

METHODS FOR THE ANALYSIS OF FUEL GASES

Part 3 Combustion characteristics

BS 3156 : Part 3 : 1968



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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 4000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 526. Definitions of the calorific value of fuels.

BS 572. Interchangeable conical ground glass joints.

BS 3156. Methods for the analysis of fuel gases.

Part 1. General analysis.

BS 3804. Methods for the determination of the calorific value of fuel gases.

Part 1. Non-recording methods.

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 BSI references relate to the work on this standard:

Committee references SFE/17, SFE/17/4.

Draft for comment 66/26692.

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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 Boiler Setters, Chimney and Furnace Constructors
- Association of Consulting Engineers
- British Cast Iron Research Association
- *British Coal Utilisation Research Association
- *British Coke Research Association
- British Electrical and Allied Manufacturers' Association
- *British Iron and Steel Federation
- British Ironfounders' Association
- British Mechanical Engineering Federation
- Chamber of Coal Traders
- *Chemical Industries Association
- Coal Utilisation Council
- Coke Oven Managers' Association
- Combustion Engineering Association
- Confederation of British Industries
- Council of Ironfoundry Associations
- *Electricity Council, the Central Electricity Generating Board and Area Boards in England and Wales
- *Gas Council
- Heating and Ventilating Contractors Association
- Imperial Chemical Industries Limited
- Institute of British Foundrymen
- *Institute of Fuel
- *Institution of Gas Engineers
- Institution of Heating and Ventilating Engineers
- Institution of Mechanical Engineers
- Iron and Steel Institute
- Low Temperature Coal Distillers' Association of Great Britain Ltd.
- *Ministry of Housing and Local Government
- *Ministry of Power
- Ministry of Public Building and Works
- *National Coal Board
- *Society of British Gas Industries
- *Water-tube Boilermakers' Association
- Women's Advisory Council on Solid Fuel

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
- British Laboratory Ware Association
- Institute of Petroleum
- Institute of Sewage Purification
- Institution of Chemical Engineers
- Institution of Civil Engineers
- Institution of Electrical Engineers
- Royal Institute of Chemistry
- Scientific Instruments Manufacturers' Association
- Society of Chemical Industry
- Society of Glass Technology

BRITISH STANDARD

METHODS FOR THE ANALYSIS OF FUEL GASES

Part 3. Combustion characteristics

FOREWORD

The edition of BS 3156 published in 1959 under the authority of the Solid Fuel Industry Standards Committee provided standard methods for the sampling and analysis of fuel gases and was the second of a series of BS Methods for the sampling and analysis of gases, of which the first, BS 1756 : 1952, dealt with the sampling and analysis of flue gases. The latter standard has now been revised and issued in separate parts, of which Part 1 deals with sampling; the sampling of gases is also dealt with in BS . . . *. It is therefore not considered necessary to deal with sampling in the present revision of BS 3156. The contents of this standard still cover well-established methods and do not deal with many specialized methods, several of which, such as those using paramagnetic and infra-red analyses, are already being studied separately and may be the subject of other standards.

The term 'fuel gas' can be applied to any gas which burns. The methods described in this standard are, in general, applicable to most fuel gases, although some minor changes in procedure may be required for the exceptional gases. These changes are indicated for the gases about which relevant information is available.

Fuel gases in the British Isles are derived chiefly from coal, coke, oil or natural gas, and this standard deals principally with such gases. It is a statutory requirement that town gas shall be substantially free from hydrogen sulphide; the term 'purified gas' refers to such gas, while the term 'crude gas' refers to gas containing hydrogen sulphide and other substances such as tar fog and naphthalene.

This standard is divided into five main parts, viz:

Part 1. General analysis.

Part 2. Special determinations.

Part 3. Combustion characteristics.

Part 4. Chromatographic analysis.

Part 5. Techniques for high pressure gases.

NOTE. Metric (SI) units have been used throughout this standard. Where appropriate, approximate British equivalents, based on current practice, have been given. More accurate conversions may be achieved by using the factors in Appendix A or by reference to BS 350, 'Conversion factors and tables'.

* In course of preparation.

METHODS

1. INTRODUCTION

The suitability of a gas for combustion in a particular appliance depends upon a number of factors and can most readily be assessed in relation to certain physical characteristics, e.g. density, calorific value, aeration number, Wobbe number, reversion pressure and sooting number. Methods for determining these characteristics are given below.

2. DETERMINATION OF RELATIVE DENSITY

2.1 General. For the purposes of this British Standard the relative density of gas is defined as the ratio of the weights of equal volumes of dry gas and dry air, both at the same temperature and pressure.

The method described involves the weighing of equal volumes of dry gas and dry air*. There are several methods for determining and recording relative densities continuously. Some references to these methods are given, but they are only intended to be a guide to the subject. In many of these methods the relative density is obtained inferentially and some instruments might have to be checked with a direct measurement such as that described below.

- (1) *Gas density balances* have been described by Edwards†, Hales and Moss‡, Kenward and Lucas§, Simons, Schreiner and Ritter|| and others.
- (2) *Effusimeters* giving relative densities, but usually only to two places of decimals, have been used a great deal. The original forms of these were described by Bunsen¶, Schilling**, Wright (the Simmance bell) and others.
- (3) *Recording densitometers (or gravitometers)* are now used extensively. There are many different models available in the British Isles, in America and on the Continent††.

It should be noted that some methods give the density of gas, saturated with water vapour, relative to air saturated with water vapour at a similar temperature. Conversion to a dry basis can be made with the following relationship or by Table 1:

If P = the percentage of water vapour in the gas

G = relative density of the wet gas,

$$\text{then correction factor} = \frac{0.622 P(G - 1)}{100 - P}$$

* An alternative and similar method, but using a Chancel flask, is described in Method IP 59/64 of the Institute of Petroleum.

† J. D. Edwards, *U.S. Bur. Mines Tech.*, Paper No. 89, 1917.

‡ J. S. Hales and W. C. Moss, *J. Sci. Instr.*, 1935, 12, 309.

§ J. R. Kenward and T. A. Lucas, *Gas World*, 1953, 137, 451.

|| J. Simons, C. L. Schreiner and H. L. Ritter, *Rev. Sci. Instr.*, 1953, 24, 36.

¶ R. W. Bunsen, *Gasometrische Methoden*, 1877, 184.

** N. H. Schilling, *J. Gasbeleucht*, 1859, 2, 370.

†† See A.S.T.M. D 1070-52 and makers' pamphlets.

TABLE 1. CORRECTION OF RELATIVE DENSITY FROM WET BASIS TO DRY BASIS

Temperature °C	Relative density of gas						
	0.3	0.4	0.5	0.6	0.8	1.0	1.2
10	- 0.005	- 0.005	- 0.004	- 0.003	- 0.003	nil	+ 0.003
15	- 0.007	- 0.006	- 0.005	- 0.004	- 0.003	nil	+ 0.003
20	- 0.010	- 0.009	- 0.007	- 0.006	- 0.003	nil	+ 0.003
25	- 0.013	- 0.012	- 0.010	- 0.008	- 0.004	nil	+ 0.004

2.2 Apparatus. The apparatus consists of:

- (1) *Two flat-bottomed glass vessels* of approximately 450 ml capacity and 75 mm diameter (see Fig. 1). Inlet and outlet connections should be provided on one vessel and a hook formed on the top of the other (sealed) vessel which acts as a counterpoise. A loop of non-corrodible wire should be secured to the counterpoise, so that it can be suspended above the balance pan on which weights are placed.
- (2) *A guard tube* consisting of a good quality stopcock with an enlarged stem.
- (3) *A drying tower or tube* filled with calcium chloride or another suitable drying agent, with glass wool at the inlet and outlet.
- (4) *A tube packed with glass wool* to act as a filter at the inlet to the glass vessel.

2.3 Procedure. Assemble the apparatus with the filter and the drying tower or tube on the inlet and the guard tube on the outlet of the glass vessel. If a combustible gas is being tested, a suitable burner or jet may be connected to the outlet of the guard tube. Pass gas through the vessel at about 0.15 m³/h (5 ft³/h) for a minimum of two minutes. Reduce the gas rate by closing the outlet tap until only a small flow is passing, then turn off the three cocks in rapid succession from the outlet backwards, retaining a slight positive pressure inside the vessel. Remove the filter (and burner if fitted) and place the vessel and counterpoise inside a balance case.

After five minutes, remove the globe from the balance case, release the pressure by opening the outlet cock of the globe and then momentarily that of the guard tube, close the outlet cock of the globe and return the globe to the

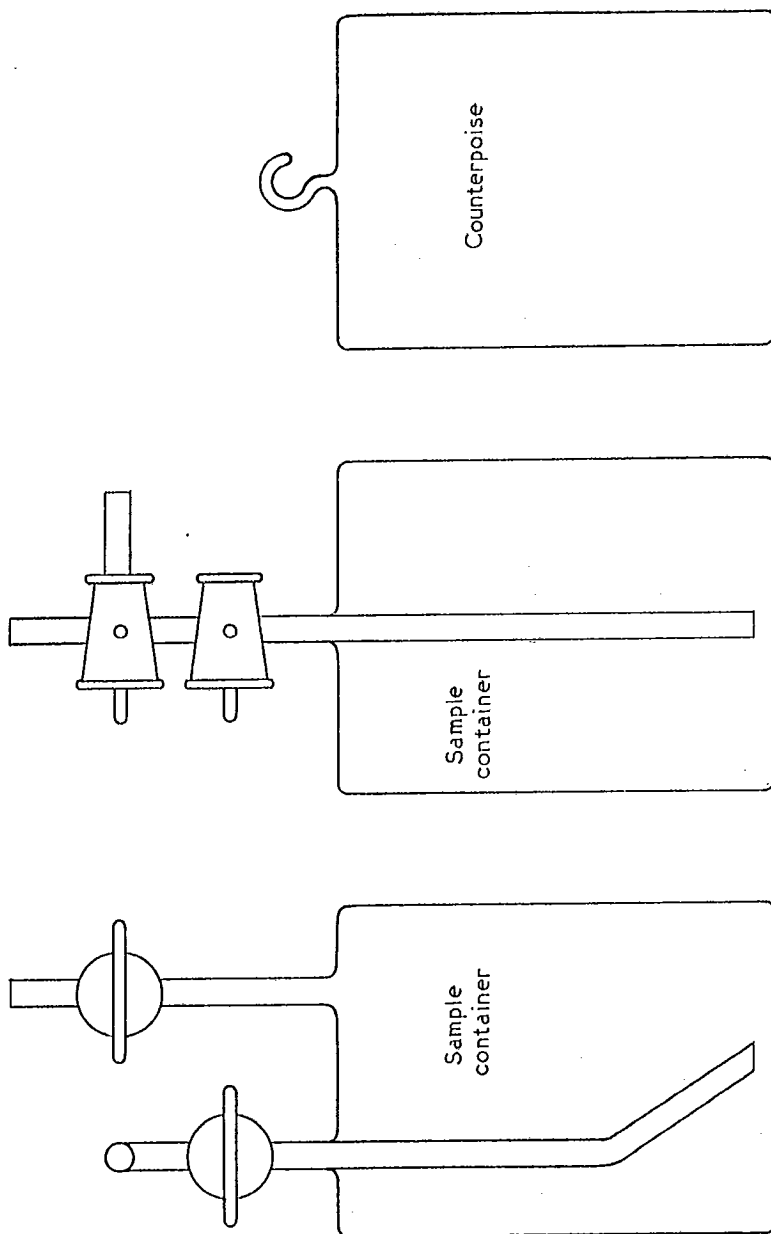


Fig. 1. Vessels for relative density determinations