BRITISH STANDARD

BS 3680-8H: 1996
ISO 11655: 1995

Measurement of liquid flow in open channels —

Part 8: Measuring instruments and equipment —

Part 8H: Method of specifying the performance of hydrometric equipment

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee CPL/113, Flow measurement of surface and ground water, upon which the following bodies were represented:

British Waterways Board
Clyde River Purification Board
Department of the Environment (Water Directorate)
Institute of Measurement and Control
Institution of Civil Engineers
Institution of Water and Environmental Management
National Rivers Authority
Water Services Association of England and Wales

The following bodies were also represented in the drafting of the standard through subcommittees and panels:

British Hydrological Society
GAMBICA
Water Research Centre

This British Standard, having been prepared under the direction of the Electrotechnical Sector Board, was published under the authority of the Standards Board and comes into effect on 15 January 1996

The following BSI references relate to the work on this standard:
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Contents

National foreword

This Part of BS 3680 has been prepared by Technical Committee CPL/113 and is identical with ISO 11655:1995 *Measurement of liquid flow in open channels — Method of specifying performance of hydrometric equipment*, published by the International Organization for Standardization (ISO).

Other standards within the BS 3680-8 series on measuring instruments and equipment are as follows:

— *Part 8A: Current meters incorporating a rotating element*;

— *Part 8B: Recommendations for direct depth sounding and suspension equipment*;

— *Part 8C: Calibration of rotating-element current-meters in straight open tanks*;

— *Part 8D: Cableway systems for stream gauging*;

— *Part 8F: Hydrometric data transmission systems: general*;

— *Part 8G: Specification for system requirements for hydrometric telemetry systems*.

Cross-reference. The Technical Committee has reviewed the provisions of ISO 772:1988 to which normative reference is made in the text and has decided that it is suitable for use in conjunction with this British Standard. A related British Standard is BS 3680 *Measurement of liquid flow in open channels* — Part 1:1991 *Glossary of terms*.

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 and ii, pages 1 to 8, 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.

Introduction

This International Standard contains recommendations for a method of specifying the performance of equipment used for the sensing, measuring and, as appropriate, recording of physical variables related to measurement of liquid flow in open channels.

The process of sensing, measuring and recording hydrological phenomena requires the conversion of a time-related physical event or state into a numerical expression in terms relative to a standard scale of measurement units. The steps in the conversion are the following:

a) adaptation or conversion (as the individual situation requires) of the naturally occurring phenomenon into a state where a representative determination can be made;

b) if necessary, identification of a surrogate parameter and the establishment of the relation between changes in that parameter value and changes in the phenomenon to be measured;

c) sensing, measurement and (if appropriate) recording of the physical phenomenon or its surrogate as it varies with the passage of time;

d) conversion of sampled data into numerical information.

The ultimate measure of equipment performance is the evaluation of the uncertainty with which the equipment converts the absolute value or level of the hydrological variable into a measured quantity, relative to another arbitrary or fixed reference datum. The suitability of a piece of equipment, however, may also be related to the particular method of measurement and to the measurement frequency.

The nature of the uncertainty is closely related to the physical method or principle employed in the process of conversion from the natural variable to the measured quantity. Different physical systems are affected to differing degrees by such factors as:

— intrinsic design of the equipment;

— calibration methods;

— natural environmental factors;

— man-made environmental factors;

— levels of care and maintenance;

— operator methods and skills.

The user should seek to identify the three fundamental factors which may affect the uncertainty; these, which should be objectively defined from study of the method of measurement, are:

a) the level of uncertainty of each individual measurement due to the principle of operation of the measurement equipment;

b) the range of factors, for example environmental conditions (expressed numerically) and other external forces which influence the performance of the measurement equipment;

c) the frequency with which the hydrological variable should be sampled by the equipment in order to achieve the required level of data uncertainty.

The previous information represents the minimum which must be made available to the manufacturer before he can recommend a product or commence design and manufacture.

Taken together these factors describe the customer specifications for the performance of the measurement equipment.

Once a design is selected for the equipment, the specifications for use are established through the relevant standards documentation on methods of measurement. Levels of care and maintenance are laid down by the manufacturer in the equipment handbook, and should be adhered to if the manufacturer's claims of performance levels are to be achieved and maintained.

If followed by the manufacturer, this method will provide the user with a basis for understanding the ability of a particular piece of equipment to meet the purpose intended. It further provides a framework within which the user may specify his requirements to the manufacturer and against which he may judge the usefulness of a product.

1 Scope

This International Standard provides a method of specifying the performance of hydrometric equipment. It identifies, within a performance framework, the factors that affect the range of uncertainty within which the hydrological quantity is converted into a numerical quantity.

This International Standard applies to all equipment used for hydrological measurement, with the exception of equipment used for the determination of water quality. The sensor, the measurement system and the recorder are treated as a unit, whether operated in mechanical, electromechanical or electronic form, or using other physical principles. Because hydrological variables are frequently determined against time, the time measurement device is also considered to be an integral part of the measurement system.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 31-1:1992, *Quantities and units — Part 1: Space and time.*

ISO 31-3:1992, *Quantities and units — Part 3: Mechanics.*

ISO 772:—, *Measurement of liquid flow in open channels — Vocabulary and symbols*[1)].

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 772 and the following definitions apply.

3.1
influencing factor

condition (environmental or otherwise), element, or activity external to the measuring equipment which may influence equipment performance

3.2
performance measure

degree to which the intended functions of the equipment are accomplished

3.3
range

span of values of the quantity being measured or of an influencing factor

3.4
conditions of storage and transport

those conditions specified by the manufacturer under which equipment may be stored and transported in an inoperative state and may be subjected to influences outside those experienced in use or operation

under these conditions the equipment may be specially packed or protected in whatever way considered appropriate by the manufacturer, in order that the equipment should not suffer damage or degradation of performance when subsequently operated within the applicable range of conditions

3.5
conditions for normal operation

those conditions within which the equipment is expected to measure the parameter under study in accordance with the appropriate criteria of performance

the range of operational conditions shall be defined by the user

3.6
extreme conditions of equipment use

those conditions which exceptionally lie outside the range normally applicable to equipment operation, and against which the equipment is provided with no special protection

the equipment is expected to resume required performance levels as soon as the influencing factors return to within the range applicable to the operation mode. The limits of these conditions should be specified by the manufacturer

3.7
hazardous area

area in which exist hazardous conditions potentially capable of endangering safety by whatever means

the danger may arise through physical location or through exposure to a potentially explosive atmosphere, for example in sewers

3.8
overall performance level

statement of expected performance of the equipment, relative to the true values of the measured hydrological variable

3.9
timing performance

statement of expected performance of any timing element of the equipment employed to control the sampling rate or frequency

[1)] To be published. (Revision of ISO 772:1988)

4 Units of measurement

The units of measurement used in this International Standard are SI units, in accordance with ISO 31-1 and ISO 31-3.

5 Objectives

The purposes of this International Standard are

— to specify the terminology and definitions related to the functional performance of equipment used for the determination of hydrological data and information,

— to specify the requirements for statements by manufacturers, and

— to recommend the criteria to be identified by users/customers at the time of ordering/acquiring equipment for hydrological measurement purposes.

6 Equipment performance

6.1 Influencing factors

Before choosing equipment for measurement purposes, the user should ascertain that the equipment will provide the required operational performance relative to the chosen method of measurement under the range of factors which may influence that performance. These influencing factors are as follows.

6.1.1 *Atmospheric conditions*

a) Ambient temperature;

b) atmospheric humidity;

c) atmospheric pressure;

d) atmospheric quality (for example atmospheric contaminants);

e) atmospheric precipitation;

f) solar radiation;

g) wind speed;

h) environmental electrical discharges (natural and man-made);

i) electromagnetic interference.

6.1.2 *Aquatic conditions*

a) Water temperature;

b) water pressure;

c) water quality (for example pH, suspended solids, conductivity, visible oil).

6.1.3 *Mechanical factors*

a) Operating position;

b) vibration;

c) mechanical shock.

6.1.4 *Other factors*

a) Nature of energy source;

b) level of biological activity;

c) electrical interference through ground or water;

d) operator skill;

e) standards of operational maintenance.

6.2 Range of values of influencing factors

Manufacturers supplying equipment for hydrometric measurement purposes, either as complete measurement systems or as elements of such systems, shall provide statements of the limiting ranges of values for each of the influencing factors listed in Annex A, **A.1** to **A.3**.

Annex A presents three equipment situations for which ranges of influencing factors shall be provided:

a) equipment storage and transport, when the equipment is in an inoperative state;

b) equipment use when required to produce a functional signal only;

c) equipment operation when required to produce data within the performance limits declared by the manufacturer and in accordance with the requirements of clause **7**.

Equipment operating in accordance with this International Standard shall show no permanent damage or degradation of performance when, whether inoperative or in use, it is subjected to conditions where one or more of the influencing factors assumes a value within the limiting values of any of the ranges assigned for the equipment during a specified time. If no time limit is specified, it should be assumed that such conditions apply for an indefinite time. On re-establishment of conditions in which values of the influencing factors lie within the operating range, the equipment is expected to operate within the stated performance limits.

It is recommended that the user and the manufacturer use the checklist form in Annex A, in order to clearly identify all environmental and other influencing factors which may affect equipment performance.

It is further recommended that there be discussion between the manufacturer and the user in order to identify any combination of factors that may result in abnormal effects.

7 Overall equipment performance

7.1 General

The user shall state the allowable tolerance on any single parameter/measurement which lies within the operational range, subject to all influencing factor values lying within the range of operational use. The allowable tolerance may vary from one part of the range to another, in which case the user shall state both allowable tolerance values and the subdivision of the operational range over which any specific tolerance value applies.

The manufacturer shall state the performance characteristics of the equipment over the full operational range required by the user.

7.2 Resolution

The resolution of a device is its ability to define the value of a parameter, as qualified by the degree of discrimination possible. (Resolution may be specified in either absolute terms or relative terms; for example ± 10 mm, ± 0,5 % of full scale, 1 ppm.)

7.3 Repeatability

The repeatability is the ability of a device to provide the same measurement response when sensing the same absolute parameter values on different occasions, and when operating under identical influence factor conditions.

7.4 Response time

Response time is the time taken by the device to react to changes in the value of the parameter to be measured. (Response time may be given in terms of seconds to register a specified proportion of change in the parameter value.)

7.5 Uncertainty

The uncertainty is an estimate characterizing the range of values within which the true value of the parameter being measured lies when operating within the operational range of influencing factors. The value of uncertainty applies only when operating under steady-state conditions, and may be indicated in absolute or relative terms.

7.6 Timing performance

7.6.1 *General comments*

The user shall state the allowable tolerance on the measurement of reference time (real or elapsed) by any timing unit which controls the operation of the equipment.

7.6.2 *Timing performance for conventional timing devices*

This International Standard recommends specifying timing performance as follows, when using conventional mechanical timing devices.

7.6.2.1 *Timing performance for equipment in storage and transport*

Not applicable.

7.6.2.2 *Timing performance for equipment operation under extreme conditions*

Tolerances are to be stated by the manufacturer.

7.6.2.3 *Timing performance for normal equipment operation*

Tolerances are as follows:

a) for any 24-hour period:

reference time ± one part in 300 (± 5 min, approximately);

b) for any 30-day period:

reference time ± one part in 3 000 (± 15 min, approximately).

7.6.3 *Timing performance for superior electronically controlled timing devices*

This International Standard recommends specifiying timing performance as follows when using superior electronically controlled timing devices.

7.6.3.1 *Timing performance for equipment in storage and transport*

Not applicable.

7.6.3.2 *Timing performance for equipment operation under extreme conditions*

Tolerances are to be stated by the manufacturer.

7.6.3.3 *Timing performance for normal equipment operation*

Tolerances are as follows:

a) for any 24-hour period:

reference time ± one part in 3 000 (± 30 s, approximately);

b) for any 30-day period:

reference time ± one part in 30 000 (± 90 s, approximately).

7.6.4 *Other devices*

Equipment which incorporates timing control systems capable of operating at the superior performance level should be designated with the suffix notation/SPT (superior performance timing).

7.7 Reliability

For equipment whose age is outside the initial warranty period and which has been maintained and operated in accordance with the manufacturer's recommendations, the manufacturer shall state the expected mean time between failures and the basis of its determination.

7.8 Period of unattended operation

The user shall state requirements for the period of unattended operation. The manufacturer shall state the maximum period over which the equipment is capable of operation without exhaustion of energy supply, saturation of the equipment data storage or memory under specified requirements of operation, or within which the equipment will operate without required adjustment or loss of performance.

7.9 Remote check calibration

Where equipment is to be operated remotely, the user may specify requirements for remote check calibration, either from a central control station or automatically at the measuring location.

7.10 Manufacturer's certification

The manufacturer shall provide the necessary certificate of calibration evaluating the performance characteristics listed in **7.2** and **7.3**, where applicable.

8 Data output formats

This International Standard does not specify the design of interfaces for the removal of data recorded by the equipment, nor the format of the data output; nevertheless the manufacturer should use approved and commonly adopted interfaces and data formats. Where data are held in solid-state memory, the equipment should be capable of releasing data at a rate of not less than 1 200 baud.

9 Energy requirement

The manufacturer shall state the energy requirement of the equipment in terms of voltage and current consumption for its various operational states, for example during quiescent periods, during sampling and data recovery. He shall state the expected life of battery-operated equipment when operating under normal conditions.

10 User requirements

In any contract, the user is required to state the following.

10.1 Requirements in terms of equipment performance

See **7.2** to **7.6**.

10.2 Primary characteristics of the hydrological phenomena to be measured

a) Maximum and minimum parameter values likely to be encountered at the measurement site;

b) maximum and minimum parameter values (i.e. the range) to be detected/indicated and, as appropriate, recorded;

c) maximum rate of change to be accommodated by the equipment (this may be stated as a single maximum rate over a given period of time, or as differential rates which correspond to different time periods).

10.3 Attenuation of oscillations in hydrological phenomena, if necessary

Specific requirements stating the degree and nature of the attenuation shall be given.

10.4 Required frequency of sampling of the hydrological parameters

User requirements will normally fall within the accepted regulations of recognized International Organizations (for example the World Meteorological Organization).

Annex A (informative) Recommended checklist

This annex presents a checklist recommended for agreement between user and manufacturer as to the values of the environmental factors which may influence the performance of hydrometric equipment.

It covers the transport and storage of the equipment, the limiting conditions for use of the equipment and the conditions for normal operation of the equipment.

A.1 Record of the atmospheric environmental factors which may influence the performance of hydrometric equipment

A.1.1 ***Ambient temperature — Range limits***

A.1.1.1 *Range limits of temperature during equipment storage and transport*

a) Upper limit: reference value + ... °C;

b) lower limit: reference value – ..... °C.

A.1.1.2 *Range limits of temperature for extreme conditions of use*

a) Upper limit: reference value + ... °C;

b) lower limit: reference value – ..... °C.

A.1.1.3 *Range limits of temperature for normal operation*

a) Upper limit: reference value + ... °C;

b) lower limit: reference value – ..... °C.

A.1.2 ***Atmospheric humidity — Range limits***

Because extreme values of both temperature and humidity are not likely to occur simultaneously, the manufacturer may specify the time period over which these values may be applied and shall specify the limits of the combination, if any, for continuous operation.

A.1.2.1 *Range limits of relative humidity for storage and transport of equipment*

a) Upper limit: to be stated by the manufacturer;

b) lower limit: to be stated by the manufacturer.

A.1.2.2 *Range limits of relative humidity for extreme conditions of equipment use and for normal operation*

a) Upper limit: ..... %

(without condensation);

b) lower limit: ..... %

(without condensation).

NOTE 1 Ranges of relative humidity for extreme conditions of equipment use and for normal operation are identical unless otherwise stated by the manufacturer.

A.1.3 ***Atmospheric pressure — Range limits***

A.1.3.1 *Range limits of atmospheric pressures for storage and transport*

a) Upper limit: to be stated by the manufacturer;

b) lower limit: to be stated by the manufacturer.

NOTE 2 Special precautions may be necessary in the event of transport by air freight.

A.1.3.2 *Range limits of atmospheric pressures for extreme conditions of equipment use and for normal operation*

a) Upper limit: local mean atmospheric pressure + ... hPa;

b) lower limit: local mean atmospheric pressure – ..... hPa.

NOTE 3 The ranges of atmospheric pressure for extreme conditions of equipment use and for normal operation are identical unless otherwise stated by the manufacturer.

A.1.4 ***Atmospheric quality — Range limits*** (with reference to the content of contaminating gas, vapour, sand or dust particles, salt spray, etc.)

The ranges of values for atmospheric quality, whether relative to equipment storage, transport or operation, are likely to be identical.

NOTE 4 While under ideal circumstances the atmospheric concentration of any contaminant would be negligible, it should theoretically be taken into account in this International Standard. Equipment may be required to operate in atmospheres subject to varying degrees of contamination. Under these circumstances the user should identify the contaminant or contaminants and their likely maximum levels in order that the manufacturer may indicate the suitability of his product for that application or state upper range limits for these contaminants.

A.1.5 ***Atmospheric precipitation — Maximum levels***

Ranges are to be provided in units of millimetres per hour (mm/h) or in millimetres per day (mm/d) according to whether the hydrological measurements will be affected by short-term (storm-type) precipitation phenomena or by cumulative precipitation over a longer period.

A.1.5.1 *Maximum levels of atmospheric precipitation for storage and transport*

The upper limit of allowable atmospheric precipitation (if appropriate) is to be stated by the manufacturer.

A.1.5.2 *Maximum levels of atmospheric precipitation for extreme conditions of equipment use and for normal operation*

The maximum values of atmospheric precipitation for extreme conditions of equipment use and for normal operation are likely to be identical and, if relevant, should be defined by the user.

A.1.6 *Solar radiation — Maximum levels*

A.1.6.1 *Maximum solar radiation levels for storage and transport*

Upper limit: to be stated by the manufacturer.

A.1.6.2 *Maximum solar radiation levels for extreme conditions of equipment use and for normal operation*

Upper limit: ..... W/m^2 (energy-related illumination)

or

..... J/m^2 (energy-related exposure)

NOTE 5 The combined heating effect of solar radiation plus ambient temperature should not cause the surface temperature of any of the component elements of the equipment to exceed the range limits of ambient temperature alone.

NOTE 6 The maximum solar radiation levels for extreme conditions of equipment use and for normal operation are identical unless otherwise stated by the manufacturer.

A.1.7 *Maximum wind speed*

A.1.7.1 *Maximum wind speeds and direction for storage and transport*

If relevant, any precautions to protect equipment during storage and transport shall be stated by the manufacturer.

A.1.7.2 *Maximum wind speeds and direction relative to extreme conditions of equipment use and to normal operation*

Only those elements of the equipment likely to be exposed to wind are subject to this recommendation. Measurements of wind speed and direction applicable to this clause are to be measured in the immediate proximity and at the same height as the equipment.

Upper limit: based on the local maximum hourly recorded wind speed

+ ..... % for gusting effects.

NOTE 7 Maximum wind speeds and direction relative to extreme conditions of equipment use and to normal operation are identical unless otherwise stated by the manufacturer.

A.1.8 *Environmental electrical discharges or electrical or electromagnetic field strengths or other radiation — Range limits*

a) Upper level: to be stated by the manufacturer;

b) lower level: no measurable value.

NOTE 8 The ranges of values of electrical discharges, electrical or electromagnetic field strengths, etc., whether relative to equipment storage, transport, extreme conditions of equipment use or normal operation, are likely to be identical.

A.2 Aquatic environmental factors which may influence the performance of hydrometric equipment

NOTE 9 These factors affect only such elements of the equipment which are in contact with or immersed in water during normal operation. Thus they do not apply to conditions for storage and transport.

A.2.1 *Water temperature — Range limits for extreme conditions of equipment use and for normal operation*

a) Upper limit: + ... °C;

b) lower limit: – ..... °C.

NOTE 10 Water temperature ranges relative to extreme conditions of equipment use and to normal operation are identical unless otherwise stated by the manufacturer.

A.2.2 *Water pressure — Range limits*

A.2.2.1 *Range of values for water pressure relative to extreme conditions of equipment use*

a) Upper limit: upper operational range limit + 50 %;

b) lower limit: 0 gauge pressure.

A.2.2.2 *Range of values for water pressure relative to normal equipment operation*

a) Upper limit: to be determined by the manufacturer but normally not less than 10 m H_2O [2)];

b) lower limit: 0 gauge pressure.

A.2.3 *Water quality — Range limits*

These limits refer to the content of dissolved solids, the presence of contaminants, dissolved gases, miscible or immiscible liquids, or suspended solids.

A.2.3.1 *Range limits of components affecting water quality for extreme conditions of equipment use and for normal operation*

The range limits of water quality parameters relative to extreme conditions of equipment use and for normal operation are likely to be identical.

While under ideal conditions the content of dissolved miscible, immiscible or suspended matter is likely to be minimal, natural waters contain highly variable levels of a wide range of matter. Under these circumstances the user shall specifically identify each component of interest affecting the water quality, in order that the manufacturer may indicate the suitability of his product for that application or state upper range limits for those components.

The components affecting water quality which are most frequently met in natural waters may be assigned limiting values.

[2)] 1 m H_2O = 9,806 65 Pa

A.2.3.2 *Range limits of pH values for extreme conditions of equipment use and for normal operation*

a) Upper level: pH ..... ;

b) lower level: pH ..... .

A.2.3.3 *Maximum level of suspended solids for extreme conditions of equipment use and for normal operation*

Upper value: ..... mg/l.

In certain cases it may be necessary to indicate the presence of bed or wash loads and floating solids.

A.2.3.4 *Maximum level of conductivity for extreme conditions of equipment use and for normal operation*

Upper value: ..... µS.

A.3 Mechanical factors which may influence the performance of hydrometric equipment

A.3.1 *Operating position — Range limits*

In the case of certain items of hydrometric equipment, their performance is sensitive to the operating position. The manufacturer shall state the recommended operating position and the acceptable tolerance during operation.

For equipment whose performance is not sensitive to orientation, no specification of operating position is required.

A.3.2 *Vibration — Maximum level*

The maximum level of mechanical vibration applicable to equipment in all modes of storage, transport and operation is likely to be identical.

Upper limit: to be stated by the manufacturer.

A.3.3 *Mechanical shock — Maximum level*

A.3.3.1 *Maximum level of mechanical shock during equipment storage and transport*

The manufacturer shall specify the mode of packaging to obviate damage.

A.3.3.2 *Maximum level of mechanical shock during extreme conditions of equipment use and during normal operation*

a) Upper limit: to be stated by the manufacturer;

b) recommended maximum upper limit:

..... g m/s in any three mutually perpendicular axes.

NOTE 11 The maximum levels of mechanical shock relative to extreme conditions of equipment use and to normal operation are likely to be identical.

A.4 Power source fluctuations — Range limits

Equipment operated through a power source drawn from a national supply utility may be sensitive

— to fluctuations in supply voltage, and

— to fluctuations in supply frequency.

The manufacturer shall state whether the equipment is sensitive to fluctuations of the above factors and accordingly specify the limits on the reference values of voltage and frequency.

Where batteries are employed as power sources, the range of voltage for proper performance of the equipment shall be specified by the manufacturer.

List of references

See national foreword.

BSI — British Standards Institution

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