Guidance Manual

for

Industry-Operated Ambient Air Quality Monitoring Networks

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Contact

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Acronyms and Abbreviations

µg/m^3	microgram per cubic metre
µm	micron/micrometre
AST	Atlantic Standard Time
API-T640	Model number for a real-time particulate monitor manufactured by Teledyne Instruments Inc.
BAM	Beta Attenuation Mass
BAM-1020	Model number for a real-time particulate monitor manufactured by Met One Instruments Inc.
DELG	Department of Environment and Local Government (New Brunswick)
FEM	federal equivalent method (US)
FRM	federal reference method (US)
HEPA	high efficiency particulate air
ID	Identification
NB	New Brunswick
NIST	National Institute of Standards and Technology (United States)
NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	oxides of nitrogen
NRC-MSS	National Research Council of Canada Measurement Science and Standards Research Centre
PM	particulate matter
$PM_{2.5}$	particulate matter ≤2.5 µm in diameter (fine)
PMT	photomultiplier tube
ppb	parts per billion
QA/QC	quality assurance/quality control
SO_2	sulphur dioxide
SOP	standard operating procedure
TRS	total reduced sulphur
TSA	technical system audit
UCT	Universal Coordinated Time
UPS	uninterruptible power supply
USEPA	United States Environmental Protection Agency

Glossary

Acceptance criteria: The maximum allowable difference (discrepancy) between an instrument's response versus a known value (as determined during a zero check, span check, multipoint verification, etc.) beyond which data must be invalidated.

Accuracy: The degree to which a measurement agrees with the correct value.

Beta Attenuation Mass (BAM): an air monitoring technology that relies on measuring the absorption of beta radiation by solid particles extracted from air flow.

Calibration: Adjustment of an instrument or firmware to establish/re-establish the relationship between instrument response and expected concentration. It compares the values generated by a device that is being tested to those of a calibration standard of known accuracy.

Calibration range: Scale used for multi-point verification and calibration.

Completeness: Comparison of the valid data collected versus the total number of data points expected for the measurement period.

Datalogger/data acquisition system: Device that collects data and other information from instruments at the monitoring site.

Data acquisition cycle rate: The frequency at which a datalogger system receives and records data from an analyzer/monitor.

Data validation: Process of examining objective evidence to confirm that the data are fit for purpose.

Detection limit: The lowest value that a method can report with confidence.

Edited data: Data that has been (at least partially) edited/adjusted/modified through the application of QA/QC procedures.

Federal equivalent method: An analytical procedure (method) for measuring the concentration of an air pollutant that has been designated as equivalent (in terms of accuracy) to the Federal reference method for that contaminant.

Federal reference method: An analytical procedure (method) that has been adopted by the United States Environmental Protection Agency (USEPA) as the standard against which other methods for the same analyte are validated.

FINAL/Final data: Data that has been reviewed and edited/adjusted/modified through all levels of QA/QC procedures.

Integrated sampling: The collection of air contaminants into a single sample over an extended period.

Linearity: An instrument response relationship that can be graphically represented as a straight line, which indicates a proportional relationship between contaminant concentration and measured output over a defined concentration range.

Metadata: Data that describes other data (*e.g.*, by recording the circumstances present while the data was recorded).

Multi-point verification: A procedure that establishes and subsequently verifies the accuracy and linearity of an instrument to ensure data validity.

Performance audit: A quantitative evaluation of a measurement system by an independent auditor to determine if criteria (primarily instrument response) are meeting specifications.

Permeation device: A device used as a reference for verifying the accuracy of gas analyzers. The devices consist of a capsule that contains the target compound in a two-phase equilibrium between its gas phase and its liquid or solid phase. When held at a constant temperature, the device emits the compound (gas) through its permeable portion at a constant rate. This can be used to establish a “known concentration” of the gas for verifying instrument response.

Quality assurance and quality control (QA/QC): Procedures and systems used to ensure and verify that collected data meets defined standards of quality.

RAW/raw data: Data that has not been edited/modified.

Reference standard: The standard (maintained by a standard-setting authority) against which all other gas mixtures or instruments are compared.

Representativeness: The degree to which data accurately and precisely represent the pollutant concentration of an air parcel surrounding the site for a specific averaging period.

Residence time: The amount of time that it takes for a sample of air to travel from the sampling inlet to the instrument.

Sampling inlet/probe: An opening through which air enters the sampling system before continuing to an analyzer, monitor, or sampler.

Span check: The comparison of an instrument’s response to a known concentration of a gas that is near the upper end of the calibration range for the instrument. The span check value is compared to a reference span value, which would have been previously established (at the most recent multipoint verification or calibration).

Standard conditions: A temperature of 21.0 degrees Celsius and a pressure of 101.3 kilopascals absolute.

Tolerance level: The maximum allowable difference (discrepancy) between an instrument’s response versus a known value (as determined during a zero check, span check, multipoint verification, etc.) beyond which instrument repair/adjustment is required.

Traceable/Traceability: A documented and unbroken chain of calibrations linking a gas or device to a reference standard.

Transfer standard: A gas mixture of known concentration or an instrument of known accuracy, as verified against a reference standard. It is used in the field for comparison and analytical purposes.

Zero air: A gas mixture that is free of a given contaminant to a concentration below the detection limit of the analyzer.

Zero drift: The absolute change in analyzer response to a zero air input over a period of unadjusted continuous operation.

Zero noise: Measure of the deviations from zero while sampling constant zero air. The noise is measured as the root mean square of the deviations from zero.

Zero check: Testing the performance of an instrument by introducing pollutant-free air (zero air) and measuring the response.

1.0 Context

1.1 Purpose

The New Brunswick *Clean Air Act* requires that industrial air pollution emitters obtain, and operate in accordance with, Certificates of Approval to Operate (Approvals) that are issued by the Minister of Environment. These Approvals can include a wide variety of conditions that the Approval holder must comply with. Certain industries in New Brunswick are required, through their Approval conditions, to conduct ambient air quality monitoring in the areas surrounding their facilities. This document provides technical guidance for the establishment and operation of these air quality monitoring networks in New Brunswick.

1.2 Authority

The requirements described herein relate to monitoring networks and individual stations established in compliance with conditions of Approval (per the *Clean Air Act*). Failure to adhere to these requirements, or case-by-case instructions provided by the Department of Environment and Local Government (DELG), may be interpreted as regulatory non-compliance by the Approval holder.

If the guidance provided herein conflicts with a condition of Approval, the condition of Approval prevails.

1.3 Scope and Limitations

The guidance set out herein describes the *minimum requirements* to satisfy DELG that the conditions of Approval associated with continuous real-time ambient air quality monitoring are being complied with and the quality of data being collected is acceptable.

Network operators may choose to follow additional or more stringent procedures, provided that they do not conflict with those provided in this document.

This document does not provide guidance for all types of equipment in all possible monitoring scenarios. Please note that sample-based (integrated sampling) methods are not addressed.

DELG may specify different requirements on a case-by-case basis.

In the interests of completeness, this document also contains guidance on certain *best practices*. These items are described in the text as “not required, but recommended”, or as items that “should” be done (rather than items that “must” be done). Items described in this way are not required to be implemented.

1.4 Compliance Verification

DELG technical staff may perform a variety of inspection and auditing activities to determine compliance with procedures described in this document. DELG technical staff are designated Inspectors under the *Clean Air Act*.

1.5 Revisions

This document will be revised as need arises to reflect changing methodologies in air quality monitoring and quality assurance/quality control (QA/QC) practices.

2.0 Network Planning and Station Design

2.1 Site Selection

The selection of monitoring sites is subject to DELG approval, and may be specified in the Approval to Operate once a selection is finalized. When determining suitability of a proposed network of monitoring sites (or individual sites), DELG will consider:

- Potential lifespan / longevity: Air monitoring stations are meant to measure air quality trends over the long term and are therefore intended to have some degree of permanency.
- Population exposure: Monitoring site locations should represent where people live, work, play, or are otherwise likely to be present.
- Other sensitive receptors: Monitoring site locations should also be representative of other sensitive receptors (e.g., sensitive ecosystems, agricultural lands, silviculture, etc.).
- Point of highest impact: A monitoring network should include representation of the "worst case scenario" for offsite ambient impact (i.e., where the worst air quality conditions are likely to be observed). Air dispersion modelling is informative when considering this element, and may be required on a case-by-case basis.
- Obstructions: Although not feasible in all situations, stations should be located such that free flow of air is possible in all directions and not obstructed by buildings, trees, etc.
- Overall representativeness: If possible, stations should generally not be placed in areas that experience very localized impacts from small sources (e.g., immediately adjacent to a small emissions source, such as a building using a wood stove, or idling vehicles).
- Sampling system requirements: Many monitoring technologies have specific installation requirements (e.g., inlet heights, spacing requirements, etc) that may place further limits on suitable locations for a station.

NOTE:	It is the responsibility of the Approval holder to obtain the property, or land-use rights, necessary for establishing their required monitoring stations. The Approval does not create obligations for anyone other than the Approval holder in this regard.

2.2 Station Design

The following subsections describe a variety of physical requirements for the design and layout of monitoring stations. These reflect an ideal scenario, which cannot always be met under real-World constraints, including location requirements which may be beyond the site operator's control.

For existing stations (as of the date of Revision 1.0 of this document), none of the requirements below are to be interpreted as requiring the relocation of any station. However, modification of existing stations will be required where feasible. Where this is not feasible, variances will be required (per Section 8).

For new stations, the requirements listed below must be met. Where this is not feasible, variances (per Section 8) will be considered.

2.2.1 Shelter (Building) Requirements

Although some monitoring technologies are designed for direct deployment to the field (no building or enclosure necessary), most permanent stations require the use of a dedicated shelter. In all cases, equipment should be installed per the documentation provided by the manufacturer. If a shelter is used, it is subject to all regulations and bylaws that would apply to any other structure. Please refer to local regulations, bylaws, safe work guidelines, and applicable building codes. In addition, a shelter must:

- Protect the instrumentation from the weather. Since temperature fluctuations can affect analyzer performance, the shelter must be ventilated, heated, and cooled to maintain a stable temperature within the range specified by the instrumentation manuals for the equipment being used.
- Be accessible throughout the year, including winter.
- Be secured from unauthorized access.
- Include sufficient internal lighting to allow work on instrumentation at all times.
- Allow easy access to instrumentation and provide workspace for the station operator.
- Have a reliable communications system (to allow real-time reporting of data).
- Have reliable power (including surge protection and/or power conditioning systems where necessary to prevent instrument damage). Uninterruptible power supplies (UPS) are preferred, but not required.
- Include secure instrument mounts/racks/bench with airflow to avoid overheating.
- Be capable of meeting the sampling probe location criteria described below.

2.2.2 Sampling Probe Placement Criteria

All sample probes (inlets) must be installed in accordance with the following criteria:

i. Air flow must be unobstructed in 3 of the 4 wind quadrants. For the purposes of the preceding, “unobstructed”, means:
   a. <u>With respect to trees</u>: a separation distance >20 metres.
   b. <u>With respect to other buildings or structures</u>: a separation distance between the station and the other structure of at least twice the height that the obstacle reaches above the probe.

ii. There can be no nearby furnace or incineration flues, other than those operated by the targeted facility (the acceptable distance depends on the height of furnace or incinerator flues, and the type of waste). Where there is doubt, a case-by-case determination will be provided by DELG.

iii. There must be unobstructed airflow in the immediate vicinity (on the shelter structure itself), including separation from air outlets, exhaust fan openings, chimneys, etc.

In addition, probe inlets must also maintain minimum separations from the supporting structure itself, and minimum heights. These are provided in Table 1 below.

Table 1. Sample Probe Inlet Location Criteria

Pollutant	Height Above Ground (meters)	Height Above Roofline (meters)	Separation[1] distance from the supporting structure (meters)
Particulate Matter ($PM_{2.5}$)	2 to 15	>2	>2
Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), and Total Reduced Sulphur (TRS)	2 to 15	>1	>1

[1] When a probe is located on a rooftop, the separation distance is in reference to walls, parapets, or penthouses located on the roof.

2.2.3 Sampling Line Requirements

2.2.3.1 Sample Line Materials

All sample inlets and associated plumbing and fittings must be made of inert, non-reactive, materials (unless contradicted by the instrument manufacturer's specifications) and be comprised of compatible materials. See Table 2, below, for details.

Important:

Mixing of manufacturer/brand fittings or materials is not permitted (this can cause pneumatic leaks in the sampling systems).

Table 2. Sample Inlet Materials

Pollutant Parameter	Allowable Inlet/Fitting Materials	Allowable Line Tubing Materials
Nitrogen dioxide (NO_2)	Polytetrafluoroethylene and stainless steel	Clear Polytetrafluoroethylene
Sulphur dioxide (SO_2) and Total Reduced Sulphur (TRS)		
Particulate matter ($PM_{2.5}$)	Provided by manufacturer (stainless or anodized aluminum)	Not applicable

2.2.3.2 Probe/Inlet Covers

The sample line system for gas analyzers must be designed to prevent water from entering the air stream (using a rain cover such as a funnel). For particulate matter (PM) analyzers, the manufacturer's installation requirements must be followed. If further details are needed, please contact DELG for site-specific guidance.

NOTE: The allowable inlet materials described in Table 2 do not apply to probe/inlet covers. For the parameters included in this manual, any durable, waterproof material is acceptable for the rain cover.

2.2.3.3 Residence Time

To reduce residence time within the system, all sample lines should be kept as short as possible. **Total residence time must be <20 seconds**.

2.2.3.4 Manifolds

Stations monitoring for multiple pollutants may use a manifold system rather than installing separate, long sampling lines (unless contradicted by the manufacturer's instructions for the instrument). Manifold designs may cause excess residence time or restrict air flow. If opting to use a manifold, site-specific (case-by-case) review/approval by DELG is required.

Manifold systems are not permitted for continuous and integrated PM monitoring. These instruments should use individual inlets, and the sampling line from inlet to instrument should be as vertical as possible to avoid particle loss due to impaction.

2.3 Instrument Specifications

All ambient air quality monitors must satisfy the requirements of the United States Environmental Protection Agency (USEPA) as "federal reference methods" (FRM) or "federal equivalent methods" (FEM). In the absence of an FRM/FEM method, the method must be reviewed and approved by DELG on a case-by-case basis.

2.4 Instrument Settings

Operators must configure and operate monitors in accordance with the operating instructions (operator's manual, technical bulletins, etc.) provided by the manufacturer, unless otherwise specified by DELG. In addition, instrument operating range must be configured per Table 3.

Table 3. Instrument Operating Ranges

Pollutant Parameter	Required Operating Range
Nitrogen Dioxide (NO_2)	0 to 500 ppb
Sulphur Dioxide (SO_2)	0 to 1000 ppb
Total Reduced Sulphur (TRS)	0 to 200 ppb
Fine Particulate Matter ($PM_{2.5}$)	0 to 1000 µg/m^3

2.5 Datalogger Requirements

All instruments require the use of dataloggers to record the data generated. Data logging can be set up locally (at the station) or remotely, with data transmitted to a central datalogging system (e.g., via radio, or internet). A variety of hardware and software solutions are available for this task. Operators are free to choose from commercially available packages, or to develop their own hardware and software solutions.

2.5.1 Communication Protocol

There are many options available for communicating data between analyzers and dataloggers (and also between data-loggers and other database systems). Many of these options (especially those used in older station designs) rely on digital-to-analog (and analog-to-digital) conversion of data. These conversions frequently introduce small errors or "noise" to the data, and can result in a variety of issues that can lead to data loss. It is strongly recommended, but not required, that stations/networks do not rely on analog signals, and instead adopt 100% digital communications.

2.5.2 Data Acquisition Cycle Rate

The "data acquisition cycle rate" is the frequency at which the datalogger system receives and records data from an analyzer/monitor. The data acquisition rate for dataloggers (local or central), if collecting data from monitors that output instantaneous subhourly data, must be **10 seconds or less**.

> **NOTE:** Continuous gas analyzers (and some particulate monitors) produce "instantaneous" readings on a constant basis (with the readings changing nearly every second). For these monitors, a 10 second (minimum) acquisition cycle rate is intended to provide at least 30 readings from the data stream every 5 minutes. These 30 readings (at minimum) are used to calculate 5-minute averages (which are subsequently aggregated into hourly averages).
>
> Many particulate monitors (e.g., the BAM-1020) operate differently, and produce a single value every hour. The data acquisition cycle rate for these instruments must be set at a frequency suitable for collecting hourly data (i.e., at least once per hour).

3.0 Instrument Verification and Calibration

3.1 Verification of Gas Analyzers

There are three types of instrument-level quality assurance and quality control (QA/QC) procedures that are used to ensure that readings from continuous gas analyzers remain accurate. Each is described below, along with guidance for their use.

3.1.1 Zero/Span Checks and Adjustments

A “zero check” involves the introduction of pollutant-free air into an analyzer to measure its response to concentrations below its detection limit. The zero-check value is compared against a zero reference value established at the time of multi-point verification or calibration. Zero checks help to identify instrument issues and can also be used to adjust the zero baseline, if needed.

If the zero-check value is outside of tolerance levels (see Table 4), a zero-adjustment should be performed using either a scrubber or zero-air source with a dilution calibrator. If the value from the zero check immediately following a multi-point verification or calibration is not essentially zero, then either the scrubber or the zero-air system scrubbing media may need to be replaced.

A “span check” involves the introduction of a known concentration of pollutant gas at a concentration higher than values expected at the site during routine operations, and near the limit of the calibration range. The span check value is compared to a reference span value established at the time of multi-point verification or calibration.

A span check can be performed using a permeation device, span gas, or a high-concentration gas via a dilution calibrator.

If the span check value is found to be outside of the tolerance level (see Table 4), an “as-found” multi-point verification should be conducted, and a subsequent corrective action should be initiated.

Table 4. Zero/Span Check Tolerance Levels

Instrument/Parameter	Check Type	Tolerance Level
NO_2	Zero	± 2.0 ppb
	Span	≤±10% of reference value
SO_2	Zero	± 1.0 ppb
	Span	≤±10% of reference value
TRS	Zero	± 1.0 ppb
	Span	≤±10% of reference value

3.1.2 Scheduling and Automation of Zero/Span Checks

Zero and span checks must be performed either manually on a weekly basis or automated via software on a daily basis. Optionally, Zero/Span checks may be omitted entirely. However, if no Zero/Span verifications are performed, multi-point verifications or calibrations must be performed on a monthly basis.

> **Important:**
>
> **If no ZERO/SPAN verifications are performed, multi-point verifications or calibrations must be performed on a monthly basis.**

In order to prevent data loss during pollution events, Zero/Span checks should only be conducted when instruments are reading near background levels. If conducted via an automated system, this may require programming data loggers or instruments to add this exception.

The total duration of an automated zero/span check is approximately 20 minutes. In order to avoid loss of hourly averages to data incompleteness, the Zero/Span cycle should be initiated 10 minutes before the end of an hour and carry over into the beginning of the next hour (resulting in only 10 minutes of lost data for each hourly average). Although not required, preferably, the cycle should commence at 23:50 hours each day.

3.1.3 Automatic Zero or Span Adjustments

Some analyzers can automatically adjust data based on automated zero and span check results. Automatic zero adjustments are permitted and may be used to correct zero drift, which is common in many analyzers. If automated zero adjustments are made, they must be reviewed during the data validation process, as zero-check results could become unreliable due to equipment failure or other issues.

Automated span adjustments are not permitted.

> **NOTE:** Frequent zero adjustment of the instrument should not be necessary and can lead to increased data uncertainty. Furthermore, frequent adjustment usually indicates that instrument issues need to be addressed.

3.1.4 Multi-point Verification

A multi-point verification (using traceable standards and materials) verifies the accuracy and linearity of the instrument at regular intervals to ensure data validity.

This verification includes a zero and at least three upscale points (*i.e.*, 30%, 60% and 80% of the instrument range).

3.1.4.1 Scheduling Multi-point Verifications

Routine multi-point verification is required every 6 months (semi-annually) if zero/span checks are being performed daily, or every 3 months (quarterly) if zero/span checks are being performed weekly. As noted in subsection 3.1.2, if no zero/span verifications are performed, multipoint verifications or calibrations must be performed on a monthly basis.

Multi-point verification is also required under any of the following circumstances:

- An instrument is being initially installed or relocated
- A span check value exceeds tolerance levels (before and after repair, if possible)
- Before instrument calibration
- Before instrument shut down

3.1.4.2 Tolerance Levels and Acceptance Criteria for Multi-point Verification

When multi-point verification values exceed tolerance levels, instrument calibration adjustment and/or repair must be initiated. However, data collected up to that point remains valid.

When multi-point verification exceeds acceptance criteria, data must be invalidated to the most recent time when such measurements were known to be valid, unless data correction can be justified. Instrument calibration adjustment and/or repair must be completed before subsequent data can be validated.

The tolerance levels and acceptance criteria for multi-point verification are detailed in Table 5.

Table 5. Multi-point Verification Criteria

Activity	Instrument	Tolerance Level	Acceptance Criteria
Zero Point	NO_2	1.0 ppb	Not Applicable
	SO_2	0.5 ppb	
	TRS	0.5 ppb	
Upscale Point[1](maximum % difference)	NO_X, SO_2, TRS	>± 4%	≤± 15%
Molybdenum Converter efficiency (NO_2 Coefficient)	NO_2	96% to 104%	≤± 15%

[1] This is the maximum difference between each measured upscale point and the transfer standard value.

3.1.5 Gas Analyzer Calibration

For continuous gas analyzers, “calibration” refers to the adjustment of an instrument to establish the relationship between instrument response and pollutant concentration. When performing a calibration, the operator must:

i. Adjust the instrument response, as necessary (per manufacturer’s instructions). This must include a zero-adjustment and an upscale-adjustment within the required operating range (refer to Table 3).

ii. Allow the analyzer to stabilize after completing the adjustments, and then perform an additional verification on the zero and at least one upscale point.

iii. Record the instrument’s response to the final verifications (i.e., “as-left” information).

iv. Verify and record the instrument’s span response as the new span response reference point (for subsequent span tolerance checks).

All instrument adjustments must be performed according to the instrument manufacturer’s documentation.

3.1.5.1 Calibration Frequency of Gas Analyzers

Calibrations must be undertaken in response to exceedance of the multi-point verification tolerance levels and/or acceptance criteria.

3.1.6 Additional Guidance for Multi-Point Verification and Calibration of Gas Analyzers

Additional instructions for gas analyzer multi-point verification and calibration adjustments are as follows:

- All calibration and multi-point verification gases must be USEPA-certified “protocol gases”, and the certification must not have expired (see: USEPA (2012) “Traceability Protocol for Assay and Certification of Gaseous Calibration Standards”, Publication No. EPA/600/R-12/53.).
- Calibration equipment (i.e., dilution calibrators, flow devices) must be certified (typically by the manufacturer of the device) as traceable to a National Institute of Standards and Technology (NIST) or National Research Council of Canada Measurement Science and Standards Research Centre (NRC-MSS) standard or transfer standard. Documented certification and/or verification must not have expired (annual recertification required). Alternatively, equipment may be cross-check verified by a certified (annually recertified) device. If using this approach, the maximum allowable variance between the cross-checked device and the certified device is 6% for gas dilution/calibration equipment and 4% for flow verification/check equipment. If the cross-check verification result exceeds the allowable variance the device must be recertified.
- The analyzer, calibrator, gas cylinders and zero air system must be equilibrated to operating temperature prior to multi-point verification or calibration.
- The certified gas should pass through as much of the sampling inlet system as possible, including all filters and other components used during normal sampling. Where applicable, injecting gas through the manifold is recommended and could identify issues with the manifold and sample lines. However, it is acceptable to inject gas directly to an analyzer’s external and/or internal particulate filter

- The instrument response must be allowed to stabilize at each point before results are recorded or adjustments made. For the upscale point, two consecutive five-minute averages must be compared. These two five-minute averages must be within 1 ppb of each other for NO_X, SO_2, and TRS. Note: some instruments feature specialized tools to check this automatically.
- All calibrations must include documentation of both "as-found" and "as-left" conditions.
- After a multi-point verification:
  - linearity must be verified to confirm that the instrument is operating within manufacturer's specifications
  - new reference zero and span check values must be updated in the data-logger or control charts/sheets
  - the sampling inlet system and analyzer must be restored to normal operation
- Multi-point verifications and calibrations must be documented (see Section 5.0).
- Each multi-point verification must include a visual inspection of all plumbing associated with the instrument (from inlet to analyzer) to ensure that there are no blockages or other issues.

Typical Workflow Scenario (Multipoint Verification / Calibration):

An instrument span check fails (tolerance criteria not met) and a technician is sent to the station to investigate the problem. The technician determines that a multipoint verification is needed.

a) If the multipoint verification finds that the instrument "passes" (i.e., response is within tolerance limits), then calibration is not necessary. However, the cause of the span failure must be investigated and corrected (e.g. a new span device may be needed).

b) If the multipoint verification "fails" (i.e., response exceeds tolerance limits), then calibration is needed. If the instrument fails to calibrate then troubleshooting/maintenance is needed.

In either case, if any physical or software adjustments are made that could affect the response of the instrument, then calibration must be performed (or repeated in the second case).

3.2 Verification of Continuous Particulate Matter Instruments

Parameters that can be verified and calibrated are flow, temperature, pressure, and other instrument-specific parameters. Instrument checks for each are described below, along with guidance for their use. Note that this guidance is provided specifically for the most common continuous PM instruments currently in use by industry in New Brunswick. These are the BAM-1020 Beta Attenuation Mass (BAM) analyzer and the API-T640 scattered light spectrometry analyzer. This section may be updated should newer technologies become more prevalent.

3.2.1 Instrument Checks for PM Analyzers

The types of instrument-level QA/QC procedures that are used to ensure that readings from particulate matter analyzers remain accurate are listed below.

3.2.1.1 Flow rate

Verification of the flow rate set-point against a certified flowmeter. A specific flow rate is required at the inlet to properly separate particles in the air.

3.2.1.2 Temperature, Pressure, and Relative Humidity

One-point verification of these parameters against traceable standards. This is important for PM instruments, as ambient conditions affect the sampled volume used for concentration calculations. (Note: relative humidity verifications apply only to the BAM-1020 analyzer).

3.2.1.3 Zero

Verification of the instrument zero by removing all particulates in the sample air using a high-efficiency particulate air (HEPA) filter. The zero check should be performed according to the instrument operating manual. Note: there is no zero-check procedure for the API-T640, but this element is included in the leak test (see 3.2.1.4).

3.2.1.4 Leak Test

Verification of the absence of leaks in the inlet system according to manufacturer recommended procedures. For BAM-1020 analyzers, the PM inlet is replaced with a leak-check adapter and the pressure or flow rate is measured and compared with manufacturer's specifications. For the API-T640 a HEPA filter is installed on the inlet and the instrument's response is verified (similar to a zero check). Instrument response outside of the 0.0 to 0.2 μg/m^3 range is interpreted as a leak (i.e., leak test failure).

3.2.1.5 Inlet and Sample Line System Inspection

Inspection of PM size selective inlets and all associated plumbing for dirt or damage. This includes cleaning/replacing inlets and emptying water-trap jars as necessary. For the BAM-1020 this also includes nozzle/inlet inspection and cleaning (per manufacturer's instructions).

3.2.1.6 Optical Chamber Inspection and Cleaning

For the API-T640 only, the optical chamber must periodically be cleaned per manufacturer's instructions to prevent contamination buildup.

3.2.1.7 Photomultiplier Tube (PMT) Test

For the API-T640 only, a special manufacturer-provided/approved dust is introduced through the sample inlet while the instrument is set to PMT test mode. This allows the instrument to determine the amount of contamination that has accumulated within the optical system. If the contamination is minor, the PMT can then be adjusted to remove the effect of the contamination on instrument response.

3.2.2 Frequency/Scheduling of Instrument Checks for PM Analyzers

Instrument checks must be completed as follows (at minimum):

- BAM-1020 zero and inlet inspections once per year

- API-T640 optical chamber inspection and cleaning every 12 months (note: more may be required in high-dust scenarios).
- API-T640 PMT test before and after each cleaning.
- All others every 3 months

All instrument checks must also be completed:

- Upon installation or relocation of the instrument
- Before and after any repairs that may affect instrument calibration
- Before instrument shut down

3.2.3 Tolerance Levels and Acceptance Criteria for PM Instrument Checks

When a PM instrument check value exceeds tolerance levels, instrument calibration adjustment and/or repair must be initiated. However, data collected up to that point remains valid.

When a PM instrument check value exceeds acceptance criteria, data must be invalidated to the most recent time when such measurements were known to be valid, unless data correction can be justified. Instrument calibration adjustment and/or repair must be completed before subsequent data can be validated. The tolerance levels and acceptance criteria for PM instrument checks are detailed in Table 6.

Table 6. PM Instrument Check Criteria

Activity	Tolerance Level	Acceptance Criteria
Flow Rate (set point vs. standard)	≤± 4%	≤± 7%
Temperature (reading vs. standard)	≤± 2°C	N/A
Barometric Pressure (reading vs. standard)	± 10 mmHg	N/A
Relative Humidity (reading vs. standard)	≤± 10%	N/A
Zero (API-T640 only)	0.2 µg/m^3	N/A
Leak Check	As per instrument manual	As per instrument manual
PMT Test (API-T640 only)	± 0.5 of the refractive index of the PMT test powder (printed on bottle)	N/A

3.2.4 Calibration of PM Instruments

For most continuous PM analyzers, “calibration” cannot directly establish the relationship between contaminant concentration and instrument response (since there are no reference standards for PM to compare against). Instead, for these instruments “calibration” refers to the verification and adjustment of an instrument’s key operating parameters: flow rate, temperature, pressure, relative humidity etc. Ensuring that these operating parameters are within specifications ensures the accuracy of the PM readings that the instrument generates.

Calibration must be performed according to the manufacturer’s operating manual.

3.2.5 Calibration Frequency for PM Analyzers

Calibrations must be undertaken in response to exceedance of the instrument check tolerance levels and/or acceptance criteria.

3.2.6 Additional Guidance for Verifying and Calibrating PM Instruments

Calibration adjustments must be performed according to the operation manual for the instrument. Procedures may also be described in instrument-specific standard operating procedures (SOPs).

Additional instructions for PM instrument verification and calibration adjustments are as follows:

- All calibration and verification equipment/standards (i.e., flow devices) must be certified (typically by the manufacturer of the device) as traceable to a NIST or NRC-MSS standard or transfer standard. Documented certification and/or verification must not have expired (annual recertification required). Alternatively, equipment may be cross-check verified by a certified (annually recertified) device. If using this approach, the maximum allowable variance between the cross-checked device and the certified device is 4% (for flow calibrator equipment). If the cross-check verification result exceeds the allowable variance the device must be recertified.
- Traceable standards, materials, and devices must be equilibrated to operating temperature prior to verification or calibration.
- A leak-check must be performed before all other quality control checks, as this will affect the instrument flow rate and resulting volume. Leaks in the sampling inlet system exceeding manufacturer’s specifications invalidate data up to the date of the previous acceptable leak check. During calibration, if the inlet system has been disassembled, a post leak check must be performed.
- Flow rate is dependent on ambient temperature and pressure; therefore, these checks and calibrations must be made before flow calibrations.
- An “as-found” flow verification must be performed before any instrument maintenance or adjustments (if possible).
- After flow calibration, an “as left” one-point flow verification must be performed.

3.3 Data-logger Output Verification

In addition to issues with the operation of instruments, data quality issues can sometimes arise through issues with data-logging and handling systems. As such it is important to ensure that data-logger readings match those of the instruments. Discrepancies can occur due to issues with the instrument analog-to-digital converters; or “time stamps” that do not match between the data-logger and the instrument.

Data-logger readings must be verified during commissioning to ensure that instrument level readings match the data recorded in the data collection and management system. Additional periodic checks (minimum yearly) are required to ensure that signal-drift over time, or any other data collection issues, do not affect the final recorded data. These annual verifications must be documented.

4.0 Service Level Requirements

Air quality monitoring networks consist of a complex mix of built infrastructure, hardware, software, telecommunications equipment, information management systems, and the human resources and expertise required to maintain and operate them. All these elements are subject to potential failures, which can impact data quality and availability. It is the responsibility of each network operator to design their networks for resiliency and to ensure contingencies are in place to prevent unnecessary disruptions to data collection. This section provides guidance with respect to network up-time and necessary actions for the avoidance of disruptions.

4.1 Performance Objectives

The performance objectives for each industry-operated air quality monitor are as follows:

i. Greater than 90% data completeness (on an annual basis); <u>and</u>,
ii. Greater than 60% data completeness (on a quarterly basis); <u>and</u>,
iii. Maximum allowable continuous data outage (including disruption of real-time data transmittal to DELG) of 7 days.

4.2 Contingency Planning

Each network operator must develop, implement, and continuously maintain a contingency plan that details the specific policies and procedures that will be followed by the network operator to ensure that the performance objectives (per subsection 4.1) will be met on a continuing basis under all reasonably foreseeable circumstances.

4.2.1 Contingency Plan Format and Content

Network contingency plans must follow the format and headings prescribed below and provide the information specified for each.

<u>Contingency Plan Section 1</u>: Network Description

The network description section must include:

a) A list of all stations in the network, their locations, and descriptions of each (including enclosure type, fencing/gating, lighting, alarms, etc. where applicable). Each station should be described in terms of age, state of repair, and any relevant hazards and security risks (e.g, flood, vandalism, etc).

b) A list of all instruments/analysers and the associated date of acquisition, model, serial number, and manufacturer. Any discontinued models should be flagged, and the year of discontinuation noted.

c) A list of all datalogger hardware and the associated date of acquisition, manufacturer, and specifications.

d) A list of the communications infrastructure/equipment in use at all stations.

e) A description of the software environment supporting the instrumentation and dataloggers at each station.

f) A description of the data management systems (information technology infrastructure and associated software) used to collect and centrally manage data from the stations.

<u>Contingency Plan Section 2</u>: Routine Operations and Preventative Maintenance

This section provides details about existing policies and procedures employed by the network operator to ensure that the network is always operating properly (i.e., in accordance with this manual), and that potential issues are identified and addressed before impacting data availability. At minimum, this section must include the following details:

a) A list of all scheduled:

   i. Manual verifications of data and instruments (i.e., visual verification of zero/span check and calibration schedule, data trending and anomaly reviews); and,

   ii. visits to, and inspection of, shelters.

b) A list and summary of any preventative maintenance plans that have been established for the network.

c) A list and summary of any life cycle management plans for network equipment (including analysers, dataloggers, network equipment, and built infrastructure).

d) A list and summary of any network policies with respect to software maintenance, updates, and upgrades.

<u>Contingency Plan Section 3</u>: Infrastructure Contingencies

This section describes the specific plans, policies, and procedures that are in place to ensure that any infrastructure failure can be remedied quickly, thus minimizing impact on data availability. This section must provide:

a) A summary of any policies, procedures, or practices in place with respect to the stocking of **spare parts** for instrument repair and maintenance.

b) A list of manufacturer-recommended spare parts for each instrument in the network (as identified in each instrument manual, and/or as suggested by the instrument sales representative). This must include an indication of whether this part is currently stocked by the operator, and its availability (i.e., general purpose, specialty item, manufacturer only, obsolete/unavailable, etc), and timeline for procurement (i.e., how long does it generally take to procure this item?).

c) A list of any non-functioning instruments stocked for “part-outs” to fix deployed analyzers

d) A summary of any policies, procedures, or practices in place with respect to the stocking of **spare instruments**.

e) A list of any spare instruments in storage, and spare instruments maintained in a “ready/operating” state.

f) A summary of any policies, procedures, or practices in place with respect to the stocking of **spare dataloggers and network/communications equipment**.

g) A list of any spare dataloggers and network/communications equipment in storage.

h) A summary of any policies, procedures, or practices in place with respect to information management system (including software environment) **security, fail-safes, and recovery**.

i) A summary of any policies, procedures, or practices in place with respect to continuance of monitoring coverage during long-term outages (e.g., due to catastrophic infrastructure failures or unanticipated delays in procurement of replacement parts/instruments/equipment). This should include any pre-identified

alternative approaches (e.g., the use of specialty consulting services) that can be used while repair/recovery is underway.

j) A summary of any policies, procedures, or practices in place with respect to the stocking of instrument **calibration equipment**.

k) A list of calibration equipment stocked and maintained for use by the network operator.

<u>Contingency Plan Section 4</u>: Human Resources Contingencies

Recognizing that network maintenance, operations, and recovery from malfunctions and infrastructure failures are not possible without the efforts of expert personnel, this section is included to provides details about existing policies and procedures employed by the network operator to ensure that appropriate human resources are available to operate the network and implement corrective and recovery actions when necessary. This section must include:

a) A list of all personnel involved in network operations and maintenance (including all aspects noted above) and their roles, responsibilities, and training, with respect to the various components of the network. Any cross-training or shared responsibilities should be noted.

b) A list of available of consultants and/or local technician(s) with whom the network operator has made prior arrangements to perform routine maintenance or repairs on any components of the air quality network, and the specific capabilities of these persons/organizations with respect to network operations and repair.

c) A list of available of consultants and/or local technician(s) with whom the network operator has made prior arrangements to lend assistance during unplanned and/or catastrophic events that impact the network infrastructure, and/or to temporarily backfill sudden unanticipated staffing gaps (e.g., due to pandemic).

<u>Contingency Plan Section 5</u>: Approach and Implementation

This section of the contingency plan provides a clear language explanation of the execution of the contingency plan. This should clarify how the information provided in the four previous sections ensures that the prescribed performance objectives (per subsection 4.1) will be achieved.

Please note that there is no singular correct way to run a network. It is expected that there will be variation in the policies, procedures, methods, and mechanisms employed by each network operator.

5.0 Data Management

5.1 Conventions

The following conventions must be adopted by all networks to ensure consistency and prevent unnecessary data conversion errors.

5.1.1 Units of Measurement

All data for gaseous parameters must be recorded and reported in "parts per billion" (ppb).

All data for particulate parameters must be recorded in micrograms per cubic meter (µg/m^3).

5.1.2 Standard Conditions

Some older data acquisitions systems may record data for gaseous parameters in µg/m^3. In order to report this data in ppb (per subsection 5.1.1), the conversion (i.e., µg/m^3 to ppb) must be made using "standard conditions" as defined in the *Air Quality Regulation* (New Brunswick Regulation 97-133) – *Clean Air Act*:

"standard conditions" means a temperature of 21.0 degrees Celsius and a pressure of 101.3 kilopascals absolute.

5.1.3 Data Logging

All gaseous parameters must be logged as 5-minute averages (or less). Other averaging periods (e.g., hourly) must be calculated from the primary (5-minute or less) data.

For the API-T640, particulate parameters must be logged as 5-minute averages (or less) and hourly averages calculated from the primary (5 minutes or less) data. For the BAM 1020, particulate parameters must be logged as hourly averages.

5.1.4 Timestamps

All data is to be recorded and reported (timestamped) in Atlantic Standard Time (AST), which is Universal Coordinated Time minus 4 hours (UTC-4). Do not adjust timestamps for Daylight Saving Time.

5.1.4.1 Hourly Time Period Definition

All hourly data is to be recorded as "period ending" in relation to the timestamp. That is, the timestamp is to reflect the end of the period referenced.

Example:
The period between 10:00 and 11:00 would be recorded as the hourly value for 11:00.

5.1.5 Completeness

When calculating and/or reporting an average (e.g., 5 minute averages, hourly, etc), a minimum of 75% of the constituent data points must be present and valid (75% completeness criterion).

> **Examples:**
> In one hour an analyser/datalogger would normally record twelve 5-minute averages. However, if due to a brief malfunction, only 8 of the 12 (67%) were deemed to be valid, then the 1-hour average cannot be calculated and reported (because the 75% completeness criterion is not met).
>
> As per the previous example, if 9 of the 12 five-minute averages (75%) are deemed to be valid a 1-hour average can be calculated and reported (since the 75% criterion is met).

5.1.6 Average Calculation

Averages must be calculated as the arithmetic mean of the valid values. Invalid values are not included in the calculation, and cannot be represented as 0 (zero).

> **Example:**
> The average for the second example above would be calculated by summing the 9 valid readings and then dividing the resultant value by the number of valid readings (in this case, 9).
>
> **Please Note:** It is a common error to instead divide the sum of the valid readings by the total number of possible readings (in this case, 12). However, this is incorrect, as it is the same as treating the invalid readings as 0 (zero).

5.1.7 Rounding

Finalized data must be rounded to one decimal place.

5.2 Data Review and Finalization

All reported data from New Brunswick (NB) networks must be reviewed and verified as “real/correct” before being finalized. The procedures described below are required for all finalized data.

5.2.1 Invalidation of “Known Errors”

There are many circumstances that can result in data being recorded by an instrument, but the data is known to be erroneous based on information available to the operator. All such data must be invalidated (flagged with the correct “invalid” status code) prior to finalization. The most common examples are:

- All data collected while an instrument has failed to meet “acceptance criteria” (See Section 3.0).

- Anomalous data associated with major infrastructure issues (e.g., data spike immediately prior to, or following, power failure).
- Data collected while instrument metadata for the same period indicates instrument malfunction.

> **NOTE:** Gas analyzers are made-up of a variety of sensitive and complex internal electronic, pneumatic, electromechanical, and chemical systems. Each instrument also contains a variety of sensors that monitor and log the internal status of these systems. It is necessary to periodically access and review this diagnostic "metadata" to ensure that instruments are operating properly, to determine if maintenance is required, and to determine the validity of pollutant data.

- Data collected during calibration.
- Data recorded by external automated data acquisition systems while instruments are actually offline.

5.2.2 Invalidation of Incomplete Data

All averaged data (e.g., hourly averages based on subhourly data) must be checked against the 75% completeness criterion (see above). Any data that fails to meet the criterion must be invalidated.

5.2.3 Zero Adjustment

Many SO_2 and TRS instruments will experience "zero drift" (a gradual change in the minimum/baseline value over time). This drift must be corrected prior to finalization via one of two methods:

i. Automated adjustment (by configuring instruments/dataloggers to automatically adjust the data in real time based on automated "zero-checks"). If automated zero adjustments are made, they must be reviewed during the data validation process, as zero-check results could become unreliable due to equipment failure or other issues.

ii. Manual adjustment using the "zero-check" metadata. Note: Zero baseline adjustment is not necessary if daily zero results are within plus or minus 0.5 ppb.

> **NOTE:** Drift is chronic and persistent. It is characterized by small changes that accumulate over time (weeks to months). Rapid or excessive changes in the zero value is not considered drift. Rather, it may indicate an analyzer malfunction. This could require that the data be invalidated rather than adjusted.

5.2.4 Negative Value Adjustment

Negative values can indicate instrument malfunction, or the need for calibration. However, small negative values can also occur due to normal instrument "noise" when detecting concentrations near or at an instrument's lower detection limit (i.e., close to, or at, zero). This can occur following zero adjustment (see above). Regardless of the cause, finalized datasets must not contain negative values. Negative values must be adjusted as follows:

- Sub-hourly values remain negative prior to aggregation into hourly averages
- Hourly average values between 0 and -3 ppb are adjusted to zero
- Hourly values below -3 are deemed invalid

NOTE: If a dataset requires any other type of adjustment, it must be completed <u>before</u> undertaking negative value adjustment.

5.2.5 Special Adjustments for Nitrogen Dioxide Data

The following information pertains to the most common nitrogen dioxide (NO_2) analysers currently used in NB networks, which are chemiluminescence-based. For other technologies, please consult DELG for case-by-case consideration and direction. This section may be amended in the future if alternate technologies become more prevalent in NB.

NOTE: Most nitrogen dioxide (NO_2) monitors do not measure NO_2 directly, but rather indirectly by converting NO_2 to nitric oxide (NO), which is then measured “photometrically” (by measuring the light intensity from a “chemiluminescent reaction” that occurs when NO is mixed with ozone). This measurement must then be corrected to remove the contribution of any NO that was already present in the air. This can be accomplished by analyzing the air via the same photometric method (but without first converting the NO_2 to NO) and then subtracting this concentration from the other value. Most NO_2 analyzers cannot perform both measurements simultaneously (this would require splitting the sample flow and running it through two different reaction cells). Instead, most instruments use a single reaction cell but switch back and forth between measuring each value (ambient NO versus ambient NO_X). This approach introduces an unavoidable source of error, since the NO_2 value is determined by a calculation involving NO and NO_X values that are each derived from different samples of air.

During data validation, it is important to ensure that expected relationships are preserved. If adjustments are applied to NO, NO_2 or NO_X (e.g., zero adjustment), it will be necessary to apply adjustments to the other parameters to preserve the relationship where $NO + NO_2 = NO_X$.

For analyzers that use a single reaction cell that switches from NO to NO_X mode (as they are not measured simultaneously), a ±2 ppb difference is allowed for the 1-hour average of the NO_X value compared to the sum of NO and NO_2 values.

6.0 Record Keeping

The following guidance describes all data, metadata, and other records that must be maintained by all site operators.

All records must be maintained in electronic format. Any notes related to any of the records described in this section should be created electronically. If this is not feasible, any physical records must be transferred/scanned to digital format. All records must be readily available for review by DELG.

6.1 Record Types and Collection Frequency

The following data must be collected for each continuous air quality monitor/parameter:

a) **Raw data files** containing the hourly averages and 5-minute averages (if subhourly readings are supported by the monitor).

b) **Finalized data files** containing one-hour averages.

c) **Editing notes** providing justification of edits of the finalized data versus raw data.

d) **Instrument diagnostic metadata** must be automatically recorded every hour (minimum) for instruments/dataloggers with this capacity. This metadata must be retrieved and reviewed by the operator every two weeks.

> **NOTE:** Diagnostic information is typically retrieved from the instruments using on-site data logging computers, which can then be accessed by the operators (onsite or remotely) as needed. In the absence of a data logger, some instruments have the internal storage capacity to retain this information, and the operator can manually download it at a chosen interval. Both of these options support hourly recording of metadata.

e) **Automated or manual instrument performance records**, including periodic maintenance, instrument checks, multi-point verifications, calibrations, daily/scheduled zero/span checks, maintenance and technical notes. Documentation must include:

- Type of activity
- Date
- Instrument location
- Name of technician performing activity
- Instrument serial number or other identification
- Verification and calibration data including both “as-found” and “as-left” conditions
- Cylinder identification number (ID), installation date, verification date, and cylinder pressure of span gas cylinders (if the span gas is from a cylinder)
- Calibration standards traceability and certification documentation
- Any comments regarding calibration issues, and instrument or system servicing that may affect calibration results

6.2 Local Data Retention Requirements

All data and information described above (Section 6.0) must be retained by the site operator for a minimum of 6 years.

7.0 Data Submission

DELG maintains a centralized database of all continuous ambient air quality monitoring data that is collected under the authority of the *Clean Air Act* (via conditions of Air Quality Approvals to Operate) in New Brunswick. In order to facilitate the entry of data into the database from non-DELG sources it is necessary that data be formatted and transmitted to DELG via standardized processes, and using standardized data formats. There are two acceptable approaches that network/station operators may adopt: direct data access, and email transmittal. These are described below.

7.1 Direct Data Access

Station operators may provide DELG with direct data access. This can be either at the station level, or at the central database level. If using this option, case-by-case direction on data access and transmission protocols (and related requirements) will be provided to station operators. A wide variety of options are supported.

7.2 Email Transmittal

If not allowing direct data access, network/station operators must instead implement information technology systems capable of automatically generating and sending data submission emails to DELG. The actual data for each submission must be included as a separate data file, <u>which must be included as an email attachment</u>.

7.2.1 Transmittal Address

Each data submission email must be sent to a designated email address provided by the Air Sciences Section, DELG.

7.2.2 Email Formatting Requirements

Each data submission email must include the following "Subject" line:

AQStation ###

Note:

- The "###" must be replaced with a three-digit "station identification number" (site ID).
- The three-digit station identification number is assigned to each station by DELG.
- There is a space between "AQStation" and the three-digit station identification number.
- All three digits must be included (including any leading zeroes). For example, a data submission email for station 56 would require the subject line "AQStation 056".

7.2.3 Transmittal Types and Associated Requirements

7.2.3.1 Hourly Submissions

An automated data transmittal email must be submitted every hour for each station. This must contain the hourly (60 minute) average data for each monitored parameter at that station.

The hourly submission email for each station must be sent within 15 minutes of the end of the preceding hour (*e.g.*, the 2:00 PM submission must be sent before 2:15 PM).

All hourly submissions must include the past 24 hours of hourly data for each parameter monitored at that station.

7.2.3.2 Annual RAW Data Submissions

A manual data transmittal email must be submitted for each station, once per year, containing all raw (unedited) data for all 60 minute averages collected in the preceding calendar year (midnight to midnight from December 31).

The annual RAW data submission must be transmitted by midnight, April 30 of the following calendar year (e.g., the raw 2018 data file must be submitted before May 1, 2019).

7.2.3.3 Annual FINAL Data Submissions

A manual data transmittal email must be submitted for each station, once per year, containing all final (verified and edited) data for all 60 minute averages collected in the preceding calendar year (midnight to midnight from December 31).

The annual FINAL data submission must be transmitted by midnight, April 30 of the following calendar year (e.g., the final 2018 data file must be submitted before May 1, 2019).

7.2.4 Data File Format and Conventions

The central DELG data receiving system has adopted certain conventions that must be respected to ensure that submitted data files are recognized and appropriately processed. These are as follows:

7.2.4.1 File Naming Conventions

All submitted data files must follow the following naming conventions:

Hourly Data Submission File Names

All automated hourly data submission files (and corrections) must adopt the following file naming convention:

```
S###T60.AQDE
```

> **Note:** The “###” must be replaced with all three digits, including leading zeroes, of the three-digit “station identification number”.

Example: Each automated hourly data file for station 45 would be named:

```
S045T60.AQDE
```

Annual Raw Data Submission File Names
All annual raw data submission files must adopt the following file naming convention:

RAW_S###T60.AQDR

Note: The "###" must be replaced with all three digits, including leading zeroes, of the three-digit "station identification number".

Example: Each annual raw data file for station 45 would be named:

RAW_S045T60.AQDR

Annual Edited Data Submission File Names
All annual edited data submission files must adopt the following file naming convention:

S###T60.AQDE

Note: This is the exact same file format used for hourly data submissions.

7.2.4.2 File Type and Format

All data files must be submitted as text files that have been generated in "comma separated text" and in ASCII format. Data within each text file must be arranged in lines, with each line ordered as follows:

A,B,C,D,E,F….etc

Where:
A = station identification number (three digits)
B = date/time (formatted as: mm/dd/yyyy h:mm:ss AM/PM
C = the reading, for that hour, for the parameter reporting in channel 1
D = status code for the reading, for that hour, for the parameter reporting in channel 1
E = the reading, for that hour, for the parameter reporting in channel 2
F = status code for the reading, for that hour, for the parameter reporting in channel 2

This pattern is continued on line 1 for all active parameters for that station.

Line order: Each line contains all of the hourly data for a single hour, ordered oldest to newest. Thus, "Line 1" includes data for the hourly (60 minute average) data for the hour 24 hours preceding the current hour. Line 2 includes data for the hourly (60 minute average) data for the hour 23 hours proceeding the current hour. This pattern repeats, with each hour on a separate line up to and including the current hour.

Note: each line **MUST** end with a comma.

Example (first three lines of a data file for station 45 reporting 2 channels, both reporting status code "1"):

045,3/15/2018 2:00:00 PM,1.3,1,43,1,
045,3/15/2018 3:00:00 PM,1.37,1,35,1,

045,3/15/2018 4:00:00 PM,1.62,1,525,1,

Status codes are described in subsection 7.2.4.3.

Pollutant channels are assigned for each air quality station by DELG.

7.2.4.3 Status Codes

Each reported value must be accompanied by a status code. The valid/allowable status codes for use in submitted data files are described in Table 7.

All real/valid data must include status code 1. Data with any other status code will be treated as "invalid" (null) by the DELG data handling system.

Documentation is required (and must be retained by the operator) to explain the use of any status code other than 1 (Data OK).

> **Notes:** Operators must ensure that all data submitted with status code 1 is, in fact, valid.
>
> Null values (i.e., blank, or missing data) should be reported with status code "0".
>
> A common error is to record null/missing data as "0" and with a status code of "1". This is incorrect, and must be avoided.

Table 7. Status Codes

Status code	Status Code Description	Documentation required to explain
0	No Data	Yes
1	Data Ok	No
2	Scan Off	Yes
3	Less Sample (less than 75 % available to compute avg.)	Yes
4	Invalid	Yes
5	Zero Check	Yes
6	Span Check	Yes
7	Out Calibration	Yes
8	Communication Failed	Yes
9	Calibration Status	Yes
16	Power Failure	Yes
17	Audit	Yes
18	Shelter Temperature Issue	Yes
19	Instrument Warm-up	Yes

7.2.5 Error Detection and Handling

Data submitted to the central DELG air quality database is pushed to the public-facing DELG Air Quality Data Portal within two hours of receipt. As such, it is of the highest priority that errors are identified and corrected as quickly as possible.

It is the responsibility of each site operator to implement appropriate automated (or semi-automated) data quality assurance processes to ensure that erroneous data is corrected and resubmitted via hourly corrections (see subsection 6.1) in a timely manner, preferably prior to it being published to the Air Quality Data Portal.

Important:

Since each hourly submission contains data for the preceding 24 hours, if data is corrected/invalidated, care should be taken to ensure it remains corrected/invalidated in subsequent submissions.

7.2.5.1 Error Corrections

If a submitted hourly data file is later found to have erroneous data, the file can be resubmitted at any time. The system will automatically revise the data in the central database. For recent (past 7 days) this will also automatically revise the data that appears on the Air Quality Data Portal. However, for corrections of older data (greater than 7 days) the Air Quality Data Portal is not automatically updated. The network/station operator must advise DELG of these changes so that the Portal can be manually updated.

7.3 Notification of Data Outages

Despite best efforts, it is expected that data interruptions will occasionally occur in all networks. All data outages can be categorized as either “planned” or “unplanned” depending on whether the network operator is in control of the timing of the outage. DELG must be notified of all outages (planned and unplanned) as per the following guidance:

7.3.1 Notification of Planned Outages

All planned outages must be communicated to the Air Sciences Section of DELG two hours prior to the outage (at minimum). The notification must include the reason for the outage and the estimated time that the outage will commence and end. A follow-up notification must also be provided to signal that ordinary operations have resumed.

7.3.2 Notification of Unplanned Outages

All unplanned outages must be communicated to the Air Sciences Section of DELG as soon as possible upon discovery of the outage by the network operator. The notification must include the reason for the outage (if/when known) and the estimated time that the outage will end. A follow-up notification must also be provided to signal that ordinary operations have resumed.

Note: any outage that is not planned in advance, even if resulting from planned work (e.g., resulting from a failed instrument check), is considered an “unplanned outage” for the purposes of the preceding.

8.0 Contact Information Requirements

Network/site operators are required to provide contact information to DELG, as follows:

8.1 Primary Technical Contact

A name, telephone number, and email address must be provided for the primary technical contact for ambient air quality monitoring. This is the person responsible for the day-to-day operation of the ambient air quality monitoring network.

This is not an emergency contact, and there is no expectation of this person being reachable outside of regular business hours.

8.2 Emergency/Afterhours Air Quality Alerts Contact

The name or position title (e.g. "shift supervisor"), telephone number, and email address must be provided for the person/position/location that will be contacted if "alert" conditions (i.e., exceedance of the Maximum Permissible Ground Level Concentrations) are detected in the automated hourly data submissions to DELG. The person/position contacted must be capable (either personally, or through accessing other personnel/resources) of quickly determining whether the hourly data submissions are correct.

This contact must be reachable at all times.

9.0 Requests for Variance

It is acknowledged that the procedures/requirements described herein may not be achievable or suitable for all circumstances. Network/station operators (Approval Holders) may contact the Air Sciences Section to request case-by-case consideration of alternate approaches, technologies, techniques, etc. All such requests must be submitted electronically to a designated contact within the Air Sciences Section, DELG.

10.0 Audits

10.1 Technical System Audits

Technical system audits (TSA) are conducted by DELG technicians to verify compliance with all aspects of this manual, and any approved variances. These occur every other year (approximate), or in response to significant data quality issues that become evident in data submissions.

Network/site operators are required to participate in and assist with TSAs.

10.2 Performance Audits

Performance audits are conducted by DELG technicians to verify instrument response. Procedures are instrument-specific and generally follow procedures used for verification and calibrations. These include multi-point checks for gas analyzers and flow checks for PM monitors.

Network/site operators are required to provide DELG technicians with access to instruments for the purposes of conducting performance audits, and to otherwise accommodate the process as necessary.