

Schedule of tests for

Gasification and reforming plants using hydrocarbon feedstocks

Co-operating organizations

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

- Gas Council*
- Heating and Ventilating Contractors' Association
- Institution of Gas Engineers*
- Liquefied Petroleum Gas Industry Technical Committee
- Ministry of Power*
- Society of British Gas Industries*

The Government department 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 Chemical Plant Manufacturers Association
- British Coke Research Association
- British Steel Industry
- Coke Oven Managers Association
- Imperial Chemical Industries Limited
- Institute of Fuel
- Institute of Petroleum
- Institution of Chemical Engineers
- National Coal Board

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This standard makes reference to the following British Standards:

BS 135, *Benzenes and benzoles*.

BS 188, *Determination of the viscosity of liquids in c.g.s. units*.

BS 410, *Test sieves*.

BS 526, *Definitions of the calorific value of fuels*.

BS 572, *Interchangeable conical ground glass joints*.

BS 616, *Methods for sampling coal tar and its products*.

BS 1016, *Methods for the analysis and testing of coal and coke*.

BS 1041, *Code for temperature measurement*.

BS 1042, *Methods for the measurement of fluid flow in pipes*.

BS 1179, *Glossary of terms used in the gas industry*.

BS 1328, *Methods of sampling water used in industry*.

BS 1427, *Routine control methods of testing water used in industry*.

BS 1756, *Methods for the sampling and analysis of flue gases*.

BS 1780, *Bourdon tube pressure and vacuum gauges*.

BS 1784, *Schedule of tests for carburetted water-gas plant*.

BS 2511, *Determination of water by the Karl Fischer method*.

BS 2690, *Methods of testing water used in industry*.

BS 2878, *Method for the determination of lead in gasoline (gravimetric method)*.

BS 3156, *Methods for the analysis of fuel gases*.

BS 3285, *Methods of sampling superheated steam from steam generating units*.

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

BS 4349, *Method for the determination of distillation of petroleum products*.

BS 4350, *Method for the determination of sulphur in petroleum products and liquefied petroleum (LP) gases (lamp method)*.

BS 4379, *Method for the determination of calorific value of liquid fuel*.

BS 4380, *Determination of Conradson carbon residue of petroleum products*.

BS 4384, *Determination of sulphur content of petroleum products (quartz tube method)*.

BS 4385, *Determination of water content of petroleum products (Dean and Stark method)*.

BS 4386, *Determination of mercaptan sulphur content of light hydrocarbon products (silver nitrate method)*.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 84, an inside back cover 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 Introduction

1.1 Scope

1.1.1 Relevance. This schedule provides a basis for the assessment of the performance of gasification and reforming plants. It applies to both cyclic and continuous processes which produce gas as a primary product and which use liquid or gaseous hydrocarbon feedstocks.

It applies particularly to the production of town, fuel and synthesis gases but may be found to have application to processes in which other gases are the chief product.

1.1.2 Provision. The schedule contains recommendations for the determination of the quality and quantity of feedstocks, fuels and utilities used, and of the gas made and other products. Where the quantity or quality, or both, of the product gas cannot be measured accurately before admixture with other gases, or removal of a fraction of the gas, or a change in composition, it may be necessary to carry out certain other measurements in order to obtain the data required.

1.1.3 Relationship of Sections 2 to 8 of the schedule. The purpose of Section 2 is to identify the plant and to give the test period and reason for test.

Section 3 includes a description of the plant and process and gives the nominal conditions for which the plant was designed.

Section 4 incorporates a summary of the operating conditions observed during the plant test and is intended to be compared with the nominal values set out in Section 3.

Sections 5 and 6 relate specifically to the properties and quantities of the material supplied and produced during the plant test.

In Sections 7 and 8, the results recorded in the earlier sections are brought together to describe the plant performance and thermal efficiency.

1.2 Preliminary survey

The preliminary survey is an essential part of any satisfactory plant test. The purpose of the survey is to ascertain the practicability of obtaining those items of information that may be desired to enable a decision to be reached as to the period for which the test is to be made and to conduct the calibration of measuring apparatus.

Measurements are subject to uncertainties, the magnitude of which may be taken into account by specifying limits of accuracy for each particular measuring device. The limits to be applied may be estimated only when all the relevant factors are known and cannot be specified in this schedule. It is a proper part of the preliminary survey to make the most realistic assessment possible of the accuracy obtainable in the various measurements and the overall effect should be applied to those items covered in 1.3.1 and 1.3.2. Normally the accuracies of the measurements and their overall effect on the results will be agreed between the contractor and the client before the test is commenced.

The minimum period of the test will depend upon the accuracy with which the feedstocks and fuel, gas and other products can be measured. It is desirable that the feedstock and fuel measurements should be accurate to within $\pm 1\%$ and this may necessitate the length of the test being related to the extent of any floating stock. The period of the test should be sufficiently long for the yields of liquid or solid products to be estimated with a sufficient degree of accuracy. The duration of the test should be such that completed cycles of operation are included. In general, it is recommended that the duration of the test should be not less than four days.

Before the commencement of a test, measuring devices should be calibrated and a second calibration should be made immediately after the test, the mean of the two calibration corrections being adopted.

For low-pressure application of not more than 2 lbf/in² (140 mbar¹⁾) above atmospheric pressure, gas should be measured by means of a positive displacement meter. For higher pressures an approved positive displacement meter designed for high-pressure use or alternatively orifice meters correctly installed in accordance with BS 1042-1²⁾ should be used. In all cases appropriate means of correction for pressure, temperature, saturation, compressibility, and density should be employed. The calibration of all measuring tanks should be checked and the dimensions should not be assumed to be necessarily the same as the dimensions marked on a drawing of the tanks. If storage tanks cannot be calibrated, it is better to make use of small measuring tanks, the dimensions of which are known.

1.3 Guarantee tests

1.3.1 Items. When a gasification plant is purchased, the contractor may be required to guarantee one or more of the following:

- 1) The plant will make per day a specified volume of gas of specified characteristics and condition.

NOTE When the gas is used hot either as a fuel gas or as a feed to another process, the latent and sensible heat of the gas should be taken into account. When the gas is produced at substantially elevated pressure, its potential energy should be duly considered.

- 2) The quantity or thermal equivalent of each feedstock used per 1 000 ft³ or 100 therms (or 100 m³ or per GJ) of product gas will not exceed a stated figure when operating either at rated or other specified output.

- 3) The quantity, pressure and temperature of steam exported from, or imported into the plant when operating either at rated or other specified output.

- 4) The quantity of electricity exported from, or imported into the plant when operating either at rated or other specified output.

- 5) The quantity or thermal equivalent of each other by-product produced per 1 000 ft³ or 100 therms (or 100 m³ or per GJ) of product gas when operating at either rated or other specified output.

- 6) The quantity of raw water consumed per 1 000 ft³ or 100 therms (or 100 m³ or per GJ) of product gas when operating at either rated or other specified output.

- 7) The quantity of chemically or otherwise treated water consumed per 1 000 ft³ or 100 therms (or 100 m³ or per GJ) of product gas when operating at either rated or other specified output.

- 8) The quantity of chemical reagents consumed per 1 000 ft³ or 100 therms (or 100 m³ or per GJ) of product gas will not exceed a stated figure when operating either at rated or other specified output.

1.3.2 Evaluation. The requirements for evaluation of the above items with a reasonable degree of accuracy are summarized below. More detailed consideration is given in Sections 5 and 6.

- 1) Duration of test and testing conditions.
- 2) Measurement of the volume, calorific value and other characteristics of the product gas.
- 3) Measurement of the quantity and quality of all feedstocks.
- 4) Measurement of the quantity, pressure and temperature of exported or imported steam.
- 5) Measurement of the quantity of exported or imported electricity.
- 6) Measurement of the quantity and quality of all by-products.
- 7) Measurement of the quantity and quality of raw water consumed.
- 8) Measurement of the quantity and quality of treated water consumed.
- 9) Measurement of the quantity of chemical reagents consumed.
- 10) Measurement of the sensible, latent and potential heat of waste or by-product gases.

These measurements shall be made in accordance with the Notes in the relevant sections of this schedule.

¹⁾ 1 mbar = 10² N/m².

²⁾ BS 1042, "Methods for the measurement of fluid flow in pipes", Part 1, "Orifice plates, nozzles and venturi tubes".

1.4 The plant test

The plant should be adjusted to the test conditions prior to conducting the test. When such adjustment has been completed, the plant should be run for an agreed period before the test is commenced. If the conditions should be deemed unsatisfactory then further adjustments should be made and another agreed period allowed. When the conditions are deemed satisfactory, the test shall be carried out as laid down in the schedule.

NOTES

2.1

- 1) Give location, identification number or letter of plant.
- 2) Give name of the main contractor generally responsible for the process design of the plant.

2.3 The test period includes the pre-test and the plant test and, if any, the post-test.

2.4 This is the period of time over which the measurements are taken, the results of which are accepted as describing the performance of the plant.

Mention any unavoidable departures from the test schedule occasioned by any features of design causing difficulties of measurement.

2 General information

2.1 General

- 1) Identification of plant
- 2) Main contractor and date of commissioning

2.2 Reason for testing the plant

2.3 Dates of commencement and termination of test period

2.4 Duration of plant test

NOTES

3 The quantities and descriptions of materials referred to in this section are those for which the plant was designed. If during the tests other materials should be used, record the relevant information.

3.1 Items recorded in this section, together with items from Section 4, will enable comparison to be made with the results of previous tests and with those from other plants.

3.1.1 e.g. "Synthesis gas plant by continuous pressure steam reforming of naphtha", or "Lean gas plant by cyclic reforming of LPG, 10M ft³/day". Refer also to **1.3.1**.

3.1.2 Give proprietary name if any, e.g. "I.C.I. 500 process", "SEGAS catalytic cyclic reformer" or "Gas Council CRG process".

3.1.3 An example of what is required:

"Hydrodesulphurization, reforming in a tubular furnace, heat recovery, CO conversion, CO₂ removal by MEA, enrichment."

3.1.4 Include manufacturer's code number.

3.1.5 Any modification likely to affect plant performance since original commissioning, including change of catalyst type.

3.1.6 Note the duration of the cycle. The adoption of 100 units of time for the complete cycle is suggested so that the time for the various phases is a percentage of the total cycle time.

3 Description of plant and process

3.1 General description of plant

3.1.1 Type of plant, function and specified output

3.1.2 Process used

3.1.3 Main process steps in sequence

3.1.4 Types and quantities of catalysts used

3.1.5 Modifications since original commissioning

3.1.6 Where a cyclic plant is the subject of the test a chart of the operating cycle should be included as illustrated in Appendix A

NOTES

3.2 Input quantities may be expressed per unit quantity of product, e.g. per 1 000 ft³ (or 100 m³) or per 100 therms (or GJ) or per ton (or Mg), or per unit time.

3.2.1

1) The terms used for the feedstocks should be those given in BS 1179³⁾. There may be more than one feedstock. State separately the description and quantity of each.

2) The volume at s.r.c. is defined in the Gas Act 1948, Clause 74 (1), as the volume of a gas at a temperature of 60 °F and a pressure of 30 in of mercury, saturated with water vapour (60 °F and 30 in Hg sat.). Reference should be made to BS 526⁴⁾, Note 14, where it is assumed that the barometer is read at 60 °F. Metric based standard reference conditions have yet to be defined.

3.2.1.1 Hydrogenation as may be either recycle gas or a gas drawn from a source external to the plant. In the latter case it will be an input to the plant and its quantity will enter into the calculation of the performance or thermal efficiency.

Even where the hydrogenation gas is recycled, the performance of the plant may depend on the provision of a proper quantity and quality of such gas, and the appropriate entries should always be made under this item. The quantity is frequently expressed (in suitable imperial or SI units) per unit quantity of feedstock.

3.2.2 There may be more than one fuel. State separately the description and quantity of each.

3.2.3 Include enrichment gas and ballast gas if any.

³⁾ BS 1179, "Glossary of terms used in the gas industry".

⁴⁾ BS 526, "Definitions of the calorific value of fuels".

3.2 Nominal inputs at specified output of product gas (see 3.4.1)

3.2.1 Process feedstock:

1) Description

Imperial units per 1 000 ft ³ or per 100 therm or per ton or per unit time	SI units per 100 m ³ or per GJ or per t (Mg) or per unit time
gal or lb or ton or ft ³ at s.r.c. or therm (10 ⁵ Btu)	m ³ kg Mg (tonne) m ³ at s.r.c. MJ

2) Quantity or thermal equivalent at specified output of product gas

3.2.1.1 Hydrogenation gas:

- 1) Source
- 2) Quantity
- 3) Analysis

Units as in 3.2.1 2)

3.2.2 Fuel:

- 1) Description
- 2) Quantity or thermal equivalent

Units as in 3.2.1 2)

3.2.3 Other feedstocks and ballast to produce final gas:

- 1) Description
- 2) Quantity or thermal equivalent

Units as in 3.2.1 2)

3.2.4 Utilities and services

3.2.4.1 Steam imported into plant:

- 1) Quantity
- 2) Pressure
- 3) Temperature

lb	kg
lbf/in ²	bar ^a
	°C

3.2.4.2 Water consumed:

- 1) Raw, quantity
- 2) Chemically or otherwise treated, quantity

gal	m ³
gal	m ³

^a The SI unit of pressure is the newton per square metre (N/m²). 1 bar = 10⁵ N/m².

NOTES

3.2.4.4 Include process air, process oxygen and chemical reagents, e.g. potassium carbonate used in CO₂ removal plant.

3.3.1 In continuously operated processes no entries are required for Items **3.3.2** and **3.3.3**. In cases where there are primary and secondary reactors and the steam/feedstock ratio is deliberately changed at the inlet to the secondary reactor, there may be more than one entry for Item **3.3.1**.

3.3.2 In cyclically operated processes, steam may be supplied to the reactor during more than one period of the operating cycle. In this case, process steam is defined as steam admitted to the reactor simultaneously with the feedstock, for the primary purpose of reacting with the feedstock but including excess steam necessary to control chemical reactions either in respect of the composition of the gaseous products or the prevention of the precipitation of carbonaceous deposits or the occurrence of undesirable side reactions.

Purge steam is defined as steam admitted to the reactor for any other purpose, and includes, for example, atomizing steam, steam purges for burners, injection nozzles, and vessels, "continuation steam", and "cushion steam". There may be more than one steam purge period in each cycle, and the total flow of steam together with the direction of flow may have important effects on the distribution of heat and of temperature within the process. In such cases the ratio for each purge steam usage may be stated separately.

It may be noted that in continuous processes steam may be used for a variety of purposes, such as atomizing steam for the burners of the furnaces of reformers and ancillary plant, gas dehydration systems, wash-oil regeneration systems, etc. Such steam usages may be stated separately if desired, but for the purpose of the overall performance of the plant undergoing test, steam usage other than for process will be accounted for by the difference between the total steam produced plus imported steam (or minus exported steam) and the process steam.

3.3.3 This item is the ratio of the sum of the process steam and purge steam to process feed-stock, and is intended to refer specifically to cyclically operated processes.

3.3.4 The ratio of steam/carbon in the process feedstock refers to feedstock before the addition of any hydrogenation gas.

3.3.5 This item refers to a situation where a hydrogenation gas is used, e.g. for hydrodesulphurization, and the hydrogenation gas contains a significant quantity of methane or oxides of carbon. In such cases, the carbon content of the feedstock supplied to the gasifier or reformer shall include the carbon in the hydrogenation gas, whether recycled or drawn from an external source.

Frequently for plant control, this ratio is expressed in the form of molecules of steam per atom of carbon. Take care to convert when necessary to a weight/weight basis.

3.3.6 }
3.3.7 } These items are of importance for partial oxidation and autothermic processes.

	Imperial units	SI units
3.2.4.3 Electricity imported into plant	kWh	MJ
3.2.4.4 Consumable process materials:		
1) Description		
2) Quantity or thermal equivalent	Units as in 3.2.1 2)	
3.3 Nominal ratios, at specified output of product gas (see 3.4.1), by weight		
3.3.1 Process steam/process feedstock		:1
3.3.2 Purge steam/process feedstock		:1
3.3.3 Total steam/process feedstock		:1
3.3.4 Process steam/carbon in process feedstock		:1
3.3.5 Process steam/carbon in feedstock supplied to gasifier or reformer		:1
3.3.6 Process air/carbon in process feedstock		:1
3.3.7 Process oxygen/carbon in process feedstock		:1

NOTES

3.4.1 See BS 526⁵⁾, and, for the calculation of calorific value, relative density and Wobbe number, BS 3156⁶⁾.

3.5 Give capacities of gas holders and tanks. Note those tanks for which depth/capacity tables are available.

3.6 List for all feedstocks and products the properties for which measurements are available. Give the methods of measurement for each property of each material.

3.7 Comment on structural and mechanical condition and give the number of hours worked since last overhaul. Give the total hours worked for each catalyst.

3.8 Give unusual features of site, operation or construction; e.g. infrequent or intermittent use, local authority limitations due to noise or effluent problem, etc.

⁵⁾ BS 526, "*Definitions of the calorific value of fuels*".

⁶⁾ BS 3156, "*Methods for the analysis of fuel gases*".

3.4 Nominal outputs

3.4.1 Specified output of product gas

3.4.1.1 Volume per day (at s.r.c.)

3.4.1.2 Calorific value (gross at s.r.c.)

3.4.1.3 Analysis, dry

3.4.1.4 Relative density (dry gas/dry air. Air = 1)

3.4.1.5 Wobbe number

Imperial units	SI units
ft ³	m ³
Btu/ft ³	MJ/m ³
% v/v	
(Btu/ft ³ at s.r.c.)	(MJ/m ³ at s.r.c.)

3.4.2 Output products at specified output of product gas (see 3.4.1)

3.4.2.1 Steam exported from plant:

- | | |
|----------------|---|
| 1) Quantity | } |
| 2) Pressure | |
| 3) Temperature | |

Units as in 3.2.4.1

3.4.2.2 Electricity exported from plant

Units as in 3.2.4.3

3.4.2.3 Other output products:

- 1) Description
- 2) Quantity or thermal equivalent

Units as in 3.2.1 2)

3.5 Storage of feedstocks and products

3.6 Measurements of feedstocks and products

3.7 Condition of plant

3.8 Special features

NOTES

4 Base the data recorded in this section on information obtained from the plant during the test. Express the rates in units appropriate to the type of plant tested; e.g. for a continuous process it may be desirable to quote rates in quantities per day or per hour, whereas for cyclic processes appropriate rates may be expressed as quantity per minute or per cycle.

4.1 This may be expressed in either volumetric, thermal, or mass units provided that self-consistent units are employed.

4.2.1 There may be more than one feedstock. Record separately the rate of each.

4.2.1.1 See Note 3.2.1.1.

4.2.2 There may be more than one fuel. Record separately the rate of each.

4.2.3 Include any enrichment or ballast gas.

4.2.4 Also enter here process air, process oxygen, steam, and consumable process materials, e.g. other chemicals and electricity consumed. See Note 3.2.4.4 and also Section 5 where lists of utilities and services are shown.

4.3 See Notes to Item 3.3.

4 Operating conditions

4.1 Loading, percentage of specified output (see 3.4.1)

4.2 Average rates, in imperial units or SI units

4.2.1 Process feedstock:

- 1) Description
- 2) Quantity per unit time

4.2.1.1 Hydrogenation gas:

- 1) Source
- 2) Quantity per unit time or unit quantity of feedstock

4.2.2 Fuel:

- 1) Description
- 2) Quantity per unit time

4.2.3 Other feedstock and ballast to produce final gas:

- 1) Description
- 2) Quantity per unit time

4.2.4 Utilities and services:

Quantity per unit time

4.3 Average ratios, by weight

4.3.1 Process steam/process feedstock	: 1
4.3.2 Purge steam/process feedstock	: 1
4.3.3 Total steam/process feedstock	: 1
4.3.4 Process steam/carbon in process feedstock	: 1
4.3.5 Process steam/carbon in feedstock supplied to gasifier or reformer	: 1
4.3.6 Process air/carbon in process feedstock	: 1
4.3.7 Process oxygen/carbon in process feedstock	: 1

NOTES

- 4.4.1 See Note 6.1.1.
- 4.4.2 See Note 6.1.2.
- 4.4.3 See Note 6.1.3.
- 4.4.4 See Note 6.1.4.
- 4.4.5 See Note 6.1.5.
- 4.4.6 See Note 6.1.6.
- 4.4.7 See Note 6.1.7.
- 4.4.8 In some instances condensible hydrocarbons, etc., may have to be considered, and may be recorded in other units. See Note 6.1.7.
- 4.4.9 See Note 6.3.8.1.
- 4.4.10 See Note 6.3.8.2.
- 4.4.11 See Note 6.3.8.3.
- 4.4.12 See Note 6.3.8.4.
- 4.4.13 See Note 6.3.8.5.

- 4.5

4.6

4.7
- In these items report only those temperatures, pressures, flows or other process variables which are deemed sufficient to define the operating conditions. Examples of what are intended are:

Temperature and pressure of reactants at the inlet of a partial oxidation process; temperature and pressure conditions at the outlet of any catalytic reactor;
the indicated rate of flow, with temperature and pressure conditions, for measuring an input or output.

4.4 Product gas outlet of process

average daily figures

4.4.1 Volume at s.r.c.

4.4.2 Calorific value (gross at s.r.c.)

4.4.3 Relative density (dry gas/dry air. Air = 1)

4.4.4 Pressure at outlet of plant

4.4.5 Temperature

4.4.6 Water content

4.4.7 H₂S in gas

4.4.8 Gas analysis

and, for town gas manufacture, these gas characteristics:

4.4.9 Wobbe number (at s.r.c.)

4.4.10 Flame-speed factor (hydrogen = 100)

4.4.11 Reversion pressure

^a The SI unit of pressure is the newton per square metre (N/m²). 1 bar = 10⁵ N/m².

4.4.12 Aeration number

4.4.13 Sooting number

4.5 Temperatures

4.6 Pressures

4.7 Indicated flows

4.8 Carbon monoxide conversion

Exit gas analysis

Imperial units	SI units
ft ³	m ³
Btu/ft ³	MJ/m ³
lbf/in ²	bar
or in w.g.	or mbar ^a
°C	
lb/ft ³	kg/m ³
p.p.m. v/v	
% v/v	
(Btu/ft ³)	(MJ/m ³)
in w.g.	mbar ^a

NOTES

4.10 For cyclic reforming plants, refer also to Notes **3.1.6** and **3.3.2**.

4.10.1
4.10.2
4.10.3
4.10.4

} Give temperature(s) and pressure(s).

4.10.5 Give duration of phases of cycle (1 cycle = 100 units).

4.10.6 Give actual duration of cycle.

4.10.7 If there is a flowmeter on the exit line from a balance holder, note changes in holder level if its volume is significant compared with the total volume of gas made during the test period.

4.9 Carbon dioxide removal

4.9.1 Exit gas analysis

4.9.2 Plant lye analysis

4.9.3 Additions to plant lye during test

4.10 Operating cycles

4.10.1 Feedstock rate(s)

4.10.2 Burner fuel rate(s)

4.10.3 Steam rate(s)

4.10.4 Air rate(s)

4.10.5 Description of cycle

4.10.6 Length of cycle

4.10.7 Make gas rate

NOTES

5 In this section, record the total quantities and average properties of materials supplied during the test. In appropriate cases, averages should be weighted.

5.1–5.3 See Note **3.2.1** for type and character of feedstock.

For *liquid feedstocks*, determine the quantity of each feedstock used by measurement of the quantities in the storage tank(s) immediately before and after the test, applying corrections for changes in temperature. The total quantities of liquid feedstocks used will be the quantities used from the storage tank(s) plus any additional quantities delivered to the storage tank(s) during the test. Where this method is not practicable, or when any feedstock is used for more than one purpose, it will be necessary to rely on feedstock meters. In this case calibrate the feedstock meters before, during (when practicable), and after the test over the range of rates used. See BS 1042⁷⁾. One convenient method for smaller or cyclic plants using liquid feedstock, where the feedstock is stored at atmospheric pressure and at temperatures not materially below atmospheric, is to install on the suction side of the feedstock pump a small calibrated tank.

For *gaseous feedstocks*, calibrate the feedstock meters by independent means before and after the test in accordance with the best current practice, e.g. high-pressure positive displacement meters checked by the manufacturers; low-pressure positive displacement meters checked in accordance with makers' instructions; orifice meters in accordance with BS 1042⁷⁾; other inferential meters checked against gasholders. Observe temperatures and pressures at least every four hours and apply the necessary corrections to the meter readings to adjust them to the appropriate standard conditions. Also it may be necessary to correct for variation in density and make allowance for compressibility factor.

5.1.1 See Note **3.2.1.1**. Hydrogenation gas may require special consideration. Such gas frequently consists of hydrogen with about 5 % of methane and less than 3 % each of carbon monoxide and carbon dioxide. The composition is usually substantially constant but the content of carbon dioxide may vary with load and performance of the carbon dioxide removal system. The concentration of carbon dioxide has a very marked effect on the relative density of the gas, a knowledge of which is required in measuring the hydrogenation gas flow through an orifice meter. A continuous record of the carbon dioxide content of hydrogenation gas is therefore desirable, using automatic analysers of either the absorption or infra red type. See also Note **6.1.7**.

The quantity of hydrogenation gas will usually be measured by an orifice meter. Its density may be calculated from the composition or determined in accordance with the methods in BS 3156⁸⁾.

5.2 See Note **3.2.2**.

5.4 Should it be necessary to check the quality of any of the process feedstocks or fuels, use the test methods indicated below. In most cases, the methods laid down are those prescribed in BS 3156⁸⁾, or in the twenty-seventh (1968) edition of the Institute of Petroleum's "Standard Methods for Testing Petroleum and its Products", or in the 1967 edition of the American Society for Testing and Materials (ASTM). When approved revised methods are published, adopt these. These tests vary according to the type of materials under examination, e.g. natural gas (NG), refinery gas, liquefied petroleum gas (LPG), light petroleum feedstock (LPF), gas oil or heavy oil.

By arrangement with the Institute of Petroleum, many of the standard IP methods are being published also as British Standards, and in such cases the BS as well as the IP reference is given below.

⁷⁾ BS 1042, "Methods for the measurement of fluid flow in pipes", Part 1, "Orifice plates, nozzles and venturi tubes".

⁸⁾ BS 3156, "Methods for the analysis of fuel gases".

5 Data relating to materials supplied

5.1 Process feedstock

Imperial units	SI units
gal	m ³
or lb	kg
or ton	Mg (tonne)
or ft ³ at s.r.c.	m ³ at s.r.c.

5.1.1 Hydrogenation gas

Units as in **5.1**

5.2 Fuel

Units as in **5.1**

5.3 Other feedstock or ballast supplied to produce final gas

Units as in **5.1**

5.4 Analysis of each feedstock and fuel

5.4.1 Carbon and hydrogen content

% v/v or % w/w

Carbon-hydrogen ratio

NOTES

5.4.1.1 Deduce the carbon-hydrogen content and ratio of NG, refinery gas and LPG from the gas chromatographic analysis (see **5.4.5**).

5.4.1.2 Determine the carbon and hydrogen content of LPF, gas oil, and heavy oil by quartz tube, i.e. combustion method (ASTM D1551).

5.4.2.1 Determine the free nitrogen content by gas chromatography.

5.4.2.2 Determine the combined nitrogen content by Kjeldahl method.

5.4.3.1 Determine in accordance with BS 3156⁹⁾ or by the Wickbold method.

5.4.3.2 Determine in accordance with BS 4350¹⁰⁾ (IP 107) with turbidimetric finish, or by the Wickbold method.

5.4.3.3 Determine by the Wickbold method or the Granatelli method.

5.4.3.4 Determine in accordance with (IP 61 Bomb method) (BS in preparation), or BS 4384¹⁰⁾ [IP 63/ASTM D1551 (Quartz tube method)].

5.4.3.5 Determine in accordance with IP 61, or IP 63.

5.4.4 Determine by the Conradson method, BS 4380¹⁰⁾ (IP 13), or alternatively determine the Ramsbottom carbon residue by IP 14 (BS in preparation).

5.4.5 Determine the following items in NG, refinery gases, propane, butane or LPG by gas chromatography. (See also BS 3156⁹⁾, where appropriate, and refer to “Gas analysis by gas chromatography” by P. G. Jeffery and P. J. Kipping, Pergamon Press, 1964, or to ASTM 1945, and to ASTM D2163 or IP 169 for the determination of hydrocarbons.)

5.4.5.1 In gases:

CO₂

CO

H₂

O₂

N₂

CH₄

C₂H₆

C₂H₄

C₂H₂

higher paraffins

higher unsaturated hydrocarbons.

⁹⁾ BS 3156, “*Methods for the analysis of fuel gases*”.

¹⁰⁾ See page iii for titles of these standards.