FOREWORD

1 STANDARD TEST METHODS FOR ANALYSIS AND TESTING OF PETROLEUM AND RELATED PRODUCTS AND BS 2000 PARTS

The Full Methods appear in numerical order followed by the Proposed Methods and appendices.

2 DESCRIPTION OF TERMS

The terms 'Determination', 'Result', 'Reproducibility' and 'Repeatability' are defined in IP 367/ISO 4259 and 'Determinability' is defined in Appendix E. The meaning of certain other terms used in IP Standards requires clarification as follows:

2.1
method of test
the terms 'Method of Test' or 'Method' are to be understood as applying to the whole of the information, description, and instructions in all of the various sections included under the Title and Serial Designation.

2.2
procedure
the term 'Procedure' is used here in a special sense, and relates to the series of operations described in the Section of the method bearing this heading.

2.3
test
a test is the process of submitting a sample to one or more determinations as described in the method of test.

3 CRITERIA FOR TEST METHOD SUITABILITY

3.1 General

The following criteria are considered, as appropriate, in assessing the suitability of a method of test as an IP Standard Test Method they are reviewed as work on the methods proceeds.

Where the method clearly fails to meet specific criteria, consideration is given to either:

— rejecting the method;
— carrying out further work, or
— inserting an appropriate comment in the 'Scope' clause.

It must be appreciated, however, that overriding considerations may require the adoption of a method despite failure to meet some of the criteria.

3.2 Criteria

3.2.1 Significance of test

— Consider the nature of the property it is desired to measure in as fundamental terms as possible. Call this 'Property A'.
— Is there a strong practical requirement to assess 'Property A'? (e.g. is 'Property A' clearly correlated with an important service performance factor?).
— Does some other existing standard test method already provide adequate information on 'Property A'?
— Does the proposed test measure 'Property A' or does it measure some other 'Property B' which is not sufficiently correlated with 'Property A' (e.g. 'Property A' may be molecular weight and the test under consideration may be the distillation test. Although boiling point is related to molecular weight, it is also influenced by molecular structure. The test could, therefore, be rejected for the purpose of measuring molecular weight.)

3.2.2 Reliability of results

— Has the precision of the test been assessed statistically?
— If so, does the method show a bias against any other methods assessing the same property?
— Is the reproducibility smaller than the smallest difference in levels of 'Property A' which it is necessary to distinguish?

3.2.3 Economic considerations

— Consider the cost of equipment and materials.
— Consider the manpower involved in carrying out the test.
— Consider the elapsed time of the test (i.e. the total time from the start of the test to the production of the result).

3.2.4 Future developments

— If the method is not automated, is an automated form desirable for laboratory, field or on-line use?
— If so, does the test readily lend itself to automation at a later date?

4 METHOD DESIGNATION

4.1 Full Methods

These are methods which are firmly established. They will normally include precision statements which have been obtained by statistical examination of interlaboratory test results or, where this is not possible, contain a statement of reliability.

4.2 Proposed Methods

These are methods which are published for information and comment, and may not include a precision statement.

They remain as Proposed Methods for a period of not more than three years, unless an extension of

a further three years is approved by the Test Method Standardisation Committee. After this, they are either upgraded to a Full Standard or withdrawn.

4.3 Joint IP/ASTM Standard Test Methods

These are Standard Test Methods which have been developed in conjunction with the ASTM D2 Committee. They are recognised as being technically equivalent and are dual numbered with an IP and ASTM number in IP number sequence.

The ASTM number is followed by a figure which indicates the year in which the method was adopted as approved. A number in parentheses indicates the year in which the method was reapproved.

4.4 ISO Standard Test Methods

ISO Standard Test Methods are reproduced in this volume with agreement of ISO, the International Organisation for Standardisation. Single copies of these standards can be obtained from ISO members or from the Central Secretariat, PO Box 56, CH-1211 Geneva 20.

4.5 European Norms (ENs)

These are standard test methods which have either been produced by CEN, or are ISO Standards endorsed by CEN. It is mandatory that they are adopted as British Standards. They are duel numbered as BS ENs and BS 2000 Parts and are published by BSI and the Energy Institute.

4.6 BS 2000 Parts

Many IP Standard Test Methods have been accorded the status of a British Standard. These methods have been developed in accordance with BSI procedures which includes making the test methods available for public comment. These methods form parts of BS 2000.

4.7 Standard Test Methods Revision

4.7.1 Full Methods

These shall be reviewed five years after publication and thereafter every five years. However there is provision for an earlier revision should technical and/or editorial alteration be required.

4.7.2 Proposed Methods

These shall be reviewed after three years of publication and if approval is given for an extension, after a further three years.

4.8 Standard Test Methods Numbering

4.8.1 Full Methods

These are arranged in numerical order with a figure after the solidus indicating the year in which the standard test method was adopted or last revised. Where methods have not required revision for several years but have been studied and reapproved, the year of the reapproval shall be shown in the Numerical List of the IP Standard Test Methods by the addition of the last two digits of the reapproval year in brackets.

4.8.2 Proposed Methods

These are given a pair of designation letters following the designation 'PM', which stands for Proposed Method. The designation letters are given in sequence starting AA and the test methods arranged in this alphabetical order, with a figure after the solidus indicating the year in which the proposed method was adopted.

4.8.3 ISO Methods

These are dual numbered with the IP numbering as in 4.8.1 above. They are arranged in IP number sequence.

4.8.4 European Norms

These are dual numbered as BS EN XXXX. In addition, they are adopted as IP Standard Test Methods and are thus numbered IP YYY and BS 2000: Part YYY.

4.8.5 BS 2000— Series

These are dual numbered IP ZZZ, BS 2000: Part ZZZ: 200X. These can be withdrawn without prior notice.

4.9 Methods Withdrawal

4.9.1 Full Methods

A notice of withdrawal shall be given at the beginning of the method and its number and withdrawal date included in the Notice of Withdrawal of IP Standard Test Methods section, two years prior to the proposed withdrawal date.

4.9.2 Proposed Methods

These can be withdrawn without prior notice.

Note should also be taken of section 4.2. wherein the lifetime of a proposed method is defined.

5 METHOD FORMAT AND PRESENTATION

5.1 General Principles

It is intended that IP Standard Test Methods remain in the forefront of international methodology, both in terms of their content, and in terms if their overall integrity. This means that there shall be strict adherence to the relationship between Scope and Precision, and where possible, all standard test methods shall have procedures laid down for Calibration, Verification, and/or Instrument Monitoring.

5.2 Format

IP Standard Test Methods shall be prepared in accordance with ISO Directives Part 3 : 1997, with the symbol for litre 'l' and the 'comma' as the decimal marker. However, some existing IP Standard Test Methods which are not called up in specifications may not be presented strictly in accordance with these requirements.

ISO and CEN Standard Test Methods adopted as IP Standard Test Methods will have been prepared in accordance with ISO and CEN directives.

Copies of BS 0, ISO Directives—Part 3 and CEN Internal Regulations, Part 3 can be obtained from BSI and are also available for study at the EI.

5.3 Normative References

Included in the majority of IP Standard Test Methods. These are standards or documents that form an integral part of the Test Method and shall be referenced by the user in order to claim compliance. Normative references may be other IP Standard Test Methods, ISO, CEN or ASTM Standards.

Where IP Standard Test Methods are listed under Normative References, the symbol ≡ adjacent to an ISO or EN Standard number indicates that the IP method listed is identical to this Standard.

6 MATHEMATICAL STYLE AND EQUATION LAYOUT

6.1 General

The primary aim is to achieve maximum clarity, and thus aid comprehension. Simple forms of notation and layout often achieve this. Avoidance of elaborate expressions built over several lines can enhance the typographical appearance of the printed page.

The following sections are based on BS 5775: Part 0 (which is equivalent to ISO 31/0), BS 0: Part 3: section 18 and IEC/ISO — Drafting and presentation.

6.2 Symbols and Numbers

Symbols for quantities are generally single letters of the Latin or Greek alphabets, sometimes with subscripts or other modifying signs. These symbols are printed in italic (sloping) type. A subscript that represents a symbol for a physical quantity is printed in italics, e.g. qm for mass flow rate. Other subscripts are printed in roman (upright) type, e.g. Ek for kinetic energy. Numbers, including those in subscripts and superscripts, are printed in roman type. Each group of three digits reading to the left or to the right of the decimal sign shall be separated by a small space from preceding or following digits, except for four-digit numbers designating years and standard numbers.

6.3 Multiplication and Decimal Signs

The preferred multiplication sign is a cross (x), and that for the decimal sign is a comma on the line (,). The symbol x shall be avoided in an equation, though if it is used (e.g. a standard symbol for a physical quantity) it shall be in italic.

6.4 Equations

Equations shall be expressed in a mathematically complete form, dimensionally balanced and unambiguous. Series of equations shall be indented consistently and aligned wherever possible on the '=' sign. Except in a standard test methods that contains a large number of equations making repeated use of several symbols (in which case these shall be explained at the outset in a separate 'Symbols and Abbreviations' clause), the meanings of the symbols used in an equation shall be explained in a formal, consistent style immediately below the equation in which they appear. See Example 1.

Example 1

$$\frac{P_1}{P_2} = 1 + \eta \left(\frac{T_2 - T_1}{T_1} \right)^{\gamma/(\gamma-1)}$$

where

$P1$	is the intake pressure, in pascal;
$P2$	is the delivery pressure, in pascal;
η	is the isentropic efficiency;
$T1$	is the inlet temperature, in kelvin;
$T2$	is the outlet temperature, in kelvin;
γ	is the ratio of specific heat capacities.

The names of units are spelt out in full when they are not preceded by a numerical value, as in 'the SI unit of pressure is a pascal', but '1 Pa = 1 N/m^2'.

No space is to be inserted between symbols that together represent a product of the individual symbols or between a number and the symbol it multiplies. A small space is used on either side of a mathematical sign.

In a standard containing more than a few isolated equations, all of them are numbered sequentially throughout the standard, including appendices, using arabic numerals in parentheses ( ).

When the resultant value to be calculated from an equation is expressed in terms of a unit of measurement or a percentage, this should be explained in the sentence that introduces the equation to avoid confusing the unit symbol with the content of the equation. See Example 2.

Example 2

The value of F (in N) is calculated from the equation:

$$F = ma$$

The value of d, expressed as a percentage, is calculated from the equation:

$$d = (a/b) \times 100$$

If it is necessary to break an equation that is too long

for the text line, the break should be made at one of the following points:

(a) at = , > , ~ and similar signs, the sign appearing only at the beginning of the 'turn-over' line;
(b) at +, −, x , /, signs, the sign appearing at the end of the first line and again at the beginning of the second;
(c) between adjacent brackets, in which case a multiplication sign is inserted at the end of the first line and again at the beginning of the second. See Example 3.

Example 3

$$f(t) = s\left[1+\frac{1}{PD}\left\{E_1(b+t_2)-E_2(b+t_3)\right\}\text{x}\right.$$

$$\left.\text{x}\left\{4E_2(1+t_3)+4E_3(1+t_4)\right\}\right]$$

6.5 Brackets

The commonly used term 'brackets' applies to several differently-named signs, three of which are most frequently used in mathematical expressions. These are parentheses ( ), braces { } and brackets [ ]. When brackets within brackets are required in equations and formulae occupying text of single-line depth, the normal order is [( )] when two sets are needed and [{ ( ) }] when three sets are needed. The size (depth) of a pair of brackets depends upon the maximum vertical space occupied by the terms enclosed and should always be sufficiently large to enclose the term of greatest depth. Pairs of brackets that enclose others should always be at least as large as any of the pairs within. Brackets of equivalent size should be of similar weight (density) to avoid giving unwarranted prominence to any one pair. Where brackets extend to a depth of two or more lines of print, [ ] are preferred to either ( ) or { }.

6.6 Solidus

The use of a solidus (/) can effect the reduction of some displayed two-line expressions to single lines, this being of particular value in text. See Example 4. The size of the solidus should be sufficient to ensure instant recognition. When using the solidus, care is essential in the use of brackets, and the order in which individual terms are placed. See Example 5.

Example 4

$\frac{a}{b}$ can be expressed as a / b

$A=\frac{a-b}{c+d}$ can be expressed as

$A = (a - b) / (c + d)$

$0 < e < \frac{1}{n+z}$ can be expressed as

$0 < e < 1/(n+z)$

Example 5

The expression $\frac{a}{b}+c$ could be expressed as $(a / b)+c$

Without the use of the brackets, $a / b+c$ could be read as $\frac{a}{b+c}$

The use of the double solidus in an expression may be ambiguous and should always be avoided. Thus a/b/c should be expressed as a/(bc) or ac/b, whichever is correct.

6.7 Bar (Vinculum)

Provided that the context makes it clear, the root sign does not require the addition of the vinculum to indicate the value it applies to, this being expressed instead, where appropriate, by brackets. See Example 6.

Example 6

$\sqrt{(a^2+b^2+c^2)}$ is preferred to

$\sqrt{(a^2+b^2+c^2)}$

6.8 Integral and Summation Signs

The limits associated with an integral sign $\int$ and the values of the summation sign $\sum$ can be printed in small type to the right of the respective signs. If this is done, the signs are not overshadowed by the associated notation and can be set in a smaller size, often within single-line depth, thus saving on vertical space and avoiding additional composition problems. See Example 7.

Example 7

$\int_b^a$ is preferred to $\int\limits_b^a$

$\sum_{i=1}^{n-1}$ is preferred to $\sum\limits_{i=1}^{n-1}$

6.9 Subscripts and Superscripts

For fractional indices, the solidus is used. Care is essential in the sizing and location of superscripts, especially outside brackets. See Example 8.

Example 8

$$y^{a/b}, t^{1/2}, \left(\frac{a-b-c}{6}\right)^{\pi/2}$$

For expressions in which superscripts appear above subscripts, it is acceptable to have the superscript to the right of the subscript rather than immediately above it. This does not apply to primes, which should always be immediately next to the term they relate to. See Example 9.

Example 9

d_3^2 and d_3^2 are both acceptable, and d_3' is correct.

Symbols having subscripts or superscripts which themselves have subscripts or superscripts shall be avoided, wherever possible. The most frequent cases occur with subscripts to subscripts and these can generally be placed on the same line as the main subscript, separated if necessary by a comma. See Example 10.

Example 10

$y_{t(n+1)}$ is preferred to $y_{t_{n+1}}$

6.10 Exponentiation

In exponentiation functions, the abbreviation 'exp' followed by the exponent on the same line is preferred to 'e' followed by the exponent as a superscript. This is particularly helpful when the exponent is lengthy or complex, as in Example 11.

Example 11

$\exp(ax^2 + bxy - cy^2)$

is preferred to $e^{ax^2 + bxy - cy^2}$

6.11 Logarithms

The mathematical symbol for a logarithm is $\lg_a$, where a is the base. The base value should always be written.

Example 12

$\lg_e y$ and $\lg_{10} T$

7 PATENTED AND REGISTERED APPARATUS

Manufacturers are advised to ascertain whether patents or registrations apply to the equipment used in IP Standard Test Methods, as the Energy Institute cannot accept responsibility in this regard.

The Test Method Standardisation Committee would be grateful if readers and users of this book would kindly inform the Energy Institute of any errors which may be identified.

8 RULES FOR ROUNDING OFF RESULTS

8.1 The general rule is that results shall not be rounded off coarser than one-tenth of the reproducibility of the test method. In practice, this means that for the decimal system, this choice is made from the series of 1 – 0,5 – 0,2 – 0,1 – 0,05 – 0,02, etc., (since 1, 2 and 5 are the only integral factors of 10). If the figure for one-tenth of the reproducibility is not among this series, the nearest lower number shall be used. Thus, if the reproducibility is 5, the result shall be rounded off to 0,5, but if the reproducibility is 4, the result shall be rounded off to 0,2.

8.2 When a number is rounded off to a rounding unit, the nearest unit shall be chosen. If two choices are available, as when the number to be rounded is exactly halfway between the two nearest rounded numbers, the rounded number that is an even multiple of the rounding unit shall be chosen. For example, if the rounding unit is 0,1, then 23,55 shall be rounded to 23,6, while 23,45 shall be rounded to 23,4. Again, if the rounding unit is 0,02, then 5,03 shall be rounded to 5,04, while 5,01 shall be rounded to 5,00.

8.3 There are cases, however, in which the rounding-off procedure is either specified or otherwise implied by the test method itself. In these cases, the above rules based on statistical reasoning might not always be applicable. For example, in a standard test method for the determination of viscosity of cutback bitumen and road oil, the reproducibility is given as 2 s, or 10 % of the mean for efflux times of 20 s and above, but a rounding-off interval of 1 s is specified.