TRANSPORT FOR NSW (TfNSW)

QA SPECIFICATION R272

AUTOMATIC WEATHER STATIONS

REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 0		First issued.	GM, CPS (Peter Letts)	23.05.14
Ed 1/Rev 1	Annex E	Table E - Pentair Environmental Systems added as AWS Panel Member	GM, CB	26.05.16
Ed 1/Rev 2	Global	References to “Roads and Maritime Services” or “RMS” changed to “Transport for NSW” or “TfNSW” respectively.	DCS	22.06.20

GUIDE NOTES

(Not Part of Contract Document)

Purpose of Automatic Weather Station

The purpose of the Automatic Weather Station (AWS) is to:

- provide a more detailed early understanding of potential rainfall and other adverse weather impacts;
- provide a proactive and early inspection and maintenance regime response to erosion and sedimentation and the effects of other adverse climatic conditions before pollution occurs;
- trigger weather alarms and messages to relevant personnel to take action;
- assess and validate the performance of installed erosion and sediment control measures against the design performance criteria;
- provide compliance data for statutory monitoring on Site.

General Guidance Notes for Specification R272

Specification R272 has been made sufficiently broad to cover most situations that may be encountered in AWS operation and maintenance activities.

It is, however, beyond the scope of R272 to cover all details of AWS siting, installation, operation, maintenance and calibration. Such information may be obtained from specifications and guidelines published by the Australian Government Bureau of Meteorology and the World Meteorological Organisation.

AWS operation and maintenance works can differ significantly from project to project. Annexure R272/A of TfNSW R272 must be completed by the Tender Documenter for each project to address the particular AWS requirements based on relevant Drawings, and the proposed types and number of stations and monitoring periods.

Annexure R272/B includes a Pay Item, R272P4, for which a Provisional Quantity should be entered by the Tender Documenter in the Schedule of Rates where appropriate.

TfNSW Project Manager must seek professional advice from a qualified consultant to help determine the number of each type (whether a “full” or a “rain gauge only”) of weather station required in the project. The monitoring period may include time before commencement of construction where appropriate.

The location of an AWS is of primary concern. The selection of a poor location may lead to the capture of poor quality, and potentially misleading, data. This Specification requires the Contractor to employ qualified personnel for siting the stations.

Transport for NSW

QA SPECIFICATION R272

AUTOMATIC WEATHER STATIONS

IC-QA-R272

VERSION FOR:
DATE:

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CLAUSE PAGE

FOREWORD

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW R272 Edition 1 Revision 1.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. ***Additional Text***.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. ~~Deleted Text~~.

TfNSW QA SPECIFICATION R272

AUTOMATIC WEATHER STATIONS

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the supply and installation of temporary Automatic Weather Stations (AWS).

The AWS comprises the following:

(a) tipping bucket rain gauges;

(b) temperature instruments;

(c) relative humidity instruments;

(d) wind speed instruments;

(e) wind direction instruments;

(f) dataloggers;

(g) telemetry devices;

(h) instrument enclosures (Stevenson screens or “beehive” enclosures);

(i) instrument masts.

Other work includes:

(i) provision of data to TfNSW and other end-users;

(ii) operation and maintenance of the AWS and telemetry services;

(iii) decommissioning of the AWS.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.2.1 Project Specific Requirements

Project specific details of work are shown in Annexure R272/A.

1.2.2 Measurement and Payment

The method of measurement and payment must comply with Annexure R272/B.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure R272/C list the **HOLD POINTS** and **WITNESS POINTS** that must be observed. Refer to Specification TfNSW Q for the definitions of **HOLD POINTS** and **WITNESS POINTS**.

The records listed in Annexure R272/C are **Identified Records** for the purposes of TfNSW Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure R272/D and must be implemented.

In all cases where this Specification refers to the manufacturer's recommendations, these must be included in the PROJECT QUALITY PLAN.

1.2.5 Minimum Frequency of Testing

The Inspection and Test Plan must nominate the proposed testing frequency to verify conformity of the item, which must not be less than the frequency specified in Annexure R272/L.

Where a minimum frequency is not specified, nominate an appropriate frequency.

Frequency of testing must conform to the requirements of TfNSW Q.

1.2.6 Referenced Documents

Unless specified otherwise, the applicable issue of a referenced document, other than a TfNSW Specification, is the issue current at the date one week before the closing date for tenders, or where no issue is current at that date, the most recent issue.

Standards, specifications and test methods are referred to in abbreviated form (AS 2350). For convenience, the full titles are given in Annexure R272/M.

1.3 DEFINITIONS AND ACRONYMS

1.3.1 Definitions

The terms "you" and "your" mean "the Contractor" and "the Contractor's" respectively.

The following definitions apply to this Specification:

Annual data capture The percentage of days on which a parameter is captured to the total operational period of 365 days.

Authorised User An individual or organisation authorised by the Principal to access AWS data.

Automatic Weather Station A selection of instruments installed for monitoring selected weather parameters. These instruments are generally connected to a datalogger.

AWS compound The area for installation of the AWS and ancillary related works.

Critical AWS activity Core AWS work activities for quality performance of the AWS, including siting, installation, commissioning, calibration and replacement of instruments, and decommissioning, that must be carried out by a member of the TfNSW AWS Panel.

Datalogger An electronic device that records measurements. It may also process these measurements, forward data to a telemetry server and issue alarms.

Dew point	The temperature at which the air cannot "hold" all of the water vapour and some of the water vapour will condense into liquid water.
Exposure ratio	Distance of an obstruction from a monitoring instrument to the height of that obstruction from the ground.
Full AWS	A monitoring station comprising a selection of instruments to monitor weather parameters of temperature, humidity, wind speed and direction, barometric pressure and rainfall.
Geotag	An electronic tag of geographical location information embedded in a digital media file, e.g. a digital image.
Instrument shelter	The housing for the temperature and relative humidity sensors which shields these sensors from precipitation and thermal radiation.
Primary datalogger	A datalogger which records multiple inputs, carries out multiple processes and communicates with a telemetry device, such as a modem of router.
Rain Gauge Only AWS	A monitoring station comprising a tipping bucket rain gauge, a datalogger, power supply and telemetry equipment.
Rainfall datalogger	A stand-alone datalogger which interfaces with a tipping bucket rain gauge and logs rain data.
Relative humidity	The ratio of the amount of water vapour in the air to the maximum amount the air could "hold" at a given temperature.
Telemetry	The transmission of data by wire, radio (including mobile telephony) or other means from remote sources to a receiving system.
Telemetry availability	The percentage of time that a telemetry device is serviceable and available to perform telemetry and alarming tasks (uptime) to the total operational period.
Time	Australian Eastern Standard Time (UTC+10).
Tipping bucket rain gauge	A rainfall measuring instrument which measures the volume of liquid precipitation collected in a "bucket". Once full, this bucket tips over to empty and can then be filled again.
Valid data	Data representative of the environmental conditions at Site at the time recorded. Gross errors in data and data logged during a period of instrumentation or datalogger malfunction or failure is not valid data.
Working day	Monday to Friday inclusive, but excluding proclaimed public holidays and the Contractor's rostered days off.

1.3.2 Acronyms

The following acronyms apply to this Specification:

AGL	Above Ground Level
AWS	Automatic Weather Station (which can be either Full AWS or Rain Gauge Only AWS)
BoM	Australian Government Bureau of Meteorology

IP Ingress Protection

SMS (Mobile telephone) Short Message Service

TBRG Tipping bucket rain gauge

WMO World Meteorological Organisation

RS232 Interface between data and communications equipment using serial binary data exchange

1.4 TfNSW AWS Panel

All critical AWS activities (refer definition given in Clause 1.3) for installation, operation and maintenance, and decommissioning of AWS(s) must be carried out by a member of the TfNSW AWS Panel.

Details of members of the TfNSW AWS Panel are given in Annexure R272/E.

2 AWS Equipment

Unless approved otherwise by the Principal, provide the following items for the AWS complying with this Specification:

(a) structures and enclosures;

(b) instruments;

(c) dataloggers;

(d) telemetry devices.

2.1 General

All equipment must be in good serviceable condition. All equipment must be “fit for purpose” and, where appropriate, calibrated.

2.2 Structures and Enclosures

2.2.1 Instrument Shelter

The instrument shelter must:

(a) be of either the Stevenson screen or “beehive” type;

(b) be white in colour;

(c) support the mounting of instruments at 1.2 m AGL.

2.2.2 Tipping Bucket Rain Gauge Stand

The Tipping Bucket Rain Gauge (TBRG) stand must be as shown in Figure R272.01.

The TBRG stand must permit levelling of the TBRG independently of the stand.

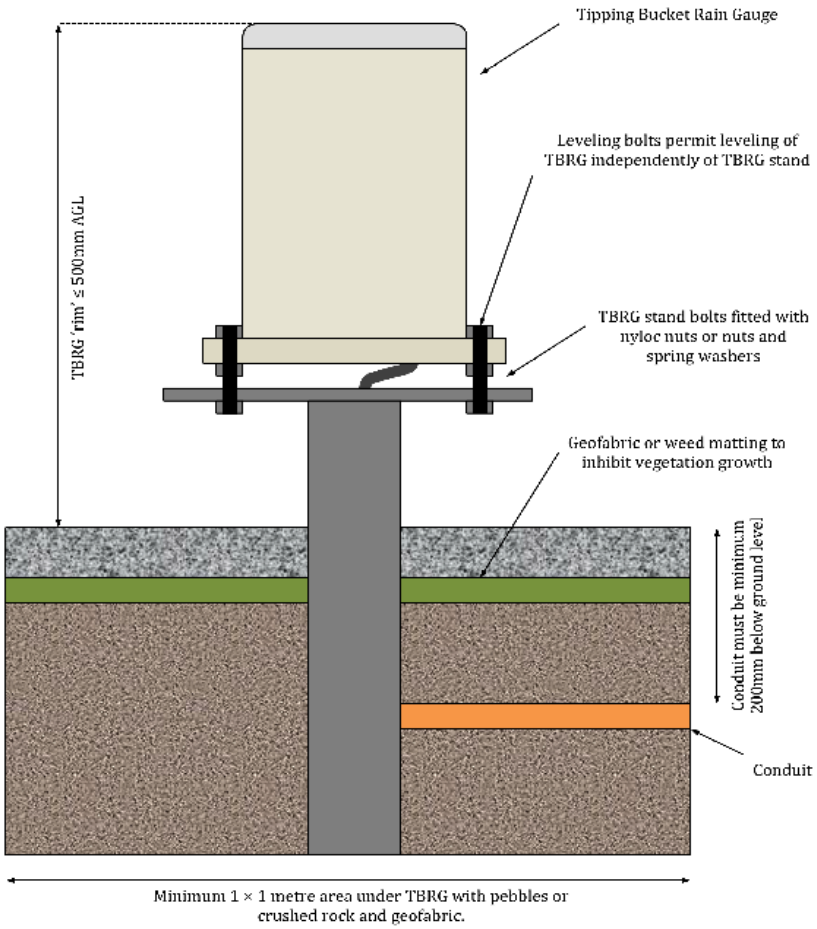

Figure R272.01 – Typical TBRG Stand

2.2.3 Wind Instrument Mast

Unless specified otherwise, use the BoM/WMO standard height of 10 m AGL for wind measurements. Where the standard height of 10 m AGL is not required or practicable, you may take wind measurement at either 5 m or 3 m AGL, with the concurrence of the Principal.

The wind instrument mast must:

(a) be designed in accordance with AS/NZS 1170.2 and AS/NZS 4676;

(b) be accompanied by a valid engineering certificate stating the:

  (i) design maximum wind speed;

  (ii) design maximum static load capacity;

(c) permit mounting of a variety of instrumentation;

(d) be of a folding or telescoping design to permit maintenance of mast mounted instrumentation without use of elevated work platforms such as “scissor lifts” or “cherry pickers”;

(e) be equipped with a suitable lug, to provide a suitable electrical earthing connection.

2.2.4 Electronics Enclosure

The electronics enclosure must:

(a) not shade the instrument shelter during daylight hours;

(b) provide environmental protection of IP43 or better in accordance with AS 1939;

(c) be fitted with vandal-resistant ventilation vents;

(d) be fitted with a lockable door. The door must open to an angle from the enclosure front of at least 100 degrees. Provide a keeper or latch to secure the door in the open position.

Provide protection to additional external junction boxes and connectors, to the following IP ratings in accordance with AS 1939:

(i) enclosures: IP65 or better;

(ii) external connectors: IP66 or better.

2.2.5 Solar Panels

The solar panels must not shade the instrument shelter during daylight hours.

To ensure best performance, arrange the solar panel(s) to:

(a) face north;

(b) have an angle from the horizontal equal to the location latitude;

(c) be fitted with adequate bird deterrent devices to reduce fouling.

Where approved by the Principal, the angle and orientation of the solar panel(s) may deviate from the above due to site limitations and seasonal power considerations; i.e. solar arrays oriented to optimise solar capture during winter.

2.3 INSTRUMENTS

2.3.1 General

Instruments must be:

(a) fully compatible with the datalogger and telemetry systems supplied;

(b) clearly labelled showing the name of the manufacturer, model or type, and unique serial number;

(c) supplied with complete technical documentation to the Principal.

Where instruments employ replaceable sensing elements, such elements must also be clearly labelled with unique serial numbers.

2.3.2 Instrument Performance

Instruments must conform to the performance requirements detailed in Table R272.1.

Table R272.1 – Instrument Performance

Instrument Type	Range	Accuracy	Resolution
Air Temperature	–20°C to +60°C	±0.5°C	0.1°C
Relative Humidity (RH)	5% to 100% RH	±3% RH (5% RH to 90% RH) ±4% RH (above 90% RH)	1% RH
Rainfall	0 to 700 mm/h	±3%	0.2 mm
Wind Speed	0 ms^{-1} to 75 ms^{-1}	0.5 ms^{-1}	0.5 ms^{-1}
Wind Direction	0° to 359°	±2°	1°

You may propose instruments which do not conform to these requirements, for approval by the Principal.

2.3.3 TBRG Specific Requirements

Each TBRG must have a circular "catch" diameter of either 200 mm or 203 mm.

The TBRG must be fitted with two (2) independent sensor outputs.

2.3.4 Instrument Calibration

Submit to the Principal a valid calibration certificate for each instrument to be installed prior to installation. As a minimum, this certificate must contain the following information:

(a) date of calibration;

(b) place of calibration;

(c) calibration method;

(d) calibration standard employed;

(e) certificate of calibration of the testing equipment.

Carry out post-installation calibration in accordance with Clause 4.1.

2.4 DATALOGGER

2.4.1 General

Each datalogger must:

(a) have sufficient memory size to retain at least six months of data;

(b) operate within the temperature range from –20°C to +50°C;

(c) retain configuration and data stored in the memory without external power for at least one year;

(d) have an internal real-time clock capable of holding time without external power for at least one year. It must be possible to update the real-time clock during a telemetry session;

(e) have a watchdog timer function to monitor the datalogger processor software and assert a reset, without losing data already accumulated, should an error be encountered;

(f) be equipped with the means to connect to a PC for the purpose of programming, configuration or data retrieval. This connection may be via RS232, USB, Bluetooth or a wireless communications protocol (Wi-Fi);

(g) allow the user to select sampling and logging intervals;

(h) be supplied with a user manual to describe the above operations.

2.4.2 Primary Datalogger

The number and type of input channels available on the primary datalogger must be compatible with the specified AWS type. Arrange the primary datalogger to allow, as a minimum, the following inputs:

(a) rain gauge;

(b) temperature;

(c) relative humidity;

(d) wind speed;

(e) wind direction;

(f) battery voltage;

(g) solar voltage.

The primary datalogger must perform data processing tasks including:

(i) calculations of maxima, minima, averages and totals;

(ii) rolling calculation;

(iii) dew point calculation (as per Annexure R272/K).

The primary datalogger must sample, process and log data as per the requirements of Table R272.2.

Table R272.2 – Time Series Parameter Sampling Regime

Parameter	Sampling Interval	Description
Air Temperature	5 minutes	5 minutes average air temperature
Relative Humidity	5 minutes	5 minutes average relative humidity
Dew Point	5 minutes	5 minutes average dew point temperature (calculation as per Annexure R272/K)
Average Wind Speed	5 minutes	5 minutes average wind speed
Wind Gust	5 minutes	Maximum wind speed measured over a rolling 3 second period
Average Wind Direction	5 minutes	5 minutes average wind direction
Rainfall Intensity	5 minutes	Rolling calculation (mm/h)

The primary datalogger must also sample and log event data as per the requirements of Table R272.3.

Table R272.3 – Event Parameter Sampling Regime

Parameter	Sampling Interval	Description
Event Rainfall	Event	Each “tip” of the TBRG

Event data must be logged with a minimum time resolution of one second.

2.4.3 Rainfall Datalogger

Implement the requirements specified below in conjunction with the requirements outlined in Clause 2.4.1.

Equip each TBRG with a stand-alone rainfall datalogger mounted locally, either within or outside the TBRG housing.

The rainfall datalogger must be connected to an output from the TBRG that is independent to that used for the primary datalogger.

If the stand-alone rainfall datalogger is to be mounted outside the TBRG housing, provide protection of IP ratings as per Clause 2.2.4.

Arrange the rainfall datalogger to log each "tip" of the TBRG as a discrete event and record the time and date of the "tip" in accordance with the requirements of Table R272.3.

Provide the rainfall datalogger with an internal power supply, and do not connect it to the station power supply.

Provide the rainfall datalogger with storing memory capacity of no less than 100,000 events.

Provide to the Principal the software, instructions and any connection hardware to connect to and download from the rainfall datalogger.

Monitor battery voltage and change battery according to the rainfall datalogger manufacturer's specifications.

2.4.4 Calibration

Where analogue instruments are used, the primary datalogger analogue-digital convertor must be calibrated at the same interval as the instruments.

Check the primary datalogger derived battery voltage periodically to ensure consistency with actual battery voltage.

2.5 TELEMETRY

Provide each AWS with telemetry. The telemetry method must be compatible with the primary datalogger, and capable of providing telemetry availability not less than 98%.

The telemetry method may be either:

(a) "push" telemetry, where the primary datalogger initiates a connection with the telemetry server and uploads logged data;

or

(b) "pull" telemetry, where a telemetry server connects to the primary datalogger and downloads logged data.

Arrange for data on the assigned webpage (refer to Clause 6.1) to be updated from the AWS at an interval no greater than every 15 minutes.

The telemetry method must support the transmission of alarm messages by SMS. Alarm messages must be transmitted as soon as practicable following an alarm condition.

Arrange telemetry to allow remote user to request data from the primary datalogger, or from the telemetry server, via SMS.

Provide telemetry equipment conforming to the Australian Communications and Media Authority technical standards (C-Tick, A-Tick or RCM).

2.6 POWER SUPPLY

2.6.1 General

Provide a self-contained extra low voltage (ELV) power supply to the AWS. Do not connect the AWS to the 240 volts alternating current consumer mains.

Provide batteries with sufficient capacity to power the AWS, and telemetry equipment, for a period of no less than 14 days without input from an external power source (i.e. solar panel).

2.6.2 Instrument Power

Provide power for all instruments either indirectly from the primary datalogger, or directly from the primary datalogger power supply.

2.6.3 Telemetry Power

Unless specified otherwise, use independent power supplies for primary datalogger and telemetry.

If use of a single battery is specified, provide the power system with a low-voltage cutout feature. In order to maintain power to the primary datalogger and ensure continued operation of the AWS, arrange for the telemetry system power supply to be isolated if the main battery voltage drops below the minimum specified for the primary datalogger and associated instruments.

2.6.4 Power Monitoring

Configure the primary datalogger to monitor battery voltage(s).

3 INSTALLATION

3.1 SITING OF AWS

Carry out the siting of the AWS using the services of a suitably qualified individual. Siting of the AWS must be in accordance with BoM OS 2013.1.

When siting an AWS,:

(a) take into consideration the purpose of the monitoring location, and its suitability for that purpose;

(b) check that the location selected are within the Project Site;

(c) ensure that the locations selected are available for the duration of the monitoring period;

(d) assess the security risks of the proposed location;

(e) determine if the proposed location is likely to be affected by environmental issues including flooding.

Refer to publicly available aerial and satellite imagery, topographic maps and Site plans to assist with making a "first pass" assessment of potential locations. Review data from nearby climatological stations to help assess the variability of weather conditions in the immediate area.

Once one or more locations have been identified for further investigation, take into consideration the following factors when deciding on the selection of the final location:

(i) Determine if the location is to support a Full AWS, a Rain Gauge Only AWS, or both;

(ii) The location must afford easy access for maintenance;

(iii) Its location, and access routes to the location, must not present operators with unreasonable safety risks, e.g. crossing a freeway to get to the station;

(iv) The location must be representative of the monitoring area. The vegetation at the location must be endemic;

(v) Avoid locations in special or sensitive environmental areas;

(vi) Avoid hilly or low-lying locations;

(vii) Avoid locations adjacent to large paved areas, or large bodies of water;

(viii) Utilities which may be present in, or adjacent to, the location that may make installation and operation complex, e.g. high pressure gas lines, overhead power cables, etc;

(ix) It is essential that the location has mobile telephone coverage – both for telemetry and safety reasons.

Select the final location in a consultative process with input from all stakeholders. Consider carefully the above factors to provide better quality data, reduced cost and a safer work environment.

3.2 AWS COMPOUND

Unless approved otherwise by the Principal, establish the AWS compound in accordance with the following provisions:

(a) For a Full AWS, the compound must have an area measuring 15 m by 15 m;

(b) For a Rain Gauge Only AWS, the area may be reduced to 5 m by 5 m;

(c) The ground surface in the compound must be generally level;

(d) The compound must be appropriately fenced for security reasons or to keep out animals;

(e) Vegetation in the compound must be kept trimmed to a height of not more than 200 mm above ground level;

(f) Provide an additional "buffer zone" with a radius of 30 m from the centre of the AWS compound which is kept free of obstructions. Vegetation in the buffer zone must be kept trimmed, ideally to a height of not more than 500 mm above ground level;

(g) Any instrumentation, communication or power cabling within the compound must be contained within conduits buried to a depth of at least 100 mm. A diagram of the cable layout within the compound must kept at the AWS for future reference.

HOLD POINT

Process Held:	Establishment of AWS.
Submission Details:	(a) Report identifying suitable locations for an AWS conforming to this Specification, Bureau of Meteorology Observation Specification No. 2013.1 (BoM 2013.1) and other relevant criteria; (b) Certified design of wind instrument mast, where appropriate; (c) Any Site specific excavation or ground disturbance permit; (d) Any environmental assessment required for the activity; (e) Valid calibration certificates for all instrumentation.
Release of Hold Point:	The Principal will consider the documentation submitted prior to authorising the release of the Hold Point.

3.3 AWS COMPOUND INSTRUMENTATION

Implement the manufacturer's installation instructions which will take precedence over any installation instructions contained in this Specification.

Comply with the following requirements for the location of instruments and ancillary equipment within the AWS compound.

3.3.1 Instrument Exposure

Position the instruments correctly in relationship to obstructions, both natural and man-made, to ensure data quality. Provide an exposure ratio not less than that shown in Table R272.4.

Table R272.4 – Exposure Ratio

Instrument	Height AGL	Minimum Exposure Ratio
Rain Gauge	500 mm	2:1
Anemometer	Variable (project specific)	10:1
Temperature/RH	1200 mm	2:1

3.3.2 Instrument Shelter

Satisfy the following conditions for the positioning of the instrument shelter within the AWS compound. The instrument shelter must be:

(a) unshaded during daylight hours;

(b) positioned such that it is not close to extensive areas of concrete, asphalt, rock, etc;

(c) installed such that the instruments are at 1.2 m AGL;

(d) positioned at least 2 m away from the enclosure fencing.

The instrument shelter mounting must be installed securely in the northern part of the AWS compound to avoid overshadowing.

3.3.3 Tipping Bucket Rain Gauge

When installed, the rim of the TBRG must be at a height no greater than 0.5 m AGL, as shown in Figure R272.01.

Position the TBRG within the compound in conformity with the exposure ratio specified in Clause 3.3.1.

The 1.0 m by 1.0 m ground surface surrounding the TBRG must be a granular material such as gravel or crushed rock. Geofabric or plastic must be installed under this material to inhibit vegetation growth as depicted in Figure R272.01.

3.3.4 Wind Instrument

Position wind instruments within the compound in conformity with the exposure ratio specified in Clause 3.3.1.

When planning the installation of the wind instruments, consider:

(a) the resting location of the wind instruments when mast is lowered for maintenance;

(b) the position of footings and guy points within the compound;

(c) reduced or restricted access resulting from the position of guy wires.

To reduce the likelihood of people within the compound colliding with the guy wires, fit all guy wires with highly visible, retro-reflective markers or tags at 1.5 m AGL.

3.3.5 Electronics Enclosure

Comply with the following provisions when locating the electronics enclosure:

(a) the electronics enclosure must be located as to avoid overshadowing of the AWS instruments;

(b) the height of the enclosure must permit easy access to the instrumentation;

(c) the enclosure must open to the south to reduce reflection on PC screens.

4 COMMISSIONING

4.1 COMMISSIONING REPORT

Submit a commissioning report to the Principal. The report must include the following:

(a) a complete inventory of equipment and instrumentation including type, make, model, serial number and date of commissioning;

(b) work-as-executed drawings showing general arrangement and schematics for all devices, connections, cabling details and equipment locations;

(c) results of the post-installation TBRG calibration;

(d) valid calibration certificates for all sensors;

(e) latitude and longitude of all instrumentation;

(f) geotagged photos clearly showing the Site before and after installation;

(g) geotagged photos clearly showing Site exposure at commissioning;

(h) a simple wiring diagram clearly showing the wiring of the primary datalogger, telemetry device and power supply;

(i) a copy of the primary datalogger program clearly outlining the method used to calculate dew point and constants used in the calculation;

(j) the Uniform Resource Locator (URL) for access to data webpage with username and password;

(k) instructions on how to view and download data from the website;

(l) instructions on how to retrieve data from any datalogger;

(m) instructions on how the Principal can add and edit alarms and alarm recipients.

The commissioning report must be provided to the Principal in a PDF format electronically within 1 week of commissioning the AWS.

5 PERFORMANCE

5.1 DATA CAPTURE REQUIREMENTS

The annual data capture rate, of valid data, for the individual parameters of the AWS, must not be less than 98%.

5.2 TELEMETRY PERFORMANCE

The telemetry availability of the AWS must not be less than 98%.

5.3 MAINTENANCE RESPONSE REQUIREMENTS

Following identification of a fault with the AWS Site and/or AWS data, notify the Principal by email within 2 working days from the time of identification. The notification must include the following details:

(a) nature, or possible nature, of the fault;

(b) parameter(s) affected by the fault;

(c) proposed response;

(d) expected date of rectification.

Rectify the fault within five (5) working days of fault identification.

6 SUPPLY OF DATA

6.1 GENERAL

Provide the Principal and other authorised users (the User) with access to data via all of the following methods:

(a) a webpage displaying the latest telemetered data;

(b) a “self service” data request web portal;

(c) email, file transfer protocol (FTP) or transmitting of hard copy in response to a data request.

6.2 DATA FORMAT

In response to an automated or manual data request, supply data in the formats outlined below.

6.2.1 Observations CSV Format

Time series data must be provided to the User in a comma separated value (CSV) file format as outlined in Table R272.5.

Table R272.5 – Observations CSV Format

Column	Variable	Format	Example	Unit
1	Station ID	nnnnnn	123456	-
2	Station Name	Xxxx_xxx	Holbrook_North	-
3	Year	yyyy	2014	-
4	Month	mm	04	-
5	Day	dd	22	-
6	Hour	hh	07	-
7	Minute	mm	25	-
8	Air Temperature	nn.nn	16.36	°C
9	Dew Point Temperature	nn.nn	14.22	°C
10	Relative Humidity (RH)	nn.n	68.0	% RH
11	Wind Direction (Degrees)	nnn	121	°
12	Average Wind Speed	nnn.nn	15.21	km/h
13	Maximum Wind Speed	nnn.nn	17.50	km/h
14	Cumulative Precipitation	nnn.n	23.0	mm

An example output is shown below for a request for five (5) minutes data for Site 123456:

123456, Holbrook_North, 2014, 04, 22, 07, 25, 16.36, 14.22, 68.0, 121, 15.21, 17.50, 23.0

123456, Holbrook_North, 2014, 04, 22, 07, 30, 16.25, 14.00, 67.8, 120, 15.45, 17.80, 25.8

123456, Holbrook_North, 2014, 04, 22, 07, 35, 16.12, 14.56, 67.9, 112, 15.21, 25.69, 32.0

6.2.2 Event CSV Format

Event rainfall data must be provided to the User in a comma separated value (CSV) file format as outlined in Table R272.6.

Table R272.6 – Event CSV Format

Column	Variable	Format	Example	Unit
1	Station ID	nnnnnnn	123456	-
2	Station Name	Xxxx_xxx	Holbrook_North	-
3	Year	yyyy	2014	-
4	Month	mm	04	-
5	Day	dd	22	-
6	Hour	hh	09	-
7	Minute	mm	05	-
8	Second	ss	23	-

An example output is shown below for a request for event rainfall data for Site 123456:

123456, Holbrook_North, 2014, 04, 22, 09, 05, 23

6.3 WEB DATA PRESENTATION

Provide a web portal for the User access to all data. The web portal must incorporate the following features:

(a) access protected by project specific login and password (refer to Clause 6.3.1);

(b) a "Current Conditions" display (refer to Clause 6.3.2);

(c) a tool to allow the User to review time period data for all parameters (refer to Clause 6.3.3);

(d) access to data from the standalone rainfall datalogger (refer to Clause 6.3.4);

(e) a web-based data request tool (refer to Clause 6.4).

Provide a web-based alarm management tool, as part of the data access web portal, to assist the User with management of alarms and alarm recipients.

6.3.1 Secure Access

Restrict access to the web portal to the User. Supply the Principal with a login and password that accesses only the AWS(s) specific to the Contract, at the time of commissioning the AWS.

6.3.2 Current Conditions

Arrange the web portal to include a "Current Conditions" section or page showing the last downloaded or received data for each AWS Site for the following parameters:

(a) temperature;

(b) relative humidity;

(c) dew point;

(d) wind speed;

(e) wind direction;

(f) rainfall, including

(i) 24 hour rainfall to 9 am;

(ii) rainfall since 9 am;

(iii) rainfall in the last hour;

(g) battery voltage;

(h) solar voltage.

The time and date of the displayed observation must be clearly displayed.

6.3.3 Time Period Selectable Data

The web portal must allow the User to select and display multi-parameter data. The User must be able to select:

(a) AWS site;

(b) parameter(s);

(c) time period.

The display of data must be graphical. Each axis of the graph must be clearly labelled with clear scaling and units.

If the User selects multiple parameters, each parameter must be clearly labelled and coloured to assist interpretation.

6.3.4 Rainfall Event Data

Event data from the standalone rainfall datalogger must be:

(a) made available to the User via the web portal within 30 days of data retrieval (refer to Clause 7);

(b) clearly identified in all web displays and data requests as being derived from a secondary source.

6.4 DATA REQUEST TOOL

Supply a data request tool as part of the Web Portal. The data request tool must allow customisation of the data request. Data must be provided to the User in either the Observations CSV format (Clause 6.2.1) or the Event CSV format (Clause 6.2.2).

6.5 DATA REQUESTS

You must respond to a data request from the User, within 5 working days from the time of receipt of the request.

The request from the User will contain the following information:

(a) AWS station to which the request relates;

(b) time interval required (hourly data, 9 am to 9 am rainfall etc);

(c) time period to which the request relates;

(d) details of further analysis or calculations that are required.

Data must be provided to the User in the Observations CSV format detailed in Clause 6.2.1.

6.6 ALARMS

The AWS and associated telemetry system must be capable of issuing SMS and email alarms.

Alarms may be issued by any of the following methods:

(a) "direct" method, whereby the alarm message is generated and issued by the primary datalogger;

(b) "back to base" method, where the primary datalogger notifies the telemetry server of an alarm condition and the alarm messages are generated and issued by the telemetry server;

(c) "telemetry server" method, where the telemetry server initiates the alert based on data downloaded from the primary datalogger. Data must be updated from the primary datalogger to the telemetry server at an interval no greater than 1 minute.

6.6.1 Alarm Parameters and Thresholds

The Principal will supply a list of alarm parameters (up to 10) and their respective thresholds for each AWS prior to commissioning of the Site. An example list is shown at Table R272.7.

Table R272.7 – Example Alarm Parameters and Thresholds

Station ID	Station Type	Period	Parameter	Threshold
123456	Full AWS	Instantaneous	Wind Speed	30 km/h (with a lag of realarming of 1 hour)
123456	Full AWS	Since 9 am	Rainfall	100 mm
123456	Full AWS	Last hour	Dew Point	15°C
654321	Rain Gauge Only AWS	Since 9 am	Rainfall	10 mm
654321	Rain Gauge Only AWS	Last 24 hours	Rainfall	20 mm

6.6.2 Alarm Recipients

The Principal will supply a list of intended alarm recipients (up to 30) prior to commissioning of the AWS. This list will include the following details of each intended recipient:

(i) name;

(ii) parameters of interest;

(iii) email address;

(iv) mobile telephone number to receive SMS;

(v) "do not contact" periods (such as weekends and public holidays);

(vi) start and finish dates for the alarm service.

The Principal may, from time to time, direct you to update the alarm recipients list. You must update the list within five days of notification.

6.6.3 SMS Alarm Message

The SMS alarm messages must contain the following information:

(a) header: "TfNSW AWS ALARM";

(b) time (24 hour format) and date (day month year format, i.e. "ddmmyy" format) of alarm issue;

(c) AWS name;

(d) alarm parameter;

(e) alarm threshold exceeded;

(f) hyperlink to latest data (optional).

An example of a SMS alarm message is depicted below.

TfNSW AWS ALARM 2245 220414 Holbrook_North Rainfall Alarm 50mm in 3hrs

6.6.4 Email Alarm Message

The email alarm messages must contain the following information:

(a) subject line: "TfNSW AWS ALARM";

(b) header: "TfNSW AWS ALARM";

(c) time and date of alarm issue;

(d) AWS name;

(e) alarm parameter;

(f) alarm threshold exceeded;

(g) graphical representation of previous 24 hours data for the alarm parameter;

(h) hyperlink to latest data.

6.7 SMS DATA REQUEST

Provide the User with access to real-time data from the primary datalogger, using any one of the following two methods:

(a) The User sends a specific command via SMS, directly to the AWS primary datalogger. The primary datalogger responds with latest data via SMS;

(b) The User sends a specific command (including details such as AWS Site name) via SMS to the telemetry server. The telemetry server then polls the AWS of interest and, following completion of the telemetry process, sends the data via SMS to the User.

To enable the request, supply the following:

(i) destination phone number for SMS data request;

(ii) format of a data request SMS (e.g. DATAREQ 123456);

7 OPERATION AND MAINTENANCE

7.1 GENERAL

Carry out regular maintenance of the instruments, mounting structures and enclosure to assist with capturing high quality, continuous data.

Undertake regular maintenance of the AWS as per the requirements of Clause 7.2.

Personnel performing maintenance on an AWS must:

(a) be trained in the operation of the instrumentation and equipment;

(b) possess a thorough understanding of BoM 2013.1;

(c) be equipped with a calibrated portable weather station, or sensor suite, to allow verification of the AWS readings.

Refer to Clauses 2.3.4 and 2.4.4 for sensor and primary datalogger specific calibration and maintenance requirements.

7.2 MAINTENANCE REGIME

Maintain the AWS at the intervals shown in Table R272.8.

Table R272.8 – Maintenance Intervals

Interval	Maintenance Item	Maintenance / Calibration Tasks
6 Months	Compound	Refer to Clause 7.4
	Structures	Refer to Clause 7.5
	Instruments	Refer to Clauses 7.3 & 7.6
	Primary datalogger	Refer to Clause 7.7
	Power supply	Refer to Clause 7.8
	Grounding	Refer to Clause 7.9
12 Months	Instruments	Calibrate or replace RH and Temp (refer to Clauses 7.3, 7.6.1 & 7.6.2)
24 Months	Power supply	Check battery condition
	Instruments	Calibrate or replace Wind

7.3 ONGOING CALIBRATION

7.3.1 Calibration Frequency

Carry out on-going calibration of all instruments at the frequencies specified by their manufacturers. If the manufacturer does not specify the calibration interval, then perform calibrations at the interval stated in Table R272.9.

Table R272.9 – Instrument Calibration Interval

Instrument Type	Calibration/Replacement Interval
Air Temperature	12 month
Relative Humidity	12 month
Rainfall	6 month
Wind Speed	24 month
Wind Direction	24 month

7.3.2 Calibration

Carry out ongoing calibration of all instruments in accordance with the manufacturer's instructions. Submit to the Principal a valid calibration certificate for each instrument following calibration. As a minimum, this certificate must contain the following information:

(a) date of calibration;

(b) place of calibration;

(c) calibration method;

(d) calibration standard employed.

WITNESS POINT

Process:	Calibration of instruments.
Submission Details:	Notification of the time and location of calibration of each instrument at least five (5) working days prior to commencing.

7.4 MAINTENANCE OF AWS COMPOUND

7.4.1 Fencing

Check the condition of the compound fencing during each inspection. Check the operation and security of any gates.

7.4.2 Vegetation

Maintain vegetation in the compound in accordance with the requirements of Clause 3.3.

Use a mower with a catcher to prevent dry clippings from blocking instrument screens and rain gauges. Protect the rain gauge by placing a suitable cover (e.g. bucket or bag) over the gauge while undertaking any maintenance that may foul the gauge. The cover must be removed following maintenance.

7.4.3 Insects and Pests

Monitor the instrumentation compound area for any adverse effects caused by insects and pests and apply appropriate mitigation measures.

7.4.4 Conduit

Conduits carrying instrumentation, communications or power cabling must not be damaged during compound maintenance activities.

7.5 STRUCTURES

7.5.1 Instrument Shelter

Paint the instrument shelter in white colour.

Keep the instrument shelter clean.

Keep the shelter vent screens free of obstructions, such as cobwebs or grass, to ensure adequate airflow.

7.5.2 Rain Gauge Mount

The rain gauge mount must be secure and rigid. Eliminate any loose connection in the rain gauge mount as soon as it is discovered.

Tighten the rain gauge mounting bolts and secure with spring washers or nyloc nuts.

7.5.3 Wind Mast

Inspect and maintain the wind instrument mast in accordance with the manufacturer's guidelines.

Inspect the condition of guy wires (if fitted), high visibility markers, anchors and footings, and the alignment of the mast.

7.6 INSTRUMENTS

Determine the operational status of the instruments prior to mobilising to Site. Confirm that "sensible" readings are being received (e.g. midday temperatures in Bourke of –5°C are unlikely).

As a check, compare readings for temperature, relative humidity and barometric pressure (but not for wind and rainfall) with those from a nearby BoM AWS. Wind and rainfall values vary greatly even over a short distance and must not be used for comparison purposes.

Once on Site, examine all instruments to ensure that:

(a) equipment is secure, clean and "fit for use";

(b) the instrument is securely mounted;

(c) all cabling is in serviceable condition with no sign of UV, animal or abrasion damage.

7.6.1 Tipping Bucket Rain Gauge Stand

Maintain the TBRG in accordance with the manufacturer's instructions.

Check that:

(a) the rain gauge filter and syphon are clean and free of debris;

(b) the rim of the rain gauge is clean and free from damage;

(c) the rain gauge is level and secure.

Add “test tips” to the rain gauge to verify that the bucket tips freely. Confirm that tips are registered on both the primary datalogger and rainfall datalogger.

Check the rain gauge for ants, especially under the electronics cover (if fitted), as ants are often attracted to the electronic components of the rain gauge.

7.6.2 Relative Humidity

Maintain the relative humidity (RH) sensor in accordance with the manufacturer’s instructions.

Inspect the RH instrument filter regularly for any blockages. Clean or replace the filter as necessary.

If the RH instrument has a removable filter, replace the filter every 12 months.

If an RH instrument has a replaceable sensing element with no facility to permit cleaning of the filter, and the filter is blocked, replace the sensing elements.

7.6.3 Temperature

Maintain the temperature sensor in accordance with the manufacturer’s instructions.

Keep the temperature instrument clean.

7.6.4 Wind Speed and Direction

Maintain the wind sensor(s) in accordance with the manufacturer’s instructions.

Inspect and clean the wind instruments.

Carefully rotate (preferably by blowing) the anemometer impellor or cups, taking note of the high starting torque or irregularities in rotation.

Check the orientation of the wind direction sensor against True North.

7.7 DATALOGGER

The datalogger(s) must be maintained in accordance with the manufacturer’s instructions.

7.7.1 Data

The datalogger(s) must be downloaded via a direct connection.

7.7.2 Memory and Real-time Clock Battery

Some dataloggers employ a non-rechargeable lithium battery to power the SRAM and the real-time clock when external power is not present. If fitted, monitor the lithium battery voltage. Replace the battery if the voltage drops below the manufacturer’s recommendations.

7.7.3 Desiccant Pack

Check the desiccant pack (if fitted) and replace if necessary.

7.8 POWER SUPPLY

Maintain all components of the power supply in accordance with the manufacturer's recommendations and the following:

(a) the power system provides adequate power to the AWS;

(b) all components are securely fitted and in serviceable condition;

(c) cabling is in serviceable condition with no sign of abrasion damage or UV degradation;

(d) junction boxes (if fitted) are secure and sealed;

(e) all connections and terminals are secure and that continuity exists;

(f) all fuses are functional;

(g) wiring is neat, tidy and adequately labelled.

7.8.1 Solar Panel

In addition to the conditions outlined in Clause 7.8, the solar panel must be:

(a) clean and free from shading;

(b) oriented to provide optimal power supply for the station (refer to Clause 2.2.5);

(c) installed with an operational bird deterrent device.

7.9 GROUNDING

If the AWS is fitted with an earth stake, check that the stake clamp is secure and the earth cable running to the electronics enclosure is intact and continuous.

8 DECOMMISSIONING

8.1 GENERAL

At the conclusion of the operation and maintenance period, or upon instruction by the Principal, carry out the decommissioning of the AWS.

Submit a copy of the final datalogger program to the Principal.

Supply all data obtained during the monitoring period to the Principal, on a solid state device such as a "memory stick". Edited data must be provided in either the Observations CSV format (Clause 6.2.1) or the Event CSV format (Clause 6.2.2).

8.2 VERIFICATION OF CORRECT SENSOR OPERATION

Immediately following decommissioning, and prior to their removal from Site, verify that all sensors, except the TBRG, have been operating correctly. For the TBRG, perform a final field calibration of the TBRG prior to its removal from Site.

Provide the results of the sensor tests and final calibration of the TBRG to the Principal.

8.3 DECOMMISSIONING REPORT

Provide a decommissioning report to the Principal within three months of decommissioning. The report must include:

(a) a station history clearly showing the monitoring period, sensor changes, faults and any Site specific issues;

(b) evidence of final verification/calibration of all sensors/TBRG;

(c) photos clearly showing the Site exposure immediately prior to decommissioning;

(d) photos clearly showing the AWS Site immediately prior to decommissioning.

(e) certification by a suitably qualified individual stating that the AWS Site has been inspected and is suitable for restoration to its original condition;

HOLD POINT

Process Held:	Removal of instruments and sensors from Site.
Submission Details:	Decommissioning report including all items detailed in Clause 8.3.
Release of Hold Point:	The Principal will consider the documentation submitted prior to authorising the release of the Hold Point. The Principal may also require a final Site inspection.

8.4 RESTORATION OF SITE

Remove from Site all equipment, structures, materials, conduits, etc which you have installed and restore the Site to its original condition, unless authorised otherwise by the Principal.

ANNEXURE R272/A – PROJECT SPECIFIC REQUIREMENTS

A1 MONITORING REQUIREMENTS

Station Type (1)	Number Required	Monitoring Period (2)	
		From	To

Notes:

(1) Station type: Full AWS or Rain Gauge Only AWS.

(2) Monitoring period may be defined using milestones, e.g. Date of Contract, Completion Date, etc.

ANNEXURE R272/B – MEASUREMENT AND PAYMENT

Payment will be made for all costs associated with completing the work detailed in this Specification in accordance with the following Pay Items.

Where no specific pay items are provided for a particular item of work, the costs associated with that item of work are deemed to be included in the rates and prices generally for the Work Under the Contract.

Unless specified otherwise, a lump sum price for any of these items will not be accepted.

Pay Item R272P1 – Supply, Installation and Commissioning of Automatic Weather Station (AWS)

Pay Item R272P1.1 – Full AWS

Pay Item R272P1.2 – Rain Gauge Only AWS

The unit of measurement is "each" AWS installed.

The schedule rate must include all materials, equipment, instruments, site inspection, testing, calibration and ancillary work required for supply, installation and commissioning of the AWS as specified. The rate must also include the cost of the services of a qualified person to carry out the siting of the AWS.

Pay Item R272P2 – Operation and Maintenance of Automatic Weather Station (AWS) Installed

Pay Item R272P2.1 – Full AWS

Pay Item R272P2.2 – Rain Gauge Only AWS

The unit of measurement is per AWS per month.

The schedule rate must include the operation and maintenance of the AWS under the Contract including provision of data on request and establishment of the telemetry services as specified.

Pay Item R272P3 – Decommissioning of Automatic Weather Station (AWS)

Pay Item R272P3.1 – Full AWS

Pay Item R272P3.2 – Rain Gauge Only AWS

The unit of measurement is "each" AWS decommissioned.

The schedule rate must include all testing, reporting, calibration and work associated with decommissioning of the AWS as specified including restoration of the Site to its original condition.

Pay Item R272P4 – Access to All Automatic Weather Station (AWS) (Provisional)

The unit of measurement is per km of all access routes to the stations.

The schedule rate must include all costs associated with the construction of the access routes to the AWS, including any site clearing and earthworks required.

ANNEXURE R272/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

Clause	Type	Description
3.2	Hold	Submission of report identifying suitable locations for AWS, and relevant certificates
7.3.2	Witness	Calibration of AWS instruments
8.3	Hold	Verification of correct sensor operation and submission of decommissioning report

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of TfNSW Q Annexure Q/E.

Clause	Description of Identified Record
3	Inspection report, certified design of wind instrument mast where appropriate and valid calibration certificates for all instrumentation
4.1	Commissioning report
7.3	Ongoing calibration records
8.1	Final datalogger program and all monitoring data
8.3	Decommissioning report

ANNEXURE R272/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

The following document must be included in the PROJECT QUALITY PLAN. The requirements of this Specification and others included in the Contract must be reviewed to determine additional documentation requirements.

Clause	Description
3.1	Procedure for siting of AWS covering potential and final locations.

ANNEXURE R272/E – TFNSW AWS PANEL

E1 AWS PANEL MEMBERS

Refer to Clause 1.4.

The following organisations, shown in Table R272/E, are acceptable to the Principal to carry out all critical AWS activities for installation, operation and maintenance, and decommissioning of the AWS.

Table R272/E – AWS Panel Member Details

Company	Contact	Phone	Email
ALS Environmental	Anthony Skinner	(02) 4721 3477	anthony.skinner@alsglobal.com
Benchmark Monitoring	Ben Clydsdale	(02) 6572 1028	ben.clydsdale@ benchmarkmonitoring.com.au
Environdata Weather Stations	Matthew Probets	(07) 4661 4699	matthew@environdata.com.au
Manly Hydraulics Laboratory	Amity Alexander	(02) 9949 0228	amity.alexander@mhl.nsw.gov.au
Pentair Environmental Systems	Antony Volcich	(07) 3866 7833	antony.volcich@pentair.com
SAGE Automation	Adam Kiryk	(02) 9878 9600	adam.kiryk@gotosage.com

ANNEXURES R272/F TO R272/J – (NOT USED)

ANNEXURE R272/K – DETERMINATION OF DEW POINT

Refer to Clause 2.4.2.

K1 CALCULATING DEW POINT

Calculate the dew point using the method based on the Magnus-Tetens formula. One version of the equation is given below:

$$T_d = C_3 \ln(V_p/C_1)/[C_2 - \ln(V_p/C_1)]$$

A number of sets of constants for calculation of T_d are in common usage, each set optimised for a range of dew point temperatures.

Table R272/K.1 – Magnus-Tetens Constants for Calculation of Dew Point

Reference	C_1	C_2	C_3	T_d Range (°C)
NOAA (after Bolton, 1980) (1)	0.6112	17.67	243.5	$-30 \le T_d \le 35$
Paroscientific (2)	0.6105	17.27	237.7	$0 \le T_d \le 50$
Campbell Scientific (3)	0.61078	17.558	241.88	$-35 \le T_d \le 50$
Environdata (4)	0.6105	17.27	237.3	Not defined

Notes:

(1) https://www.rsmas.miami.edu/users/pzuidema/Bolton.pdf

(2) http://www.paroscientific.com/dewpoint.htm

(3) ftp://ftp.campbellsci.com/pub/csl/outgoing/uk/technotes/16_oct05.pdf

(4) P Rodeck, pers. comm, 6 February 2014

State clearly the constants used in the calculation of dew point.

It must be noted that the method of calculating dew point requires an estimation of vapour pressure and, hence, saturation vapour pressure. It is beyond the scope of this specification to discuss the methods of calculating or estimating vapour pressure. The references in the notes to Table R272/K.1 give good explanation of a number of possible methods.

You may also refer to the following reference for an approximation polynomial:
Lowe, P.: 1977, "An approximation polynomial for computation of saturation vapour pressure", Journal of Applied Meteorology, 16, 100 – 103.

ANNEXURE R272/L – (NOT USED)

ANNEXURE R272/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.6.

TfNSW Specifications

TfNSW Q	Quality Management System

Australian Standards

AS/NZS 1170.2	Structural design actions – Wind actions
AS 1939	Degrees of protection provided by enclosures for electrical equipment (IP Code)
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 4676	Structural design requirements for utility service poles

Other Documentation

OS 2013.1	Bureau of Meteorology Observation Specification 2013.1
WMO-No. 8	Guide to Meteorological Instruments and Methods of Observation