aeroqual

Cold Climate Air Monitoring Technology

Maintaining Performance and Data Integrity in Cold Conditions

MRK-D-0557

How Aeroqual's Technology Makes It Easier to Operate in Cold Climates

Even the most robust ambient air quality monitoring systems can struggle to maintain reliable performance in cold weather. Common issues when deploying ambient monitoring solutions over winter include:

- Electronic components and pumps falling outside their operating temperature range
- Battery-powered solutions experiencing rapid capacity loss or permanent damage
- Inlet icing
- Power systems becoming overwhelmed by constant heating loads.

For many operators, these issues can cause a spike in unplanned site visits, diverting valuable time and resources away from higher-level tasks. Data gaps and inaccuracies caused by cold weather can lead to regulatory non-compliance, potentially resulting in fines, and even putting workers or surrounding communities at risk.

By aligning monitoring hardware, power solutions, and reporting outputs with cold climate and remote air monitoring realities, Aeroqual enables organizations to meet regulatory requirements without compromising operational efficiency.

"The Aeroqual Winterization Kit is essential for reliable air monitoring in our Canadian winters. It gives us confidence that our data remains accurate, even at -40 °C."

Jim Shorey,
Regional Manager C.D. Nova Instruments Ltd.

Fig. 1: Aeroqual AQS 1 with Winterization jacket.

Aeroqual Winterization Kit: Insulate First, Heat Second

To help consultants and air quality professionals mitigate the operational impact of extreme cold weather, we developed the Aeroqual Winterization Kit. Comprised of a custom silicone-impregnated fiberglass jacket and built-in heater module, the Winterization Kit wraps easily around the AQS 1 and Dust Sentry outdoor monitors, extending the lower operating range from -10 °C to -40 °C with jacket and heater module, or to -20 °C with the jacket alone - with no additional power requirements. This prevents the internal electronic components and pumps falling outside their operating temperature range.

In addition to expanding the instrument's operating range, the jacket enables the instrument to better retain its internal heat and only require additional active heating when necessary. The energy-efficient, temperature-controlled heater module will automatically turn off once the defined thermostat setpoint is reached, further conserving power.

The effectiveness of the Winterization Kit in minimizing cold-weather interference was recently verified as part of a co-location evaluation study in Northern Alberta, Canada, detailed in a later section of this document.

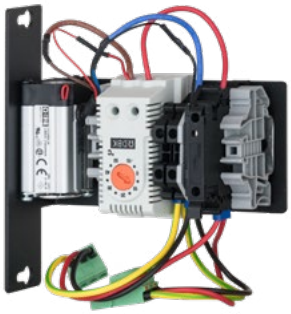


Fig. 2: Winterization Heater Module

PCX Particulate Module: Simultaneous PM Measurement

The Aeroqual PCX particulate module is an optical particle counter that uses scattered light to size and count particles. The amount of scattered light is converted to a voltage pulse, and the amplitude of that voltage pulse is calibrated to a particle diameter assigned to one of six particle count channels. Using a proprietary algorithm, particle counts for each size fraction are converted into mass measurements, providing continuous and simultaneous measurement of PM_1, $PM_{2.5}$, PM_4, PM_{10} and TSP. The PCX incorporates a number of elements which contribute to its high performance in cold weather.

Integrated Inlet Heater

Aeroqual's PCX module also contains an integrated inlet heater to remove fog and condensation artefacts, improving measurement accuracy and preventing inlet icing in cold temperatures. When deployed in tandem with the Winterization Kit, the PCX module can maintain optical stability and flow integrity in even the coldest climates.

Fig. 3: Aeroqual PCX Module

Easy Calibration

The PCX module is factory calibrated against a EN16450 certified reference instrument and ISO 12103-1 test dust (A1 Arizona Test Dust). A recommended re-calibration interval of two years helps to reduce on-site maintenance and mitigate against winter site visits. The PCX module also features an automatic built-in auto-zero PM calibration, which can be triggered on start-up, placed on a continuous schedule, or manually triggered on the Aeroqual Cloud platform - further reducing manual interventions and site visits. AQS 1 Performance, Calibration and Service Requirements

Cold Start with Automatic Baseline Correction (ABC)

For monitoring of VOCs, Aeroqual offers Photo-ionization detector (PID) based modules equipped with our patented Automatic Baseline Correction (ABC) technology.

PID lamps can fail to strike (ignite) in cold conditions. Low temperatures and moisture can affect lamp operation and the associated electronics. This effect is often observed after long periods of non-operation. The Aeroqual PID module includes a cold-start software routine that automatically applies a repetitive startup voltage to condition the lamp. This eliminates lamp startup issues in cold climates - without it, manual power cycling of the module would be required.

Aeroqual's ABC technology uses proprietary selective filters and response algorithms to provide baseline stability and lower detection limits for ambient gas measurement, reducing sensor drift caused by variable temperatures. The recommended Aeroqual VOC (PID) calibration frequency is 30 days. Span Stability of the Aeroqual VOC module

With the automatic correction of the 'zero' baseline every 60 seconds, ABC eliminates sensor drift (as shown in the graph comparison below), reducing the need for field recalibration and saving time on site. This is especially critical in Canada, where frequent calibrations are impractical for remote winter sites.

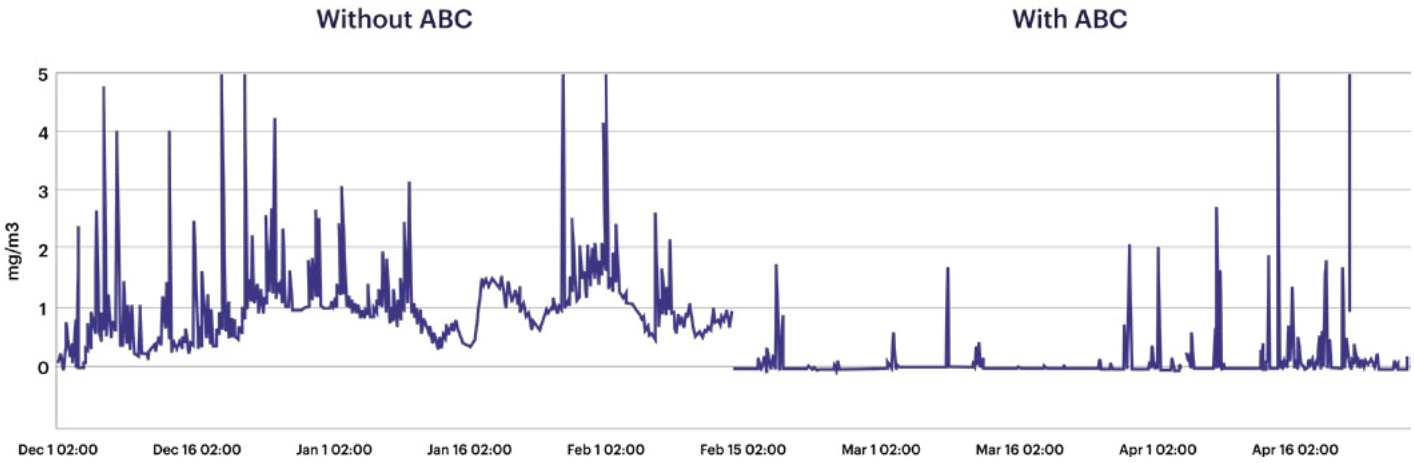


Fig. 4: ABC Comparison Chart

Using Aeroqual Air Monitors on Remote and Low-connectivity Sites

In remote settings wireless connectivity is not always reliable. Air monitoring systems should ideally be designed with local data logging to avoid data loss and automatic data synchronization for when connectivity is restored. This is where Aeroqual excels.

Aeroqual air monitoring systems provide:

- More than 5-years of onboard data storage, with auto data sync to Cloud when connection is restored
- Connection to a Wi-Fi hotspot using local or satellite communication
- Remote power scheduling allows you to automatically control the system power, turning the device on and off on a daily schedule to save power
- Remote diagnostics which enable you to upgrade the firmware and make changes to the instrument's settings remotely, reducing site visits and improving service efficiency
- Local wireless access allows onsite checks and data recovery from the comfort of your vehicle, minimising exposure to cold conditions
- Extended pump life expectancy of 18,000 hours, reducing field failures
- Automatic Baseline Correction reduces cross-interferences and calibration, increasing data confidence
- Lower calibration needs while ensuring sensor performance, with recommended calibration intervals of 2 years for the PCX and 30 days for the VOC module
- Data-safe shutdown - integrated back-up battery enables the system to safely shutdown in the event of power loss, mitigating against data corruption

Aeroqual OneView: Automated Reporting and Alerts

OneView automatically calculates upwind and downwind locations based on current wind conditions. This eliminates the need to physically move equipment around the site, cuts down on human error and helps to reduce overheads. Aeroqual also employs self-orientating ultrasonic wind sensors with an inbuilt compass to simplify set up. The Airmar 200WX lower operating range is -25 °C, while the Airmar 200WXH is fitted with a heater and has an operating range as low as -40 °C. Wind data is automatically referenced to true north — no need for manual orientation! OneView's centralized dashboard provides a snapshot of air quality across your entire project, while two-way communication allows you to gather data, manage alerts, and troubleshoot on-the-go without having to visit the site. Request a demo.

Recommended Minimum Power Configuration for a Canadian Winter Deployment

- Two heated LiFePO batteries (total 220Ah) plus three solar panels (total 450 W).
- Add block-style insulation and self-heating batteries for consistent battery temperature and continuous winter operation.

This power setup provides sufficient margin for low solar input, heavy cloud cover, and sub-zero temperature derating for all but extreme latitudes.

Conquering the cold

Reliable air monitoring in extreme temperatures

The Aeroqual AQS 1 is specially designed to operate continuously in harsh winter conditions, minimizing cold-related sensor effects, condensation risk, and data loss through robust environmental protection and thermal stability.

1. WINTERISZATION JACKET

Custom silicone-impregnated fiberglass jacket extending the lower operating range to -20 °C, with the jacket alone and no additional power requirements.

2. INTERNAL HEATER

Built-in smart heater module further extending the lower operating range to -40 °C (with jacket) while optimizing power use by heating only as needed.

3. PCX HEATER

Controls sample humidity and prevents inlet icing in cold temperatures.

4. COLD START VOC MODULE

Cold start software logic eliminates lamp start up issues in cold climates.

5. ROBUST INTERNAL COMPONENTS

All materials and components have been selected and tested to withstand the harshest environmental conditions.

6. AUTOMATIC BASELINE CORRECTION (ABC)

Continuously auto-corrects the ‘zero’ baseline, eliminating cross-interferences and drift, reducing calibration requirements.

7. SMART POWER INTERFACE WITH DATA-SAFE SHUTDOWN

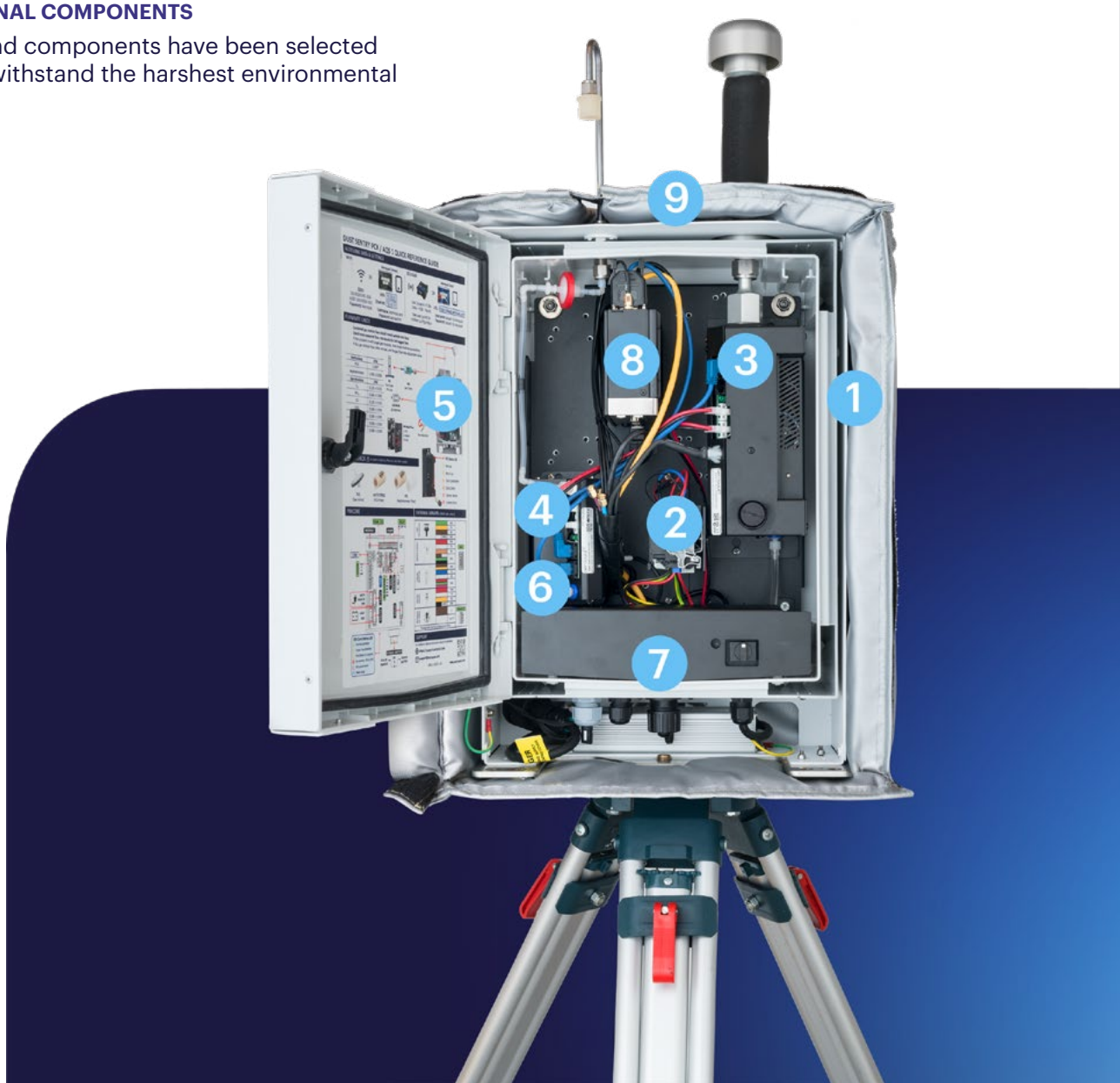
Includes a small backup battery that enables the system to safely shutdown in the event of power loss, preserving data.

8. ON-BOARD DATA STORAGE

Robust industrial ePC with 5+ years of onboard memory storage for data logging without internet connectivity.

9. MULTIPLE COMMUNICATION OPTIONS

4G Cellular and Wi-Fi, with automatic data re-sync after temporary internet connection loss.



North Alberta Co-location Study: Demonstrating Reliable Performance

To test the all-weather effectiveness of Aeroqual Ambient Air Quality Monitors we recently partnered with Peace Airshed Zone Association (PAZA), an Alberta-based environmental non-profit, on a year-long co-location study. A Dust Sentry with a PCX PM module was deployed at the Henry Pirker Air Monitoring Station in Grande Prairie, Alberta, Canada, and co-located with a Teledyne T640x instrument, a US EPA-designated method for monitoring $PM_{2.5}$ and PM_{10}.

During the winter months the Dust Sentry was equipped with the Aeroqual Winterization Kit, with temperatures reaching as low as -37 °C. The below graph shows the hourly ambient temperature data across the winter months (recorded by the reference station) in red, with the internal temperature of the Dust Sentry in grey. Following installation of the Winterization Kit in early December, the Dust Sentry consistently maintained an internal temperature above 15 °C, despite the extreme cold.

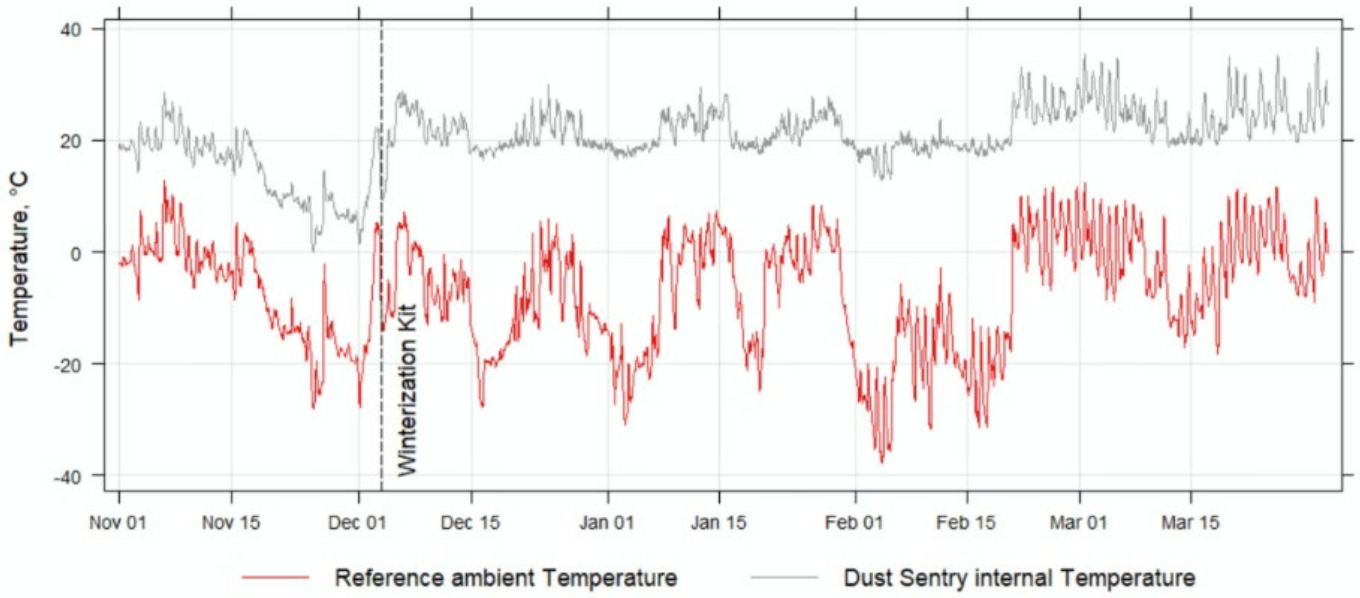


Fig. 5: Hourly temperature measured at the Henry Pirker site.

By mitigating the impact of the extreme cold, the Winterization Kit enabled the Dust Sentry to continue recording PM measurements with excellent correlation to the T640x reference instrument throughout the winter, shown graphically here:

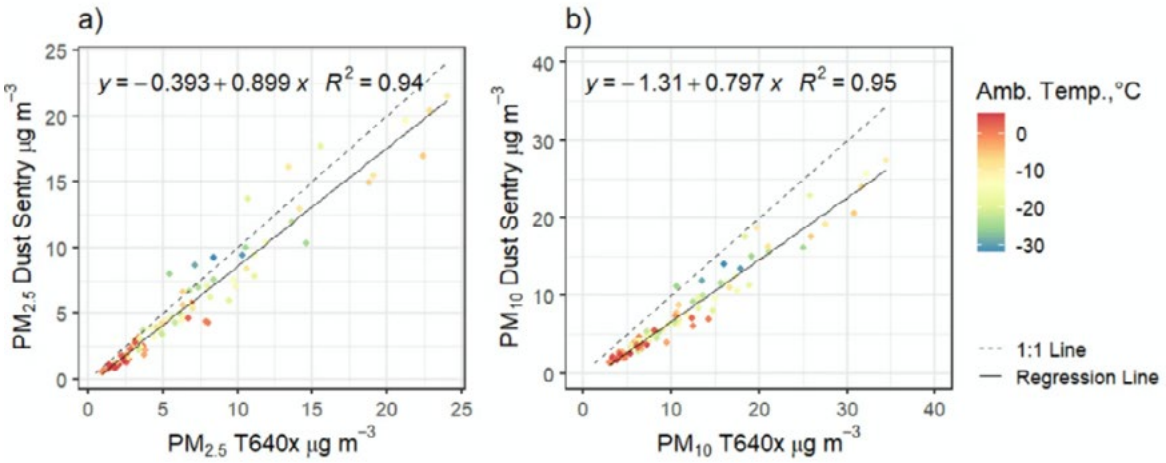


Fig. 6: Scatterplot showing daily averaged $PM_{2.5}$ (a) and PM_{10} (b) against the T640x data for $PM_{2.5}$ and PM_{10}, respectively. Points are coloured by the ambient reference temperature.

This evaluation showcases the effectiveness of the Winterization Kit in minimizing cold-weather interference. The Dust Sentry with PCX exhibited 100% data capture across the year-long evaluation, remaining fully operational while located outdoors on a standard tripod with no external heated shelter.

For consultants and regulators, this demonstrates that sensor-based systems can achieve near-reference performance in extreme cold, provided the hardware is engineered and winterized appropriately. In addition to fewer site visits and reduced data gaps, the Winterization Kit also results in a lower total cost of ownership compared to solutions requiring heated sheds and generator infrastructure.

Fig. 7: The Dust Sentry deployed at the Henry Pirker station, showing the winterization jacket.

Summary – Overcoming Extreme Weather Challenges with Aeroqual

Cold-climate air quality monitoring is not about measuring more - it is about measuring reliably and operating continuously, regardless of weather or location.

Aeroqual systems are built to meet these challenges, supporting projects through the coldest winters (-40 °C), with flexibility, near-reference performance, -20 °C operational capability with no additional power draw, 24/7 runtime stability, remote diagnostics, automated calibration, and continuous data assurance.

Aeroqual's suite of cold-climate air monitoring innovations stabilize performance in even the most severe winter conditions. By combining the Aeroqual Winterization Kit with one of our industry-leading ambient air monitoring systems (Aeroqual AQS 1, Dust Sentry), consultants and environmental professionals can gather defensible, near-reference data all year round.

Aeroqual's PCX module facilitates simultaneous measurement of key particle fractions, while the patented Automatic Baseline Correction (ABC) technology ensures stable measurement of VOCs and other airborne gas pollutants. Aeroqual OneView ties it all together, producing automated reports and alerts, accessible from anywhere, in any season.

Winterization Deployment Checklist

Ensure successful cold-climate deployment, achieving excellent data capture with minimal winter callouts, by following this simple checklist:

- Check that the thermostat and heater are both functional when applying the insulating jacket
- Use insulated appropriately sized battery packs (supplement with heat packs as required)
- Select the right connectivity mode based on site coverage, testing in site before leaving
- Mount units at least ~1.2m above ground and out of direct snow-blower or plow paths

To learn more visit:
aeroqual.com