BS 7843-2:2012

BSI Standards Publication

Acquisition and management of meteorological precipitation data from a raingauge network

Part 2: Code of practice for operating raingauges and managing precipitation data

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Publishing and copyright information

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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 30, 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BS 7843-2:2012 supersedes BS 7843-2.2:1996 and BS 7843-2.3:1996, which are withdrawn. Together with BS 7843-1, it also supersedes BS 7843-2.1:1996, which is withdrawn.

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 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.

Use of this document

As a code of practice, 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.

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".

The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

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

Any user claiming compliance with this British Standard 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.

[1)] In preparation. Publication expected early in 2012.

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.

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Introduction

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.

1 Scope

This part of BS 7843 gives recommendations for all operational practices relating to the site location, installation, inspection and maintenance of the site and raingauge, manual readings, data management, fault management and corrective action, quality control and archiving of precipitation data, and management review.

It is not applicable to the design, development and review of a raingauge network. Such guidance is given in BS 7843-1.

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 7843-1, *Acquisition and management of meteorological precipitation data from a raingauge network – Part 1: Guide for design, development and review of a raingauge network*

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 newpapers 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 rain gauge 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.

4 Siting and installation

4.1 Site location

4.1.1 General

The choice of raingauge site should be based on user requirements, operational constraints and such factors as:

a) the number and distribution of other precipitation measurements in the locality;

b) the representativeness of the site with respect to the local area;

c) the degree of shelter from the wind and the presence of trees or large structures nearby;

d) the need to meet a specific user requirement in the locality;

e) the need to collocate precipitation measurements with other environmental measurements, particularly other meteorological or hydrometrical measurements;

f) the long-term viability of the site for precipitation measurements;

g) the availability of power at the site (if required);

h) the security of the site; and

i) the availability of observers and the accessibility of the site, particularly where daily manual readings are taken.

NOTE 1 These and other factors are considered in more detail in BS 7843-1.

The site should be representative of the local area defined by the typical separation of precipitation sites within the network. In particular, the altitude of the site should not differ greatly from the average for the local area. Ideally, the raingauge should be on level ground with no steep slopes in the area immediately surrounding it.

NOTE 2 The measurement of precipitation is highly dependent on the altitude of the site and the topography.

Where a second raingauge is deployed at the site for check or backup purposes, it should be positioned close to the primary gauge.

NOTE 3 A separation of at least 1.5 m is recommended.

4.1.2 Local terrain

If the only site available is near a terrace, cliff, steep bank or a sharp disctontinuity in the slope of the ground, the raingauge should be located no nearer to the feature than a distance equal to four times the height of the feature above the rim in order to minimize the effects of turbulence.

NOTE In particularly mountainous or hilly regions it might not be possible to meet the recommendation for level ground in the immediate vicinity of the raingauge.

4.1.3 Urban sites

Where there are no alternative sites, a flat rooftop or non-standard mounting on top of a long pole may be used, though users should be informed of the large uncertainties in the measurements.

NOTE Urban environments pose severe problems for the accurate measurement of precipitation as urban structures have a large, unpredictable impact on the collection of precipitation and security considerations often greatly limit the choice of site.

4.1.4 Changes in the location of the raingauge

To ensure consistency of measurement the raingauge should be deployed at the same location at all times wherever possible. Where events force a move (e.g. an owner does not allow a sheltering tree to be lopped), a new location for the raingauge should be found as close as possible to the original location to offer the best long-term continuity of measurement. Where the new location is within a horizontal displacement of 400 m of the previous location and the new raingauge altitude is within 15 m of the previous altitude, the change should be treated as a minor change to the deployment at the site for which the details should be recorded by precipitation metadata in accordance with **7.3**. Where either of these criteria are exceeded, a new site should be defined.

4.2 Raingauge exposure

4.2.1 General exposure considerations

When choosing a site particular attention should be paid to its exposure to wind. Uniform obstacles in the surrounding area reduce the overall wind speed and improve raingauge collection efficiency, provided such objects are not so large as to cause the wind to eddy and gust to higher speeds near the raingauge nor so close to the raingauge that they prevent precipitation entering the collector.

NOTE The largest errors in the measurement of precipitation are usually caused by the effects of wind in the immediate surroundings of the raingauge. Such errors may be minimized by installing reference raingauges in a ground level raingauge pit. The construction of such a pit for reference purposes is specified in BS EN 13798. This design, though optimum, might not be used widely in the precipitation network on grounds of cost and difficulty of maintenance.

4.2.2 Exposure criteria

One or more of the following methods should be used to reduce overexposure.

a) Placing a windshield around the raingauge.

b) Siting the raingauge in a small hollow or natural dip.

c) Placing a windbreak in the vicinity of the raingauge.

d) Building a turf wall.

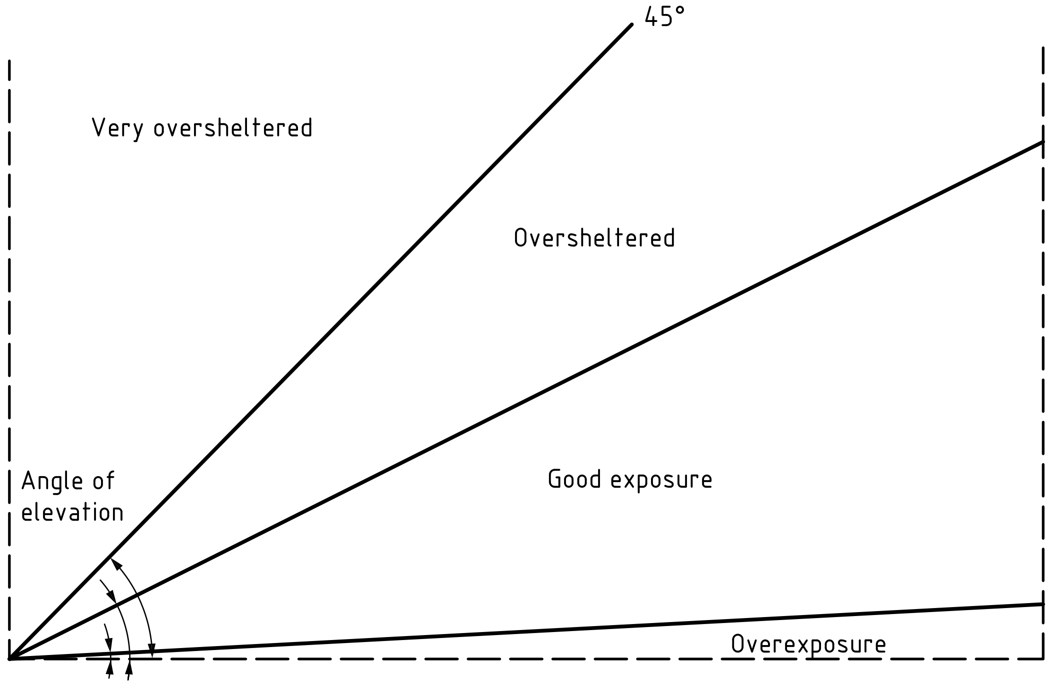
e) Installing a ground level raingauge.

NOTE 1 Raingauge sites that are subject to strong winds and have no shelter (e.g. moorland sites) are overexposed (overexposure normally reduces the raingauge catch). Obstacles around the site such as trees or buildings act as windbreaks and can be effective for a distance of up to 30 times their height (2° angle of elevation from the rim of the raingauge to the top of the windbreak). Greater effect is achieved where the distance from the raingauge is 20 times their height [3° angle of elevation (see Figure 1)].

NOTE 2 Sites where the distance between the raingauge and the surrounding objects is less than twice the height of the object above the rim are considered to be underexposed (angle of elevation greater than 26°). Generally, the raingauge catch is reduced by an amount dependent on the wind speed at an underexposed site.

Where possible, only those sites with good exposure (angle of elevation between 3° and 26°) in most azimuth directions, especially in the direction of the prevailing wind, should be selected.

Figure 1 **Diagram for assessing the exposure of a raingauge**



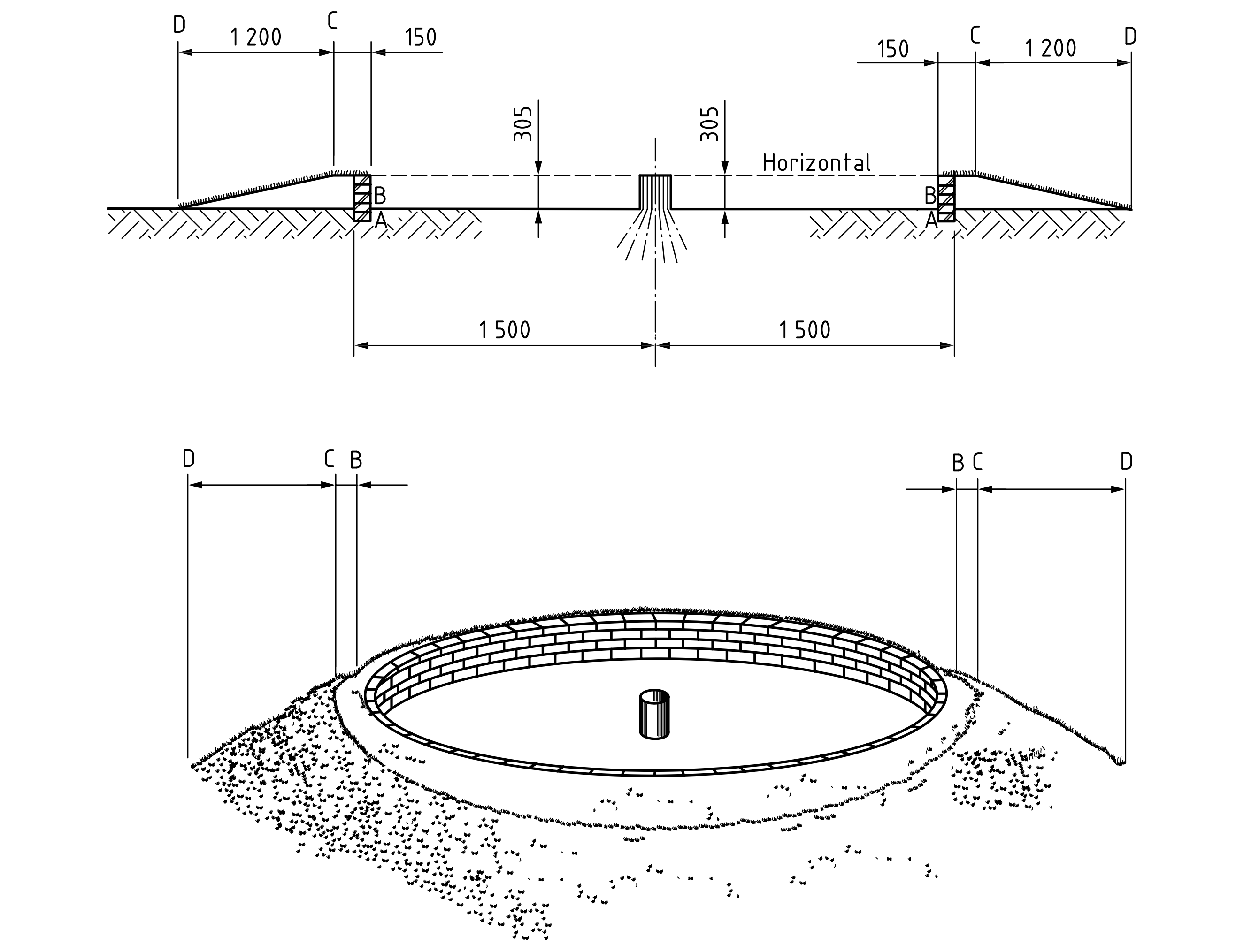
Objects with angle of elevation above 26° cause overshelter. If there are no objects with an angle of elevation above 3°, the area is overexposed.

4.2.3 Turf wall construction

A circular turf wall should be erected around any raingauge (see Figure 2 for established UK practice) located in an overexposed, windswept site. The central well should be adequately drained. The raingauge rim should be level with the top of the turf wall, for example, the raingauge may be partially set into the ground.

Where a turf wall encloses more than one raingauge, the height of all the raingauge rims should be level with the top of the turf wall. The raingauges should be installed between 1 m and 1.5 m from the turf wall and any other raingauge.

Figure 2 **Turf wall construction**



4.3 Raingauge installation

4.3.1 Wherever possible, the raingauge should be placed within a flat area where it can be easily maintained (see **4.1.2** and **4.1.3** for exceptions).

4.3.2 The raingauge should be securely fastened with its rim horizontal at a height above the ground specified by the manufacturer or determined by established practice. Where its base is at ground level a paving slab, small enough not to cause splash-in, may be placed beneath the raingauge to provide a firm base. Some designs allow for deployment on a post while the base of some storage raingauges may be set in the soil. Wherever possible, raingauges in the network should be deployed in a consistent way.

NOTE Established practice might be the height of deployment used in an international intercomparison trial or the deployment of the UK standard storage raingauge at 305 mm.

4.3.3 Installation should be such that no objects around the raingauge can cause heavy rain to splash-in. If the surrounding area is grass it should be trimmed regularly to prevent it impeding the collection of rain by the raingauge. A narrow area should be provided around the raingauge free of vegetation (e.g. stone chippings), as this simplifies maintenance procedures.

4.3.4 Suitable fencing and other barriers should be constructed to minimize the risk of damage by any form of wildlife likely to be in the area, including large animals like cattle or deer and smaller animals like rabbits. Taking into account the permeability of any fencing or barriers, they should not cause the raingauge to be underexposed according to **4.2.2**.

4.3.5 Windbreaks should be suitably placed, where necessary, to increase shelter at overexposed sites.

4.3.6 Site-specific security arrangements should be made where there is the risk of damage by malicious persons.

4.3.7 Further levelling of the instrument should follow the manufacturer's instructions where applicable.

4.3.8 The drainage of the site should be considered. If the site is liable to flooding or saturated ground conditions, drainage should be installed.

4.3.9 Where data from the site are used for climate studies or other applications that require a complete data record, a second raingauge should be deployed at the site of an automatic raingauge for performance monitoring and backup purposes.

4.3.10 After the installation all relevant precipitation metadata records should be updated (see **7.2** to **7.4**).

4.4 Installation at sites prone to snow

Where a raingauge is to be installed at a location prone to frequent snowfall:

a) the site selected should be well sheltered in all azimuth directions to minimize wind effects;

b) any location where snowdrifts are known to form should be avoided; and

c) windshields or windbreaks should be installed, and either:

   1) raingauges that operate in snow (e.g. weighing raingauges) should be installed; or

   2) thermostatically controlled heating elements should be installed to prevent the temperature of the raingauge, or relevant part of the raingauge, falling below freezing.

NOTE The measurement of snow is prone to error as wind effects are often very large. BS 7843-1 considers the uncertainties relating to the measurement of all types of solid precipitation in more detail. Because snowfall is an infrequent occurrence in many areas of the UK, the raingauge in use might not be optimally designed for its measurement and its limitation in snow events is accepted.

5 Maintenance

5.1 General

Maintenance activities should be undertaken at planned intervals to ensure that the site and the equipment continue to function correctly for precipitation measurement. The frequency at which maintenance activities are undertaken should be determined by management review (see **14.1** to **14.3**).

Records of all maintenance and remedial activities should be maintained. Records should include the date, site identifier and instrument identifier for each activity undertaken.

5.2 Site

Periodic visits to the raingauge site should be made to ensure its suitability for precipitation measurement. Maintenance activities should include checks that:

a) the means of protecting the site against intrusion from animals or malicious persons are effective (including fences, gates and locks);

b) the grass and/or vegetation surrounding the raingauge is cut to a short length;

c) where an area of stone chippings has been set around the base of the raingauge, it is weed-free;

d) vegetation around raingauges retains the desirable exposure conditions defined in **4.2.1** and **4.2.2**;

e) where a turf wall or raingauge pit has been installed, its condition is as originally installed;

f) where a reference raingauge pit has been installed, it is clear and drained; and

g) there is no wind-blown litter or debris at the site.

Defects at the site should be rectified at the time of the visit wherever possible. A schedule for completing any remaining remedial work should be produced immediately after the visit.

5.3 Raingauges

5.3.1 Storage raingauges

On each visit to make a measurement the observer should:

a) check for leaks in all parts of the raingauge where rain water passes or is collected;

b) check for damage or defects in any part of the raingauge or the rain measure (for example, corrosion occuring where the raingauge base unit has been set in the ground, particularly where the soil is acidic);

c) remove any debris that has collected in the funnel, delivery pipe or collecting vessel;

d) ensure the raingauge is firmly set on the ground with its rim level;

e) add oil to the emptied collecting vessel where required by the design; and

f) ensure the correct disposal of any unwanted oil.

A raingauge that is found to be defective should be replaced by a spare unit at the earliest opportunity.

5.3.2 Automatic raingauges

Periodic maintenance of automatic raingauges should be undertaken to ensure they function correctly for precipitation measurement. In addition to the activities in **5.3.1**, maintenance should include:

a) checking for damage to or defects in any part of the supporting infrastructure (e.g. data loggers, power or communications connections);

b) cleaning the raingauge according to the manufacturer's instructions or as determined by the management review (e.g. ensuring that debris, insects and cobwebs that have been collected in the measurement mechanism are removed and that the filter, where fitted, is clean);

c) levelling the measurement mechanism, if applicable;

d) any other checks of the mechanism according to the manufacturer's instructions or as determined by the management review (such checks might include passing a known quantity of water through the funnel to ensure raingauge conformance); and

e) end-to-end testing of the observing system at the site.

Spurious data generated during testing should be controlled to ensure no inadvertent use. A raingauge that is found to be defective should be replaced by a spare calibrated unit at the earliest opportunity.

5.4 Calibration

The accuracy of all automatic raingauges in use should be determined at regular intervals under specified conditions. Before deployment, a raingauge should be calibrated by the method appropriate to its class (see BS 7843-3).

NOTE BS 7843-3 defines two types of automatic raingauge: those that are calibrated over a range of rainfall intensities (Class A), and those that are calibrated at a single rainfall intensity (Class B).

Once raingauges are in operational use, one of the following three different approaches should be followed.

a) Regular site performance checks, in which a known quantity of water is poured through the collecting orifice of the raingauge.

b) Differences between rainfall measured by the raingauge and another collocated raingauge are regularly compared to ensure they do not exceed agreed limits.

c) In addition to undertaking a) or b), the raingauge is also recalibrated under controlled conditions (not on site).

Any raingauge that fails checks a) or b) should be replaced by a calibrated raingauge. Where the raingauge is installed for a short period it should be calibrated before and after deployment.

Approach c) should be used where measurements from the site are used for climatological or hydrological monitoring. The calibration process should establish the relative error of the rainfall measurement at a number of different rainfall intensities. Estimates of the uncertainty of measurement should be made.

The period of validity of the calibration for each type of automatic raingauge in use, and the frequency and nature of any site performance checks, should be determined by management review. A process should be put in place which:

a) uniquely identifies each automatic raingauge in use or intended for use;

b) maintains permanent records of the calibration results for each raingauge and the period of validity of the calibration; and

c) maintains a permanent record of the results of any site performance checks undertaken.

Calibration results for each automatic raingauge in use should be linked to the measurements from the raingauge in a way that allows users of the data to apply appropriate corrections.

6 Inspection

6.1 General

An inspection of the site and instrumentation should be made at intervals determined by management review (see **14.1** to **14.3**). It should review the suitability and effectiveness of all aspects of the site, and the equipment and the processes undertaken that impact on the quality of precipitation data from the site. Records of the findings of an inspection visit should be maintained.

In addition to information gained during the visit, an inspection should take into account other sources of information relating to the site, including:

a) an assessment of the quality and completeness of precipitation data;

b) the frequency and nature of reported faults;

c) maintenance records; and

d) comments supplied by maintenance staff or others.

6.2 Maintenance

Maintenance inspection of the raingauge site should include:

a) checking all maintenance activities have been undertaken in accordance with **5.2** and **5.3**; and

b) identifying any weaknesses in the maintenance process, e.g. poor grass cutting.

This activity may be included as part of the agreed schedule of maintenance visits.

6.3 Precipitation metadata

Precipitation metadata inspection should include:

a) checking the validity of all precipitation metadata relating to the site listed in **7.2** to **7.4**;

b) establishing the cause of any differences between the present state and identifying existing records; and

c) correcting erroneous records.

Where differences are due to unrecorded changes at the site, new precipitation metadata records should be created which include the date of change.

6.4 Assessment of the exposure

During inspection, measurements of the exposure to the rim of each raingauge should be taken. Using a suitable instrument, the elevation of all substantial obstacles in the line of sight from the rim should be measured to the nearest degree. For each raingauge, 36 measurements should be made in all, one for each 10° sector. Each measurement should represent the average elevation of impermeable obstacles in the sector. The overall exposure at the site should be assessed using a suitable algorithm applied to these elevation measurements.

Where the exposure at the site falls below the acceptable limits given in **4.2** (especially in the direction of the prevailing wind) the inspector should recommend what remedial action is possible, including pruning vegetation or moving the raingauge a small distance (see **4.1.4**). The inspector should ensure that appropriate action is taken and record any changes as new precipitation metadata records. Where improvement is not possible closure of the site may be recommended.

6.5 Observer training

Where manual readings of precipitation are made from the site the inspector should assess the level of observing skill, making use of all information available, including:

a) contact with the observer(s);

b) assessment of data quality; and

c) comments from other sources.

Where skills are lacking, appropriate instruction should be given during the visit or a training activity agreed.

7 Precipitation metadata

7.1 General

NOTE Precipitation metadata are essential for a full understanding of the characteristics of the precipitation measurements.

Precipitation metadata records should be kept permanently and organized in such a way that they can be linked to any measurement to which they relate.

Processes should be put in place to ensure that precipitation metadata records are updated each time any item is changed. Records that are no longer valid should be maintained with from and to dates indicating their period of validity. In this way a complete history of the observing practice at the site should be available to all users of the measurements.

7.2 Site details

Precipitation metadata relating to the site should include:

a) a unique site identifier;

b) site name;

c) horizontal location, accurate to within 10 m (Ordnance Survey national/Irish grid reference, or latitude and longitude);

d) altitude above mean sea level to within 5 m (to the appropriate national ordnance datum);

NOTE Record both the coordinate system used to locate the site and the datum used to establish its altitude above mean sea level in the site metadata.

e) characteristics of geography of area;

f) hydrometric area;

g) opening date; and

h) closing date, if applicable.

The site details should be applicable to all measuring devices at the location which might include more than one raingauge and devices for measuring parameters other than precipitation. Where minor changes in location of a raingauge occur at a site, details should be recorded by the raingauge deployment, as recommended in **7.3**c); for more significant changes, see **4.1.4**.

7.3 Equipment details

Metadata relating to the measurement of precipitation should include the following elements for each raingauge deployed at the site and its supporting infrastructure where applicable.

a) Raingauge identifier.

b) Raingauge type.

c) Deployment details (horizontal location of raingauge, altitude of the base of the raingauge above mean sea level, height of rim above ground, use of turf wall, pit or other sheltering device).

d) From and to dates for each deployment.

e) Exposure assessment (as recommended in **6.4**, with date of assessment).

f) Calibration details (method used, date of calibration and corrections if applicable).

g) Observing system details (e.g. software systems that log and process data before transmission to users or archive).

h) From and to dates for each version of the observing system.

i) Data transmission system details.

j) From and to dates for each version of the transmission system.

k) Maintenance, inspection and incident records (status, incident types and dates of visit).

7.4 Operational details

Metadata relating to the operational practices for each raingauge deployed should include the following.

a) Pecipitation measurement characteristics (e.g. 0.2 mm tip times, 24 h accumulations).

b) Observing schedule (time the measurements are made, e.g. 0900 UTC daily readings, tip times, 1 min data).

c) From and to dates for the observing schedule.

d) Reporting schedule (time data are sent from the site, e.g. monthly, real time).

e) From and to dates for the reporting schedule.

f) Observer details (if applicable, e.g. identification, training, dates).

g) Quality control methods.

h) Methods for correcting for systematic errors.

NOTE Attention is drawn to the requirements of the Data Protection Act [1] when handling personal details about the observer.

8 Observing practice

8.1 General

The user requirement should determine the types of instrument deployed at the site, the observing practice, the observing schedule and the reporting schedule, taking into account the requirements for the data and the resources available.

8.2 Measurement of rainfall

8.2.1 Storage raingauges

Where storage raingauges are deployed the frequency and time of day at which readings are taken should be selected on the basis of the availability of observers. Wherever possible a manual reading should be made each day at 0900 UTC. On each visit to the site the observer should also undertake the checks recommended in **5.3.1**.

NOTE 1 Monthly readings, taken within 5 days of the 1st of the month, are acceptable at remote sites.

The amount of liquid precipitation collected by a storage raingauge should be measured with the aid of a rain measure or dip rod appropriate for the size of the raingauge (see BS 7843-3:2012, **7.1.3** and **7.1.4**). Every drop of water should be poured from the collecting vessel into the rain measure. Water quantities greater than the capacity of the measure should be totalled from a number of part readings.

Surface tension causes the surface of the water to be drawn up the glass sides of the measure for a short distance. The resulting concave meniscus should be measured at its lowest point while the measure is held vertically and level with the observer's eye.

NOTE 2 Duplicate engravings of the main graduations, marked on the back of the measure, reduce parallax errors and facilitate accurate reading.

Readings should be recorded to the nearest tenth of a millimetre with the date and time of the measurement. If the meniscus is below the 0.05 mm mark, the reading should be recorded as a trace (TR). If the observer considers that the liquid collected is dew or melted frost, this should be noted along with any other comments on the nature of the precipitation.

8.2.2 Automatic measurement of rainfall

The design of automatic raingauges for the measurement of rainfall intensity is covered by BS 7843-3. To ensure accuracy of rainfall measurement attention should be paid to operational performance monitoring (see Clause **10**) and maintenance (see Clause **5**).

NOTE 1 Some automatic raingauges are not designed to detect accumulations of 0.05 mm or less, rendering them incapable of reporting trace accumulations. Tipping bucket raingauges having a resolution of 0.2 mm fall into this category. Where there are other sensors at the site for measuring the presence of precipitation particles, they may be used to generate a report of trace.

Automatic raingauges can suffer malfunction or blockage by wind-blown materials. A second raingauge should be deployed at the site where it is important to minimize gaps in data.

NOTE 2 This may be a storage raingauge read by an observer according to an agreed schedule (e.g. daily, weekly or monthly at 0900 UTC). Alternatively, a second automatic raingauge may be installed for use as the source of precipitation measurements in the event of malfunction of the primary raingauge.

Other parts of the observing system that represent vulnerable single points of failure should also be duplicated as necessary.

8.3 Measurement of water equivalent of solid precipitation

8.3.1 Measurement of snow

8.3.1.1 The water equivalent of new snow should be obtained by melting a column of new snow that has fallen since the previous measurement, and should be recorded in mm.

8.3.1.2 The water equivalent of lying snow should be obtained by melting a column of snow obtained from an untouched location, made up of any new snow and accumulations from previous snowfalls, and should be recorded in mm. Where possible snow should be taken where the underlying surface is grass, or a surface with similar thermal properties to grass.

NOTE Water equivalent of new snow provides the precipitation data in the archive, while the record of water equivalent of lying snow provides information for hydrologists on unmelted water resources.

8.3.2 Measurement of slight falls of new snow, hail and hoar frost

The water equivalent of slight falls of new snow, hail or hoar frost captured by the funnel of a storage raingauge without overtopping should be measured by one of the following methods.

a) If precipitation is not falling, the funnel with its snow catch and the collecting vessel should be taken to a warm place to melt, and covered to prevent evaporation. The resultant quantity should be measured in the recommended way for rainfall (see **8.2.1**).

b) If snow is falling at the time of measuremant, a more immediate method of melting should be used to ensure that any loss of snowfall is minimized. A measured amount of warm water should be poured into the funnel to melt the snow. The total of melted snow and water is reduced by subtracting the amount of added water to give the water equivalent of snow.

8.3.3 Measurement of heavy falls of new snow

NOTE The measurement of the water equivalent of moderate or heavy falls of new snow in the area of a storage raingauge is liable to large error, particularly if the fall has drifted in strong winds.

8.3.3.1 When the precipitation is entirely snow, which started to fall after the beginning of the period for which measurement is required, and the raingauge has clearly overtopped, a sample should be obtained by pressing the empty and inverted funnel of the raingauge vertically down through snow least affected by any drifting and best representative of the area as a whole. The sample should be melted indoors and the liquid measured in accordance with **8.2.1**. At least three samples should be taken and processed to give an average value for the area. A white board, flush with the top of the snow, should then be deployed to provide a reference level for the next new fall. Thin rods may be used to identify its location.

8.3.3.2 When snow has been lying prior to the period for which measurement is required, new snowfall should be measured with reference to the white board previously deployed in accordance with **8.3.3.1**. After the measurement has been made the board should be cleared, placed in a fresh location flush with the top of the snow and its location identified by thin rods.

8.3.3.3 When there has been both solid and liquid precipitation during the period for which measurement is required, the water equivalent of new snow should be measured in accordance with **8.3.3.1** or **8.3.3.2**, as applicable. The value should be added to the measurement of any liquid in the collecting vessel to give the measurement of total precipitation for the period.

8.3.3.4 Where snow has built up on the funnel to form a partial or complete bridge over the raingauge orifice, the inverted funnel technique (see **8.3.3.1**) should be used to make measurements.

NOTE Freshly fallen snow has a variable relative density which is frequently as low as 0.1. If no melting occurs in the funnel it can be overtopped and the water equivalent underestimated. At a relative density of 0.1, snowfall will overtop a standard daily raingauge when about 12 mm water equivalent has fallen.

8.3.4 Measurement of snow at monthly raingauges

Slight falls of snow collected by a monthly raingauge should be measured in accordance with **8.3.2**.

*NOTE For greater falls the water equivalent of a snow core may be measured (see **8.3.5**).*

Missing data should be recorded where the uncertainly in the measurement is large.

8.3.5 Snow cores

To obtain a snow core, a tube of 50 mm to 80 mm diameter with a sharp edge should be pressed downwards through snow until it reaches the ground that is representative of average conditions for the area, or the white board previously deployed (see **8.3.3.1**). Preferably, the core should be taken vertically over level ground, but where this is not possible it should be at 90° to the slope. The weight of the tube with snow minus the weight of the empty tube gives the weight of the snow core. The water equivalent of snow in mm should be obtained by dividing the weight of the snow core in kg by the cross-sectional area of the tube in m^2.

Alternatively, the snow core can be stored in a suitable sealed container and allowed to melt. The water equivalent of snow in mm should be obtained using a rain measure (see **8.2.1**).

8.3.6 Measurement of snow by automatic raingauges

Where an automatic raingauge is not designed to operate in snow conditions, users of the data should be made aware of the poor quality of data in snow events.

NOTE 1 Many types of automatic raingauge operate poorly in snow. Not only is the effect of wind on the collection of snow far greater than for rain, some types of raingauge are only designed to measure the weight or mass of liquid. For example, snow collects in the funnel of an unheated tipping bucket raingauge only registering tip events during a period of thaw which might occur slowly long after the precipitation event. Many types of weighing raingauges are better in this respect for slight or moderate snow events. Heavy snowfall and drifting are a major source of error for all automatic raingauges.

NOTE 2 Snow pillows employing a pressure sensor are used for the automatic measurement of the water equivalent of snow. Snowfall intensity may be measured by a number of types of remote sensing device which sample the characteristics of snow particles in a small volume. All such non-collecting instruments are outside the scope of this document.

8.4 Measurement of depth of solid precipitation

8.4.1 General

All measurements of snow depth should be made over grass, or some other surface having similar thermal properties to grass.

NOTE Where snow falls on bare soil, concrete or other surface with high thermal capacity after a period of weather with temperatures above freezing, its depth will generally be less than over grass.

8.4.2 Manual measurement of total snow depth

The depth of lying snow should be measured in cm with a ruler at three or more different locations as near as possible to the raingauge. If there has been any drifting of snow, the locations for measurement should be chosen to be as representative of the average conditions as possible. The snow depth reported should be the average of all readings taken.

NOTE The total snow depth is the height of the snow surface above the ground. It is made up of the day's new snow and any accumulations from previous snowfalls.

8.4.3 Manual measurement of new snow depth

The depth of new snow falling during the preceding 24 h should be measured in cm on a white board (see **8.3.3**) flush with the previous day's snow surface.

8.4.4 Automatic measurement of snow depth

NOTE 1 Ultrasonic ranging sensors are available for the measurement of total snow depth. The increment in a given time period is a measure of new snow.

Ultrasonic ranging sensors should be deployed at a height greater than the maximum likely depth of snow, pointing directly down onto a patch of artificial material having the similar thermal properties of grass. Because of errors introduced by slow grass growth, even in winter, sensors should not be deployed over grass.

NOTE 2 The specification of remote sensing instruments, such as snow depth sensors, are outside the scope of this standard.

9 Data formats and exchange

9.1 Data terminology

9.1.1 Recording precipitation elements

With each measurement of precipation, the following information, as a minimum, should be recorded.

a) Site identifier.

   NOTE 1 This provides a link to other attributes of the site through the precipitation metadata.

b) Raingauge identifier.

   NOTE 2 This provides a link to other attributes of the raingauge through the precipitation metadata.

c) Date and time of the end of the measurement period.

d) Accumulation period covered by the measurement.

e) Measured precipitation amount in mm to the nearest 0.1 mm, including the water equivalent of new snow.

NOTE 3 Some automatic raingauges have a resolution greater than 0.1 mm.

f) The value of the estimate of precipitation, if provided by the quality control process (see **12.1**).

Where the need has been identified, the following items should also be recorded.

1) Occurence of trace precipitation.
2) Depth of new snow in cm to the nearest cm.
3) Depth of lying snow in cm to the nearest cm.
4) Water equivalent of new snow in mm to the nearest 0.1 mm.
5) Water equivalent of lying snow in mm to the nearest 0.1 mm.
6) Notes that might be helpful for the quality control of precipitation data (e.g. confirming that a thunderstorm caused an unusually large accumulation of rain).

9.1.2 Data flags

Data flags should be recorded with each measurement of precipitation to identify the following characteristics.

a) The extent of quality control performed.
b) A measurement identified as erroneous by the quality control process (departing from the most likely value by an amount that exceeds reasonable expectations).
c) Whether an estimate has been made.
d) A measurement which represents the water equivalent of snow.
e) The nature of any error.

Records should be maintained of the definition of all data flags, details of any changes to the definitions and the dates of the changes.

9.1.3 Time of measurement

Because of the existence of long historical records of daily precipitation that have 0900 UTC as the measurement time, manual readings from storage raingauges should continue to be made at 0900 UTC wherever possible. The date and time of a precipitation measurement should refer to the end time of the accumulation period.

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

9.2 Processing of raw data

Any corrections to the measured values (including intensity dependent corrections for tipping bucket raingauges established by a calibration process) should be applied to the data by the observing system. Where this does not occur, the corrections should be linked to the measurements from the raingauge in a way that allows them to be applied by users of the data.

Daily precipitation for the 24 h period up to 0900 UTC, hourly precipitation for the 60 min up to each hour, or other selected periods should be calculated from the intensity data from automatic raingauges.

9.3 Data formats

9.3.1 Electronic data

NOTE The preferred format for electronic precipitation data, including the output of raw data from automatic raingauges and precipitation metadata, is defined by OGC [2].

Where old systems operate with other formats a change to modern formats should be implemented at the earliest convenient opportunity.

9.3.2 Manual readings from storage raingauges

Manual readings should be transferred to electronic format by a process that minimizes the possibility of error. Where the transfer is made by an electronic device at the point of measurement, the observer should carefully check the entry before transmission. The system should have in-built checks to ensure that the site identifier, instrument identifier, date and time are all consistent, and to alert the observer to any unusual combinations. Where manual readings are written onto paper or card before conversion to electronic format, the observer should ensure that the values are correct and legible. Where data on paper or rainfall postcards (see Annex A) are converted to electronic format at a later date, dual keying, or other methods that ensure accurate transcription, should be used.

9.3.3 International exchange

The format for international exchange should conform to WMO [3 and 4] recommendations.

NOTE The principal formats for the international exchange of precipitation data are SYNOP (synoptic surface observations), SREW (synoptic rainfall Europe west), BUFR (binary universal form for the representation of meteorological data) and CREX (character form for the representation and exchange of data).

9.4 Data transmission and exchange

9.4.1 General

Systems and processes should be put in place to ensure the timely transmission of rainfall data according to planned reporting schedules.

Processes should be implemented to identify and retrieve missing data (e.g. automatic observing systems should be designed to store data on site during periods of communication outage and to resend non-transmitted data when communication systems are restored).

9.4.2 Electronic data

Electronic precipitation data, including precipitation metadata (see Clause **7**), should be formatted for transfer between the observing site and the national archive or user systems. Processes for regular data exchange, ideally in real time, should be established.

9.4.3 Paper records

Readings from storage raingauges should be transferred for processing and storage as soon as possible after the measurement has been made. Where local monthly transfers are agreed this should be effected as soon as possible after the end of each month to meet user requirements.

10 Operational performance monitoring

10.1 General

NOTE The objective of operational performance monitoring of precipitation data is the identification of possible faults and the initiation of corrective action through the creation of a fault incident. The degree of confidence in the identification of error by operational performance monitoring might be less than that for the quality control procedures described in ***12.1****; there need only be a possibility of a fault in the system which subsequent actions might confirm or deny.*

Performance monitoring should be undertaken in a timely manner, usually within 24 h of the measurement time, and ideally within an hour or two.

10.2 Methods for operational performance monitoring

A process of operational performance monitoring should be implemented to identify erroneous or missing data. Missing data should be identified by reference to the agreed schedule of reports from raingauges in the network.

NOTE 1 Identification of erroneous values of precipitation data is most conveniently undertaken using hourly accumulations from all raingauges in the network reporting in real time.

Checks should include comparison with data available in real time from:

a) weather radars;

b) collocated raingauges, if any; and

c) neighbouring sites, using the quality control methods in **12.2**.

NOTE 2 The most common problems are system faults leading to a loss of data, and blocked raingauges.

The results of operational performance monitoring should be recorded and maintained.

11 Fault management and corrective action

A process for managing and correcting faults in the end-to-end system for the production, processing, transmission and archiving of precipitation data should be established. Service restoration times should be agreed with the users of the data.

A fault management process should be implemented which:

a) records incidents raised by operational performance monitoring or by any other source;

b) initiates action to mitigate the impact of the fault on users of the data;

c) records the current status of any fault and the details of any actions taken;

d) checks the effectiveness of corrective actions and investigates failures to meet agreed timescales; and

e) verifies the closure of incidents.

Corrective actions taken may include:

1) initiating action to resolve the incident within an agreed timescale;

2) remote access to the precipitation measurement system on site to obtain more details of the system status;

3) excluding erroneous data from a particular raingauge;

4) switching any back-up automatic raingauge into use;

5) visits to the site by local caretaking or maintenance staff; and

6) requesting support from third party providers of services (for example, telecommunication companies).

All incident records should be retained for period of time determined by management review (see **14.1** to **14.3**). Details of all incidents within the fault management system should be analysed at regular intervals to identify the root cause of any common areas of failure. Proposals for the prevention of future occurrences should be presented to management review.

12 Quality control

12.1 General principles

NOTE 1 All quality control processes described in these subclauses are suitable for data contained in a national archive. They relate to measurements of precipitation made up of rainfall plus the water equivalent of new snow.

NOTE 2 A measurement is erroneous if it lies outside the range of values that might be reasonably expected.

Quality control processes should be implemented to:

a) identify erroneous measurements of precipitation while distinguishing them from extreme precipitation events;

b) provide accurate estimates for missing or erroneous measurements; and

c) be applied in a consistent way over time.

The quality control process should be based on all available relevant evidence, the known variability of the weather and the likelihood of extreme precipitation events. Measurements judged to be in error should be identified with data flags (see **9.1.2**).

Estimates for missing or erroneous measurements should be based on all relevant information available, including data from sources other than raingauges. The method of estimation should be as accurate as possible.

Errors in the quality control process should not be permitted to introduce biases to long-term climate averages, in particular to the frequency of extreme precipitation events. Wherever possible, quality control checks should be applied consistently from raingauge to raingauge and over time. The methods of quality control and the dates of any changes to these methods should be recorded and maintained.

NOTE 3 A quality control result is in error if, in the considered opinion of expert personnel using all available information, a true measurement is identified as erroneous or an erroneous measurement is misidentified as true.

12.2 Methods for quality control

NOTE 1 At any one time precipitation intensity might show large variability over small horizontal space scales; this is particularly true in convective weather events dominated by upward motion on the scale of individual cumulus clouds. Equally, there are frequently large variations in precipitation intensity over short periods of time, for example during the passage of a thunderstorm cell or an active frontal boundary. These considerations imply that very few reliable quality control checks might be applied to short period accumulations. In practice, 24 h is the optimum accumulation period for quality control. It is the precipitation period most commonly requested by users and it is also a typical period for synoptic scale precipitation events. Many features on small spatial and temporal scales acquire smoother characteristics when averaged out over a 24 h period.

The principal method for the quality control of precipitation data should be based on the comparison of measurements from one raingauge with those from neighbouring raingauges.

NOTE 2 To achieve the comparison it might be most convenient to estimate the expected precipitation at the location of a raingauge using information from as many relevant sources as possible, but excluding the measurement from the raingauge in question.

The information used to make the estimated measurement should include:

a) measurements from collocated raingauges at the same site;

b) measurements from raingauges at neighbouring sites; and

c) measurements from weather radar.

The estimate should take into account the:

1) distance of each neighbouring raingauge from the site of interest;

2) distance of each neighbouring raingauge from other neighbours used in the estimate, favouring a spatially uniform distribution of neighbours;

3) altitude above sea level of each of the raingauges;

4) annual average rainfall at each of the comparison sites; and

5) uncertainty of each of the measurements used.

Quality control on each measurement of precipitation should take into account:

i) the difference between the measured value and the estimate;

ii) other measurements not used in the estimate (e.g. from thunderstorm location systems);

iii) the synoptic weather characteristics during the measurement period;

iv) known characteristics of precipitation measurements at the site;

v) known characteristics of the raingauge, its exposure and the method of measurement;

vi) any additional information provided by the observer; and

vii) the history of the quality of measurements from the raingauge of interest.

Statistical tests should be applied to assess the significance of the difference between the measured value and the expected value. Allowance should always be made for the large variability in daily precipitation accumulations that can occur between neighbouring locations on days dominated by deep convection. Weather radar and thunderstorm location fixes are very valuable on these occasions. Allowance should also be made for instances where uncertainties in the estimates are large. For example, estimates are likely to be unreliable in mountainous areas where there are few neighbouring sites and local effects of the topography are large.

NOTE 3 Precipitation measurement is highly dependent on the altitude of the raingauge site and orographic effects. For quality control purposes, site-to-site variability of precipitation may be reduced by normalizing with respect to the annual average rainfall at each site. Rainfall averages are normally calculated from 30 years' data, e.g. 1971-2000 (see BS 7843-4).

12.3 Sub-daily precipitation

Where a site has two or more collocated raingauges, each providing sub-daily data, quality control of data at the highest common time resolution should be undertaken. Statistical tests should be applied, using as their basis data from correctly functioning collocated raingauges over long periods.

Because of the large spatial and temporal variability of precipitation, quality control of short period precipitation using neighbouring measurements at distant locations is difficult to achieve successfully. Instead, a few simple quality control checks should be applied to high time-resolution data, preferably at source, by the raingauge system in real time. These should include the following.

a) A check for precipitation intensity that exceeds climatological extremes. For a tipping bucket raingauge a minimum time between successive tips may be specified to identify cases where the bucket mechanism double bounces.

b) A check for isolated precipitation intensity peaks, e.g. very short period intense events that are not preceded or followed by precipitation of lower intensity. Such an event might indicate that the engineer has failed to isolate the system during testing.

Appropriate flags should be set on sub-daily data if the daily value to which they contribute has itself been flagged as erroneous.

12.4 Daily precipitation

12.4.1 The schedule for quality control

The principal quality control checks undertaken on precipitation data should be for daily values from the whole network, though preliminary runs of the quality control may be undertaken on a smaller number of sites. Quality control should be undertaken in accordance with Clause **12** on timescales that best meet the requirements of users. In general, this should occur as soon as the large majority of the data have been received, with a subsequent rerun, or multiple reruns, to capture any data values that are received late. Where several quality control runs are performed, each subsequent run having a better coverage of data than its predecessor, previous flags should be replaced by flags from the latest run.

12.4.2 Daily total values

Daily total values should be produced from high time-resolution data from automatic raingauges. These daily total data should be included with daily values from storage raingauges for quality control purposes. Flags should be set on data that lie outside the range of values that might be reasonably expected. In doing so, the methods used should take account of the extent of atmospheric variability and give the benefit of any doubt to the measurement. Reasons should be given for identifying a value as erroneous, for example the past history of measurements from the site or comments provided by service engineers. Other flags that indicate the possibility of errors with lower probability or confidence may also be applied to the data.

Where a measurement from a storage gauge spans two or more days quality control methods should be applied in accordance with Clause **12** using data from other sources for the appropriate period. Estimates for each of the daily values should also be provided. Where the multi-day measurement passes the quality control checks, the estimates should represent a reapportionment of the measurement into daily accumulations. Where it fails the quality control checks, the estimate of the multi-day accumulation should be reapportioned into daily values. The reapportionment method should be based on data from neighbouring sites.

12.5 Monthly precipitation

Where the network includes storage raingauges that are read monthly or at other long intervals, quality control of monthly data should be undertaken. Sub-daily, daily and multiple day measurements should be converted into monthly values. Quality control based on the methods in **12.2** should be employed to identify and flag erroneous data. Readings not made at 0900 UTC on the first day of the following month should be reapportioned to reflect an estimate for the true monthly accumulation.

12.6 Further quality control checks

Further quality control checks should be implemented according to a regular schedule to identify problems.

NOTE Quality control and monitoring checks applied to data on sub-daily, daily and monthly timescales identify single instances of error. However, such checks are often unable to identify problems which on any one occasion are of a lesser magnitude, but which are highly significant when viewed over a longer period. For example, a measurement which is 25% too low due to underexposure of the raingauge by vegetation is unlikely to be flagged as erroneous on a single occasion, but the accumulated measurements from the raingauge over a period of a month or more will lie outside the range of values that might be reasonably expected.

Systematic errors in the measurements from a raingauge should be identified by the following methods.

a) Analysing departures from long-term averages at neighbouring sites using statistical techniques to test for significance (see **12.2**).

b) Where a site has two or more collocated raingauges, analysing differences between the two sets of data over a period of time. Comparisons should be made with data from trials conducted under controlled conditions.

c) Analysing differences between raingauge measurements and radar estimates over a period of time.

d) Compiling summaries of the frequency of quality control flags raised for each raingauge. Those sites with a frequency well above average should be identified.

As soon as problems are identified appropriate corrective action should be initiated (see Clause **11**). The results of these checks should be recorded and maintained.

12.7 Managing the quality control process

To minimize the occurrence of erroneous quality control an expert review process should be implemented at regular intervals, at least annually. A panel of experts, staff who are fully trained and experienced in quality control methods, should review the quality control results produced during selected events. Input to the expert review should include:

a) a set of precipitation events selected by agreed methods;

b) all the precipitation measurements relating to the selected events, available at the time quality contol was undertaken;

c) any ancillary data available at the time quality control was undertaken; and

d) the flags set as a result of quality control.

The panel should evaluate the validity of the quality control results and make recommendations for any necessary improvements. In particular, the panel should ensure long-term consistency of quality control methods. The results of the reviews should be recorded and maintained.

13 Archiving

13.1 General

The permanent national archive of precipitation data for the UK should be maintained. Some network operators may maintain a regional or local archive which contributes data to the national archive.

13.2 National archive

The national archive should contain data relating to all sites that make, or have in the past made, regular measurements of precipitation. Sites should be excluded from the archive if:

a) the data are considered to be of unacceptable quality (e.g. due to poor exposure or poor observing standards); or

b) there is an overabundance of precipitation sites in the locality; or

c) the owner of the intellectual property does not allow general use of the data.

The archive of current data should be in electronic format; any paper records may be discarded once digitization and quality control processes are complete. Processes should be put in place to retrieve non-transmitted data, even if long after the event, to ensure that the archive is as complete as possible. Where resources permit, historical paper records from sites where precipitation has been measured over a long period should be digitized.

NOTE 1 The data in the national archive are designated as permanent as defined by the Public Records Act 1958 [5]. The Act specifies approved places of deposit for historical paper records.

NOTE 2 All precipitation data in the national archive since 1961 are in electronic format. Many older records, some dating back to the 19th century, are only available in manuscript format. However, a complete electronic record exists for selected long-period stations.

13.3 Database design

The electronic archive should be a database meeting current practices of design, containing:

a) precipitation data (see **9.1.1**);

b) data flags (see **9.1.2**); and

c) precipitation metadata (see **7.2**, **7.3** and **7.4**).

There should be unambiguous links between the data that associate each measurement with the relevant flags, metadata and estimates. In order that reviews and investigations into past precipitation events can be properly conducted, all original measured values should be stored in the archive, even if flagged as erroneous. However, if measurements from a raingauge are judged to be worthless (e.g. as a result of known system problems), they should be discarded. A catalogue of the current contents of the database should be maintained.

13.4 Data security

Processes should be put in place to ensure that the risk of the loss or corruption of data held in the electronic archive is kept to an absolute minimum. Actions that should be taken include:

a) ensuring that the database management system and the computer system on which it resides meet up-to-date security standards;

b) ensuring the computer system is designed in such a way as to minimize the risk of infection by viruses and other malicious software;

c) ensuring those given write permissions to the database are fully aware of the risks of corruption: the number of people with write access should be kept to a minimum consistent with efficient operations;

d) undertaking regular monitoring of the pattern of changes to the data held in the database;

e) making regular backups of the database;

f) maintaining off-site backups which may include archives for local use; and

g) regularly reviewing the effectiveness of security procedures.

14 Management review

14.1 General

All processes and equipment used in the production of precipitation data should be reviewed at planned intervals to ensure their continuing suitability, adequacy and effectiveness. The review should include the assessment of the risks to the production system, opportunities for improvement and the need to change processes and systems. Records of the reviews should be maintained.

14.2 Review input

The following should be take into account:

a) the user requirements for precipitation data and customer feedback;

b) precipitation data quality summaries based on quality control and operational performance monitoring activities;

c) inspectors' reports;

d) the frequency and severity of faults in the production system;

e) maintenance and calibration records;

f) records of reviews of the quality control process;

g) the results of trials or intercomparisons of raingauges;

h) information provided by the manufacturers of equipment used;

i) recommendations for improvement; and

j) the cost of any proposed changes.

14.3 Review outcomes

The management review should identify and implement improvements that can be made to the end-to-end system for making precipitation measurements and delivering data to users. Items for improvement should be related to:

a) processes for site selection, installation, manual observing, delivery, maintenance, inspection, calibration, monitoring, quality control and archiving;

b) training of staff and observers;

c) the frequency of maintenance and inspection visits;

d) the frequency of calibration for each type of raingauge;

e) the suitability of different types of raingauge for meeting user requirements;

f) sites to be closed because of poor observing or exposure;
g) areas where new sites are to be opened to meet user requirements; and
h) the need to seek new suppliers for equipment or services.

Annex A (normative) Rainfall postcard

A.1 Manual tabulation of daily precipitation accumulations on rainfall postcards should be recorded in accordance with **A.2** to **A.12** (see Figure A.1 for example). Also, any electronic method for recording and submitting rainfall data should be recorded in accordance with **A.2 to A.12**,

A.2 All entries should be clearly marked in ink or ballpoint pen.

A.3 The site name and number, and the month and year, should be entered where indicated.

A.4 Measurements made at 0900 UTC each day should be entered against the previous day's date.

A.5 When measurements are missed a bracket should be drawn, connecting the day or days of missing reading(s) with the next day that a measurement was made. Such a measurement is called an accumulation. No entry other than the bracket should be made on days when no observation was made.

A.6 A nil measurement of precipitation should be written as a dash.

A.7 If a measurement is not made between 0845 UTC and 0915 UTC the actual time of reading should be entered as the first item in the notes column.

A.8 The total precipitation measurements for the period should be added up and entered in the total line. This enables any subsequent user to repeat the check after data transcription to confirm that no errors have occurred.

A.9 Measurement of trace precipitation should be entered as TR.

A.10 Measurements should always be entered as millimetres and tenths of millimetres. Values of less than a millimetre should have a leading zero and the decimal point, and whole values of millimetres should be followed by the decimal point and a trailing zero, as in the following examples.

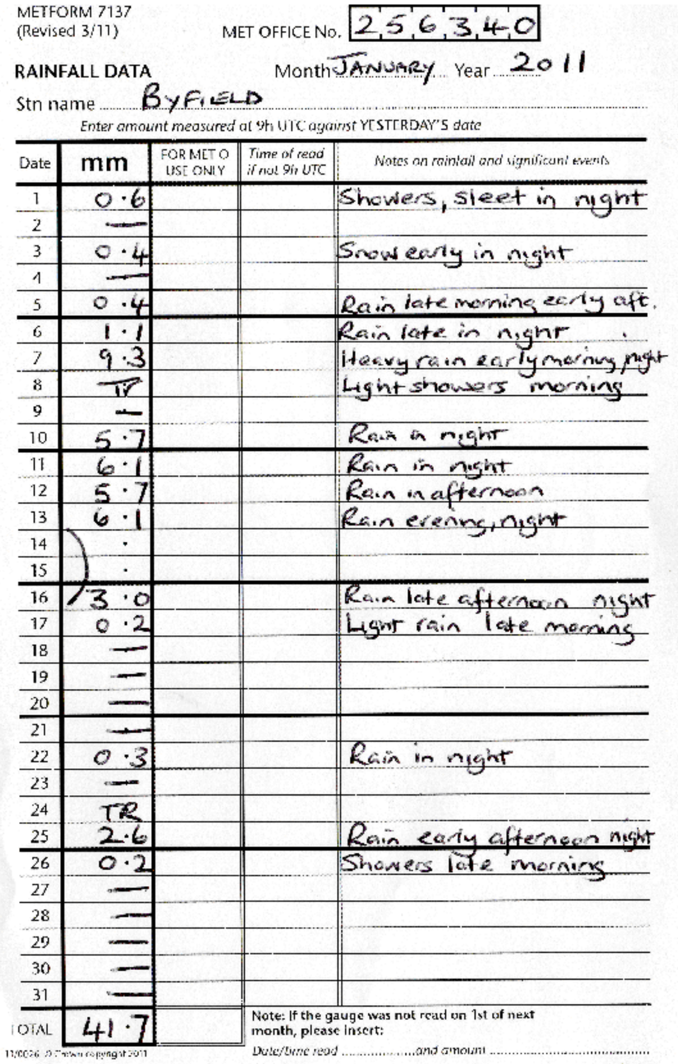
a) Two tenths of a millimetre: 0.2 mm.

b) Two millimetres: 2.0 mm.

A.11 The amount read from a monthly raingauge should be entered in the total column. A space is provided to enter the actual date in the event of the reading not being made in respect of the last day of the month.

A.12 Information should be provided in the notes column to describe any significant weather event that might be useful to the user of the precipitation measurement.

Figure A.1 **Example of rainfall postcard**



METFORM 7137
(Revised 3/11)

MET OFFICE No. 2,5,6,3,4,0

RAINFALL DATA Month JANUARY Year 2011

Stn name BYFIELD

Enter amount measured at 9h UTC against YESTERDAY'S date

Date	mm	FOR MET O USE ONLY	*Time of read if not 9h UTC*	*Notes on rainfall and significant events*
1	0·6			Showers, sleet in night
2	—			
3	0·4			Snow early in night
4	—			
5	0·4			Rain late morning early aft.
6	1·1			Rain late in night
7	9·3			Heavy rain early morning night
8	TR			Light showers morning
9	—			
10	5·7			Rain in night
11	6·1			Rain in night
12	5·7			Rain in afternoon
13	6·1			Rain evening, night
14	·			
15	·			
16	3·0			Rain late afternoon night
17	0·2			Light rain late morning
18	—			
19	—			
20	—			
21	—			
22	0·3			Rain in night
23	—			
24	TR			
25	2·6			Rain early afternoon night
26	0·2			Showers late morning
27	—			
28	—			
29	—			
30	—			
31	—			
TOTAL	41·7			Note: If the gauge was not read on 1st of next month, please insert: *Date/time read ....and amount ....*

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Annex B (informative) Common problems

Common problems encountered in the quality control of daily precipitation from storage raingauges are:

a) failure to indicate that the reading spans more than one day;

b) failure to record a single measurement, or more likely a series of measurements, as the previous day's reading;

c) reading not made at the time indicated;

d) transposed daily readings;

e) transposed digits;

f) reading in error by a factor of 10 too high or too low;

g) miscounts of the number of times the rain measure has been filled; and

h) clerical errors in transferring values from one format to another.

Common problems encountered in the quality control of daily precipitation from automatic raingauges at unmanned sites are:

1) funnel blocked by wind-blown debris or other matter causing rain to form a small pond, perhaps dripping very slowly into the measurement mechanism;

2) funnel blocked by snow which slowly releases melt water into the measurement mechanism over a period of hours or days;

3) drifting snow; and

4) rain following a period of heavy frost when the measurement mechanism is still frozen.

The quality control of data from unheated automatic raingauges when there has been widespread snow is a major problem. It generally requires the judgement of skilled staff to identify where apparent rainfall on one day is really due to the melt of snow from a previous day.

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For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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Further reading

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