

Methods for the sampling and analysis of flue gases —

Part 3: Analysis by the Haldane apparatus

Co-operating organizations

The Solid Fuel Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Association of Consulting Engineers	Gas Council*
British Cast Iron Research Association	Heating and Ventilating Contractors' Association
British Coke Research Association*	Institute of British Foundrymen
British Ironfounders' Association	Institute of Fuel*
British Mechanical Engineering Confederation	Institution of Gas Engineers*
British Steel Industry*	Institution of Heating and Ventilating Engineers
Chamber of Coal Traders	Institution of Mechanical Engineers
Chemical Industries Association*	Low Temperature Coal Distillers' Association of Great Britain Ltd.
Coal Utilisation Council	National Coal Board*
Coke Oven Managers' Association	Society of British Gas Industries*
Combustion Engineering Association	Water-tube Boilermakers' Association*
Council of Ironfoundry Associations	Women's Advisory Council on Solid Fuel
Department of the Environment*	
Department of Trade and Industry*	
Domestic Solid Fuel Appliances Approval Scheme	
Electricity Council, the Central Electricity Generating Board and Area Boards in England and Wales*	

The Government departments and scientific and industrial organizations 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:

British Ceramic Research Association	Institution of Electrical Engineers
British Laboratory Ware Association	Iron and Steel Institute
Cement Makers' Federation	Scientific Instrument Manufacturers' Association
Institute of Petroleum	Society of Chemical Industry
Institute of Water Pollution Control	Society of Glass Technology
Institution of Chemical Engineers	
Institution of Civil Engineers	

This British Standard, having been approved by the Solid Fuel Industry Standards Committee, was published under the authority of the Executive Board on 27 October 1971

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First published March 1952
First revision August 1965
Second revision October 1971

The following BSI references relate to the work on this standard:
Committee references SFE/17 and SFE/17/1
Draft for approval 70/38595

ISBN 580 06556 1

Amendments issued since publication

Amd. No.	Date of issue	Comments
7754	August 1993	Indicated by a sideline in the margin

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Foreword

This standard makes reference to the following British Standards:

BS 410, *Test sieves*.

BS 1751, *General purpose glass stopcocks*.

BS 2069, *Gas sampling tubes*.

BS 2775, *Rubber stoppers and tubing of flexible materials for laboratory use*.

BS 3535, *Safety isolating transformers for industrial and domestic purposes*.

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 purpose 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 subsequent revision was extended to cover not only flue gases from domestic and industrial fuel-burning installations but also those from various industrial processes. The present edition is virtually unaltered except for the introduction of SI units, where necessary.

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

- 1) checking and controlling the efficiency of combustion,
- 2) calculating heat balances,
- 3) detecting air or gas inleakage,
- 4) determining compositions and hence calculating volumes of waste gases,
- 5) determining moisture contents,
- 6) assessing the effect of the gas on other parts of the plant, e.g. corrosion or tube blockage,
- 7) determining substances likely to cause pollution of the atmosphere,
- 8) determining toxic gases.

For the control of combustion efficiency, calculation of heat balances and detecting air inleakage, the determination of carbon dioxide, carbon monoxide and oxygen covers most practical requirements. For more precise work sulphur dioxide, hydrogen and methane must 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.

The revised standard has been 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 determinations;*
- *Part 5: Semi-routine analyses.*

The standard deals with the following determinations:

- Carbon dioxide
- Oxygen
- Carbon monoxide
- Hydrogen
- Methane
- Moisture
- Dew-point
- Sulphur dioxide
- Sulphur trioxide
- Nitrogen oxides
- Total oxides of sulphur

Except in Part 5, no reference has been made to modern procedures for gas analysis by chromatographic, infra-red or other physical methods, some of which form the basis of other British Standards.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 24 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This Part of this British Standard deals with the analysis of flue gases by means of the Haldane apparatus.

NOTE The titles of the British Standards referred to in this standard are listed on page ii.

2 General

The Haldane apparatus¹⁾ is a constant pressure gas analysis apparatus suitable for the precise determination of carbon dioxide, oxygen, carbon monoxide, hydrogen, methane and nitrogen in flue gas containing not less than 75 % of nitrogen. The principle involved for carbon dioxide and oxygen is the measurement of the reduction in volume which occurs when these constituents are absorbed in potash solution and alkaline pyrogallol or chromous chloride solution respectively. Carbon monoxide, hydrogen and methane are determined by measuring the contraction, the carbon dioxide formed and the oxygen used when they are burned over a heated platinum filament; nitrogen is determined by difference.

Measurements of gas volume are made using a calibrated burette, the readings of which are compensated automatically for small variations of temperature and barometric pressure during the analysis. Nevertheless the apparatus should be used in a laboratory where the temperature is reasonably uniform, in a position where it is not subjected to draughts or to direct sunshine. The apparatus is not intended to be portable for use on plant. Accurate results can only be obtained by meticulous attention to experimental detail; under favourable conditions an experienced operator can obtain a repeatability of 0.02 % absolute for all constituents, but greater "between laboratory" differences may be expected.

The apparatus (see Figure 1a) is essentially of conventional pattern, with a 21 ml burette. The design incorporates certain important modifications to that described in the 1952 edition of BS 1756. The replica of the burette which served as a compensator has been replaced by a simple bulb which allows equilibrium between the air and the dilute sulphuric acid in it to be more rapidly established. Screw operated precision adjustment is now recommended for the reservoirs which control the level of both the mercury in the burette and the caustic potash solution in the carbon dioxide absorption vessel. Difficulties were experienced in the manufacture of the combustion pipette and the design has been modified to enable the glass-platinum seals to be easily coated externally with a high-vacuum sealing wax. A simplified apparatus (Figure 1b) comprising a compensated burette and potash pipette is recommended when only carbon dioxide determinations are required.

Three other forms of Haldane apparatus or parts of the apparatus are worthy of note. One form was designed by the Scientific Department of the National Coal Board²⁾ and another by Lloyd³⁾. Both have a burette capacity of 10 ml and are consequently more conveniently operated than the standard 21 ml pattern. The National Coal Board design was developed primarily for the analysis of mine air, in which the principal combustible gas is methane. The Lloyd apparatus, which is patented in several countries, incorporates novel features intended to overcome the fundamental shortcomings of the conventional Haldane design, particularly those associated with compensation for changes in pressure and temperature. Although the apparatus was originally designed for the analysis of respiratory gases, a combustion pipette can be fitted for the analysis of flue gases. The third form incorporates a modification to the combustion pipette suggested by Clarkson and Gooderham⁴⁾. These three designs have not, however, been checked over the full range of compositions which might be encountered in flue gas analysis.

¹⁾ *Methods of air analysis*: J.S. Haldane and J. Ivor Graham, Griffin, London, 1935.

²⁾ *Comprehensive Analytical Chemistry*, C. L. Wilson and D. W. Wilson (Eds.), 1A, 273 (Amsterdam, Elsevier Publishing Co., 1959).

³⁾ B.B. Lloyd, *J. Physiol.*, **143**, 5.

⁴⁾ A. Clarkson and W. J. Gooderham, *Chem. and Ind.* (1962), 402.

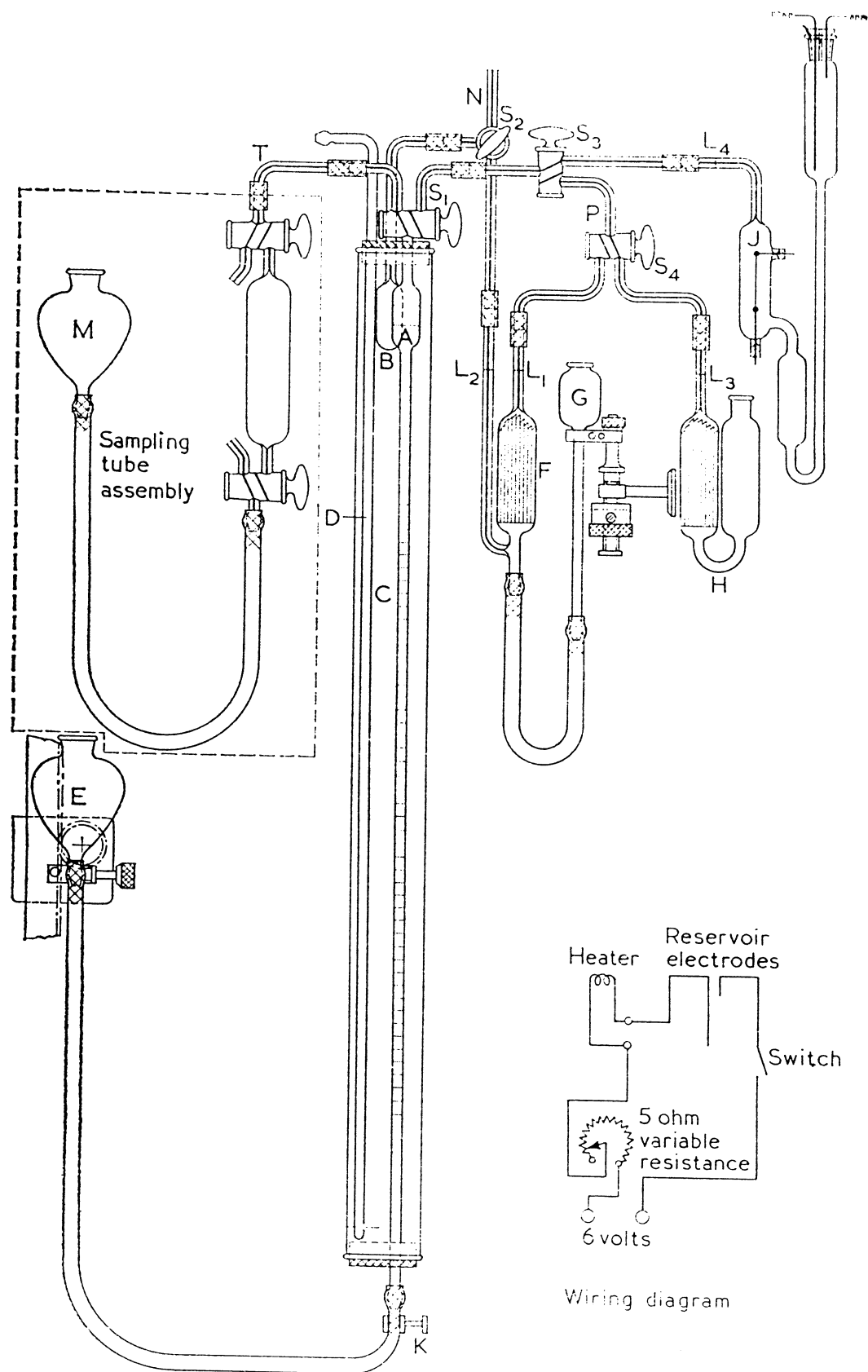


Figure 1a — General arrangement of the Haldane apparatus (diagrammatic)

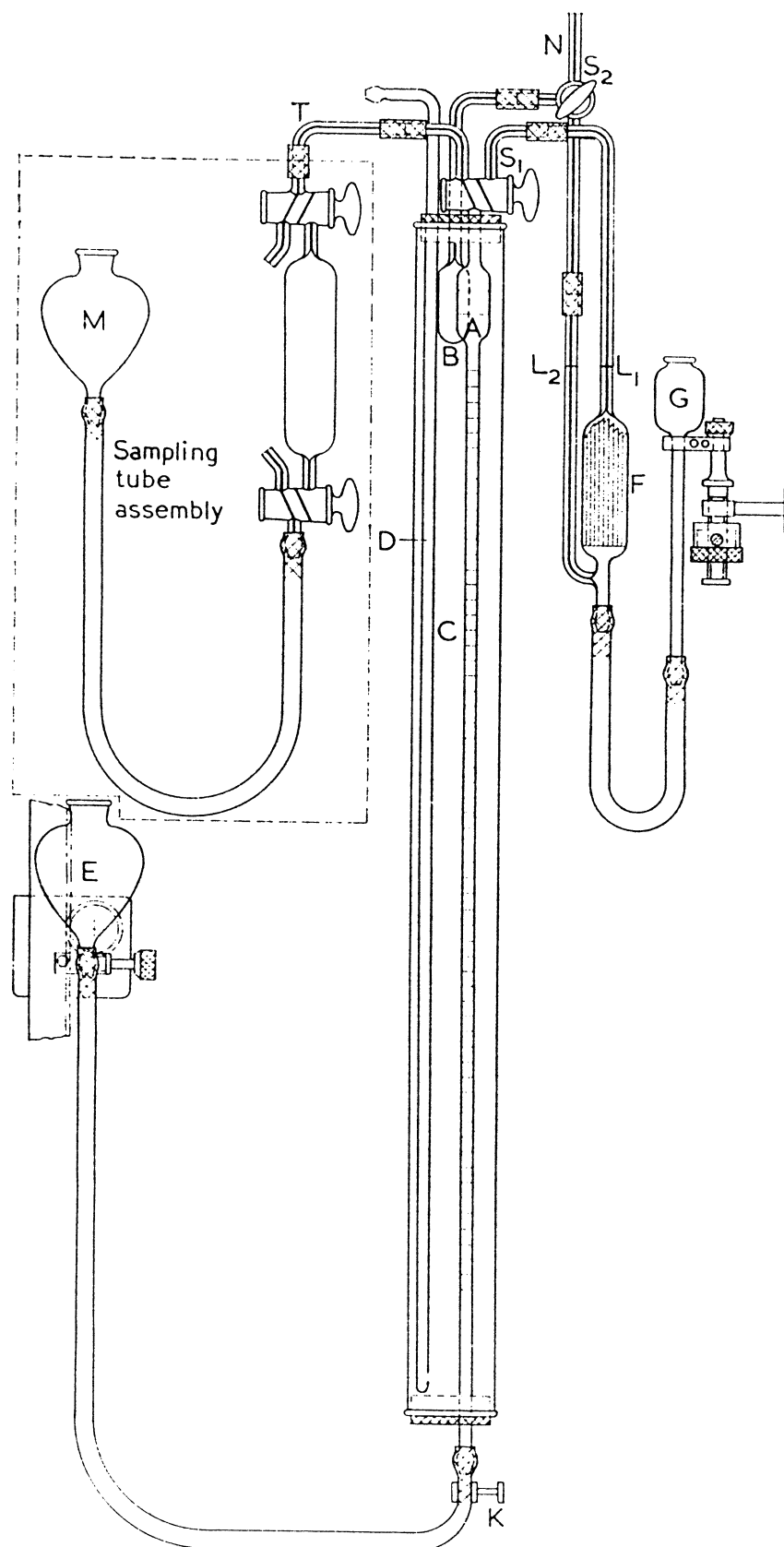


Figure 1b — General arrangement of the modified Haldane apparatus for carbon dioxide only (diagrammatic)

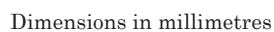


Figure 2 — Burette (A — Figure 1a and Figure 1b)