of carbon monoxide
(diagrammatic)

In the key to figure 21, in G, K and K₁, delete 'soda asbestos' and substitute 'sodium hydroxide adsorbed onto synthetic silicate granules'.

Foreword

This British Standard was first issued in 1952 as a guide to the selection of suitable procedures for the sampling and analysis of flue gases. For the purposes of this standard, flue gas is defined broadly as the gaseous product arising from the combustion of fuel or from the combustion of any carbonaceous matter in materials being processed. The revised standard has been extended to cover not only flue gases from domestic and industrial fuel-burning installations but also those from various industrial processes.

The sampling and analysis of a flue gas is most often required for one or more of the following purposes:

- (a) checking and controlling the efficiency of combustion;
- (b) calculating heat balances;
- (c) detecting air or gas in-leakage;
- (d) determining compositions and hence calculating volumes of waste gases;
- (e) determining moisture contents;
- (f) assessing the effect of the gas on other parts of the plant, e.g. corrosion or tube blockage;
- (g) determining substances likely to cause pollution of the atmosphere;
- (h) determining toxic gases.

For the control of combustion efficiency, calculation of heat balances and detecting air in-leakage, the determination of carbon dioxide, carbon monoxide and oxygen covers most practical requirements. For more precise work sulphur dioxide, hydrogen and methane should be taken into account and a separate method used for low concentrations of carbon monoxide. In assessing the effect of flue gases on other parts of a plant and in guarding against pollution of the atmosphere, determinations of dew-point, sulphur dioxide, sulphur trioxide and nitrogen oxides may be necessary.

When revised in 1965, the standard was divided into the following Parts:

- Part 1 Methods of sampling
- Part 2 Analysis by the Orsat apparatus
- Part 3 Analysis by the Haldane apparatus
- Part 4 Miscellaneous analyses
- Part 5 Semi-routine analyses

In general the information in Part 1 was similar to that in the previous edition but the recommendations were brought up to date. The Orsat apparatus described in Part 2 was modified to give increased accuracy and appreciable changes were made in the design and operation of the type of Haldane apparatus recommended in Part 3. Improvements and additions, based on experience during the intervening years, were also made to the methods in Part 4. Alternative methods in use for the analysis of flue gases from domestic gas appliances, commonly employed as a measure of combustion performance, were given in Part 5, which also included the total sulphur method.

Parts 1, 2, 3 and 5 were converted to metric units and re-issued in 1971 without technical changes, but a revision of Part 4 was undertaken to incorporate the latest information on the determination of oxides of sulphur and oxides of nitrogen.

Also, in previous issues no reference was made to procedures for gas analysis by chromatographic, infra-red or other physical methods (except briefly in Part 5), because these additional techniques were still under investigation. Now, however, with the publication of the glossary of terms for gas chromatography (BS 3282) and recommendations for the selection of apparatus and techniques for the analysis of gases by gas chromatography (BS 4587), the basis of sound gas chromatographic methods has been established and a new Part 6 describes recommended procedures for the gas chromatographic analysis of flue gases.

The complete standard (Parts 1 to 6) deals with the following determinations:

carbon dioxide; oxygen; carbon monoxide; hydrogen; methane; moisture; sulphuric acid dew point; sulphur dioxide; sulphur trioxide; nitrogen oxides; total oxides of sulphur.

British Standard Methods for Sampling and analysis of flue gases

Part 4. Miscellaneous analyses

1. Scope

This Part of BS 1756 specifies methods for the determination of moisture content, sulphuric acid dew point, carbon monoxide, oxides of sulphur and oxides of nitrogen.

2. References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

Throughout this standard reference is made to the use of reagent solutions, distilled water and laboratory glassware. Unless otherwise specified, reference should be made to BS 572, BS 1752, BS 1792, BS 2761, BS 3978 or BS 4123, as appropriate.

3. Determination of moisture

3.1 Introduction. Hot flue gases normally contain up to about 10 % moisture by volume. For calculations involving combustion efficiency, it is necessary to know the moisture content; this is usually calculated from the known composition of the fuel, but sometimes a determination of the actual moisture content of the flue gases is required by a recommended method that is simple and reliable.

3.2 Principle. A measured volume of flue gas is passed through tared tubes containing either dried magnesium perchlorate or phosphorus pentoxide as desiccant. The increase in mass of the tubes gives the moisture content of the flue gas*.

3.3 Performance. It is possible to achieve a standard deviation of about 0.05 % at the 10 % moisture level.

3.4 Apparatus. All glassware shall be constructed of clear borosilicate glass, shall be as free as possible from striae and other visible defects and shall be well annealed. All open ends of tubes shall be cut off square and flame polished. All stopcocks and standard ground glass joints shall comply with the requirements of BS 572, BS 1751 or BS 2761, as appropriate.

The following components shall be used for the apparatus and shall be assembled as shown in figure 1.

3.4.1 Sampling probe. A suitable probe (A) for withdrawing the flue gases from the duct (see BS 1756 : Part 1 : 1971, clause 4).

3.4.2 Filter tube. A filter tube (B) containing about 0.25 g of silica wool, to prevent solid particles entering the absorption train. A suitable form of filter tube is shown in figure 5.

3.4.3 Heating apparatus. Heating apparatus is required to maintain the filter tube and the portion of the sampling probe outside the duct at a temperature of about 250 °C. Electric heating tape (C) is suitable.

3.4.4 Midvale tubes. Two Midvale tubes (D₁ and D₂) (see note 1) containing either dried magnesium perchlorate, 0.7 mm to 1.2 mm (see note 2) or an intimate mixture of two volumes of phosphorus pentoxide and one volume of glass powder, 355 µm to 425 µm. The Midvale tubes shall be as shown in figure 2.

NOTE 1. When the Midvale tubes contain desiccant but are not connected to the absorption train the sidearms should be closed by means of rubber caps.

NOTE 2. No attempt should be made to regenerate used magnesium perchlorate; it should be disposed of by the use of copious quantities of water.

3.4.5 Guard tube. A guard tube (E) containing the same desiccant as in the Midvale tubes D₁ and D₂. A third Midvale tube is suitable for this purpose.

3.4.6 Gas meter. A calibrated gas meter (F), capable of being read to an accuracy of 0.005 litre.

3.4.7 Suction device for drawing flue gas through the train. An electrically driven pump, a water vacuum pump or, failing these, an aspirator bottle, is suitable for drawing the flue gas through the absorption train. It is convenient to provide a stopcock between the gas meter and the suction device (G).

3.5 Procedure. Insert the sampling probe into the required position in the flue gas stream (see BS 1756 : Part 1) and, by means of the heating apparatus, maintain the temperature of the probe and filter tube at 250 °C (see note 1). Connect the assembled absorption train (see note 2), open the stopcocks and draw about 2 litres of flue gas through the train at the rate of about 250 ml/min to condition the Midvale tubes.

Close the stopcocks, disconnect the Midvale tubes D₁ and D₂ from the absorption train and close the sidearm of each tube with a rubber cap. Carefully wipe the tubes with a soft cloth or chamois leather and place them in the balance case (see note 3).

Allow the tubes to stand in the balance case for 20 min then temporarily remove the rubber cap from the sidearm of one of the tubes and immediately weigh this tube to the nearest 1 mg. Replace the rubber cap, then weigh the second tube in a similar fashion.

Reconnect the tubes to the absorption train and note the gas meter reading. Open the stopcocks and, using a flowrate of about 250 ml/min, draw sufficient flue gas

*The moisture not absorbed from the flue gas during the test is low enough to be ignored; see Trusell, F. and Ditch, J. *Anal. Chem.* 1963, 35, 674.

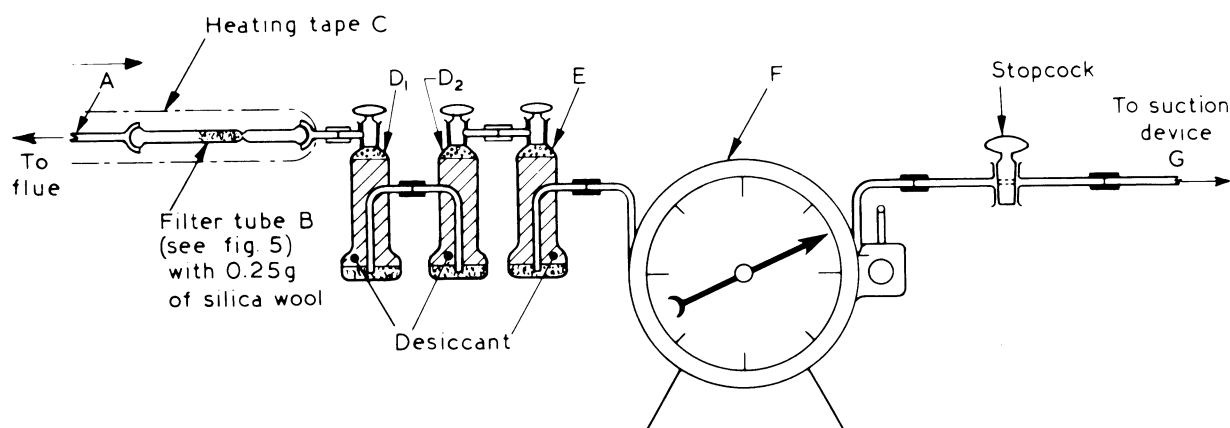
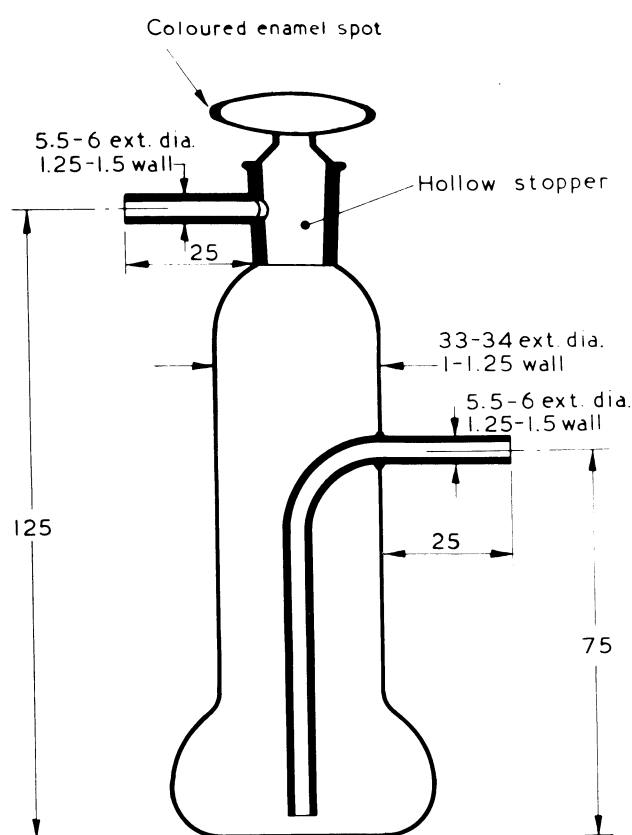


Figure 1. Typical absorption train for the determination of moisture in flue gases



Dimensions in millimetres.

Figure 2. Midvale tube

through the train to collect about 0.3 g of moisture.

† About 1 litre to 10 litres of gas will be required.

Close the stopcocks and note the gas meter reading and the temperature and pressure at the gas meter. Disconnect tubes D_1 and D_2 from the absorption train and refit the rubber caps to the sidearms. Wipe and reweigh the tubes as before (see note 4).

NOTE 1. It is essential to so arrange the heating that no condensation occurs in any part of the apparatus before Midvale tube D_1 (figure 1).

NOTE 2. Good quality rubber tubing should be used and the components butted together.

NOTE 3. While the tubes are connected to the absorption train and during transit to the balance case, they should be protected from dust and other contamination.

NOTE 4. If, in any single determination, tube D_2 shows an increase in mass greater than 10 % of the increase in mass of D_1 , both tubes should be refilled with fresh desiccant and the test repeated.

3.6 Calculation. The mass of moisture present in the flue gas passed through the train is given by the total increase in mass of tubes D_1 and D_2 . The difference between the gas meter readings gives the volume of the flue gas passed at the temperature and pressure at the meter (see note). Calculate the volume of water per 100 volumes of dry gas at 15 °C and 1013.25 mbar* (see table 1).

NOTE. If a wet gas meter is used the indicated volume of gas will be the volume of dry flue gas plus the volume of water needed to saturate it at the temperature and pressure at the meter.

4. Determination of oxides of sulphur: propan-2-ol (isopropanol) method

4.1 Introduction. Depending on the fuel burned, hot flue gases may contain up to about 3000 p.p.m. by volume of sulphur oxides; up to about 4 % of this may be sulphur trioxide and the remainder sulphur dioxide.

The determination of sulphur dioxide at the concentrations occurring in flue gases is relatively simple but a comparatively complex method is necessary to achieve accurate measurement of sulphur trioxide in the presence of sulphur dioxide. However, the information obtained is of great importance in investigating low-temperature corrosion problems and the advantages of determining sulphur dioxide and trioxide individually outweigh the disadvantages of using a method more complicated than the simple determination of total oxides of sulphur.

Two alternative methods are now recommended: one† requires the use of propan-2-ol (as previously described in the 1965 edition of BS 1756 : Part 4) and the other‡ is a direct method that makes use of a condenser; full details are given for the sampling and simultaneous determination of sulphur dioxide and sulphur trioxide. A simple method for total sulphur oxides is given in Part 5 of BS 1756.

4.2 Principle. A filter removes suspended solids from the hot gas, which is then saturated with cold 80 % propan-2-ol. This promotes the formation of sulphuric acid mist and at

* 1 mbar = 10^2 N/m² = 100 Pa.

† Fielder, R. S., Jackson, P. J. and Raask, E. *J. Inst. Fuel*, 1960, **33**, 84; Fielder, R. S. and Morgan, C. H. *Anal. Chem.*, 1960, **32**, 888.

‡ Goksyr, H. and Ross, K. *J. Inst. Fuel*, 1962, **35**, 177.

the same time inhibits the oxidation of sulphur dioxide. The sulphuric acid mist is collected by passing the gas through a sintered glass disc and is retained, together with excess propan-2-ol, in a collecting vessel. Some sulphur dioxide is also dissolved at this stage but most of it passes on with the gas stream and is absorbed in standard iodine solution; the quantity of sulphur dioxide can therefore be calculated.

At the end of the sampling period, the sulphuric acid in the propan-2-ol in the collecting vessel is determined by titration of an aliquot portion with barium perchlorate to the change point of thoron indicator and the amount of sulphur trioxide is calculated. The small quantity of sulphur dioxide also present is determined by iodometric titration of an aliquot portion of the propan-2-ol and the amount found is added to that already determined by absorption in the iodine solution.

4.3 Performance. It is possible to achieve the following values for precision and accuracy.

(a) *Sulphur dioxide*

Standard deviation (10 results):

10 ml/m³ at 200 ml/m³

20 ml/m³ at 2000 ml/m³

Accuracy:

± 5 % at 200 ml/m³

± 2 % at 2000 ml/m³

(b) *Sulphur trioxide*

Standard deviation (10 results):

0.025 ml/m³ at 5 ml/m³

0.2 ml/m³ at 20 ml/m³ to 50 ml/m³

Accuracy:

± 10 % at 5 ml/m³

± 5 % at 20 ml/m³ to 50 ml/m³

Lower limit of detection:

0.5 ml/m³

4.4 Reagents. Reagents shall be of a quality recognized as being suitable for analysis and water complying with the requirements of BS 3978 shall be used.

4.4.1 80 % propan-2-ol reagent. Prepare this reagent by mixing four volumes of propan-2-ol (see note) with one volume of water. This reagent should not be stored.

NOTE. Good quality propan-2-ol, free from iron, should be used. Technical grades are not suitable.

4.4.2 Potassium iodide solution (40 g/l).

4.4.3 Standard iodine solution (0.100N).

4.4.4 Standard iodine solution (0.010N).

4.4.5 Absorbent for sulphur oxides. An absorbent capable of absorbing sulphur oxides but not carbon dioxide shall be used in the pump protection column (see 4.5.3.6), if this is included in the assembly.

The following preparation is satisfactory. Mix 40 g of filtration asbestos* with 25 g of anhydrous sodium carbonate; add 0.25 g of methyl red, 50 ml of industrial methylated spirit (68 degrees O.P., see BS 3591) and 50 ml of water. Mix the constituents thoroughly in a mortar, rub through a 1.4 mm mesh test sieve complying with the requirements of BS 410 and dry the sieved material in a loose layer, about 6 mm thick, at 120 °C for 2 h.

4.4.6 Starch solution (10 g/l). Suspend 1 g of soluble starch in 10 ml of water, then pour the mixture rapidly into 90 ml of boiling water. Boil the solution for a further 1 min, then cool. The solution should be freshly prepared daily.

*Appropriate safety precautions should be taken in handling asbestos.

4.4.7 Standard barium perchlorate in propan-2-ol solution (0.005N). Dissolve 0.975 g of barium perchlorate trihydrate in 200 ml of water and dilute to 1000 ml with propan-2-ol. Using a pH meter, adjust the pH of the solution to 3.5 ± 0.5 by adding perchloric acid (approximately 1.25N). Standardize the solution by titration against the standard sulphuric acid in propan-2-ol solution (0.005N) (see 4.4.8), using thoron indicator (see 4.4.9) and the procedure described in 4.9.2.

4.4.8 Standard sulphuric acid in propan-2-ol solution (0.005N). Prepare approximately 0.1N reagent by cautiously adding 2.8 ml of sulphuric acid (d = 1.84) to about 250 ml of water; cool the solution and dilute it to 1 litre with water. Mix the solution thoroughly and standardize it by any recognized method.

Take a convenient volume of the standardized solution and adjust the normality to exactly 0.025N by adding the appropriate volume of water. Prepare the 0.005N standard solution of sulphuric acid in propan-2-ol by diluting one volume of the 0.025N acid to five volumes with propan-2-ol.

1 ml of 0.005N solution ≡ 0.2 mg of sulphur trioxide.

4.4.9 Thoron indicator (0.4 g/l). Dissolve 0.04 g of thoron (sodium salt of 1-(*o*-arsenophenylazo)-2-naphthol-3, 6-disulphonic acid) in 100 ml of water. Store in a cool place away from light.

4.5 Apparatus

4.5.1 General. All glassware, other than the liquid and gas flowmeters, shall be constructed of clear borosilicate glass, shall be as free as possible from striae and other visible defects and shall be well annealed. All open ends of tubes shall be cut off square and flame polished. All stopcocks and standard ground glass joints shall comply with the requirements of BS 572, BS 1751 or BS 2761, as appropriate.

Inaccurate results will be obtained if the materials of the sampling probe and absorption train react with sulphur oxides or catalyse the gas phase oxidation of sulphur dioxide. The materials specified are known to be suitable but even these should be conditioned in situ (see 4.8.2). Frequent renewal of filter material may be necessary. The assembled apparatus is illustrated diagrammatically in figure 3.

4.5.2 Sampling

4.5.2.1 Sampling probe (A) (see also BS 1756 : Part 1). For flue gas temperatures up to 500 °C, the sampling probe may be a silica tube of 13 mm external diameter.

For temperatures above 500 °C, a heated silica sampling probe with a water-cooled jacket shall be used; it is also suitable for lower temperatures. Details of its construction are given in figure 4. At very high temperatures, special precautions may need to be taken.

A spherical cup to fit the ball of an S19 spherical glass joint (see BS 2761) shall be welded to one end of the probe (see note).

The sampling probe shall be long enough to permit representative sampling of the flue gas from the duct and the portion of the sampling probe outside the duct shall be maintained at about 250 °C to avoid the deposition of sulphuric acid (see 4.5.3.11).

NOTE. This assumes that the inlet of the filter tube leading to the absorption apparatus is already fitted with the ball of a BS 2761 S19 joint. Alternatively, the socket can be on the filter tube and the ball on the probe.

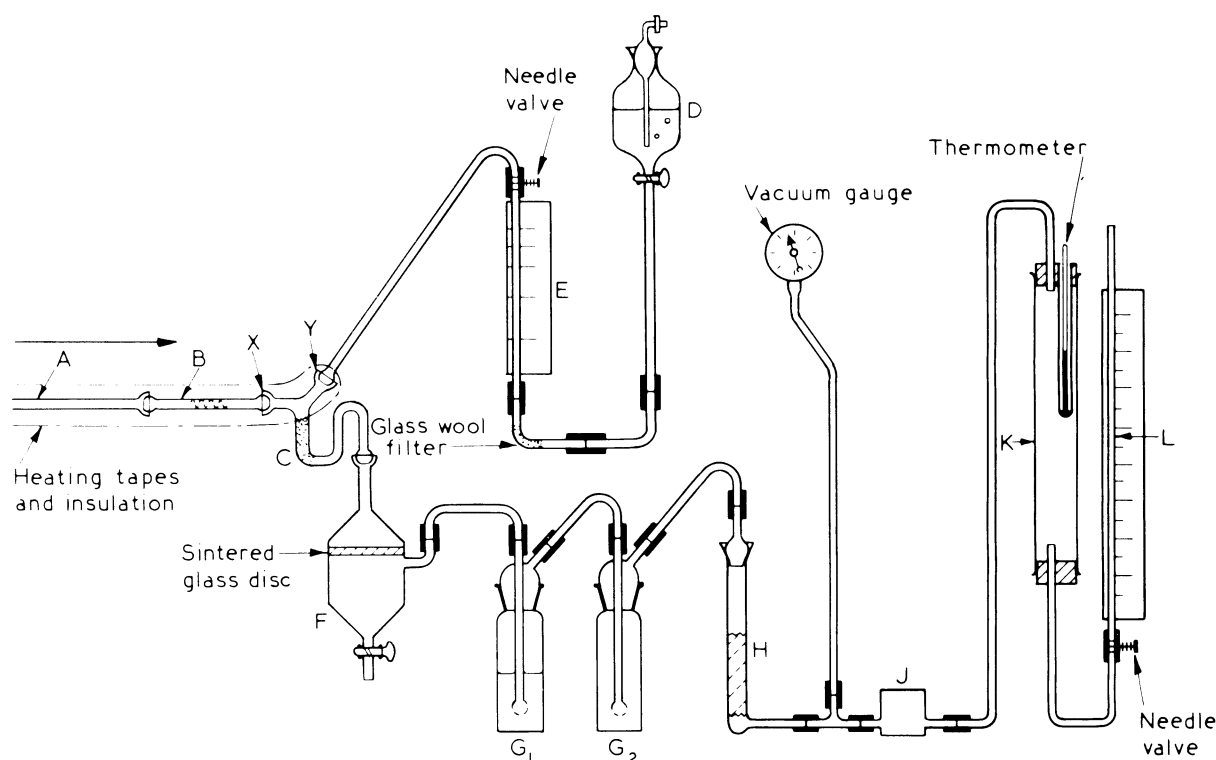


Figure 3. Diagram of absorption apparatus for determination of sulphur trioxide and sulphur dioxide

4.5.2.2 Filter tube (B). This is to prevent solid particles from entering the absorption apparatus (see note 1) and is maintained at about 250 °C to avoid trapping, as mist, sulphuric acid which may be present in the flue gas.

A suitable filter tube consists of two S19 spherical glass joints (see BS 2761) connected as shown in figure 5. The constriction in the middle of the tube is to retain a 40 mm length (about 0.25 g) of silica wool packing (see note 2).

NOTE 1. Solid particles from flue gases often contain soluble metal sulphates (possibly with absorbed sulphur trioxide).

NOTE 2. Glass wool should not be used for packing the filter tube because it reacts with sulphur trioxide at temperatures above the dew point.

4.5.3 Collection

4.5.3.1 Propan-2-ol saturating tube (C). This shall conform to the dimensions shown in figure 6.

4.5.3.2 Propan-2-ol reservoir (D). A 250 ml separating funnel complying with the requirements of BS 2021 fitted with a Mariotte tube is suitable.

4.5.3.3 Propan-2-ol flowmeter, filter and control (E).

A flowmeter* calibrated for a flow of 1.5 ml/min of 80 % propan-2-ol at a range of ambient temperatures from 15 °C to 35 °C, fitted with a bold indelible scale, shall be used.

To prevent dust and gas bubbles from entering the flowmeter the propan-2-ol shall pass through a filter placed immediately before the flowmeter inlet. A suitable filter consists of glass wool placed in the tubing between the reservoir and flowmeter. A suitable valve shall be provided to control the flow rate of the propan-2-ol.

4.5.3.4 Sulphur trioxide collecting vessel (F). This shall conform to the dimensions shown in figure 7.

It is imperative that the internal sintered glass disc is of porosity grade no. 4 (see BS 1752) and that at least 100 ml of liquid can be collected in the lower part of the vessel without the liquid obstructing the free passage of gas.

*A model 101 Rotameter is known to be suitable.

†A gastight Dymax Mk 1 pump with felt inlet filter removed is known to be suitable.

‡A model 101 Rotameter, with the special float for corrosive gases, is known to be suitable.

4.5.3.5 Sulphur dioxide collecting vessels (bubblers G₁ and G₂). Gas washing bottles complying with the requirements of BS 2461 (125 ml capacity) are suitable.

4.5.3.6 Pump protection column (H) (optional).

If considered necessary, a pump protection column may be made to the dimensions given in figure 8. It is packed with a suitable absorbent (see 4.4.5) held between cotton wool plugs.

4.5.3.7 Pump (J). An airtight diaphragm pump with a nominal rating of about 0.1 m³/ht is required.

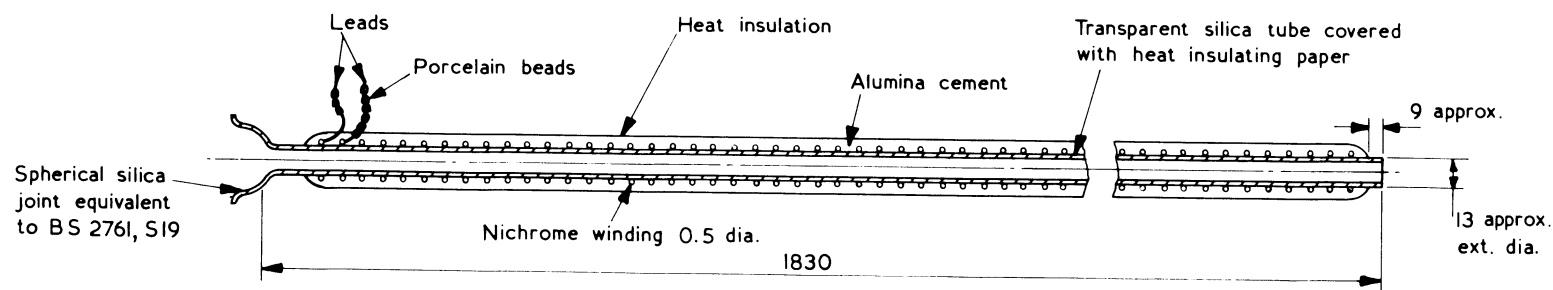
4.5.3.8 Expansion chamber (K). The expansion chamber shall have a volume of approximately 200 ml and may be constructed of metal or other suitable material. It shall incorporate a metal pocket to contain a thermometer graduated from 0 °C to 50 °C and so positioned that the thermometer indicates the correct temperature of the gas in the chamber. The form of expansion chamber shown in figure 9 is suitable.

4.5.3.9 Flue gas flowmeter (L)‡. This shall be of a type designed for corrosive gases and calibrated for flow rates of 0.5 litre/min to 1.3 litres/min at s.t.p. It shall have a bold indelible scale and shall incorporate a suitable valve for adjusting the gas flow (see note).

NOTE. Use of this valve in conjunction with the pump speed control smooths out pulsations in the gas flow.

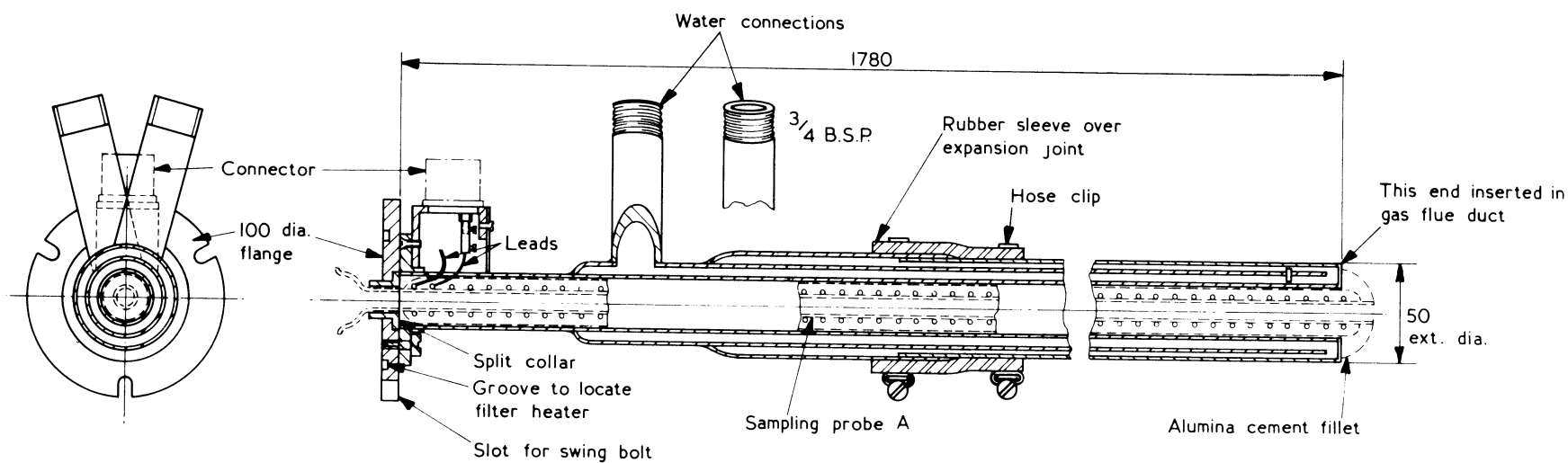
4.5.3.10 Connections. The spherical joints of B and C (figure 3) shall be held in place by low heat capacity spring clips (see note) made of spring wire 1.6 mm in diameter complying with the requirements of BS 5216 or BS 2056. All flexible connections through which gas passes shall be of PVC tubing and flexible connections through which propan-2-ol flows shall be of silicone rubber.

NOTE. Most spring clips for spherical glass joints have too high a heat capacity for the correct operation of this apparatus.



Dimensions in millimetres.

(a) Detail of sampling probe (A)



Dimensions in millimetres.

(b) Detail of water jacket on sampling probe (A)

Figure 4. Sampling probe with water jacket for the determination of sulphur oxides