WBEA – Standard Operating Procedure

SOP Title	**Temperature and Relative Humidity**
SOP Number	**WBEA SOP-MET-006**
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Revision History

Revision #	Date	Description	Author

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Introduction and Background

This procedure is intended to convey the knowledge required to operate, calibrate and maintain ambient temperature and relative humidity sensors. Temperature data is collected at all WBEA ambient monitoring stations, typically at the 2 metre height, with several stations measuring at various intervals from 2 to 167 meters.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by Alberta Environment in 1989. In some cases the limits and specifications exceed the requirements of the current AMD and subsequent amendments. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the WBEA network. Information used to write this procedure was also taken from sources identified in the reference section.

Principle of the Method

Temperature in ambient air is measured using a thermistor sensor mounted within an aspirated protected shield. The typically white shield is to reduce the effect of solar energy, as well as terrestrially reflected energy. Thermistor is a device that's name describes its function; a thermal resistor. There are two types of thermistors one which has a resistance that decreases as temperatures rise as with Negative Temperature Coefficient (NTC) and one which the resistance increases as temperatures rise as with Positive Temperature Coefficient (PTC) Thermistors. The majority of thermistor sensors used in the application of air quality monitoring use NTC style thermistors. The thermistor is for the most part made up of a solid state metal oxide ceramic which when heated decreases the amount of resistance in the probe. The temperature is then calculated by measuring the difference in the direct current (DC) voltage. This produces a resistance charge inversely proportional to the ambient temperature being monitored and is sent either as an analog signal to the Data Acquisition System or interrogated digitally via serial connection.

The method used to measure Relative Humidity (RH) in ambient air is that of a shielded probe unit combined with a translation system. The RH sensor is typically combined in the same housing with the temperature sensor and is mounted in one radiation shield. The sensor operates by measuring the capacitance change of polymer film capacitor. A porous one micron thin dielectric polymer layer draws molecules of water by metal electrodes; the water molecules change the capacitance in a manor directly proportional to the relative humidity. Because the polymer layers are so thin, the sensor reacts quickly to changes in RH with minimal lag in response. The voltage change is calculated by the in-sensor translator and sent either as an analog signal to the Data Acquisition System or communicated via serial connection.

Measurement Range and Sensitivity

Ambient temperature sensors used in this method are commercially available models. The measurement range of temperature is typically -50°C to +50°C. Range sensitivity is typically ± 0.1 °C. Please refer to the instrument specific installation and operating instructions for more information on range and sensitivity.

Relative humidity sensors used in this method are commercially available models. The measurement range is 0 – 100% of relative humidity within a temperature range of -20° C – +60° C. Please refer to the instrument specific installation and operation instructions for more information on range and sensitivity.

Equipment and Apparatus

The following are commercially available sensors are used by WBEA in this method:

Met One Models: 64-2, 592, T200

Vaisala HMP 155

RM Young 43440

Interferences

Interferences with temperature measurement accuracy can be caused by improper location of the sensor. Improper mounting can result in the probe being exposed to direct solar energy and even to ventilation of a permanent shelters air conditioning. It should also be noted that glass enclosures, mounting within or next to windows also increases solar energy albedo and magnification effects and can give false readings. Dust and debris may also build up within the shield aspiration which may affect the flow and over all ambient temperature reading. Proximity to large paved areas, open water and other sources of artificial heat will also affect the ambient temperature of an area.

Interferences with relative humidity measurement accuracy can be caused by improper location of the sensor. Dust and debris may also build up within the shield aspiration which may affect the flow and over all relative humidity reading. Dust and particulate matter on the sensor it's self can affect the pores of the polymer capacitor and absorb water. The same problem will occur if the sensor is accidentally touched during cleaning; oils from skin can transfer to the polymer and greatly affect the accuracy of measurement.

Precision and Accuracy

The measurement precision is generally considered to be the "repeatability of the measurement". Precision of the data output by the sensor is established by the manufacturer, but confirmed by reference during monthly site visits as well as annual National Institute of Standards and Technologies references.

The accuracy of the sensor is generally considered the "deviation from true". This means how close it is to what it should be. The benchmark of "what it should be" is provided by the Alberta Environment Audit Program staff and the use of high quality standards such as available from the National Institute of Standards and Technology (NIST). Refer to the sections identified above for further information on accuracy relating to referencing and audit procedures.

Site Requirements

Site location of ambient temperature and relative humidity monitoring station should be determined according to the intended application of the monitoring data. As the Alberta Air Monitoring Directive does not have specific criteria regarding the placement and site requirements of ambient temperature monitoring referenced documents include; California Air Resources Board Air Monitoring Quality Assurance Standard Operating Procedures for Air Quality Monitoring, Volume II, Section 2.0.4 (Siting Criteria for Meteorological Equipment) and the "Guidance Document on Achievement Determination-Canada Wide Standards for Particulate Matter and Ozone". ISBN: 1-896997-41-4 PN 1330, October 2002, Canadian Council of Ministers of the Environment.

Installation Requirements

All the installation requirements as specified by the manufacturer in the installation procedures as well as the general requirements below must be followed.

- Buildings, trees and vegetation can cause disturbance of airflow patterns and relative humidity which can affect measurements. To minimize this effect, the distance between the sample probe and the drip line of the tree must be at least twice the height of the tree, building or other obstruction above the inlet probe or at least 10 meters away whichever is greater.
- It is recommended that the probe be placed over top of grass or natural earth. Free standing water, concrete, asphalt and other surfaces should be avoided as they may cause artificial heating and cooling of ambient air which may affect the relative humidity within a localized area.
- In an ideal situation it is recommended that temperature sensors be located between 1.25 and 2 meters above ground, however any tower mounted sensors will encounter interferences with the permanent shelter at this height. As such the sensor should be mounted on a boom extending 1 meter past the roof of the site at 1.25 to 2 meters above the roof height.
- A data acquisition system is used to record the signal output from the sensors. For connection to record analog voltage signals, the system should be set to match the voltage range of the translator output. Generally this is 1V or 5V full scale and is scaled to convert the output signal to engineering units. See the instrument manufacturer and DAS operations manual for instructions on configuring these channels.
- Range Set – the range of each system is identified in the operations manual. The range set for relative humidity is 0 – 100%. This is done as soon as the system is powered up after installation. Refer to the operations manual for instructions on this procedure.

Operating Parameters and Instrument Configuration

Configuration is completed at the CR300 datalogger where the output signals of the sensors are captured, stored and converted to engineering units. Consult the sensor manual for specific configuration details.

Operational and Maintenance Requirements

The following table of activities must be performed when operating a continuous ambient temperature and relative humidity sensors. Operational and maintenance manuals must be accessible to the operator on site.

Analyzer Operational Requirements

Action	Time and Frequency	Procedure	Documentation	Action by
Set data system range	After installation	As per operations manual	Entry to Doc-It and Met Calibration Report	Station operator
System Verification Check	weekly	Visual check and verification of data values	Entry to Doc-It	Station operator
Cleaning	Semi-annually	See Calibration Section as well as operation manual	Entry to Doc-It	Station Operator
Accuracy Audit	monthly	See Calibration Section as well as operation manual	Entry to Doc-It and calibration form	Station Operator

Calibration Requirement

Ambient Temperature and Relative Humidity are factory calibrated sensors; however, the accuracy of the unit must be challenged by performing reference checks monthly as well as before and after any maintenance performed on the instrument. This section will describe the daily and weekly verification checks as well as the process involved in referencing the unit against NIST certified material.

Temperature sensor

Ambient temperature sensors are referenced and calibrated at the factory when new. Calibration of the sensor is not possible in the field, so reference checks are completed and adjustments can be made to the signal conditioning in the datalogger if required. This is done by referencing the sensor against a known NIST traceable standard.

Reference Equipment

- National Institute of Standards and Technology certified thermometer
- Insulated container or “bath”

- Water
- Ice

Procedure

Flag the channels collecting the data for the ambient temperature as down for calibration. Open the RTMC screen to monitor the signal during the calibration.

Fill the bath with ice and water stirring to achieve uniform temperature and minimal thermal stratification. Place the thermistor and thermometer at the same level and allow both to stabilize. Record both readings in the applicable calibration form.

Use the water at room temperature, approximately 20° C, repeat the process and record both readings in the calibration form.

If needed, the slope and offset can be adjusted in the CR3000.

Return the temperature sensor to its original location and ensure all cables are connected and the data is flagged back to normal operating conditions.

System Verification Check

During site visits technicians should verify operation by referencing the station temperature to a thermometer to get a comparison at ambient temperature. The thermometer must be shielded from external heat/solar energy sources, aspirated and located at the same height as the thermistor. If it is at all possible it is strongly recommended that the reference thermometer be placed beside the thermistor to reproduce the exact conditions.

Relative Humidity sensor

Relative Humidity sensors are referenced and calibrated at the factory when new. Calibration of the sensor is not possible in the field, so reference checks are completed and adjustments can be made to the signal conditioning in the datalogger if required. This is done by referencing the sensor against a known NIST traceable standard.

A primary standard RH sensor traceable to the National Institute of Standards and Technology (NIST) is used for this application.

Reference Equipment

- NIST primary standard RH sensor
- Psychrometer, either sling or battery-fan powered.
- Distilled water
- Psychrometric chart

Reference Procedure

The reference transfer standard sensor should be positioned in the immediate vicinity of the sensor to compare resulting data. Flag the channels collecting the data for the relative humidity as down for calibration. Open the RTMC screen to monitor the signal during the calibration.

Record the output from the NIST sensor and the data from the RTMC screen for the ambient sensor on the calibration sheet. Repeat these observations and record 5 times a minimum of 5 minutes apart.

Calculate a new slope and offset if required.

Return the sensor to active data capture for ambient readings.

If an electronic transfer standard is not available the method to determine relative humidity via sling psychrometer is as follows:

- Use the distilled water to wet the wick of the wet bulb thermometer. The amount of water may vary depending on the make, see operating manual for details, however enough to ensure the wick is fully wet.
- Place both thermometers in the psychrometer and ensure it's properly contained as well as aspirated to ensure proper air flow. If the psychrometer uses a fan or pump to allow for airflow to move past the thermometers turn this on and allow to stabilize in an area as close to the relative humidity sensor as possible. It is best to avoid direct sunlight or artificial heat sources as these will affect the temperature differential and will throw the humidity calculations. Allow to stabilize for ten minutes. If a sling psychrometer is being used the same conditions apply, try to get the reading as close to the sensor as possible within safe working conditions. As the operator will be spinning the psychrometer it will be very important to avoid any obstructions within the path. Spin the psychrometer for ten minutes and reach stability.
- calculate the difference between the dry bulb and the wet bulb and follow the psychrometric chart to determine the relative humidity.

Repeat this process three to five times to find an average relative humidity reading and compare with the readings the sensor unit is finding. If the unit is more than 15% out it is considered a fail in an AENV audit, as such, if the findings of the reference are greater than 15% out the unit must be shipped to factory to be recalibrated.

System Verification Check

While more challenging than temperature, it is recommended that operators visually reference the operation of the relative humidity sensor regularly. During mid-day hours where the ambient temperature is high the relative humidity should be at its lowest. During rain storms, if the time and duration is known, the relative humidity sensor should read at or near 100%.

Data Collection and Management

Ambient temperature and relative humidity sensors should be wired to the station Campbell's CR3000 Datalogger. For more specific information consult the operator manual to determine specific output voltage and ranges. This data recorded at 5 minute intervals and is then polled remotely via cellular modem. It is a best practice to down load all the data filed into a separate storage device monthly to ensure data is backed up.

Reference Documents

- Vaisala model HMP155 Temperature/RH operations manual
- Met One Model 064-1/064-2 Temperature Sensor Operations Manual
- Campbell Scientific HMP 45C Temperature and Relative Humidity Sensor Operations Manual
- "Guidance Document on Achievement Determination-Canada Wide Standards for Particulate Matter and Ozone". ISBN: 1-896997-41-4 PN 1330, October 2002, Canadian Council of Ministers of the Environment.
- CARB Air Monitoring Quality Assurance Standard Operating Procedures for Air Quality Monitoring, Volume II, Section 2.0.4 (Siting Criteria for Meteorological Equipment)
- Measurement of Ambient Air Temperature using Solid State Sensors, Ambient Air Monitoring Program Methods, Method No.: AQ02/01/14.00M, Greater Vancouver Regional District, Air Quality and Management Division.