

Guide to the acquisition and management of meteorological precipitation data —

Part 1: Network design —

Section 1.1 The user requirement for precipitation data

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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
- 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:

- Forth River Purification Board
- Imperial College, London
- Institute of Hydrology
- Meteorological Office

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Foreword

This Section of BS 7843 has been prepared by Technical Committee CPL/113. BS 7843 is a new publication and no other standard has been superseded or withdrawn.

This Section is one of a series of related publications on the acquisition and management of meteorological precipitation data, the overall structure of which is as follows:

- *Part 1: Network design;*
- *Section 1.1: The user requirement for precipitation data;*
- *Section 1.2: Network design and monitoring;*
- *Part 2: Field practices and data management;*
- *Section 2.1: Technical aspects in the field;*
- *Section 2.2: Methods of observation and data tabulation;*
- *Section 2.3: Data management;*
- *Section 2.4: Areal rainfall.*

This British Standard 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.

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 18, 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

Precipitation totals are measured with varying frequencies, over periods of time ranging from minutes to months, and the data are required to be made available to the user with a timeliness varying from immediate to several months in arrears. Many different agencies and individuals make the measurements for a very wide spectrum of users, and there is a plethora of instruments and techniques available. Single instruments may be operated for a dedicated purpose, or larger numbers may be arranged into networks of various densities. Radar has made an impact upon the estimation of areal rainfall totals.

The user may be confronted with data containing elements of varying quality and reliability with a consequential reduction in confidence in meeting the accuracies specified for many applications. In some cases, there is the additional complication of differing data formats. Development and use of this British Standard will result in a database of known minimum quality and hence accuracy.

There is a continuing need for a national network and a related archive. These act as a reference to which regional and local networks may be related as well as describing broad scale climatology. Part 1 of this British Standard describes good practice for all networks and related archives, regardless of areal extent or status.

1 Scope

British Standard BS 7843:1996 provides guidance on procedures for the measurement of meteorological precipitation, and for the collection, quality control, archiving and exchange of the data obtained from the measurement.

Part 1 of BS 7843 describes the user's criteria, and the design of rain gauge networks to enable the desired data to be obtained.

Part 2 of BS 7843 gives guidance on practical aspects of field work for the acquisition of the data, and for the subsequent transmission, quality control and archiving of the data obtained.

This Section considers in detail the users' needs from precipitation data.

2 References

2.1 Normative references

This Section of BS 7843 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on the inside back cover. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this Section of BS 7843 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This Section of BS 7843 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this Section of BS 7843 are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Section of BS 7843, the definitions given in BS 3680-1:1991 apply together with the following.

3.1

national

throughout the United Kingdom

3.2

regional

within regional sub-divisions of the United Kingdom

3.3

local

within an area which is smaller than a region, such as the whole or part of a river basin

3.4

precipitation

any aqueous deposit, in liquid or solid form, derived from the atmosphere

3.5

frozen precipitation

deposits of snow, hail and hoar frost that melt, the resulting water being measured and recorded as rainfall

**3.6
rainfall**

the total liquid product of precipitation or condensation from the atmosphere as received and measured in a raingauge

**3.7
daily rainfall**

the total rainfall that accumulates over 24 hours ending at 0900 UTC. For general use this total is credited against the previous day's date

**3.8
monthly rainfall**

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

**3.9
areal rainfall**

the value of rainfall averaged over a specified area

**3.10
raingauge**

an instrument for measuring rainfall

**3.11
standard raingauge**

a manual raingauge having a level circular collector 127 mm (5 in) in diameter, exposed at 305 mm (12 in) above ground level

**3.12
real time data**

data which is obtained in sufficient time to influence a process whilst it is still in progress

**3.13
event data**

rainfall measured by an automatic measuring system comprising a collector of fixed volume and time recording apparatus. Each "event" is represented by the point in time at which the accumulation of the fixed volume is recorded

**3.14
period data**

the sum of "event" data or a single measurement accumulated at a point in time; e.g. hourly rainfall at 1 100 hrs would be the sum of tipping bucket tips counted over a period of one hour between 1 001 and 1 100 and accredited to 1 100

**3.15
mesoscale**

the scale appropriate to atmospheric systems ranging from individual cumulus clouds to major depressions and anticyclones

**3.16
macroscale**

the scale covering the majority of a continent or a substantial part of the Earth's surface

**3.17
domain**

a geographical area with specific and common characteristics of precipitation

**3.18
averaged annual rainfall (AAR)**

the arithmetic mean of the water equivalent of the annual sums of daily amounts of precipitation, measured at a point over a period of time, usually 30 years

**3.19
depth/duration/frequency (of precipitation)**

the amount of precipitation at a point, or within a domain, in terms of equivalent depth on the ground, the time taken for an amount to fall, or the frequency of occurrence of the amount

**3.20
point/area precipitation data**

the relationship between data averaged over an area and the assorted set of measurements taken by raingauges at points within or close to that area

**3.21
reference raingauge site**

- 1) A site where comparisons between raingauges are carried out.
- 2) A site where rainfall measurements have been made for a long period of time, e.g. in excess of 10 years.

**3.22
normalization**

a mathematical procedure for adjusting rainfall data according to the annual average rainfall for the locality

4 Identifying the users' needs for precipitation data

4.1 General

For all purposes, the aim of a precipitation gauge network is to provide a density and distribution of raingauges such that, by interpolation of the data from different locations and using data from other sources (e.g. radar) as appropriate and when available, it is possible to determine with sufficient accuracy the characteristics of precipitation within the area of the network. It is necessary to determine what is meant by sufficient accuracy and this can only be done by surveying the likely uses of the data with due regard to the causes of error, (see Annex A). In general, precipitation totals for periods of a day or longer are used rather differently from those accumulated over periods of hours (i.e. less than 24h) or minutes. For this reason, the daily or longer term data are considered separately in this document from the shorter period data.

4.2 Daily, monthly and longer period totals

4.2.1 Data uses

Some of the major uses of daily and longer period totals are as follows. An analysis of a survey of data usage is given in Annex B.

a) Water resources operation

Essential water resources operation requires real-time or near real-time data. For example, river regulation requires real-time telemetred data so that operational decisions can be made on the basis of catchment model forecasts of natural flows. For catchment areas of 100 km² errors of up to 5 % for daily totals are acceptable on days with rainfall totals in excess of 1 mm. Historical data are needed at the design stage of regulation projects. Longer term uses of regulation to reduce soil deficit by irrigation requires monthly area rainfall totals with errors not exceeding approximately 10 %.

b) Agricultural use including soil moisture deficit (SMD)

Agricultural use includes drainage design, crop growth modelling and also estimation of irrigation needs. The latter application usually demands "on-farm" gauging, and in some cases near real-time data. Typically, an accuracy of 10 % is required with a 30 km to 40 km resolution. However, the acceptable error range for SMD applications varies from less than 5 % to 20 %.

c) General climatology, climate change and enquiries

The climatological need is for daily and monthly areal totals, for areas of 5 km² and larger, whereas climatic change demands monthly point totals with errors of less than 5 % from groups of long period stations. The World Meteorological Organization's recommendations for gauge separation specify a minimum network of raingauges for climatological purpose. Further details are given in the *Manual on the global observing systems* WMO 544 [1] and the *Guide to hydrological practices* WMO 168 [2].

The main user of rainfall data for enquiry purposes is the Meteorological Office which requires daily and monthly totals with errors not exceeding 10 % to 20 %. Often a gauge is required within 5 km of the location concerned in the enquiry, at least in areas of higher population density. Usually, the data are required in arrears, but in some cases there may be a near real-time need.

d) Operational aquifer management

This use is important where water supplies are derived from groundwater sources, and estimates of recharge are required to assess the likely yield of the aquifer. For long term planning, monthly areal totals are required with an error not exceeding 20 %. Operational aquifer management requires recharge data in the form of daily areal totals with errors of less than 10 % on days where the total precipitation exceeds 1 mm. The areas concerned vary in size between 35 km² and 200 km². Data are not required in real-time.

e) Water resource planning

Either monthly areal totals or daily totals aggregated over periods of 5 days to 10 days may be used for this purpose. Acceptable errors are stated as being less than 10 % for subcatchments having areas between 5 km² and 50 km². The data are used for modelling streamflow to extend flow records when contemplating expansion of the reservoir area.

f) Non-urban flood design

This type of flood design is concerned with land drainage and estimation of spillway design for reservoirs. The catchment areas are small, often less than 100 km², and in some cases a point rainfall measurement will suffice. Sufficient daily measurements are required from one recording gauge to give daily areal averages with an error of between 5 % and 10 %. In terms of accuracy this requirement is not dissimilar to that for general water management except that the latter demands monthly areal totals and catchment areas vary from very small to very large.

g) Investigations of leaching, pollution and acid rain

Waste tips situated over aquifers are likely to cause pollution due to contaminated precipitation percolating into groundwater. Daily and monthly rainfall totals and depth/duration/frequency data are required with an error not exceeding 5 % to 10 %. Investigations of pollution events demand daily rainfall totals with an error not greater than 10 % to decide whether the occurrence was rainfall related. Weekly and monthly rainfall totals with an error not exceeding 5 % provide the data source for acid rain studies.

In summary:

- The majority of users of daily point rainfall can accept an error of less than 10 %.
- Most users of daily areal totals need errors to be less than 10 %, but assessment of reservoir yield and river regulation requires higher accuracy with errors of less than 5 %.
- Monthly point totals should not have errors exceeding 10 %.
- Monthly areal totals should not have errors exceeding 10 %.

4.2.2 Accuracy of estimation of point rainfall, and implied gauge separation

The accuracy required by the user and expressed in terms of an acceptable error implies a maximum inter-gauge separation for both a raingauge network alone, and a combination of gauge network and radar data. The relationship between gauge separation and design technique varies with method but an example is given in Annex C. It should be noted that the United Kingdom national daily raingauge network has a mean spacing of 7 km (varying locally and regionally from 3 km to 30 km) and therefore is probably just adequate overall to meet a 10 % RMS error requirement, i.e. point values within 20 % of occasions of uniform rainfall.

4.3 Sub-daily rainfall totals

4.3.1 Data uses

Some of the major uses of sub-daily and shorter period totals are as follows. The results of a survey of data usage is given in tabular form in Annex D.

a) Forecasting

Forecasting requirements vary, but all require near real-time or real-time response for data collection. General forecasting requires hourly, 3 hourly or 12 hourly totals, and a network spacing of 40 km to 150 km is acceptable depending upon the application. Errors not exceeding 50 % to 100 % are adequate for the requirement. Mesoscale modelling has rather more stringent requirements in terms of network separation, areal totals being necessary over 5 km × 5 km or 10 km × 10 km areas with an eventual need for totals for a 2 km × 2 km area. Totals for durations of 5 min to 10 min are required with errors not exceeding 30 % to 50 %. Access to the data within 20 min of measurement will eventually be required.

b) Flood warning

The issue of flood warnings depends upon telemetred real-time short duration precipitation totals. Errors of up to 20 % are acceptable.

c) Operation of waste water treatment works

One of the factors affecting the performance of waste water treatment works is short duration precipitation. Continuous monitoring at 2 min intervals for subcatchments allows real-time calculation of a performance indicator. Precipitation amounts are required as catchment areal totals with an error of up to 10 %.

d) Pollution control

Pollution control requires point rainfall totals for durations of 30 min in real-time, with data in arrears for particular incidents where verification is necessary. Errors of up to 15 % are acceptable for this application.

e) Agriculture

Certain crop and animal diseases can be either dispersed or activated by rain, while other diseases or pests may be inhibited by rainfall. Daily totals of rainfall in near real-time are available but it is desirable to have totals divided between day and night, and the duration of rainfall events and a measure of leaf wetness is ideally required. Typically errors of less than 10 % are required.