
ENVIRONMENTAL MANAGEMENT AUTHORITY



AMBIENT AIR QUALITY MONITORING AND STACK EMISSIONS TESTING GUIDE

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List of Acronyms

APR- Air Pollution Rules, 2014

AS- Australian Standard

BS- British Standard

CEC- Certificate of Environmental Clearance, 2001

Cd- Cadmium

Cl- Chlorine

CO- Carbon Monoxide

F- Fluorine

FAA- Flame Atomic Absorption

GFAA- Graphite Furnace Atomic Absorption

HCl- Hydrogen Chloride

H₂S- Hydrogen Sulphide

ICAP- Inductively Coupled Argon Plasma

ICP- Inductively Coupled Plasma

IR- Infrared Rays

ISO- International Standard Organization

MS- Mass Spectrometry

NAA- Neutron Activation Analysis

NH₃- Ammonia

NO₂- Nitrogen Dioxide

NO_x- Oxides of Nitrogen

O₃- Ozone

Pb- Lead

PIXE- Proton Induced X- Ray Emission

PM₁₀- Particulate Matter of diameter less than or equal to 10 µm (PM₁₀)

PM_{2.5}- Particulate Matter of diameter less than or equal to 2.5 µm (PM_{2.5})

QA- Quality Assurance

QC- Quality Control

Sb- Antimony

SO₂- Sulphur Dioxide

TSP- Total Suspended Particulates

USEPA- United States Environmental Protection Agency

UV- Ultraviolet

XRF- X-Ray Fluorescence

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Introduction

Background

Air pollutant levels or standards are established due to their harmful impacts on human health and the environment. The World Health Organization (WHO) sets recommended limits for health-harmful concentrations of key air pollutants for outdoors, based on global synthesis of scientific evidence (WHO 2020). Countries set their own standards based on their unique circumstances and scientific studies. Greater air pollution concentrations result in poor air quality which leads to more severe impacts on human health and the environment. Air or stack emission monitoring is a measurement exercise. It is undertaken to characterise pollutants in ambient air or from emission sources. Monitoring of pollutants is necessary to determine or ascertain the pollutant concentrations in the ambient air and emissions from stationary sources. Monitoring is an essential tool in environmental protection.

High quality air pollution data is needed by regulators and managers to implement the national Ambient Air Quality Standards and to develop effective preventative and mitigation strategies to protect air quality (United States Environmental Protection Agency (USEPA) 2020). Data quality is heavily dependent on the air quality methodologies utilised and the Quality Assurance (QA) and Quality Control (QC) procedures implemented during monitoring.

Two pieces of legislation in Trinidad and Tobago that identify requirements for ambient air and stack monitoring, where applicable, are the Air Pollution Rules, 2014 (APR) and the Certificate of Environmental Clearance Rules, 2001. These requirements are stipulated through the issuance of permits and information requests / requirements, under these Rules. Facilities that generate air pollutants from their activities and processes are required to characterise the emissions generated.

The primary aim of the APR is to protect human health and the environment from the adverse effects of air pollution. This is achieved by identifying the activities that generate air pollutants (*i.e.*, [Schedule 3](#)) and by setting permissible levels for Ambient Air (*i.e.*, [Schedule 1](#)) and Point Sources / Stack Emissions (*i.e.*, [Schedule 2](#)). Standard permissible levels are set out in Schedules 1 and 2 of the APR. The values are used to compare the pollutant concentration results, in order to determine compliance.

The emissions generated through the activities and processes of a facility must be characterised, in order to identify and quantify the pollutants associated with the facility's operation. The APR allows for different approaches for determining air quality and emissions.

In accordance with Rule 32(1) of the APR, “air quality shall be determined through the use of any one or combination of the following methods which may be approved by the Environmental Management Authority (EMA):

- a) measurement of actual chemical concentrations;
- b) measurements of parameters that represent chemical constituents;
- c) engineering calculations;
- d) modelling of meteorological and pollutant dispersion characteristics; or
- e) any other method as determined by the Authority.”

Options (a) and (b) involve the monitoring of ambient air and point source/stack emissions. Ambient air and stack emissions monitoring data are used to determine compliance with the permissible levels outlined in the APR; support decision making for permit applications; develop emission inventory databases of pollutants and assess the efficiency and effectiveness of air pollution control devices, or, the implementation of Best Management Practices. Therefore, it is imperative that the data is representative and accurate when utilised for the outlined objectives. Trinidad and Tobago has not developed standard ambient air and stack emission testing methodologies. The list of methodologies provided in the body of the document are acceptable methods which have been developed by other jurisdictions, such as, the United States of America, Canada, the United Kingdom, India, New Zealand and Australia.

Internationally approved standard ambient air and stack emissions monitoring methods are listed in subsequent sections of the document. These standards are presented according to the pollutant listing, in Schedules 1 and 2 of the APR. The principle of operation, analysis, equipment and standard code or name of the standard details are provided and summarised for each standard. There are also sections which address Quality Assurance and Quality Control (QA/QC) guidelines and concepts for performing monitoring.

Aim/Objective

The purpose of this document is to provide a list of EMA approved / accepted methodologies and QA/QC guidance which can be utilised for determining compliance with the ambient air and stack emissions levels, as required by environmental regulations, in Trinidad and Tobago. The document aims to improve the accuracy and representativeness of air quality data through use of internationally approved monitoring methods and QA/QC procedures. This will ensure that the data produced is representative and acceptable. The document will be used internally and will be shared externally.

The guide will serve as a reference document for:

- Service providers to select appropriate methodologies for monitoring; to develop a quality system with QA/QC measures, to successfully conduct measurements of ambient air quality and stack emissions;
- Applicants to review further information requirements, in order to develop Terms of Reference (T.O.R) documents for consultation with potential service providers;
- EMA staff to review Quality Assurance Project Plans (QAPP), ambient air quality monitoring reports, stack emission testing reports and Environmental Impact Assessment (EIA) baseline reports and to provide guidelines for monitoring methodologies.

Ultimately, the aim is to obtain data of high quality that can be used confidently in decision-making. The data collected shall be known to be of a high quality and defensible, being:

- accurate – air quality monitoring is of high quality and free from errors;
- representative – spatial / temporal variations and the extent of human exposure are considered when designing monitoring plan for facility layout and operating conditions; and
- consistent – air quality data is recorded, analysed, processed and reported, and follows best practice principles.

Measurement Methods

Ambient air and stack emissions testing methods are constantly updated and comprise of a mix of real time and manual methods. There is a wide range of methods that can be used for measuring pollutants in ambient air and stack emissions. There is also an equally wide variation in cost and precision. Therefore, purpose and objectives of the monitoring data should be taken into consideration, when selecting monitoring methods.

Ambient Air Quality Monitoring Methods

Monitoring methodologies are divided into four (4) categories, according to, the level of accuracy and precision, cost and technology.

- **Continuous Monitoring Methods:** These are high-resolution automated methods that provide continuous records of contaminant levels. They can operate over extended periods (weeks or months) with minimal operator intervention. They have a high degree of measurement precision, and have low detection levels, at times below background levels. These are the most expensive monitoring methods. A high standard of maintenance, calibration, and operational and quality control procedures are required for the collection of good data quality.
- **Manual Methods:** These are time integrated methods which involve the sampling or collection of a specific volume of ambient air onto, or, into some medium, followed by laboratory analysis. These methods are cheaper to characterise emissions and are known as wet chemistry methods. However, the data is of lower accuracy in comparison to the continuous methods.
- **Passive Monitoring Methods (diffusion tubes and badges):** Diffusion tubes work when a contaminant is diffused into a tube containing either an adsorbent or reactive material. Analysis of the tubes follow a set exposure time and provide a time-averaged contaminant concentration. Badges work in a similar way, the difference being the sampler configuration with higher uptake rates. Both are simple and low cost methods which can provide a good picture of spatial variation, over a large area. They are particularly useful in screening surveys and during the initial stages of designing air quality monitoring programmes. Though a low cost screening tool, there are a number of limitations to these methods, such as, lower accuracy and no indication of peak levels. Quality control and assurance during laboratory analysis must be of the highest standard to attain consistent

results. The results from passive samplers can be used in conjunction with high-resolution instruments to determine spatial variation, across an air shed and over a relevant averaging period. These method are useful for comparison with annual guidelines.

- Sensors: Air sensor monitors are lower in cost and power requirements, portable and generally easier to operate than regulatory-grade monitors (USEPA Air Sensor Toolbox, 2020). Low-cost air pollution sensors and monitors were introduced into the public domain, within recent years. Air pollution sensors are in the early stages of technology development. Many sensors have not been evaluated to determine the accuracy of their measurements. Application of results include research, personal exposure monitoring, supplementing existing monitoring data, source identification and characterisation and information awareness. However, no low cost sensors meet the requirements for use in determining environmental regulatory compliance, at this time.

Table 1 provides a list methodologies for ambient air quality monitoring according to pollutants. The information included are details on equipment, operating principles and type of methods and analysis.

Table 1: Ambient Air Quality Monitoring Methods

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Particulates			
<p>Total Suspended Matter (TSP), Particulate Matter of Diameter Less than or Equal to 10 μm (PM₁₀) and</p> <p>Particulate Matter of Diameter Less than or Equal to 2.5 μm (PM_{2.5})</p>	Manual Method	<p>1. Reference method for the determination of Suspended Particulate Matter with size selective inlet ^{1 3}</p> <p>Sampling Methodology: High volume and low volume samplers, Single channel sampler, dichotomous sequential sampler and portable audit sampler.</p> <p>Analysis: Gravimetric weight analysis</p> <p>Samples are collected on pre-weighed Teflon filters. Mass concentrations are calculated from the difference between pre- and post-sampling weights using sampled volumes. Gravimetric analysis is performed under controlled environmental conditions.</p>	<p>Tisch PM₁₀ and PM_{2.5} High Volume Sampler</p> <p>Air Metrics Low Volume Sampler</p>

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Particulate Matter of Diameter Less than or Equal to 10 µm (PM₁₀) and</p> <p>Particulate Matter of Diameter Less than or Equal to 2.5 µm (PM_{2.5})</p>	<p>Continuous Automated Method</p>	<p>1. Beta Attenuation¹: Particle sizes (e.g., ≤2.5 or ≤ 10 µm) are aerodynamically separated before analysis. For these measurements, filter tape is exposed to ambient sample flow, and PM is deposited on the filter. Beta rays are emitted from a source and attenuated when they pass through the deposits on the filter. The beta attenuation through the deposit is blank corrected using beta attenuation through a clean filter. The blank-corrected attenuation readings are converted to mass concentrations.</p> <p>2. Light Scattering¹: This method relates light-scattering measurements to mass measurements, where particle light scattering is determined by illuminating particles and measuring the scattered intensity at different orientations from the incident light. The scattering measurement is often highly correlated with mass</p>	<p>Met-One Instruments Beta Attenuation Monitor – 1020</p> <p>Teledyne Advanced Pollution Instrument Model T640 PM Mass Monitor (with 640X option)</p>

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Particulate Matter of Diameter Less than or Equal to 10 µm (PM₁₀) and</p> <p>Particulate Matter of Diameter Less than or Equal to 2.5 µm (PM_{2.5})</p>		<p>concentrations, but the relationship can depend on particle properties like size, shape and composition.</p> <p>3. Tapered Element Oscillating Microbalance¹ (TEOM): Particle sizes are aerodynamically separated before analysis. A TEOM consists of a hollow glass element that oscillates at a known frequency. The air sample passes through a filter attached to the tapered element. As particles are deposited on the filter, the oscillating frequency changes in proportion to the amount of mass deposited. This change in frequency is used to determine PM concentration. For US EPA equivalency, TEOMs measuring PM_{2.5} must be operated with a Filter Dynamics Measurement System, which corrects for volatilization and other filter mass loading issues.</p>	

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Particulate Matter of Diameter Less than or Equal to 10 µm (PM₁₀) and</p> <p>Particulate Matter of Diameter Less than or Equal to 2.5 µm (PM_{2.5})</p>		<p>4. Synchronized Hybrid Ambient Real-time Particulate¹ (SHARP) Monitor: The SHARP monitor provides a real-time measure of the PM mass concentration using a C14 beta attenuation monitor in combination with a fast response light scattering photometer. The monitor utilises digital filtering to continuously calibrate the photometer using integrated beta attenuation data.</p> <p>Note: A size selective inlet based on inertial separation of large and small particles is used to fractionate the PM. Impaction and or cyclonic inlets precede sample collection in order to selectively determine the particle size of interest. PM_{2.5} monitors uses a sharp cut cyclone or a very sharp cut cyclone. (Canadian Council of Ministers of the Environment, Ambient Air Monitoring Protocols for PM_{2.5} and Ozone).</p>	

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Non Metallic Inorganic Substances			
Carbon Monoxide (CO)	Manual Method	<p>1. Sampling Methodology: Integrated sample drawn into Tedlar bag.</p> <p>Analysis: Sample is analyzed by Thermo 48i CO Analyser.</p>	Thermo 48i CO Analyser
	Continuous Automated Method	<p>2. Non-Dispersive Infrared²: This is the most commonly used continuous CO measurement method. These analysers operate on the principle that the CO molecule has a sufficiently characteristic infrared (IR) absorption spectrum for detection. Sample air passes through a chamber in front of an IR source. Optical band pass filters focus the wavelength of the IR energy to the CO absorption range. The detector produces a signal proportional to the amount of IR absorbed, enabling the concentration of CO to be calculated.</p>	<p>Thermo 48i CO Analyser</p> <p>Teledyne Advanced Pollution Instrumentation Model T300/T300M Carbon Monoxide Analyser</p>

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Carbon Monoxide (CO)		3. Australian Standard (AS) 3580 7.1	
Nitrogen Dioxide (NO ₂)	Manual Method	1. Sodium Arsenite Method for the Determination of Nitrogen Dioxide in the Atmosphere ³ 2. TGS-ANSA Method for the Determination of Nitrogen Dioxide in the Atmosphere ³ Sampling Methodology: Pumped (active) sampling; Impinger and vacuum sampling pump Analysis: Colorimetry	SKC Sampling Pump Model PCXR4 Buck Libra Sampling Pump Model number: LP-1, LP-4
	Continuous Automated Method	3. Chemiluminescence ³ : NO concentrations are determined photometrically by measuring the light intensity from the chemiluminescent reaction of NO mixed with excess O ₃ . The chemiluminescence method detects only NO, so NO ₂ must first be converted to NO for measurement purposes. Sample flow either is directed through a	Teledyne Advanced Pollution Instrumentation NO _x Teledyne Advanced Pollution Instrumentation Model T204 NO _x and Ozone analyser

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Nitrogen Dioxide (NO ₂)		<p>converter to reduce NO₂ to NO, or it bypasses the converter to allow detection of only NO. The sample stream with reduced NO₂ is a measurement of NO plus NO₂, expressed as NO_x. The difference between NO_x and NO detection is calculated as the NO₂ concentration.</p> <p>4. Cavity Attenuated Phase Shift³ (CAPS) (NO₂ only): Direct measurements of NO₂ using CAPS technology. CAPS instruments use low-power LEDs, where NO₂ light absorption is directly correlated to NO₂ concentration. CAPS analysers measure only NO₂, not NO or NO_x.</p> <p>5. AS 3580 5.1</p>	
Sulphur Dioxide (SO ₂)	Manual Method	<p>1. Reference Method for the Determination of Sulfur Dioxide in the Atmosphere (Pararosaniline Method)³</p>	<p>SKC Sampling Pump Model PCXR4</p> <p>Buck Libra Sampling Pump Model number: LP-4, LP-1</p>

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Sulphur Dioxide (SO ₂)		<p>Sampling Methodology: Pumped (active) sampling; Impinger and vacuum sampling pump</p> <p>Analysis: Spectrophotometry</p> <p>2. Passive Air Samplers analyzed via USEPA method 300 (Ion Chromatography)</p>	Radiello Passive Samplers and All Seasons Maxxam Analytics Passive Samplers
	Continuous Automated Method	<p>3. UV fluorescence²: This is the most commonly used continuous SO₂ measurement method. This method is based on the principle that SO₂ molecules absorb UV light at one wavelength and emit UV light at a different wavelength. The intensity of the emitted light is proportional to the number of SO₂ molecules in the sample gas. SO₂ molecules are excited to higher energy states by UV radiation. These excited</p>	Teledyne Advanced Pollution Instrumentation Model T100 UV Fluorescence SO ₂ Analyzer

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Sulphur Dioxide (SO ₂)		molecules then release their energy as fluorescent radiation. The intensity of this is used to measure the concentration of SO ₂ in sampled air. 4. AS 3580 4.1	
Ozone (O ₃)	Manual Method	1. Method 411, Air Sampling and Analysis, 3rd Edition (Determination of Oxidizing Substances in the Atmosphere)⁴ Sampling Methodology: Pumped (active) sampling; Impinger and vacuum sampling pump. Analysis: Spectrophotometry	Buck Libra Sampling Pump Model number: LP-4, LP-1
	Continuous Automated Method	2. Ultraviolet (UV) photometry²: An air sample passes through a beam of light from a UV lamp, which is absorbed by O ₃ . The amount of UV light absorbed is proportional to the amount of O ₃ in the sample. The absorption of	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Ozone (O ₃)		UV by sampled air is used to calculate the O ₃ concentration. 3. Chemiluminescence Method⁵: Measurement / Determination of the mass concentration of O ₃ in ambient air by chemiluminescence analyser. The O ₃ is measured continuously by utilising the gas phase chemiluminescent reaction between ozone and ethylene.	
Sulfuric Acid (H ₂ SO ₄)	Manual Method	1. Inorganic Compendium Method 4⁶: Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles in Ambient Air Using the Annual Denuder Technology. Analysis: pH & Ion Chromatography 2. BS ISO 21438-1: 2007 Workplace Atmospheres. Determination of Inorganic Acids by Ion Chromatography⁵	To be determined

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Sulfuric Acid (H ₂ SO ₄)		<p>Active Sampling of non-volatile acids (H₂SO₄) onto filters. The inhalable fraction of airborne particles is collected onto filters extracted and analysed by ion chromatography.</p> <p>Note: The workplace standard method can be easily modified for ambient air applications. There is no differentiation between the acids and their salts in analysis.</p>	
Hydrogen sulphide (H ₂ S)	Continuous Automated Method	<p>UV Fluorescence Monitoring⁵: Direct reading continuous measurements made using a UV fluorescence SO₂ analyzer coupled to an H₂S converter unit containing a scrubber to remove to SO₂ and a catalyst to convert H₂S passing through the scrubber into SO₂.</p>	Thermo Scientific Model 450i Hydrogen Sulphide and Sulphur Dioxide analyser

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Ammonia (NH ₃)	Manual Method	<p>1. Sampling of Aqueous Ammonia⁵¹: Manual sampling methods are used for time-integrated (i.e., 24-hour or shorter) measurements of both particle-phase ammonium ion (NH₄⁺) and gaseous ammonia (NH₃) by initial collection on specific substrates and subsequent chemical analyses. The procedure used involves collection of NH₃ using a citric acid coated denuder and NH₄⁺ subsequently collected on a Teflon filter with analysis following aqueous extraction.</p> <p>Analysis: Ammonia Flow Injection and Ion Chromatography</p> <p>Note: Specific care is required during preparation and handling of the reactive substrates to minimize contamination (from ambient air exposure).</p>	To be determined

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Ammonia (NH ₃)		<p>2. Indophenol Method (method 401, Air Sampling and Analysis, 3rd Edition)⁴:</p> <p>Ammonia in the atmosphere is collected by bubbling a measured volume of air through a dilute solution of sulphuric acid to form ammonium sulphate. The ammonia sulphate formed in the sample is measured colorimetrically by reaction with phenol and alkaline sodium hypochlorite to produce indophenol, a blue dye.</p> <p>Analysis: Colorimetry</p>	<p>Buck Libra Sampling Pump Model number: LP-4, LP-1</p>
	<p>Continuous Automated Method</p>	<p>3. Chemiluminescence NOx monitors with NH₃ Converter Automated Thermodenuders⁵</p> <p>Chemiluminescence analysers with modifications is used in combination with an upstream thermal NH₃ converter module whereby nitrogen species such as NH₃ and NO₂ are transformed to NO within the initial converter</p>	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Ammonia (NH ₃)		<p>and, together with the original air NO content, are detected as a total N signal. The instrument then sequentially detects NO_x and the associated (NO, NO₂) components in the normal mode, in conjunction with NH₃ scrubbers on separate channels, such that NH₃ is recorded by the total N and NO_x signal difference (i.e., signal subtraction).</p> <p>Note: Specific precautions are required to address possible measurement interferences from substances that, if present, could also transform to NO within the high temperature converter (e.g., organic nitrogenous compounds, nitric acid vapour and / or ammonium containing aerosols). The possibility of losses of NH₃ in sampling lines before the analyser also requires consideration.</p>	To be determined

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Total Fluoride	Manual Method	<p>1. Method for Sampling and Analysis of Ambient Air-Determination of Gaseous and Acid-Soluble Particulate Fluorides - Manual, Double Filter Paper Sampling⁶</p> <p>Sampling Method: Automated, double paper tape sampling method; Manual, double filter paper sampling method; sodium acetate coated tube absorption method</p> <p>Collection and separation of acidic gaseous and acid-soluble particulate fluorides from ambient air and their determination using a fluoride ion-selective electrode.</p> <p>Ambient air is drawn through an inlet tube and passed through an acid-impregnated paper tape (initial filter tape) to collect particulate fluorides and then through an alkali-impregnated paper tape (final filter tape) to collect acidic gaseous fluorides. The sampler is programmed to</p>	To be determined

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Total Fluoride		<p>collect and store samples over selected time periods of up to 3 hours. The fluorides from the exposed filter tapes are extracted into aqueous solution and determined using a fluoride ion-selective electrode. This method is applicable to the measurement of acidic gaseous and acid-soluble particulate fluorides suspended in ambient air at concentrations of 1 µg/m³ and greater.</p> <p>2. AS 3580 13.2 2013</p>	
Hydrogen Chloride (HCl)	Manual Method	<p>1. Inorganic Compendium Method 4⁶: Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles in Ambient Air Using the Annular Denuder Technology. Active sampling of HCl by Denuder Tubes.</p> <p>Analysis: pH & Ion Chromatography.</p>	To be determined

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Chlorine and its compounds	Manual Method	<p>1. Inorganic compendium Method 4⁶: Determination of Reactive Acidic and Basic Gases and Strong Acidity of Atmospheric Fine Particles in Ambient Air Using the Annular Denuder Technology. Active sampling of by Denuder Tubes.</p> <p>Analysis: pH & Ion Chromatography</p> <p>Pumped (active) sampling of air through a Dreschel bottle with alkaline absorbent solution; analysis by acidimetric titration or other end-methods (e.g., ion chromatography)⁵</p> <p>Note: The filter is removed where a determination of total chlorine is required.</p>	To be determined
Asbestos (Fibres > 5 µm in Length) and Asbestos (Total)		<p>1. USEPA Environmental Asbestos Assessment Manual, Superfund Method for the Determination of Asbestos in Ambient Air for Transmission Electron Microscopy (TEM)</p>	To be determined

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Asbestos (fibres > 5 µm in length) & Asbestos (Total)</p>		<p>2. U.S. EPA's Modified Yamate Method for TEM is also used for ambient air sampling due to high volume requirements.</p> <p>3. National Institute for Occupational Safety and Health (NIOSH) Method 7402 (direct method only) for TEM; and</p> <p>4. NIOSH Method 7400 for Phase Contrast Microscopy (PCM)</p> <p>All methods identified above are based on a sampling pump drawing air at different flow rates and resultant air volumes. The air passes through or is deposited on a filter cassette. The filter is then analysed using TEM and PMC.</p> <p>(USEPA Environmental Response Team Asbestos Monitoring 1994)</p>	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Metallic Substances			
Cadmium (Cd) and its Compounds	Manual Method	<p>1. Inorganic compendium Method 3 (3.1-3.7)⁶: Chemical species analysis of filter--collected suspended particulate matter.</p> <p>Sampling:</p> <ul style="list-style-type: none"> • High volume samplers for collecting TSP (total suspended particulate with aerodynamic diameters less than 100 µm) and PM₁₀ (particulate matter with aerodynamic diameters less than 10 µm); and • Low volume samplers for collecting PM₁₀ utilizing dichotomous and Partisol samplers. <p>Determination of Metals in Ambient Particulate Matter using analysis methods:</p> <ul style="list-style-type: none"> • Flame and graphite furnace Atomic Absorption Spectroscopy (FAA/GFAA); 	High and Low volume samplers

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Cadmium (Cd) and its Compounds	Manual Method	<ul style="list-style-type: none"> • X-Ray Fluorescence (XRF) Spectroscopy; • Inductively Coupled Plasma (ICP) Spectroscopy; • Inductively coupled plasma/mass spectrometry (ICP/MS); • Proton Induced X-Ray emission (PIXE) Spectroscopy; and • Neutron Activation Analysis (NAA) Gamma Spectrometry. <p>2. BS EN 14902:2005 Ambient Air Quality: Standard Method for the Measurement of Pb, Cd, As and Ni in the PM₁₀ Fraction of Suspended Matter⁵.</p> <p>Pumped active sampling of particulate metals on to filters followed by GF/AAS and ICP/MS analysis.</p>	
Mercury (Hg) and its Compounds	Manual Method	<p>1. Inorganic Compendium Method 5⁶: (Sampling and analysis for vapour and particle phase mercury in ambient air utilising cold vapour atomic</p>	To be determined

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Mercury (Hg) and its Compounds	Manual Method	fluorescence spectrophotometry). 2. BS EN 15852:2010 Ambient Air Quality – Standard Method for the Determination of Total Gaseous Mercury⁵ Gaseous mercury is collected via pumped (active) sampling onto sorbent tubes and analysis via a fluorescence detector.	
Antimony (Sb) and its Compounds and Beryllium (Be) Compounds	Manual Method	Inorganic Compendium Method 3 (3.1-3.7)⁶: Chemical species analysis of filter-- collected suspended particulate matter. Sampling: <ul style="list-style-type: none"> • High volume samplers for collecting TSP (Total Suspended Particulate with aerodynamic diameters less than 100 µm) and PM₁₀ (Particulate matter with aerodynamic diameters less than 10 µm); and • Low volume samplers for collecting PM₁₀ utilising dichotomous and Partisol® samplers. 	High and Low Volume Samplers

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Antimony (Sb) and its Compounds and Beryllium (Be) Compounds	Manual Method	Determination of Metals in Ambient Particulate Matter using Analysis Methods: <ul style="list-style-type: none"> • Flame and graphite furnace Atomic Absorption Spectroscopy (FAA/GFAA); • X-Ray Fluorescence (XRF) Spectroscopy; • Inductively Coupled Plasma (ICP) Spectroscopy; • Inductively coupled plasma/mass spectrometry (ICP/MS); • Proton Induced X- Ray emission (PIXE) Spectroscopy; and • Neutron Activation Analysis (NAA) Gamma Spectrometry. 	
Lead (Pb)	Manual Method	1. Inorganic Compendium Method 3 (3.1-3.7)⁶: Chemical species analysis of filter--collected suspended particulate matter.	High Volume Samplers

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Lead (Pb)	Manual Method	<p>Sampling:</p> <p>High volume samplers for collecting TSP (total suspended particulate with aerodynamic diameters less than 100 µm) and PM₁₀ (particulate matter with aerodynamic diameters less than 10 µm);</p> <p>Determination of Metals in Ambient Particulate Matter using analysis methods:</p> <ul style="list-style-type: none"> • Flame and graphite furnace Atomic Absorption Spectroscopy (FAA/GFAA); • X-Ray Fluorescence (XRF) Spectroscopy; • Inductively Coupled Plasma (ICP) Spectroscopy; • Inductively coupled plasma/mass spectrometry (ICP/MS); • Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES); 	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Lead (Pb)	Manual Method	<ul style="list-style-type: none"> • Proton Induced X- Ray emission (PIXE) Spectroscopy; and • Neutron Activation Analysis (NAA) Gamma Spectrometry. <p>2. BS EN 14902:2005 Ambient Air Quality: Standard Method for the Measurement of Pb, Cd, As and Ni in the PM₁₀ Fraction of Suspended Matter⁵.</p> <p>Pumped active sampling of particulate metals on to filters by high volume PM10 samplers, followed by GF/AAS and ICP/MS analysis.</p> <p>3. AS 2800</p>	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Organic Substances			
<p>Biphenyl (C₆H₅)₂</p>	<p>Manual Method</p>	<p>1. Organic Compendium Method 4A⁶: Determination of Pesticides and Polychlorinated Biphenyls in Ambient Air Using High Volume Polyurethane Foam (PUF) Sampling followed by Gas Chromatographic/Multi-Detector Detection (GC/MD)</p> <p>2. Organic compendium Method 10A⁶: Determination of Pesticides And Polychlorinated Biphenyls In Ambient Air Using Low Volume Polyurethane Foam (PUF) Sampling followed By GC/MD</p> <p>Both procedures are based on the adsorption of chemicals from ambient air on polyurethane foam (PUF) or a combination of PUF and granular sorbent using a high or low volume sampler.</p>	<p>High volume PUF sampler</p>

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Carbon Disulfide (CS ₂)	Manual Method	<p>Modified NIOSH 1600⁵</p> <p>Pumped active sampling of CS₂ on to solid charcoal absorption tubes. Flow rate modified and increase volume sampled for ambient applications.</p> <p>Analysis: GC-FPD, GC/PID, or GC/TCD.</p>	To be determined
Ethylbenzene (C ₆ H ₅ C ₂ H ₅)	Manual Method	<p>1. Organic Compendium Method 1⁶: Determination of volatile organic compounds (VOCs) in ambient air using Tenax® adsorption and GC/MS. Ambient air is drawn through organic polymer sorbent where certain compounds are trapped. The cartridge is transferred to the laboratory, thermally desorbed and analysed using GC/MS or GC/FID.</p> <p>2. Organic Compendium Method 14A⁶: Determination of Volatile Organic Compounds (VOCs) In Ambient Air Using Specially Prepared Canisters with</p>	Silonite Canister (Specially prepared canisters)

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Ethylbenzene (C ₆ H ₅ C ₂ H ₅)	Manual Method	<p>subsequent analysis by Gas Chromatography.</p> <p>Whole air samples are collected in an evacuated stainless steel canister. VOCs are concentrated in the laboratory with cryogen trap. VOCs are re-volatilised, separated on a GC column, and measured by a mass spectrometer or by multi-detector techniques.</p> <p>3. Organic Compendium Method 15⁶: Determination of VOCs in air Collected in Specially-Prepared Canisters and Analysed by Gas Chromatography Mass Spectrometry (GC/MS).</p> <p>Whole air samples are collected in a specially prepared canister. VOCs are concentrated on a solid sorbent trap or other arrangement, re-focused on a second trap, separated on a GC column, and passed to an MS detector for identification and quantification.</p>	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Ethylbenzene (C₆H₅ C₂H₅)</p>	<p>Manual Method</p>	<p>4. Organic Compendium Method 16⁶: Long-Path Open-Path Fourier Transform Infrared Monitoring of Atmospheric Gases.</p> <p>VOCs are monitored using real-time long-path open path (FTIR).</p> <p>5. Organic Compendium Method 17⁶: Determination of VOCs in Ambient Air Using Active Sampling onto Sorbent Tubes.</p> <p>Ambient air is drawn through a multi-bed sorbent tube where VOCs are trapped. The cartridge is returned to the laboratory, thermally desorbed and analyzed by GC/MS.</p> <p>6. BS EN 14662 part 1-5:2005 Ambient Air Quality – Standard Method for Measurement of Benzene Concentrations –</p>	<p>Buck Libra Sampling Pump Model number: LP-1, LP-4</p>

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Ethylbenzene (C ₆ H ₅ C ₂ H ₅)	Manual Method	<ol style="list-style-type: none"> 1. Pumped sampling followed by thermal desorption and gas chromatography; 2. Pumped sampling followed by solvent desorption and gas chromatography; 3. Automated pumped sampling with in situ gas chromatography; 4. Diffusive sampling followed by thermal desorption and gas chromatography; 5. Diffusive sampling followed by solvent desorption and gas chromatography. <p style="text-align: center;">New Zealand Ministry for the Environment Good Practice Guide for Air Quality Monitoring and Data Management, 2009</p>	
Formaldehyde (CH ₂ O)	Manual Method	<ol style="list-style-type: none"> 1. Organic Compendium Method 11A⁶: Determination of Formaldehyde in Ambient Air Using Adsorbent Cartridge Followed by High Performance 	Buck Libra Sampling Pump Model number: LP-1, LP-4

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Formaldehyde (CH ₂ O)	Manual Method	<p>Liquid Chromatography (HPLC) [Active Sampling Methodology].</p> <p>An ambient air sample is drawn through a commercially-coated dinitrophenylhydrazine (DNPH) cartridge. The cartridges are returned to the laboratory in screw-cap glass vials. The cartridges are then removed from the vials and washed with acetonitrile by gravity feed elution. The eluate is diluted volumetrically and an aliquot is removed for determination of the DNPH-formaldehyde derivative by isocratic reverse phase HPLC with UV detection at 350 nm.</p> <p>2. Pumped Active Sampling of Formaldehyde through Water in an Impinge Bottle; Analysis by Spectrophotometry⁵.</p> <p>Air sampled at 1 L/min through distilled water contained in two coarse fritted bubblers.</p>	

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Formaldehyde (CH ₂ O)	Manual Method	<p>Analysis Colorimetric Procedure: Chromotropic acid and sulphuric acid are added and the purple coloured dye formed from the reaction is determined spectrophotometrically at 580nm.</p>	
Mercaptan (as Methyl Mercaptan- CH ₃ SH)	Manual Method	<p>1. Organic Compendium Method 1⁶: Determination of VOCs in ambient air using Tenax® adsorption and GC/MS. Ambient air is drawn through organic polymer sorbent where certain compounds are trapped. The cartridge is transferred to the laboratory, thermally desorbed and analysed using GC/MS or GC/FID.</p> <p>2. Organic Compendium Method 14A⁶: Determination of VOCs in Ambient Air Using Specially Prepared Canisters with subsequent analysis by Gas Chromatography.</p>	Silonite Canister (Specially prepared canisters)

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Mercaptan (as Methyl Mercaptan- CH₃SH)</p>	<p>Manual Method</p>	<p>Whole air samples are collected in an evacuated stainless steel canister. VOCs are concentrated in the laboratory with cryogen trap. VOCs are re-volatilized, separated on a GC column, and measured by a mass spectrometer or by multi-detector techniques.</p> <p>3. Organic Compendium Method 15⁶: Determination of VOCs In Air Collected in Specially-Prepared Canisters and Analysed by Gas Chromatography Mass Spectrometry (GC/MS).</p> <p>Whole air samples are collected in a specially prepared canister. VOCs are concentrated on a solid sorbent trap or other arrangement, re-focused on a second trap, separated on a GC column, and passed to an MS detector for identification and quantification.</p> <p>4. Organic Compendium Method 16⁶: Long-Path Open-Path</p>	

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Mercaptan (as Methyl Mercaptan- CH₃SH)</p>	<p>Manual Method</p>	<p>Fourier Transform Infrared Monitoring of Atmospheric Gases.</p> <p>VOCs are monitored using real-time long-path open path (FTIR).</p> <p>5. Organic Compendium Method 17⁶: Determination of VOCs in Ambient Air Using Active Sampling onto Sorbent Tubes.</p> <p>Ambient air is drawn through a multi-bed sorbent tube where VOCs are trapped. The cartridge is returned to the laboratory, thermally desorbed and analyzed by GC/MS.</p> <p>6. Pumped (Active) Sampling of Mercaptans onto an Impregnated Filter; Analysis by GC-FPD⁵.</p> <p>The sample (volume 100 l) is collected on a treated filter paper (glass-fibre impregnated with HgOAc). Analysis is by GC-FPD. This method is similar to the</p>	

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Mercaptan (as Methyl Mercaptan- CH₃SH)	Manual Method	OSHA method IMIS 1220 for ethanethiol and there are a number of workplace methods (e.g. NIOSH 2542) that could be adapted (e.g., increase volume sampled) for ambient air applications.	
Polychlorinated Biphenyls (PCBs)	Manual Method	<ol style="list-style-type: none"> 1. Organic Compendium Method 4A⁶: Determination of Pesticides and Polychlorinated Biphenyls in Ambient Air Using High Volume Polyurethane Foam (PUF) Sampling followed by Gas Chromatographic/Multi-Detector Detection (GC/MD). 2. Organic Compendium Method 10A⁶: Determination of Pesticides and Polychlorinated Biphenyls In Ambient Air Using Low Volume Polyurethane Foam (PUF) Sampling followed by GC/MD. 	To be determined

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Polychlorinated Biphenyls (PCBs)		Both procedures are based on the adsorption of chemicals from ambient air on polyurethane foam (PUF) or a combination of PUF and granular sorbent using a high or low volume sampler.	
Xylenes (C ₆ H ₄ (CH ₃) ₂) (Isomers and Mixture)	Manual Method	<p>1. Organic Compendium Method 1⁶: Determination of VOCs in ambient air using Tenax® adsorption and GC/MS. Ambient air is drawn through organic polymer sorbent where certain compounds are trapped. The cartridge is transferred to the laboratory, thermally desorbed and analysed using GC/MS or GC/FID.</p> <p>2. Organic Compendium Method 14A⁶: Determination of VOCs In Ambient Air Using Specially Prepared Canisters with subsequent analysis by Gas Chromatography.</p> <p>Whole air samples are collected in an evacuated stainless steel</p>	

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Xylenes Mixture (C₆H₄(CH₃)₂) (Isomers and</p>	<p>Manual Method</p>	<p>canister. VOCs are concentrated in the laboratory with cryogen trap. VOCs are re-volatilised, separated on a GC column, and measured by a mass spectrometer or by multi-detector techniques.</p> <p>3. Organic Compendium Method 15⁶: Determination of VOCs in Air Collected in Specially-Prepared Canisters and Analysed by Gas Chromatography Mass Spectrometry (GC/MS).</p> <p>Whole air samples are collected in a specially prepared canister. VOCs are concentrated on a solid sorbent trap or other arrangement, re-focused on a second trap, separated on a GC column, and passed to an MS detector for identification and quantification.</p> <p>4. Organic Compendium Method 16⁶: Long-Path Open-Path Fourier Transform Infrared Monitoring of Atmospheric</p>	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Xylenes (C₆H₄(CH₃)₂) (Isomers and Mixture)</p>	<p>Manual Method</p>	<p>Gases. VOCs are monitored using real-time long-path open path (FTIR).</p> <p>5. Organic Compendium Method 17⁶: Determination of VOCs in Ambient Air Using Active Sampling onto Sorbent Tubes.</p> <p>Ambient air is drawn through a multi-bed sorbent tube where VOCs are trapped. The cartridge is returned to the laboratory, thermally desorbed and analysed by GC/MS.</p> <p>6. Pumped (Active) Sampling Of Dioxins And Furans And PCBs Onto Filters And Traps; Analysis By Gas Chromatography With Mass Spectrometry (GC-MS) or Electron Capture (GC-ECD)⁵.</p> <p>Analysis stage covered by BS EN 1948-3:2006 Stationary Source Emissions: Determination of the mass concentration of polychlorinated dibenzo-p-</p>	<p>Buck Libra Sampling Pump Model number: LP-1, LP-4</p>

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Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Xylenes (C₆H₄(CH₃)₂) (Isomers and Mixture)</p>	<p>Manual Method</p>	<p>dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs).</p> <p>A high volume sampler is used to collect the sample. The sorbent trap and filter set is extracted with dichloromethane and toluene. After removal of a proportion of the extract for PAHs analysis, the remaining sample is chromatographically separated and cleaned-up for PCDDs/Fs and PCBs analysis by the following end-methods:</p> <ol style="list-style-type: none"> 1. Gas chromatography coupled with high-resolution mass spectrometry (GC-HRMS) for the PCDDs/Fs and for those PCBs with dioxin-like effects, in accordance with analytical method EN1948-3:2006; 2. Low-resolution mass spectrometry or GC with electron capture detector (GC-ECD) for the other PCBs. 	

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
<p>Total Dioxins and Furans</p>	<p>Manual Method</p>	<p>1. Organic Compendium Method 9A⁶: Determination of Polychlorinated, Polybrominated and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air.</p> <p>The method uses a high volume air sampler equipped with a quartz-fiber filter and polyurethane foam (PUF) adsorbent for sampling 325 to 400 m³ ambient air in a 24-hour sampling period. Analytical procedures based on high resolution gas chromatography-high resolution mass spectrometry (HRGC-HRMS) are used for analysis of the sample.</p> <p>2. Pumped (Active) Sampling of Dioxins and Furans and PCBs onto Filters and Traps; Analysis by Gas Chromatography with Mass Spectrometry (GC-MS) or Electron Capture (GC-ECD)⁵.</p>	<p>High Volume air sampler</p>

Pollutant	Manual / Automated Method	Methodology / Operating Principle / Lab Analysis	Equipment and Samplers Accepted
Total Dioxins and Furans	Manual Method	Analysis stage covered by BS EN 1948-3:2006 Stationary Source Emissions : Determination of the mass concentration of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs).	

¹ Canadian Council of Ministers of the Environment, Ambient Air Monitoring Protocols for PM_{2.5} and ozone Canada-wide Standards for PM and Ozone, 2011

² Canadian Council of Ministers of the Environment Ambient air monitoring and Quality Assurance/Quality Control Guidelines 2019

³ USEPA of List Designated Reference and Equivalent Methods, June 2020

⁴ India. Central Pollution Control Board. Guidelines for the Measurement of Ambient Air Pollutants, 2013

⁵ UK. Environment Agency. Technical Guidance Note (Monitoring Ambient Air) M8, 2011

⁶ USEPA. Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air, 1999

Note: When utilising passive samplers, the following standards must be adhered to:

- BS EN 13528-1 2002 “Ambient air quality – Diffusive samplers for the determination of gases and vapours – Requirements and test methods: General requirements”
- BS EN 1352-2 2002 “Ambient air quality – Diffusive samplers for the determination of gases and vapours – Requirements and test methods: Specific requirements and test methods”
- BS EN 13528-3 2003 “Ambient air quality – Diffusive samplers for the determination of gases and vapours: Guide to selection, use and maintenance”

The methods identified in Table 1 are sourced from various agencies, such as, Standard Association of Australia, Standards New Zealand, USEPA, British Standards and the International Organization for Standardization (ISO). See: References.

The standard monitoring methods set out the basic principles of operation, instrument performance requirements, apparatus and set-up, calibration procedures, and the calculation and expression of results. It is essential that the equipment is operated and procedures followed according to the relevant standard, at all times. Where standard methods descriptions and operating principles were not available, codes are referenced.

Note: If non-criteria pollutants sampling does not conform to the methods specified in Table 1 above, the applicant must demonstrate that the sampling equipment and methodology proposed is comparable to that of the specified sampling and analysis method. Additionally, the monitoring period must be in accordance with the averaging time in Schedules 1 &2 of the APR.

Stack Emissions Monitoring Methods

Table 2 provides a list methodologies for Stack emissions monitoring according to pollutants. The information included are description of the methodologies, type of analysis and operating principles.

Table 2: Stack Emissions Monitoring Methods

Pollutant / Substance	Methodology
Particulates	
Particulate Matter (PM)	<p>1. USEPA Air Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>Method 5: Determination of particulate matter emissions from stationary sources</p> <p>Particulate matter is withdrawn isokinetically from the source and collected on a glass fiber filter maintained at a temperature of 120 ±14 °C (248 ±25 °F) or such other temperature as specified by an applicable subpart of the standards or approved by the Administrator for a particular application. The PM mass, which includes any material that condenses at or above the filtration temperature, is determined gravimetrically after the removal of uncombined water.</p> <p>2. Australian Standard (AS) 4323.2</p>
Physical Parameter	
Opacity	<p>USEPA Air Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>Method 9: Visual determination of the opacity of emissions from stationary sources</p> <p>The opacity of emissions from stationary sources is determined visually by a qualified observer. Opacity observations shall be made at the point of greatest opacity in that portion of the plume where condensed water vapor is not present. The observer shall not look continuously at the plume, but instead shall observe the plume momentarily at 15-second intervals.</p>

Pollutant / Substance	Methodology
Non- Metallic Inorganic Substances	
Sulfur Dioxide (SO₂)	<p>1. USEPA Air Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>i. Method 6: Determination of SO₂ emissions from stationary sources</p> <p>A gas sample is extracted from the sampling point in the stack. The SO₂ and the sulfur trioxide, including those fractions in any sulfur acid mist, are separated. The SO₂ fraction is measured by the barium-thorin titration method.</p> <p>ii. Method 6A: Determination of SO₂, moisture, and carbon dioxide (CO₂) from fossil fuel combustion sources;</p> <p>iii. Method 6B: Determination of SO₂ and (CO₂) daily average emissions from fossil fuel combustion sources;</p> <p>iv. Method 6C: Determination of SO₂ emissions from stationary sources (instrumental analyzer procedure).</p> <p>2. ISO (1998) Method 11632, European Standard (EN) 14791, Environment Canada, Standard Reference Methods for Source Testing: Measurement of Emissions of Sulphur Dioxide from Stationary Sources, EPS 1-AP-74-3.</p> <p>3. USEPA Environmental Technology Verification (ETV) for O₂, CO, NO, NO₂, SO₂, H₂S, and hydrocarbons.</p>
Oxides of Nitrogen (NO_x)	<p>1. USEPA Air Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>i. Method 7: Determination of nitrogen oxide emissions from stationary sources</p> <p>A grab sample is collected in an evacuated flask containing a dilute sulfuric acid-hydrogen peroxide absorbing solution, and the nitrogen oxides, except nitrous oxide, are measured colorimetrically using the phenoldisulfonic acid (PDS) procedure.</p> <p>ii. Method 7A: Determination of nitrogen oxide emissions from stationary sources (Ion Chromatographic Method);</p> <p>iii. Method 7B: Determination of nitrogen oxide emissions from stationary sources (ultraviolet spectrophotometric method);</p>

Pollutant / Substance	Methodology
<p>Oxides of Nitrogen (NO_x)</p>	<ul style="list-style-type: none"> iv. Method 7C: Determination of nitrogen oxide emissions from stationary sources (alkaline permanganate/colorimetric method); v. Method 7D: Determination of nitrogen oxide emissions from stationary sources (alkaline-permanganate/ion chromatographic method); vi. Method 7E: Determination of nitrogen oxides emissions from stationary sources (instrumental analyzer procedure). vii. Method 320: Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy. <ol style="list-style-type: none"> 2. ISO (1993) Method 10396, 3. European Standard, EN 14792, Stationary source emissions – Determination of mass concentration of nitrogen oxides – Standard reference method: chemiluminescence. 4. US EPA Conditional Test Method (CTM) 034- Determination of Oxygen, Carbon Monoxide and Oxides of Nitrogen from Stationary Sources For Periodic Monitoring (Portable Electrochemical Analyzer Procedure)
<p>Carbon Monoxide (CO)</p>	<ol style="list-style-type: none"> 1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods <ul style="list-style-type: none"> i. Method 10: Determination of CO emissions from stationary sources (Instrument Analyzer Procedure) <p>In this method, continuously or intermittently sample the effluent gas and convey the sample to an analyzer that measures the concentration of CO.</p> <ul style="list-style-type: none"> ii. Method 10B: Determination of CO emissions from stationary sources. iii. Method 320: Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy. <p>An integrated gas sample is extracted from the sampling point, passed through a conditioning system to remove interferences, and collected in a Tedlar or equivalent bag. The CO is separated from the sample by GC and catalytically</p>

Pollutant / Substance	Methodology
Carbon Monoxide (CO)	<p>reduced to methane (CH₄) which is determined by flame ionization detection (FID).</p> <p>iv. European Standard, EN 15058: Stationary Source Emissions - Determination of the mass concentration of carbon monoxide – non dispersive infrared.</p> <p>v. US EPA Conditional Test Method 034- Determination of Oxygen, Carbon Monoxide and Oxides of Nitrogen from Stationary Sources For Periodic Monitoring (Portable Electrochemical Analyzer Procedure)</p>
Sulfuric Acid (H ₂ SO ₄) Mist or Sulphur Trioxide (SO ₃)	<p>USEPA Air Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>Method 8: Determination of sulfuric acid and sulfur dioxide emissions from stationary sources.</p> <p>A gas sample is extracted isokinetically from the stack. The H₂SO₄ and the SO₂ are separated, and both fractions are measured separately by the barium-thorin titration method.</p>
Hydrogen Sulphide (H ₂ S)	<p>1. USEPA Air Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>i. Method 11: Determination of H₂S content of fuel gas streams in petroleum refineries.</p> <p>A sample is extracted from a source and passed through a series of midjet impingers containing cadmium sulfate (CdSO₄) solution; H₂S is absorbed, forming cadmium sulfide (CdS). The latter compound is then measured iodometrically.</p> <p>ii. Method 15: Determination of H₂S, carbonyl sulfide (COS), and carbon disulfide (CS₂) emissions from stationary sources.</p> <p>A gas sample is extracted from the emission source and diluted with clean dry air (if necessary). An aliquot of the diluted sample is then analysed for CS₂, COS, and H₂S by GC/FPD.</p> <p>iii. Method 16: Semi-continuous determination of sulfur emissions from stationary sources.</p>

Pollutant / Substance	Methodology
	<ul style="list-style-type: none"> iv. Method 16A: Determination of total reduced sulfur emissions from stationary sources (impinger technique). v. Method 16B - Determination of total reduced sulfur emissions from stationary sources. vi. Method 16C: Determination of total reduced sulfur emissions from stationary sources.
Ammonia (NH ₃)	<ol style="list-style-type: none"> 1. USEPA Method CTM-027 Procedure for Collection and Analysis of Ammonia in Stationary Sources 2. European and International Standard (EN ISO) 21877
Fluorine (F) and its Compounds Hydrogen Fluoride (HF)	<ol style="list-style-type: none"> 1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods <ul style="list-style-type: none"> i. Method 13A: Determination of H₂S, carbonyl sulfide (COS), and carbon disulfide (CS₂) emissions from stationary sources. Gaseous and particulate F⁻ are withdrawn isokinetically from the source and collected in water and on a filter. The total F⁻ is then determined by the SPADNS Zirconium Lake Colorimetric method. ii. Method 13B: Determination of H₂S, carbonyl sulfide (COS), and carbon disulfide (CS₂) emissions from stationary sources. Gaseous and particulate F⁻ are withdrawn isokinetically from the source and collected in water and on a filter. The total F⁻ is then determined by the specific ion electrode method. iii. Method 320: Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy
Acids and Acid Gases as Hydrogen Chloride (HCl)	<ol style="list-style-type: none"> 1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods <ul style="list-style-type: none"> i. METHOD 26: Determination of hydrogen halide and halogen emissions from stationary sources non-isokinetic method.

Pollutant / Substance	Methodology
	<p>ii. Method 26A: Determination of hydrogen halide and halogen emissions from stationary sources isokinetic method.</p> <p>iii. Method 320: Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy</p>
Chlorine (Cl) and its Compounds	<p>1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>i. METHOD 26: Determination of hydrogen halide and halogen emissions from stationary sources non-isokinetic method.</p> <p>ii. Method 26A: Determination of hydrogen halide and halogen emissions from stationary sources isokinetic method.</p>
Metallic Inorganic Substances	
<p>Lead (Pb) and its Compounds Antimony (Sb) and its Compounds Cadmium (Cd) and its Compounds Arsenic (As) and its Compounds Heavy Metals (Other)</p>	<p>1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>Method 29: Determination of metals emissions from stationary sources.</p> <p>A stack sample is withdrawn isokinetically from the source, particulate emissions are collected in the probe and on a heated filter, and gaseous emissions are then collected in an aqueous acidic solution of hydrogen peroxide and an aqueous acidic solution of potassium permanganate.</p> <p>The recovered samples are digested, and appropriate fractions are analyzed for Hg by cold vapor atomic absorption spectroscopy (CVAAS) and for Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Lead (Pb), Manganese (Mn), Nickel (Ni), Phosphorus (P), Selenium (Se), Silver (Ag), Thallium (Tl), and Zinc (Zn) by inductively coupled argon plasma (ICAP) emission spectroscopy or atomic absorption spectroscopy (AAS). Graphite furnace atomic absorption spectroscopy (GFAAS) is used for analysis of Sb, As, Cd, Co, Pb, Se, and Tl.</p> <p>2. EN 14385: 2004 Stationary Source Emissions. Determination of the Total Emission of As, Cd, Cr, Co, Cu, Mn, Ni, Pb, Sb, Tl and V.</p>

Pollutant / Substance	Methodology
<p>Mercury (Hg) and its Compounds</p>	<p>1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods Method 29: Determination of metals emissions from stationary sources.</p> <p>A stack sample is withdrawn isokinetically from the source, particulate emissions are collected in the probe and on a heated filter, and gaseous emissions are then collected in an aqueous acidic solution of hydrogen peroxide and an aqueous acidic solution of potassium permanganate.</p> <p>The recovered samples are digested, and appropriate fractions are analyzed for Hg by cold vapor atomic absorption spectroscopy (CVAAS) and for Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Ni, P, Se, Ag, Tl, and Zn by inductively coupled argon plasma emission spectroscopy (ICAP) or atomic absorption spectroscopy (AAS). Graphite furnace atomic absorption spectroscopy (GFAAS) is used for analysis of Sb, As, Cd, Co, Pb, Se, and Tl.</p> <p>2. BS EN 13211: 2001 Air Quality. Stationary Source Emissions. Manual Method of Determination of the Concentration of Total Mercury</p>
Organic Substances	
<p>Volatile Organic Compounds (VOCs)</p>	<p>1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods</p> <p>i. Method 25: Determination of total gaseous non-methane organic emissions as carbon.</p> <p>This method is applicable for the determination of VOC (measured as total gaseous non-methane organics (TGNMO) and reported as carbon) in stationary source emissions.</p> <p>ii. Method 25A: Determination of total gaseous organic concentration using a flame ionization analyzer.</p> <p>A gas sample is extracted from the source through a heated sample line and glass fiber filter to a flame ionization analyzer (FIA).</p> <p>iii. Method 25B: Determination of total gaseous organic concentration using a non-dispersive infrared analyzer (NDIR). A gas sample is extracted from the source through</p>

Pollutant / Substance	Methodology
<p>Volatile Organic Compounds (VOCs)</p>	<p>a heated sample line, if necessary, and glass fiber filter to a NDIR.</p> <p>iv. Method 320: Vapor Phase Organic and Inorganic Emissions by Extractive Fourier Transform Infrared (FTIR) Spectroscopy</p> <p>2. EN 12619: 2013 - Stationary Source Emissions. Determination of the Mass Concentration of Total Gaseous Organic Carbon. Continuous Flame Ionisation Detector Method</p> <p>3. EN ISO 13199: 2012 Determination of Total Volatile Organic Compounds (TVOCs) in Waste Gases from Non-Combustion Processes — Non-Dispersive Infrared Analyser Equipped with Catalytic Converter</p> <p>4. EPA (Vic) Method 4230 - Applicable to hydrocarbons in the boiling point range 36–126°C and involves collection of a representative sample of stack gas on a solid sorbent. The method should not be used to sample very volatile organic compounds because low molecular weight hydrocarbons, such as, methane and propane, breakthrough the absorption trap and are not measured.</p>
<p>Dioxins</p>	<p>1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods Method 23: Determination of polychlorinated dibenzo-p-dioxins (PCDD's) and polychlorinated dibenzofurans (PCDFs) from stationary sources.</p> <p>A sample is withdrawn from the gas stream isokinetically and collected in the sample probe, on a glass fiber filter, and on a packed column of adsorbent material. The sample cannot be separated into a particle vapor fraction. The PCDD's and PCDF's are extracted from the sample, separated by high resolution gas chromatography, and measured by high resolution mass spectrometry.</p> <p>2. Environment Canada Method EPS 1/RM/2</p>

Pollutant / Substance	Methodology
<p>Furans</p>	<p>1. USEPA Emission Measurement Center (EMC) Promulgated Test Methods Method 23: Determination of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) from stationary sources</p> <p>A sample is withdrawn from the gas stream isokinetically and collected in the sample probe, on a glass fiber filter, and on a packed column of adsorbent material. The sample cannot be separated into a particle vapor fraction. The PCDD's and PCDF's are extracted from the sample, separated by high resolution gas chromatography, and measured by high resolution mass spectrometry.</p> <p>2. Environment Canada Method EPS 1/RM/2</p>

All stack testing require the measurement of the parameters to enable the calculation of mass emission rates, Table 3 lists the methodologies for the following parameters:

- Gas Velocity
- Gas Pressure and Temperature
- Gas Composition and Density
- Moisture Content
- Volumetric Flow Rate

Table 3: Stack Emissions Testing Methods

Parameter	Method
Determination of Sampling Location / Traverse Points	USEPA ⁷ Method 1 Environment Canada EPS 1-AP-74-1
Stack Gas Velocity or Volumetric Flow Rate	USEPA ⁷ Method 2 EN 16911-1 Environment Canada EPS 1-AP-74-1
Determination of Dry Molecular Weight of Stack Gas	USEPA ⁷ Method 3 Environment Canada EPS 1-AP-74-1
Determination of Moisture Content of Stack Gas	USEPA ⁷ Method 4 EN 14790 Environment Canada EPS 1-AP-74-1

⁷ USEPA Emission Measurement Center (EMC) Promulgated Test Methods

The USEPA methods identified were sourced from USEPA Emission Measurement Center (EMC) Promulgated Test Methods and Air Emission Measurement Center (EMC) and Environmental Technology Verification (ETV) Programme’s Advanced Monitoring Systems (AMS) Center.

Environment Canada standards are sourced from Environment Canada Reference Methods for Source Testing.

EN and EN ISO standards sourced from:

The United Kingdom. The United Kingdom Environment Agency, “Monitoring stack emissions: techniques and standards for periodic monitoring,” 2019.

Australian, ISO and Environment Protection Agency (EPA) Standards sourced from:

- Australia. EPA Victoria. “A Guide to the Sampling and Analysis of Air Emissions and Air Quality,” 2002.
- Australia. New South Wales. Department of Environment and Conservation, “Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales, 2006”

Data Quality Objectives

Data Quality Objectives (DQO) are qualitative and quantitative statements that define the tolerable level of data uncertainty. They are defined as measurable attributes of the monitoring data that will allow programme objectives and measurement objectives to be met. The DQO define the acceptable level of data uncertainty. To ensure that the data which is collected, analysed and interpreted, and reported are of acceptable quality. They should meet the data quality objectives. Whilst, the measurements should meet the DQO attributes. Pollutant monitoring DQO which are required to achieve the primary objective of the data are defined below.

Important DQO elements are:

- **Accuracy:** The comparison of a measurement to a known value. Accuracy can include measures of agreement among repeated measurements (precision) and measures of positive or negative systematic errors (bias).
- **Comparability:** A measure of confidence that one data set or method can be compared with another.
- **Completeness:** Comparison of the valid data collected versus the total number of data points expected for the measurement frequency. This assessment confirms whether enough information is collected to ensure confidence in the conclusion, or, decisions made from the data analysis.
- **Detection Limit:** Detection limit is the lowest value that the method can report with confidence.
- **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. A monitoring site may also be representative of surrounding environments and other influences (e.g., exposure of the general population or the impacts of emissions from traffic). These sites can be used for grouping, interpreting and extrapolating data.

Table 4 identifies acceptance criteria for some DQO elements for the criteria pollutants. In developing Quality Assurance Project Plans (QAPP) DQOs are to be identified, in order to demonstrate the data's quality and uncertainty, during analysis. There are DQO approved guidance from international organisations, such as, the USEPA, Victoria Environmental Protection Agency and the United Kingdom Environmental Agency. Additionally, note that, pollutants should be monitored and reported, based on, and in accordance with the averaging time, as outlined in Schedule 1 of the APR.

Table 4: Data Quality Objectives for Ambient Air Criteria Pollutants

Parameter	Accuracy	Precision	Completeness	Averaging Time
PM _{2.5}	+/- 20%	<10%	>75%	24 hours
Ozone	10%	<10%	>75%	8 hours
CO	15%	<10%	>75%	15 minutes
				30 minutes
				1 hour
				8 hours
SO ₂	15%	<10%	>75%	10 minutes
				24 hours
PM _{10-2.5}	+/- 20%	<10%	>75%	24 hours
NO _x	15%	<10%	>75%	1 hour

Source: Canadian Council of Ministers of the Environment, 2011

Quality Assurance and Quality Control

Quality Assurance

Quality assurance is a system of management activities designed to ensure that the data collected from the operations fits the type, meets the quality, and requirements of the data user, that is, the EMA and the applicant. Quality assurance is inextricably linked to the outcome of entire air quality monitoring process, from the choice of sampling locations, selection of methodology / instrumentation, proficiency of staff, sample and data collection, analytical procedures, validation, calibration and maintenance processes and data storage, retrieval and analysis systems. The final products (ambient air quality monitoring and stack testing data) should be as reliable as, the systems that managed the process and derived the results.

Figure 1 presents a flow chart of the essential elements of the quality assurance process that ultimately aims to provide quality assured data as the end product. It shows that the quality assurance process comprises of quality control procedures and factors that lead to a quality output, such as, staff training, standard operating procedures, and, the use of standard methods for monitoring. Internal quality control should complement any external assessment, or, audit of systems, procedures and processes, to provide an appropriate level of confidence in the data collection and analysis.

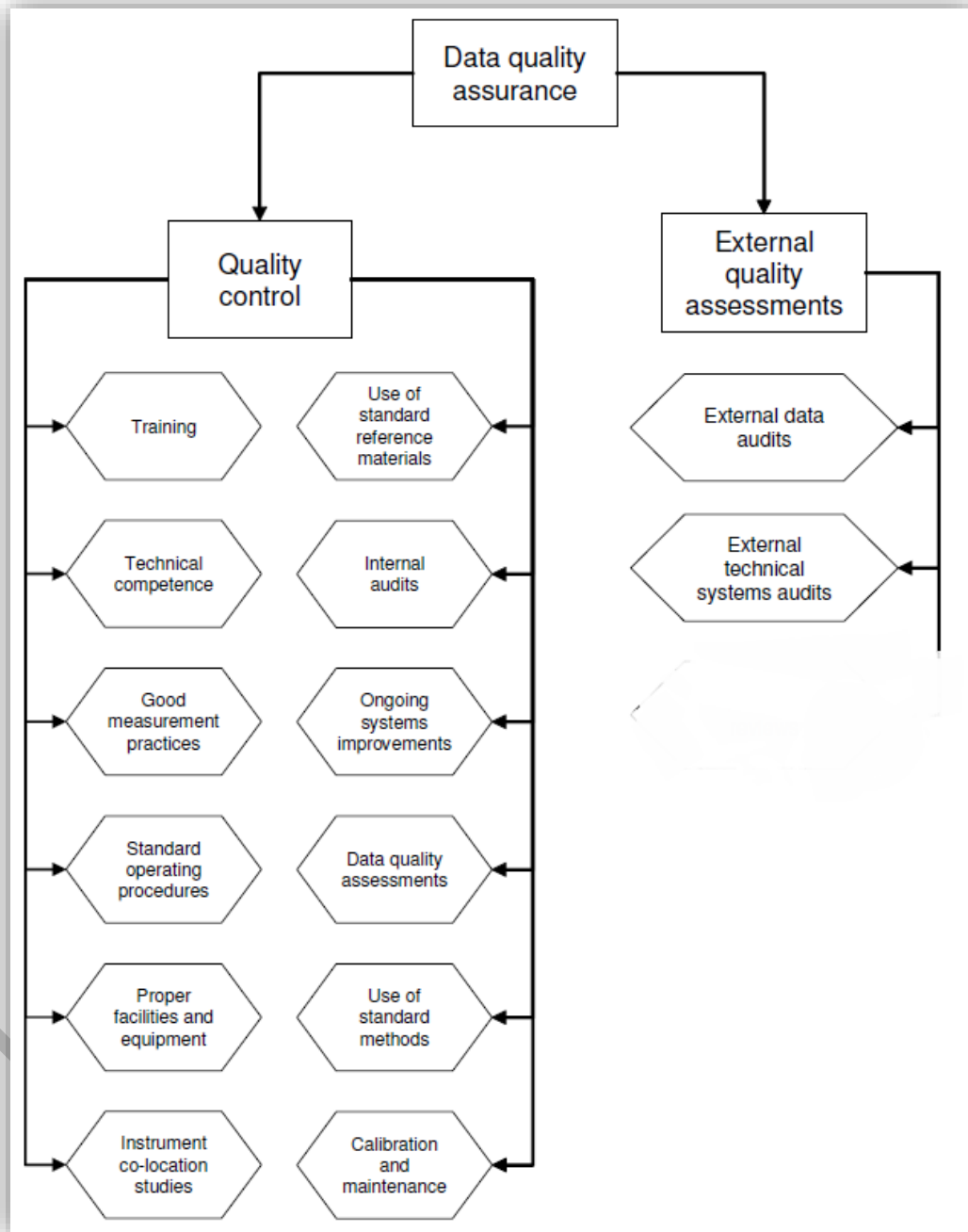
Quality Control

Quality control defines the procedures implemented to assure that acceptable precision, bias, completeness, representativeness, and comparability are obtained and maintained in the generated data set. It is the overall system of technical activities that measure the attributes and performance of a process, item, or, service against defined standards. Quality control should verify that these procedures meet the stated requirements of the output, Figure 1. For air quality monitoring, quality control is used to ensure measurement uncertainty is maintained within acceptable limits, such as, those defined by standard monitoring methods and data quality objectives. The fundamental objectives of a quality assurance / control programme should be as follows:

- The data obtained from air quality measurement is representative of the spatial scale being investigated.
- A minimum of 75 per cent valid data is available when calculating averages.
- Measurements are accurate, precise and traceable.

- Data is comparable and reproducible. The data results are comparable with national, international and other accepted standards.

Figure 1: Quality Assurance and Quality Control Systems



Source: New Zealand Ministry for the Environment, 2009.

Preventative Maintenance and Calibration

Preventative Maintenance

Preventative maintenance and routine checks are necessary to increase the reliability of equipment and data; to have the equipment operate at optimal levels, and help to identify potential problems, and apply corrections prior to the deployment of the equipment out in the field. Preventative maintenance schedules should be developed in accordance with the manufacturers' requirements and recommendations. Reference or equivalent method requirements, instrument specific Standard Operating Procedures (SOPs), and manufacturers' information will provide detailed preventative maintenance schedules and specific requirements or recommendations. Consequently, it is important that instrument SOP and manufacturers' manuals are used for reference during maintenance or repair. An up-to-date preventative maintenance checklist and record should be available (either electronically or as a paper log) to keep track of the maintenance performed in a consistent manner. The following examples highlight some of the typical preventive maintenance and systems checks to ensure good data quality, but they by no means constitute an exhaustive list:

- Check instrument diagnostics for normal operation of electronics;
- Check sample inlets and filters (service or change as required);
- Check vacuum pumps and pump filters (service as required), leak checks;
- Ensure / check equipment data logging is functional prior to sampling event;

Calibration

The calibration of analysers, sampling and laboratory analytical equipment establishes the relationship between instrument response and known contaminant concentrations, flow rate etc. This response / contaminant concentration relationship is then used to convert analyser / equipment response to corresponding ambient pollution concentrations or flow rate. Air quality monitoring equipment (analysers, sampling pumps) has to be calibrated at regular intervals (monthly, quarterly, bi-annually) to compensate for drift and to check the linearity of instrument response. Instrument calibration and maintenance should follow the recommendations and requirements of the appropriate reference standard methodology and the manufacturer's instructions. Calibrations should be also performed following any repairs or service. Verification checks should be performed prior to use in sampling events. Materials and devices used for calibration must be certified for accuracy against reference standards, which can be recognised primary standards (e.g., The US National Institute of Standards and Technology (NIST)) or, be traceable to one.

Sampling and Handling

Appropriate sample handling procedures are to be implemented to prevent contamination or sample loss prior to sampling, during preparation, handling and transportation to and from the field and laboratory, during sampling and storage of samples. SOPs should be available and followed for sample collection and handling. Due to the manner in which concentrations are determined, it is critical that samples are handled as specified in SOPs. SOPs will include details on proper care and handling to ensure integrity. Sample collection procedures entail adequate tracking and sample integrity, sample preparation, labeling and identification, Storage containers, installation and setup of sampling media and sampler, transportation protocols, storage (type of containers, temperature, pressure) and details for analysis (analytical procedure, preparation of sample for analysis).

Chain of custody reports, Figures 2 & 3, are essential documentation that provide records to verify the quality assurance procedures, to track the handling of samples and to support the integrity of the sample from the collection of media to final reporting of results. In transporting samples, it is important that precautions be taken to eliminate the possibility of tampering, accidental destruction, and / or physical and chemical action on the sample. The integrity of samples can be affected by temperature extremes, air pressure (air transportation), and the physical handling of samples (packing, jostling, etc.). These practical considerations must be dealt with on a site-by-site basis and should be documented in the organisation's QAPP and site specific SOPs.

. The various phases of sample handling that should be documented in a QAPP and SOP include:

- Sample preparation, labeling, and identification;
- Sample collection;
- Transportation;
- Sample analysis; and
- Storage (at all stages of use) and archive.

Sampling Locations

In selecting the sampling locations, there are a number of factors that require consideration for the data to be representative:

- **Number of sampling locations:** A minimum two sampling locations should be selected for a site, an upwind and downwind location.
- **Wind direction:** Obtain prior meteorological monitoring data for the site as it is necessary to determine the prevailing wind direction for the localised area. This information will determine where to site the equipment.
- **Operations and activities:** Monitoring equipment should be placed downwind and upwind of the activities and operations generating air pollutants.
- **Size of facility operation or site:** More sampling locations should be taken into consideration for greater acreage or size of operation.

Figure 2: Chain of Custody Field Report Example

Chain of Custody Record						
Project No.		Project Title			Organization	Contact
Shipping Container No.		Address				
Field Technician: <i>print</i> <i>signature</i>						
Date	Time	Site/Location	Sample Type	Sample ID	Remarks	
Relinquished by (<i>print and signature</i>):			Received by (<i>print and signature</i>):		Comments	

Source: USEPA. Quality assurance handbook for air measurement system, 2017

Figure 3: Chain of Custody Laboratory Report Example

Chain of Custody Record					
Project No.	Project Title			Organization	
Laboratory/Plant: _____					
Sample Number	Number of Container	Sample Description			
Person responsible for samples			Time:		Date:
Sample Number	Relinquished By:	Received By:	Time:	Date:	Reason for change in custody

Source: USEPA. *Quality assurance handbook for air measurement system*, 2017

Data Management

Management of the data collection is equally important as accurate collection of the data. Data management is the “development, execution and supervision of plans, policies, programmes and practices that control, protect, deliver and enhance the value of data and information assets”. The method by which a monitoring organisation manages its data should be documented in its Quality Management Plan (QMP) and QAPP.

Data Validation and Reporting

Pollutant data should be reported in common formats and in concentration (mg/Nm^3). The units of the reporting values should be in accordance with the units of standards in Schedules 1 and 2, of the APR. It is essential to screen air quality data by visual examination for outlier, drift values and non-recorded measurements with established and consistent data validating procedures. Data validation, data flagging and meta-data are all important elements of an effective quality system, though requirements are dependent on the sampling methods employed (continuous automated methods verses manual sampling method) and resources available.

Data Storage, Archive and Retrieval

Two parallel data sets should be maintained; one that preserves raw data in its original form and another that has been quality assured and is available for further analysis. Maintenance of an archived raw data set allows the data to be reviewed and re-analysed. This is important should problems arise with the original quality assurance process.

Reporting Requirements

Checklist for the Review of Ambient Air Monitoring Reports

Ambient Air Monitoring

The results of ambient air monitoring required by the EMA must be provided in a report which is signed, by the facility representative. The report must contain, but not be limited to, the following from the Checklist in Table 5, unless the permit or request for information states otherwise:

Table 5: Checklist for the Review of Ambient Air Monitoring Reports

Element of Report	Details	✓ / X	Comments
General Report Information	Name and address of reporting organisation or individual		
	Date of report issue		
	Description of facilities operations and activities		
Pollutants	Pollutants requested in permit or SER		
Monitoring	Date(s) of monitoring		
	Pollutant sampling times and periods (Start and end times of sampling) and consistency with APR Schedules 1 averaging times		
	Activities occurring at the site during monitoring event and/or any factors which may have affected results		
Sampling Locations	Number of sampling locations, at minimum one upwind and one downwind		

Element of Report	Details	√ / X	Comments
	locations, at nearest sensitive receptor.		
	Site layout of facility illustrating location of sampling points		
	GPS coordinates of sampling points		
	Justification for selection of sampling points in relation to emissions sources and wind direction		
Methodologies	Identification and details / description of methodologies and equipment used		
	Detection limits of equipment / methodologies		
	Methodology description		
Meteorological Data	Identification of equipment used		
	Wind rose		
	GPS coordinates of meteorological points		
Results and Data Reporting	Average concentration for monitoring period for each pollutant measured		
	Minimum and Maximum concentration values for the monitoring period		
	Comparison with APR permissible levels / standards (Schedule 1)		
QA / QC Data	Qualifications of personnel conducting monitoring		
	Raw data inclusive of laboratory analytical reports		
	Laboratory accreditation		
	Sample records		
	Chain of Custody Reports		

Element of Report	Details	√ / X	Comments
	Records of calculation and verification. Field and data records		
	Calibration certificates and verification records of all equipment used inclusive of meteorological equipment		

Checklist for the Review of Stack Emission Testing Reports

Stack Emissions Testing

The results of stack emissions testing required by the EMA must be provided in a report signed by, the facility representative. The report must contain, at least, the following from the Checklist, in Table 6, unless the permit or request for information states otherwise:

Table 6: Checklist for the review of stack emission testing reports

Element of Report	Details	√ / X	Comments
General Report Information	Name and address of reporting organisation or individual		
	Date of issue of report		
	Description of stack operations at time of monitoring		
	Identification of source tested and dimensions of stacks		
	Application reference number		
Pollutants	Pollutants requested in permit or SER		

Element of Report	Details	√ / X	Comments
Monitoring	Details of source or process operating conditions during sampling and a statement about the representativeness of the sample taken, ambient conditions such as the temperature, weather, rainfall, etc. Any upset conditions at the site.		
	Period of sampling (start and end times)		
	Date(s), time and place of monitoring		
	Average stack gas velocity in m/s		
	Average stack gas temperature		
	Stack gas volumetric flow rate on a dry basis under standard conditions, in m ³ /s		
	Water / moisture content of stack gas, expressed as a percentage by volume		
	Contaminant molecular weight or density in kilograms per cubic metre		
Sampling Locations	Number of traverse/sampling points		
	GPS coordinates of point source		
	Location of sampling plane, with respect to the nearest upstream and downstream flow disturbances		

Element of Report	Details	√ / X	Comments
Methodologies	Identification and details of methodologies and equipment used		
	Detection limits of equipment / methodologies		
	Methodology description		
Results and data reporting	Concentration of pollutant on a dry basis under standard conditions, in mg/Nm ³ . Isokinetic deviance		
	Minimum and maximum concentration values for the emissions tests		
	Comparison with APR permissible levels / standards (Schedule 2)		
QA/QC data	Qualifications of personnel conducting monitoring		
	Raw data inclusive of laboratory reports		
	Laboratory accreditation certificate		
	Sample records		
	Chain of Custody Reports		
	Calibration certificates and verification records of all equipment used inclusive of analytical equipment		

Conclusion

The list of ambient air quality monitoring and stack emissions testing methodologies / equipment was sourced from several jurisdictions, organisations and agencies. These organisations and agencies published a series of standards, methodologies and approved equipment, all of which have been tested and proven to meet the performance criteria required to produce air quality data of high accuracy. It has been noted that across organisations and countries, the different standards have similar operating principles for the same pollutant. This is a good indication that the operating principle has been shown to be sufficient to analyse the pollutant concentrations.

This document should be consulted by monitoring contractors, applicants and EMA staff when air pollution monitoring has been requested through permits, and requests further information. These methodologies and equipment will be accepted by the EMA for use in air monitoring and environmental regulatory purposes. The resultant data should demonstrate compliance with the APR. Guidance is provided on quality assurance and quality control procedures and criteria pollutants DQOs, to aid in data quality output. All parties should utilise the checklists provided to ensure that the submission of all required documentation for the reports.

Methods / equipment not included in the listing may be permitted for use in air monitoring, on the discretion and approval of the EMA. The applicant has to demonstrate that the results will be of high accuracy, and comparable, to internationally recognised standards.

Note: This document does not include all ambient air monitoring and stack testing methodologies and equipment. The document will be updated or revised, as needed.

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