

BS 7843-1:2012



BSI Standards Publication

Acquisition and management of meteorological precipitation data from a raingauge network

Part 1: Guide for the design, development and review of a raingauge network

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Contents

Foreword *ii*

Introduction *1*

1	Scope	1
2	Normative references	1
3	Terms and definitions	2
4	Data requirements	4
5	Objectives of a precipitation data acquisition system	7
6	Network design	8
7	Implementation of change	11
8	Network monitoring and review	16

Annexes

Annex A (informative) Summary of typical user requirements for precipitation data **18**

Annex B (informative) Analysis of the uncertainty of precipitation measurement **19**

Annex C (informative) Characteristics of precipitation estimates from radar **23**

Bibliography **30**

List of figures

Figure 1 – A process for network design **9**

Figure 1 – Typical production system showing flow of precipitation data **11**

Figure C.1 – The radar network in 2010 giving coverage over the UK, Ireland and Jersey **24**

Figure C.2 – 15 year time series of RMSF with a 0.2 mm hr⁻¹ threshold **29**

List of tables

Table A.1 – Summary of typical user requirements for precipitation data **18**

Summary of pages

This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 32, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 7843 is published by BSI and came into effect on 31 December 2011. It was prepared by Technical Committee CPI/113, *Hydrometry*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

BS 7843-1:2012, together with BS 7843-4:2012, supersedes BS 7843-1.1:1996 and BS 7843-1.2:1996, which will be withdrawn on the publication of BS 7843-4:2012.¹⁾

Together with BS 7843-2:2012, BS 7843-1:2012 supersedes BS 7843-2.1:1996, which is withdrawn.

Together with BS 7843-3:2012, it supersedes BS 7843-3.1:1999 and BS 7843-3.2:2005, which will be withdrawn on the publication of BS 7843-3:2012.¹⁾

Relationship with other publications

BS 7843, *Acquisition and management of meteorological precipitation data from a raingauge network*, comprises four parts.

- *Part 1: Guide for design, development and review of a raingauge network.*
- *Part 2: Code of practice for operating raingauges and managing precipitation data.*
- *Part 3: Code of practice for the design and manufacture of storage and automatic collecting raingauges.*¹⁾
- *Part 4: Guide for the estimation of areal rainfall.*¹⁾

Information about this document

This is a full revision of the standard.

As a guide, this part of BS 7843 takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this part of BS 7843 is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

¹⁾ In preparation. Publication expected early in 2012.

Introduction

Precipitation totals and intensities are measured at frequencies ranging from seconds to months, and the data are required on timescales ranging from the immediate to several weeks in arrears. The requirements for precipitation data are numerous and varied, and measurements are made by many different organizations and individuals using a variety of instruments and techniques. Individual instruments might be operated for a dedicated purpose at specific locations, or larger numbers might be arranged into networks covering wide areas. Radar has made a major impact on the estimation of areal precipitation totals and intensities by detailing precipitation events at high resolution in space and time. However, the techniques for converting radar measurement to an estimate of areal precipitation are subject to uncertainties that might be particularly large in certain meteorological or topographical situations. Measurements from raingauges complement radar measurements and play a central role in providing precipitation data.

Many different types, shapes and sizes of raingauge are acceptable for the measurement of rainfall, each reflecting a specific requirement. Most consist of a circular collecting device, delineating the fixed area of the sample, and a funnel leading into a storage reservoir and/or measuring system. Some types of automatic gauge do not require a funnel.

Raingauge networks are of particular importance at a time of actual, or anticipated, change in rainfall patterns or characteristics. Identifying and quantifying any such changes is a strategic imperative with direct relevance across a broad range of applications. A national raingauge network providing data for a national archive is essential to meet these and other requirements. The national archive holds precipitation data collected by many different regional and local network operators, each of which may hold its own archive locally. The methods of implementing and operating such a system described in this British Standard ought to result in the generation and storage of precipitation data of known quality.

1 Scope

This part of BS 7843 gives guidance on the design, development and review of UK networks of collecting raingauges that meet user requirements in the most cost-effective way. It is applicable to raingauges deployed at ground level or close to the ground for the purpose of measuring precipitation in mm of water equivalent.

Remote sensing raingauges, devices that detect the presence of precipitation particles and weather radars are not covered by this standard.

This part does not give guidance on the installation or maintenance of individual collecting raingauges. Recommendations for these are given in BS 7843-2.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7843-2:2012, *Acquisition and management of meteorological precipitation data from a raingauge network – Part 2: Code of practice for operating raingauges and managing precipitation data*

BS EN ISO 772:2001, *Hydrometric determinations – Vocabulary and symbols*

3 Terms and definitions

For the purposes of this part of BS 7843, the terms and definitions given in BS EN ISO 772:2001 and the following apply.

3.1 areal precipitation

value of precipitation within a specified time interval averaged over a specified area

3.2 calibration

process which establishes, under specified conditions, the relationship between the values indicated by a raingauge and the corresponding known values indicated by a measurement standard with associated measurement uncertainties

3.3 daily precipitation

total precipitation that accumulates over 24 h ending at 0900 UTC

NOTE Some newspapers and websites attribute the 24 h accumulation measured at 0900 UTC to the previous day.

3.4 data flag

indicator relating to the quality and characteristics of a precipitation value

3.5 exposure

extent of shelter or protection from the weather

3.6 inspection

review of the suitability and effectiveness of all aspects of the site, the equipment and the processes that impact on the quality of precipitation data from the site

3.7 maintenance

process that ensures that the site and equipment continue to function correctly for the measurement of precipitation

3.8 manual reading

measurement of precipitation made by an observer using a storage raingauge and a rain measure

3.9 monthly precipitation

total precipitation from 0900 UTC on the first day of the month to 0900 UTC on the first day of the following month

3.10 observer

person who takes manual readings

3.11 observing system

equipment and processes at the site employed for the measurement of precipitation and the logging and processing of precipitation data

3.12 operational (adj)

undertaken regularly, on a permanent basis and according to well-defined methods

3.13 operational performance monitoring

process for identifying possible problems or incidents with the production of precipitation data on short timescales

NOTE Generally less than 24 h.

3.14 precipitation

water or ice derived from the atmosphere and deposited at ground level

NOTE Measured in terms of the depth in mm of its liquid equivalent.

3.15 precipitation metadata

records relating to the site, the equipment and the operating practices that specify the circumstances under which precipitation measurements are made

3.16 production system

equipment and processes employed for the operational production of precipitation data

3.17 quality control

process for identifying measurements of precipitation which are erroneous to the extent that they lie outside the range of values that might be reasonably expected

NOTE The quality control process includes the provision of best estimates of the true values of erroneous data.

3.18 rainfall

total liquid component of precipitation, including condensation from the atmosphere, collected and measured by a raingauge

3.19 rain measure

graduated measuring cylinder made of clear glass or plastic used by the observer for measuring the volume of collected liquid and melted solid precipitation

3.20 raingauge**3.20.1 automatic raingauge**

collecting raingauge that measures rainfall by automatic means

NOTE Also known as a recording raingauge. This may include data processing and logging capability.

3.20.2 collecting raingauge

instrument that collects precipitation falling through an orifice of known cross-sectional area for the measurement of its water equivalent volume, mass or weight accumulated over a measured period

3.20.3 storage raingauge

collecting raingauge that accumulates rainfall and melted solid precipitation in a collecting vessel for manual measurement of its volume

3.21 real-time data

data obtained while the precipitation event to which it relates is occurring

3.22 site

area of ground where a raingauge is deployed for measurement or has been deployed in the past

NOTE Other instruments for measuring the environment may also be deployed at the site.

3.23 UTC

Coordinated Universal Time

4 Data requirements

4.1 Application areas

4.1.1 General

Different organizations require precipitation data for varying applications, and these are described in 4.1.2 to 4.1.15. The design, function, siting, etc., of a raingauge network depends upon these requirements.

NOTE A summary of typical user requirements is given in Annex A.

4.1.2 Flood forecasting and warnings

High temporal and spatial resolution rainfall data are required in real time for rainfall run-off models used for fluvial and pluvial flood warnings. Combined with radar rainfall data they are used for monitoring rainfall events to identify when predetermined thresholds have been exceeded. In non real time, rainfall data are required for developing run-off models and generating statistics that put forecasts into context (e.g. return periods).

4.1.3 Weather forecasting

High temporal and spatial resolution rainfall data are required in real time for numerical weather prediction models and general weather forecasting. Combined with radar rainfall data they are used for monitoring weather events and informing decisions on forecasts and warnings. In non real time, rainfall data are required for validating models and generating statistics that put forecasts or events into context.

4.1.4 Water resources operation

For river regulation and reservoir operations purposes rainfall data might be required in real time for inputs to rainfall run-off and reservoir flow routing models. These help to inform abstraction and compensation-flow decision making during drought and flood events. For groundwater and soil moisture models, daily rainfall data are normally sufficient.

4.1.5 Water resources planning

Resource planning decisions, often with the aid of simulation models, require daily, weekly or monthly interval data for both rainfall and aquifer recharge estimates held in long-term archives. Sometimes this involves simulating critical droughts with the use of low monthly rainfall and reservoir inflow time-series sequences combined with high soil moisture deficits.

4.1.6 General climatology

High spatial resolution rainfall data are needed to define the general climatology as part of the public weather service provided for the national benefit. The data are analysed to generate a wide range of products, including gridded averages, extremes and return periods.

NOTE The methodology used for creating gridded data is described in BS 7843-4.

4.1.7 Detecting climatic variability and change

Long-term trends and multi-decadal cycles in the patterns and intensity of rainfall are significant in relation to a wide range of user needs, and are of particular importance for the development of climate change adaptation strategies. The detection of changes in average and extreme rainfall patterns requires long historical records from a selection of sites where, over time, there have been few changes to the conditions under which the measurements have been made. The exceptionally demanding requirements for minimizing measurement uncertainty have led to the publication of WMO GCOS Climate Monitoring Principles 1-10 [1].

4.1.8 Flood risk management

Extreme storm and flood frequency analysis requires long-term statistical analysis of rainfall depth durations and their probability of occurrence expressed in terms of a return period.

Long-term records for both daily storage and recording raingauges are used:

- a) to compile these statistics which are routinely used with incoming intensity data for estimating the return period of recent storm and flooding events; and
- b) as the basis for producing design flood hydrographs in flood alleviation schemes generated from rainfall run-off models in combination with hydrodynamic flow routing models, or reservoir routing models for reservoir safety planning.

Intensity data are used in real time from radar and raingauge networks, often a combination of both, for input into rainfall and/or flood forecasting models, and when issuing flood warnings.

4.1.9 Environmental protection and improvement

Point rainfall intensities are required for urban drainage improvement design studies for reducing sewer flooding or pollution of watercourses or bathing beaches, e.g. from combined sewer overflow (CSO) spills. This normally requires data to be collected for short-term surveys of between 1 and 6 months for input into sewer drainage design models. Increasingly, intensity data are required in real time from both recording raingauges and radar for monitoring sewer and CSO performance, and for alerting sewer maintenance teams.

4.1.10 Ecosystem management

The use of rainfall data to estimate river flows and water storage is key to meeting the requirements of the European Water Framework Directive [2]. The Directive promotes ecological status as the fundamental environmental objective. This requires consideration of the quantity and dynamics of river flows that drive hydro-morphological processes and the creation of floodplain habitats. Flow data are also used by regulating bodies to license activities that have potential to degrade ecological status such as water abstraction, effluent discharge, river impoundment and engineering activities. Rainfall inputs are also used to understand site hydrology for effective wetland conservation and impact assessment. Typical applications include quantifying recharge sources (rainfall verses groundwater), site sensitivity and recovery times.

4.1.11 Waste water treatment

The performance of waste water treatment works can be impacted by high intensity precipitation. High temporal resolution rainfall data covering sub-catchments is required for real-time operational purposes.

4.1.12 Agriculture

Agricultural uses of rainfall data include drainage design, crop growth modelling, irrigation operations and the prediction of the spread of certain crop and animal diseases.

4.1.13 Commerce and industry

Rain and snow events can have a large impact on many areas of commerce and industry, e.g. disrupting transport or a construction programme, and can lead to costly insurance claims. Retail sales of some products are significantly correlated with rainfall. For many commercial companies point rainfall data are used in both the operations and planning sides of the business.

4.1.14 Radar adjustment

The UK radar product that provides values of precipitation intensity on grids of 1 km, 2 km and 5 km resolution is used for flood forecasting, weather forecasting and for many other applications. Radar measurements are subject to systematic bias which can be reduced by the use of raingauge data. Real-time precipitation data from sites in the vicinity of each radar are required for this purpose.

4.1.15 Research

A very wide range of precipitation data are required for research purposes. Where past data acquired for other applications do not meet a specific research requirement, a small dedicated network should be established, normally for a limited period, to generate the relevant data. Measurements of other environmental parameters might also be required.

4.2 Aspects of precipitation data requirements

Requirements for precipitation data should take into account both the liquid and solid phases, including the amount of rain in a stated period; the amount of solid precipitation in a stated period and the amount of accumulated solid precipitation lying on the ground at a stated time. An assessment of requirements should take into account a number of factors including the following.

- a) *Spatial density.* Many different application areas have a requirement for precipitation data from a number of sites, which is usually best expressed in terms of the spatial density of raingauges. The required density could be greater in some areas than others.
- b) *Specific locations.* For example, collocation with other environmental networks already in place.
- c) *Time resolution.* High time resolution intensity data are required to capture the detail of extreme rainfall events.
- d) *Length and continuity of record.* Some applications require long-term series of data where there is consistency of measurement over time. Other requirements can be met by a temporary monitoring programme.
- e) *Uncertainty of measurement.* Upper bounds for uncertainty should differentiate between systematic and random errors. Where data are required to generate areal estimates, the degree to which measurements are representative of the local area should be taken into account.

NOTE See Annex B for further information on uncertainty.

- f) *Timeliness.* Operational activities generally require data in real time, while planning and research activities often make use of data long after the event.

- g) *Reliability and completeness of data record.* Gaps in the data record could be a serious problem for some applications.
- h) *Instrument performance for frozen precipitation and in freezing conditions.*
- i) *Quality control.* Timeliness and scope of the quality control process might be important.
- j) *Precipitation metadata.* Current and historical metadata required to understand the characteristics of the precipitation measurements.
- k) *Format and delivery.* Requirements for digitized historical data should be considered.
- l) *Archiving and access to data.*

4.3 Statement of data requirements

An analysis of requirements for precipitation data should be undertaken at regular planned intervals. Representatives of data users from each relevant application area (see 4.1) should be consulted for their assessment of the data requirements listed in 4.1 and 4.2. Records of this statement of requirements should be maintained.

The statement of requirements should:

- a) be technology-free wherever possible;
- b) address present and future requirements;
- c) identify whether requirements are for operational or long-term applications; and
- d) give an indication of the value of the data and their dependence on the degree to which the requirements might be met.

For most applications, there is usually no abrupt transition in the utility of data as changes are made to meet specific requirements. For this reason it is helpful to express requirements for each application area at three different levels:

- 1) a minimum level that has to be met to ensure the data are useful;
- 2) a maximum level, beyond which further improvement in observing capability delivers little significant additional benefit; and
- 3) an optimum level, between the minimum and the maximum, which delivers the greatest benefit for a given cost.

5 Objectives of a precipitation data acquisition system

The requirements for precipitation data covering the applications outlined in 4.1 can be met by various networks of sites and systems for the processing and storage of data. For many applications the development and support of a national archive of precipitation data is an important objective. The national archive should:

- a) include current and historical precipitation measurements from as many sites as possible;
- b) provide a complete set of precipitation metadata;
- c) provide assurance of the quality of the measurements, including data flags; and
- d) provide ease of access to the data.

A procedure should be undertaken at regular intervals to determine which raingauges contribute to the national archive. Selection should be based on the suitability of the site and the quality of the precipitation data, taking into consideration inspectors' reports, quality control results and other relevant information.

6 Network design

6.1 Change programme

Network design is a process that, taking as its input the statement of requirements for precipitation data, identifies a programme of change that meets the data requirements in the most cost-effective way. The stages of design are shown in Figure 1 which follows the procedure defined by WMO No. 544, Part II, Requirements for observational data [3]. For a country such as the UK with well-established raingauge networks that have evolved over a great many years, a change programme usually builds on existing infrastructure, but small networks may be created to fill significant gaps. Development of the capability of weather radars is out of scope of the change programme, but the ability of radar to meet many aspects of the user requirements should be taken into account at all stages of the network design process.

NOTE See Annex C for characteristics of precipitation estimates from radar.

Many applications require raingauge data to estimate areal accumulations on a local or a national scale. Guidance on raingauge densities that allow areal estimates to be calculated to a target accuracy are a valuable aid to network design. For the purpose of calculating areal estimates of precipitation (see BS 7843-4), measurements should capture geographical variability and be spatially and temporally representative of the actual precipitation over the extent of the network.