

**METHODS OF SAMPLING
SUPERHEATED STEAM
FROM
STEAM GENERATING UNITS**

B.S. 3285 : 1960

METHODS OF SAMPLING
SUPERHEATED STEAM
FROM
STEAM GENERATING UNITS

B.S. 3285 : 1960

BRITISH STANDARDS INSTITUTION
INCORPORATED BY ROYAL CHARTER

THIS BRITISH STANDARD, having been approved by the Chemical Divisional Council, was published under the authority of the General Council on 25th November, 1960.

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 3000, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook,

This standard makes reference to the following British Standards:

- B.S. 806. Ferrous pipes and piping installations for and in connection with land boilers.
- B.S. 970. Wrought steels, En series.
- B.S. 1113. Water-tube boilers and their integral superheaters.
- B.S. 2690. Methods of testing water used in industry, Addendum No. 1.

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 B.S.I. references relate to the work on this standard:
Committee references C/37, C/37/2 and C/37/2/2
Draft for comment A(C) 7914

CO-OPERATING ORGANIZATIONS

The Technical Committee under whose supervision this British Standard was prepared consists of representatives from the following Government Departments and scientific and industrial organizations.

- *Admiralty
- *Association of British Chemical Manufacturers
- *Association of Shell Boiler Makers
- *British Iron & Steel Federation
- *British Launderers' Research Association
- D.S.I.R.—Lab. of the Government Chemist
- *Electricity Council, the Generating Board and the
Area Boards in England and Wales
- Institute of Fuel
- *Institute of Marine Engineers
- *Institution of Chemical Engineers
- Institution of Gas Engineers
- *Institution of Mechanical Engineers
- Institution of Municipal Engineers
- Lloyds Register of Shipping
- London County Council
- Ministry of Labour (Factory Inspectorate)
- *Ministry of Works
- National Coal Board
- National Physical Laboratory (D.S.I.R.)
- *Royal Institute of Chemistry
- *Society for Analytical Chemistry
- Society of Laundry Engineers and Allied Trades Ltd.
- War Office

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 Sugar Refiners' Association
- British Electrical and Allied Manufacturers' Association
- British Waterworks' Association
- Engineering Equipment Users' Association
- Parsons and Marine Engineering Turbine Research and
Development Association
- United Kingdom Atomic Energy Authority
- Water-tube Boilermakers' Association

BRITISH STANDARD METHODS OF SAMPLING SUPERHEATED STEAM FROM STEAM GENERATING UNITS

FOREWORD

The more general use of boilers operating at higher pressure has created a need for the standardization of sampling and testing methods for superheated steam, since the purity of the steam cannot always be accurately predicted from the composition of the water from which it is generated.

In preparing this standard, it has been considered desirable to quote the best possible, and, therefore, frequently the most difficult techniques. It is realized that in view of the rapid development in these fields the methods will have to remain under review continually and be revised when necessary.

Standards are in course of preparation for the sampling of saturated steam of lower quality.

NOTE. Where metric equivalents are stated the figures in British units should be regarded as the standard. The metric conversions are approximate. For more accurate conversions reference should be made to B.S. 350, ' Conversion factors and tables '.

METHODS

SECTION ONE : GENERAL

SCOPE

1. The purpose of this British Standard is to establish a procedure for the sampling of superheated steam for the measurement of purity. The procedures laid down may also, in the majority of cases, be used for the sampling of saturated steam with a moisture content of up to about 0.5 per cent, for the measurement of purity. The standard is primarily intended for units of the conventional water tube type, but may be used, where applicable, for other types of units.

The standard gives basic requirements for apparatus and for procedure for obtaining a representative sample of superheated steam flowing in a pipe, or pipes. It also covers the extraction and processing of the sample, for delivery to measuring and analytical devices suitable for continuous field testing or for delivery to a container in which the sample may be preserved for subsequent laboratory investigation. For details of analytical procedures see B.S. 2690, Addendum No. 1*.

Application of the procedure laid down in this standard is limited only by the requirements that sampling of steam be confined to steam flowing through

* B.S. 2690, ' Methods of testing water used in Industry ', Addendum No. 1.

pipes and that the steam being sampled must be under sufficient pressure to establish the required rate of flow through the sampling probe or probes.

DEFINITIONS

2. For the purposes of this British Standard the following definitions apply:

Superheated steam. Steam having a temperature at least 100 degF above the saturation temperature corresponding to its pressure, and as delivered from the exit of the final superheater or re-heater section of the steam generating unit.

Impurities in steam. The quantity of matter, other than pure liquid water substance, present in the steam and expressed in parts per million by weight.

Sampling of steam. The withdrawal of a representative portion of superheated steam flowing in a pipe and the delivery of this portion, in suitable form, to an apparatus for immediate analysis or to a container in which the sample may be preserved for subsequent analysis.

Isokinetic sampling. Sampling conducted in such a manner that steam enters the ports of the sampling probe at the same velocity as it flows through the pipe, in the immediate vicinity of the sampling probe.

GENERAL PRINCIPLES

3. *a. Impurities in steam.* The impurities in steam may be solid, liquid, or gaseous and may consist of:

Boiler solids, including silica.

Products of corrosion.

Gaseous impurities such as ammonia, carbon dioxide, oxygen, volatile amines and other gases arising from the breakdown of conditioning chemicals or which may be introduced into the boiler via the feed water, or may be generated within the boiler.

Such substances may not necessarily be deleterious.

The impurities may not be uniformly dispersed in the steam and the methods of sampling described in the following sections have taken this factor into account.

Water in itself is not involved in this concept of steam purity, except insofar as it may carry solids in solution or suspension.

b. Sampling for impurities in steam. A sample of superheated steam is drawn from a pipe by a probe at a predetermined isokinetic rate. The entire sample is condensed under positive pressure and the condensed steam is collected in a suitable container and solid and gaseous impurities are measured.

A probe designed for isokinetic sampling is used. The probe is provided with sampling ports of equal diameter, the total cross-sectional area of which is not greater than about half the inside cross-sectional area of the probe. The pressure drop in the probe is kept low to provide an equal flow through the sampling ports. Sampling lines and connections are kept as short as possible.

c. Processing of the sample for measurement of impurities in steam. The sample is processed by one of the following methods, the choice depending on the information required.

NOTE. For complete analytical investigation the sample is condensed under pressure, delivered to a container and forwarded to a laboratory for analysis as described in B.S. 2690, Addendum No. 1*.

(i) *Determination of solids by evaporation.* This method is the most accurate but is not suitable for field testing. The sample is condensed under pressure and delivered to a container in which it is retained for subsequent laboratory investigation. At the laboratory the solids content is determined by evaporation to dryness and weighing the residue and the results expressed in parts per million.

(ii) *Determination of ionizable impurities by conductivity where gaseous impurities are negligible.* The steam is condensed under pressure by means of a simple condenser and the electrical conductivity of the condensed sample measured by means of any suitable conductivity meter. The appropriate conversion factor is used to convert conductivity into parts per million. This sample may also be used for the laboratory determination of silica, iron oxide and total solids.

(iii) *Determination of solid impurities by conductivity when gaseous impurities significantly interfere with conductivity measurement.* The preferred method is to condense the steam in a degasifying condenser (see Clause 7b). In this equipment the interfering gases are removed before the conductivity measurements are made. It is important that the satisfactory removal of gases by this equipment should be confirmed in each case before accepting the conductivity results.

NOTE. Certain volatile substances, e.g. amines are not removed by this equipment and other methods will have to be used.

Alternatively, the sample may be treated exactly as under (ii) above and a correction to the conductivity applied based on the ammonia and carbon dioxide contents of the sample which have to be measured separately. (B.S. 2690, Addendum 1*.) This correction is only very approximate and the method is not recommended if the interfering gases are present in such amounts that the conductivity correction exceeds 20 per cent of the measured conductivity. The method of applying the correction is described in Appendix A.

(iv) *Determination of gaseous impurities.* For this purpose the sample is obtained as described under sub-clause (ii) above and the concentration of gaseous impurities determined by the appropriate method described in B.S. 2690, Addendum No. 1*.

* B.S. 2690, 'Methods of testing water used in industry', Addendum No. 1.

SECTION TWO : SAMPLING

APPARATUS

4. The apparatus for the sampling of steam shall consist of the following items:

- Sampling probe (see Clause 5).
- Piping, valves and fittings (see Clause 6).
- Cooler-condenser (see Clause 7a).
- Degasifier and cooler-condenser (see Clause 7b).
- Equipment for the storage and transport of condensed steam sample (see Clause 8).

NOTE. The apparatus should be designed and tested for the pressure range in which it is intended to be used (B.S. 806*).

SAMPLING PROBE

(See also Appendix B for sets of calculations)

5. The sampling probe shall be of round section in a suitable stabilized austenitic steel of En 58 type, and designed for isokinetic conditions at the flow rate at which sampling is required. (B.S. 970†.) Alternatively, a streamlined section may be used where required by circumstances to reduce drag on the probe or minimize the disturbance of flow in the pipe.

The outside diameter of the probe shall be as small as practicable consistent with sufficient strength to eliminate the possibility of failure through vibration or erosion, but the wall thickness shall in no case be less than $\frac{1}{16}$ in (1.6 mm). The bore of the probe shall be such that its internal cross-sectional area is not less than about twice the total cross-sectional area of the ports.

For pipe diameters up to 8 in (203 mm) nominal bore the probe shall be inserted through the pipe wall and extend across the pipe on a diameter to within $\frac{1}{16}$ in (1.6 mm) of the opposite wall, as shown in Fig. 1. The length of the probe shall be fixed, after full allowance has been made for manufacturing tolerance on the pipe wall thickness, outer diameter and standpipe. This should be confirmed by actual measurement.

For pipe diameters of over 8 in (203 mm) nominal bore diametrically opposed probes are used as shown in Fig. 2 and clearance between the probes at the centre should not be greater than $\frac{1}{16}$ in (1.6 mm). The number of ports as given in Table 1 shall be equally divided between the diametrically opposed probes.

a. Sampling ports. The sampling ports shall be of equal size, not less than $\frac{1}{16}$ in (1.6 mm) diameter and face upstream into the steam flow. Each hole shall be cleanly drilled and free from burrs, and shall not be counter-sunk or chamfered. The total cross-sectional area of the ports shall be within ± 10 per cent of the exact area required for isokinetic sampling.

* B.S. 806, 'Ferrous pipes and piping installations for and in connection with land boilers'.

† B.S. 970, 'Wrought steels, En series'.