

Series of CEMS Guidelines

Volume I:

**GUIDELINE FOR THE
INSTALLATION & MAINTENANCE
OF CONTINUOUS EMISSION
MONITORING SYSTEMS (CEMS)**

FOR

**INDUSTRIAL PREMISES /
FACILITIES**



Department of Environment
Ministry of Natural Resources and Environment
Level 1 - 4, Podium 2 & 3, No.25, Wisma Sumber Asli, Precint 4,
Federal Government Administrative Centre,
62574 Putrajaya.

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Introduction

Continuous Emission Monitoring refers to a packaged system of gas analyzers, gas sampling system, temperature, flow and opacity monitors that are integrated with a data acquisition system, that is involved in the measurement of gases, particulates and smoke (opacity) emitted from stationery source of air pollutants and to provide a continuous record of air pollution control equipment performance and to determine compliance with emission of operation limits.

This guideline is issued for the purpose of providing guidance in respect to the installation, certification, operations and maintenance and reporting of continuous emission monitors.

All the matters addressed in this document are general in nature and the recommendations given herein should not be construed as providing specific directions for any particular CEM System. Each installation is site specific. No particular brands of equipment are endorsed.

The information in this paper is intended solely as a guideline and does not represent final Department of Environment (DOE) action. The DOE may choose to issue more detailed, technical guideline in the future. This document may be reviewed and modified periodically as warranted by modifications to Environmental Quality (Clean Air) Regulations 1978 or developments in the field of continuous emission monitoring.

1.1 Objectives

This guidance document explains:

- a) The industrial sectors (activities) that are subjected to the CEMS requirements under the revised clean air regulations;
- b) A general description of the types of CEMS;
- c) A general description of what the requirements are;
- d) Types of CEMS tests; and
- e) Reporting requirement.

1.2 Definitions

As-found (Unadjusted Value): With regard to CEMS response during an audit, calibration or performances check. An “as-found” check is the current instrument / monitor output.

Audit: An as-found accuracy assessment of CEMS components using an authoritative certified standard.

Calibration: Is the process of adjusting the CEMS, so that its readings can be correlated to the actual value being measured.

Calibration Error: The difference between the response of the pollutant, diluent and flow to the know value of the appropriate reference gas, pressure, filter or signal.

Calibration Gas: Calibration gases shall be certified by USEPA Protocol 1 methods or other NIST traceable methods to be within $\pm 2\%$ of the true value of the gas.

Continuous Emission Monitoring System (CEMS): The total equipment required to sample, condition, analyze and provide a permanent computer record of pollutant concentration. This includes the equipment necessary to perform the required routine calibration and audits.

Cylinder Gas Audit (CGA): A challenge of the monitoring system with the cylinder gas of a known concentration that is traceable to NIST standards.

Data Acquisition System (DAS): The component of the CEMS designed to interpret and convert individual output signals from pollutant concentration monitors, flow monitors, diluent gas monitors and other components of the monitoring system to produce a permanent continuous record of the measurement and desired parameters.

Department of Environment (DOE): The Malaysian Department of Environment or Jabatan Alam Sekitar.

Downstream: In the direction of the stack gas flow (e.g. a point near the top / exit of the stack would be downstream of a point near where the gases enter the stack).

Equivalent Diameter: A calculated value used to determine the upstream and downstream distances for locating flow to pollutant concentration monitors in flues, ducts or stacks with rectangular cross-sections.

Excess Emission: For CEMS, it is an exceedance of the applicable emission limit as indicated by valid measurement of the monitor and reported using the appropriate significant digits, units and averaging period that directly corresponds to the applicable emission limit.

Extractive Monitoring System: A system that withdraws gas sample from the stack and transports the sample to the analyzer.

Flow Monitor: A component of the CEMS that measures the velocity and volumetric flow rate of the source's exhaust gas and generates an output proportional to flow rate. The output must not only be proportional but also scaleable to represent actual verifiable volumetric flow rate that can be used for calculation of mass emission.

Full-Scale Range: The absolute calibrated maximum value of a pollutant monitor's measurement ability that may equal or exceed the span value.

In-Situ Monitor: CEMS design that measures source-level gas emissions directly inside a stack or duct at actual conditions. For pollutant or combustion gas measurements, the source emission gas is not conditioned, so it is considered a 'wet' measurement.

Industrial Premises / Facility: Any applicable stationary air contaminant emission source (institutional, commercial, industrial structure, installation, plant, source or building) required by the DOE to operate a CEMS.

Inspection: A check for the conditions that is likely to affect the reliability of the system. E.g. of these conditions would include the following: damage to system components, leaks, a low flow condition in sample transport system, alarms, adequate supply of consumables, etc.

Internal Diameter: The inside diameter of a circular stack, or the equivalent diameter of a rectangular duct (4 times the duct area, divided by the duct perimeter).

Malfunction: Any sudden, infrequent and not reasonably preventable failure of any part of the CEMS that are caused by the equipment to function outside established design and/or performance specifications. Failures that caused in part by poor maintenance or careless operations, in the opinion of DOE, are not considered malfunction.

Monitor Downtime: Time periods of source operation in which invalid CEMS data or no data is collected due to any appropriate reason. This includes periods of documented QA activities, calibration, preventive maintenance, malfunction, audits which results in periods of invalid data and 'out-of-control' periods.

Operational Test Period: A minimum specified period of time, as designated by DOE, over which a measurement system is expected to operate within performance specifications without unscheduled maintenance, repair or adjustments.

Out-of-Control Period: Any period when the CEMS is operating outside specifications and criteria for daily calibration and quarterly QA procedures.

Protocol Gas (EPA): A calibrated gas that has been prepared and certified by the vendor according to the US-EPA Protocol 1 method.

Quality Assurance: An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item or service is of the type and quality needed and expected by the end users.

Quality Assurance Plan (QAP): A formal document describing in comprehensive detail the necessary quality assurance procedures, quality control activities and other technical activities that need to be implemented to ensure that the results of the work performed will satisfy the stated performance or accepted criteria.

Quality Control: The overall system of technical activities that measure the attributes and performance of a process, item or service against defined standards to verify that they meet the specifications established by the customer, operational techniques and activities that are used to fulfill the need for quality.

Reference Method: Any emission test method identified in a user permit or DOE regulation.

Relative Accuracy: The absolute mean difference between the gas concentrations by a CEMS and the value determined by an appropriate Reference Method. The relative accuracy provides a measure of the systematic and random errors associated with the data from the CEMS.

Source Shutdown: The cessation of operation of an emission source for any purpose.

Span Value: A design value that represents an estimate of the highest expected value for a parameter, based on the applicable emission limit. Span is calculated as a percentage range of the emission limit.

Source Startup: The starting in operation of an emission source for any purpose.

Standard Condition: A temperature of 273.15K and an atmospheric pressure of 101.3kPa.

Upstream: In the direction opposite of the stack gas flow (e.g. a point near where the gases enter the stack would be upstream of a point near the top / exit of the stack).

Valid Data: Any representative data average that meets the validation criteria.

Applicability

This guideline is applicable to any industrial premise / facility that is required by regulation, permit, agreement or order to install, operate and maintain a CEMS for the purpose of continuously determining and reporting compliance with applicable emission limits or operating permits.

2.1 Emission Standards

Emission standards for stationary sources are as prescribed in the Environmental Quality Act (EQA), 1974 under the Environmental Quality (Clean Air) Regulations 1978 and its subsequent revisions.

These regulations and subsequent revisions specify activities and pollutants that are to be monitored and their limit values.

The activities specified in the regulations and subsequent revisions are:

- a) Heat and Power Generation.
- b) Production and processing of ferrous metals (iron & steel mills).
- c) Production and processing of non-ferrous metals with a capacity ≥ 0.5 tons per day for lead or cadmium or ≥ 2 tons per day for other metals.
- d) Oil and gas industries: Refineries (all sizes); Natural gas processing and storage, storage and handling of petroleum products.
- e) Non-metallic (mineral) industry: Cement production (all sizes); Manufacture of glass including glass fiber with a melting capacity ≥ 1 ton of product per day; Manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain with a production capacity ≥ 10 tons of product per day.
- f) Chemical and petrochemical industry (all sizes)
- g) Waste Incinerators (all sizes)
- h) Palm oil mills (all sizes).

The segmented parameters for the above source activities are as outlined briefly in Table 2-1.

| Source Activities | Source Capacity | Fuel Type | Pollutants | Limit Value (mg/m ³) | Data Frequency | | |
|--|---|----------------------|--------------------------------------|----------------------------------|-----------------------|----|-------------|
| Heat & Power Generation | Boiler ≥ 10 MW | Solid & Liquid Fuels | SO ₂ | 500 | ½ H Average | | |
| | | | NO ₂ | 500 | ½ H Average | | |
| | | | CO | 200 | ½ H Average | | |
| | | | Total PM | 50 | ½ H Average | | |
| Boiler ≥ 10 MWe | Gaseous fuels in general | NO ₂ | 350 | ½ H Average | | | |
| | | CO | 50 | ½ H Average | | | |
| | | Total PM | 5 | ½ H Average | | | |
| Combustion turbines ≥ 10 MWe | Gaseous Fuels | NO ₂ | 150 | ½ H Average | | | |
| Combustion Turbines ≥ 10 MWe | Liquid Fuels | CO | 100 | ½ H Average | | | |
| | | NO ₂ | 200 | ½ H Average | | | |
| Production & Processing of ferrous metals (Iron and Steel Mills) | Sinter plants (waste gas from sintering belt) | | SO ₂ | 500 | ½ H Average | | |
| | | | NO ₂ | 400 | ½ H Average | | |
| of ferrous metals (Iron and Steel Mills) | Blast Furnace (Regenerator; @ 3% O ₂) | | Total PM | 50 | ½ H Average | | |
| | | | Basic oxygen furnace (converter gas) | | Total PM | 50 | ½ H Average |
| | | | | | Electric Arc Furnaces | | Total PM |

| Source Activities | Source Capacity | Fuel Type | Pollutants | Limit Value (mg/m ³) | Data Frequency |
|--|---|-----------|---|---|---|
| Production & Processing of non-ferrous metals With capacity ≥ 0.5 tons per day for lead or cadmium Or ≥ 2 tons per day for other metals (Iron and Steel Mills) | Sinter plants (waste gas from sintering belt) | | SO ₂ NO ₂ Total PM | 500 400 50 | ½ H Average ½ H Average ½ H Average |
| | Production of copper & zinc | | Total PM | 20 | ½ H Average |
| | Production of lead | | Total PM | 10 | ½ H Average |
| | Primary aluminum | | Total PM | 10 | ½ H Average |
| | Secondary aluminum | | Total PM | 10 | ½ H Average |
| Oil & gas industries: Refineries (all sizes); Natural gas processing and storage; storage and handling petroleum products | Catalytic cracking | | Total PM SO ₂ | 40 1200 | ½ H Average ½ H Average |
| | Calcination | | Total PM | 40 | ½ H Average |
| Non-metallic (mineral) Industry (all sizes) | Cement kilns | | NO ₂ Total PM | 800 50 | ½ H Average ½ H Average |
| | Glass Furnaces | | SO ₂ NO ₂ Total PM | 800 800 50 | ½ H Average ½ H Average ½ H Average |
| Waste Incinerators (all sizes) | | | Total PM NMVOC as Total C Hydrogen chloride (HCl) Hydrogen fluoride (HF) SO ₂ NO ₂ CO | 100 10 40 1 50 200 50 | ½ H Average ½ H Average ½ H Average ½ H Average ½ H Average ½ H Average ½ H Average |
| Palm Oil Mills (all sizes) | | | Total PM Opacity (Smoke) | 50 20% | ½ H Average Minute Average |

Note:

¹ Production and processing of non-ferrous metals with a capacity ≥ 0.5 tons per day for lead or cadmium; ≥ 2 tons per day for other metals

‘ MW = megawatt

‘ H = hour

‘ t/day = tons of product per day

Table 2-1: Emission standards for some of the source sectors

Although every effort has been made to ensure the accuracy of the information in Table 2-1, complete accuracy cannot be guaranteed as the guidance requirements i.e. the EQ (Clean Air) 1978, will be subjected to revisions and amendments.

2.2 Valid Averages

The sub average period for determining half-hour average is **1-minute average**. A valid half-hour average must contain at least 22 sub average data within half-hour period (75%).

A valid 1-minute average must contain valid data readings representing any 45 seconds over the previous 1-minute period.

2.3 Registration Requirement

A registration requirement will be required to supply information to the DOE to update the existing database. The information required is:

- a) Name of Industrial premises / Facility
- b) Address of Industrial premises / Facility
- c) Plant operators (organizational chart)
- d) Permit number and limits (if any)
- e) Process Description – source specific information
- f) Process activity – the type & quantity of fuel burned (load factor)
- g) Installed Control devices
- h) Exhaust Stack / Vent ID
- i) Operation Time
- j) CEMS type and location
- k) CEMS analyzer types.
- l) List of parameters monitored

All industrial premises / facility that fall under the EQ (Clean Air) 1978 and its revised regulations are to submit / update the database, based on individual operating permit.

NOTIFICATION

All industrial premises / facility subject to CEMS requirements shall notify the DOE as soon as possible if any changes are made to any part of a CEM system, including its Quality Assurance Plan (QAP).

The industrial premises / facility shall notify the DOE of the findings of the annual audits required under Section 5.2 of this Guideline.

CEM System

The CEM system shall comprise of the following:

- a) Instrumentations and programs that will determine & analyze and quantify the concentration of the specified pollutants in the gas stream.
- b) Instrumentations and/or programs that will determine the flow rate of the gas stream.
- c) Instrumentations and programs that will record and process the information produced and produce electronic and printed reports showing the emission rate of the specified pollutant with the time resolution.
- d) Quality Assurance programs and Quality Control procedures to ensure that all pollutant measurement, instrument verification and reporting activities are performed adequately.

There is a wide range of instruments and systems available for continuous emission monitoring, using a variety of technologies. The sampling of the pollutants comes down to two (2) main techniques, extractive systems (source level and dilution) and in-situ systems. An expended classification is shown in Table 3-1.

Table 3-1: Classification of Source Monitoring Systems

| Extractive Systems | In-Situ Systems |
|--------------------------|---|
| Source-level Dilution | Point Path Single-pass Double-pass |

3.1 Sampling Techniques

3.1.1 Extractive

Source-level

This technique typically involves extracting the sample gas from the stack using a sample probe, heated line, gas conditioning equipment and a heated sample pump. The gas sample is not diluted, so higher range analyzers are used (i.e. 0 – 5000ppm). Generally the gas is transported via a heated sample line under vacuum to the analyzer(s). This is “dry-based” measurement technique where reporting units are usually lbs/mmBtu.

Dilution Extraction

As above, this technique involves the use of probe, sample line and pump to transport the sample gas to the analyzer(s). The main difference between the two technique is that with dilution extraction, the sample is diluted with dry zero material, typically air to a predetermined factor (e.g. 100:1) as recommended by the instrument manufacturers. Transport is under positive pressure. This is “wet-based” measurement technique where reporting units are usually lbs/hr if volumetric flow is to be measured. As the sample gas is diluted, lower range “ambient” gas analyzer (i.e. 0 – 10,000ppb) can be used.

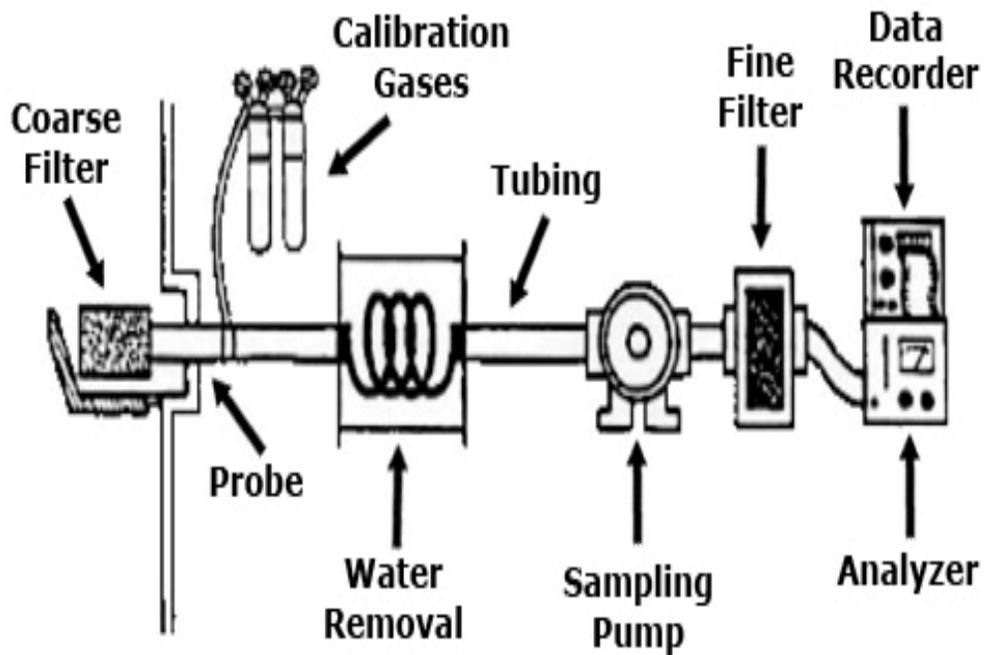


Figure 3-1: Extractive CEM System

3.1.2 In-Situ

Point

These are close coupled instrument and probe, where the analyzer is directly connected to the probe and is installed in-situ at the point of measurement. The instruments consist of an electrochemical or electro-optical sensor, which measures the absorption of energy from the sample, which diffuses through the measurement cavity at the end of the probe.

Path

Cross-duct or Path CEM system is basically an energy source (IR or UV) projected across the stack from one side to the other. Specified target gases absorb some of this energy at specific wavelengths resulting in an altered energy state of the gas molecule. In single path, the energy is transmitted from one side to the other making one pass through the stack. In a double path, the energy is reflected from a mirror on the opposite side, doubling back on itself.

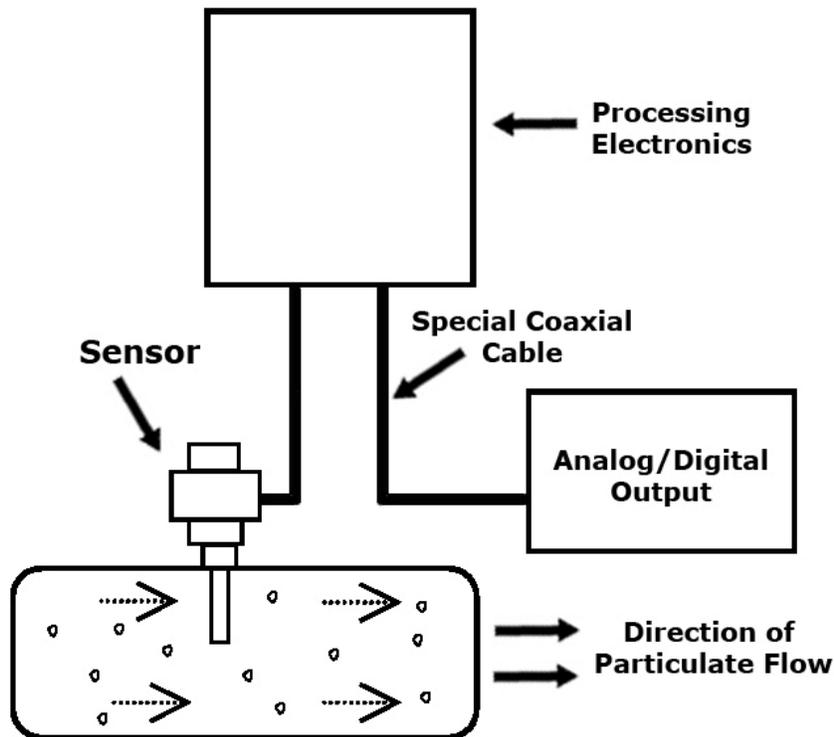


Figure 3-2: Typical in-situ CEM System (for particulates (Total PM) and opacity (smoke))

3.2 Types of CEMS analyzers

- a). Extractive gas analyzers are designed to be used with heated or dilution sampling systems and therefore draw a gas sample into the analyzer for analysis. These systems are therefore of pneumatic / electronic design and many techniques are available depending on the type and number of gases to be monitored. These systems are amenable to verifications with calibration gases that can prove the entire sample conditioning & handling system as well as prove the specific gas analyzer function.
- b). In-Situ analyzers do not involve pneumatics (pumps and sample lines, etc.) and generally work on various optical absorption techniques such as FTIR, DOAS, and 2nd derivative UV absorption. All techniques involve a transmitter and receiver system and rely on gas absorption laws such as the Beer-Lambert law. These analyzers measure gases passing through the stack due to specific energy absorbing spectral characteristics of the various gases. These analyzers are often able to measure multiple gases.
- c). Opacity are in-situ analyzers that work on electronically modulated light source. When the stack is clear, the light transmission is 100% (zero opacity) and when the stack passes no light the transmission is zero (100% opacity). Opacity can be correlated to dust concentration via optical density. Dust concentration can also be correlated by the same measured signals.
- d). Particulate Monitors are in-situ analyzers that work on the scattering of energy from a modulated light source. If the stack is clear, the mg/m^3 measurement is zero. At full scale, the measurement is the maximum mg/m^3 for the specific facility. Particulate monitors are not opacity monitors and cannot measure opacity.

Table 3-2 highlights some examples of continuous emission monitoring techniques.

| Technique | Type | Gases Measured | Comments |
|---|-------------------|---|---|
| Chemiluminescence | Extractive | NO, NO _x , NO ₂ * | *NO ₂ calculated (NO _x – NO) |
| UV Fluorescence | Extractive | SO ₂ (H ₂ S, TRS) | Gases in brackets can also be measured but not simultaneously |
| IR Gas Filter Correlation (GFC) | Extractive | CO, CO ₂ , NO _x , SO ₂ , N ₂ O | Multiple gases can be monitored, generally no more than 2-5. |
| Fourier Transform Infra-red (FTIR) | Extractive / Path | CO, CO ₂ , SO ₂ , NO _x , HCl, HF etc. | Multiple gases can be monitored, typically 5+ |
| Differential optical absorption spectroscopy (DOAS) | Path | CO, CO ₂ , SO ₂ , HCl, HF, NO, NO ₂ , NH ₃ , VOCs, H ₂ O | Multiple gases can be monitored, typically 5+ NO ₂ measured directly. Additional gases can be added at relatively low cost. |
| Flame Ionization Detector (FID) | Extractive | Total HC | Requires hydrogen carrier gas. |
| Tunable Laser Diode (TLD) | Path | HCl, HF, NH ₃ , CH ₄ , CO, CO ₂ , H ₂ O | Cost effective for single component applications. |
| Zirconia oxide cell | In-situ | O ₂ | Widely used, maximum temperature generally 500°C |
| Paramagnetic | Extractive | O ₂ | |
| Photo acoustic spectroscopy (PAS) | Extractive | CO, CO ₂ , SO ₂ , HCl, HF, NO, NO ₂ , NH ₃ , VOCs, H ₂ O | Can measure virtually any gas that absorbs IR. Detailed analysis of other compounds that may be present other than target gases required. |
| Transmissometry (Laser Optical Backscatter) | In-situ | Opacity (smoke), & Total PM (dust) | 2400Hz intensity controlled LED & Solid State Diode Laser |

Table 3-2: Examples of CEM techniques

3.3 Data Acquisition System (DAS) / Data Logger

A CEM system is not complete without incorporating a subsystem that records the data produced by the monitors/analyzers. The data acquisition system (DAS) provides this record of emission measurements. Activities such as reviewing data, checking calibration values, responding to excess emissions problems and generating reports are all performed within the DAS.

Monitor/Analyzer analogue signals must be converted to digital signals in order to be processed or saved in a computer. Facilities that are required to operate CEM to record emission data shall install and operate a system that provides a means of sending data out to the state DOE office on a daily basis.

The minimum requirement for this is most easily done by installing a modem, phone line and a data logger / recorder. Data loggers / recorders store data in digital form and can be archived, copied and transmitted securely, quickly and easily.

There are various types of data loggers available in the market, supplied either by the CEMS vendor or by companies that manufacture data acquisition system.

Telemetry

The CEM system has to be designed to transmit data to the state DOE and the protocol used to transmit data via a dial-up telecommunications system or other methods should follow a data telemetry access protocol.

Volume II: Guideline for the Continuous Emission Monitoring System – Data Interface System (CEMS-DIS) for Industrial premises / Facilities is the guideline for the developing and implementing CEMS-DIS with standard data format and units of the standards for the transmission of data to the state DOE office.

Please refer to Volume II of this guideline for detailed data transfer guidelines and the Environmental Quality (Clean Air) Regulation 1978 and subsequent revisions for the limit values and unit of standards.

CEM System Requirements

It is not the monitor/analyzer that is the controlling element but the total system (probe or stack interface, conditioning system, monitor/analyzer and the controller-DAS) that must be installed properly and evaluated to prove that accurate data can be provided. The installation specifications, performance specifications and test procedures are developed for this evaluation. However, it should be noted that the performance specifications do not evaluate the continuing operation of the system. The long term operation of the system depends on the quality assurance (QA) program developed for the system.

4.1 General Requirements

- a) Each and every analyzers and equipment installed as a CEM system for compliance monitoring and reporting should be in compliance with one or more of the international standards e.g. US-EPA, German TUV and MCERTS from UK Environment Agency. It is not necessary to meet all three.
- b) All CEMS shall be installed according to the Manufacturer's recommendations and the operation, maintenance and calibration is in a manner consistent with the manufacturer's recommendations.
- c) The CEMS must be designed to be able to perform a system calibration check automatically every 24 hours on all components separately, while the source is operating.
 - i) The system calibration check must be performed daily at 2 levels: a low level (0-20% of span value) and at a high level of 1.5 times the emission limits.
 - ii) The daily high-level calibration concentration input is close to the equivalent level of the permit emission limit to qualify the data error at this level.
 - iii) Opacity monitor calibration checks must be performed daily at 2 levels; a low level (0-10%) and span level of (40-60%). PM monitors must conduct a daily calibration at a low level (0-10%) and span level of (50-100%) of the full scale range (max. mg/m³).
 - iv) Flow monitor calibration checks shall be at a low value of (0-10%) and a span level of (40-60% of 125% x maximum velocity)
- d) The CEMS must be continuously operate at all times, collecting and recording valid data for at least 95% for all required parameters during all periods of source operation. This allows a reasonable period of monitor downtime in the following situation:
 - i) Monitor breakdown
 - ii) Schedule monitor maintenance
 - iii) Daily zero and span checks
 - iv) Performance specification testing.

If less than 55%, RATA must be conducted.

- e) The CEMS must be continuously operated and maintained following manufacturer's recommendation and the facilities' quality assurance (QA) plan.

4.2 Installation Specifications

Three overriding principles for CEM system installation are:

- a) That measurements must be representative of the actual emission, i.e. that the pollutant concentration or emission rate measurement are directly representative of the total emission from the affected facility.
- b) The effluent gases are well mixed.
- c) The sampling location should be accessible for system maintenance and repairs. For stack installations of in-situ analyzers, factors such as vibration, lightning, ambient atmosphere and temperature extremes, in addition to accessibility must be considered for long-term operation.

Recommended Locations

US EPA defines an appropriate location for the installation of the CEM system by referencing 40 CFR 60, Appendix A; Method 1. The desired probe location would be one with:

- a) Eight (8) equivalent internal stack / duct diameter downstream and two (2) equivalent internal stack / duct diameter upstream of any flow disturbances or
- b) A minimum sitting requirement of two (2) equivalent internal diameter downstream and half ($\frac{1}{2}$) equivalent internal diameter upstream of any flow disturbances.
- c) An opacity monitor requires four (4) equivalent internal diameters downstream and two (2) equivalent internal diameter upstream of any flow disturbance, or a minimum of two (2) downstream and ($\frac{1}{2}$) upstream.
- d) A PM monitor requires eight(8) equivalent internal diameters downstream and two (2) equivalent internal diameter upstream of any flow disturbance, or a minimum of two (2) downstream and ($\frac{1}{2}$) upstream.
- e) A flow monitor requires eight(8) equivalent internal diameters downstream and two (2) equivalent internal diameter upstream of any flow disturbance, or a minimum of two (2) downstream and ($\frac{1}{2}$) upstream.

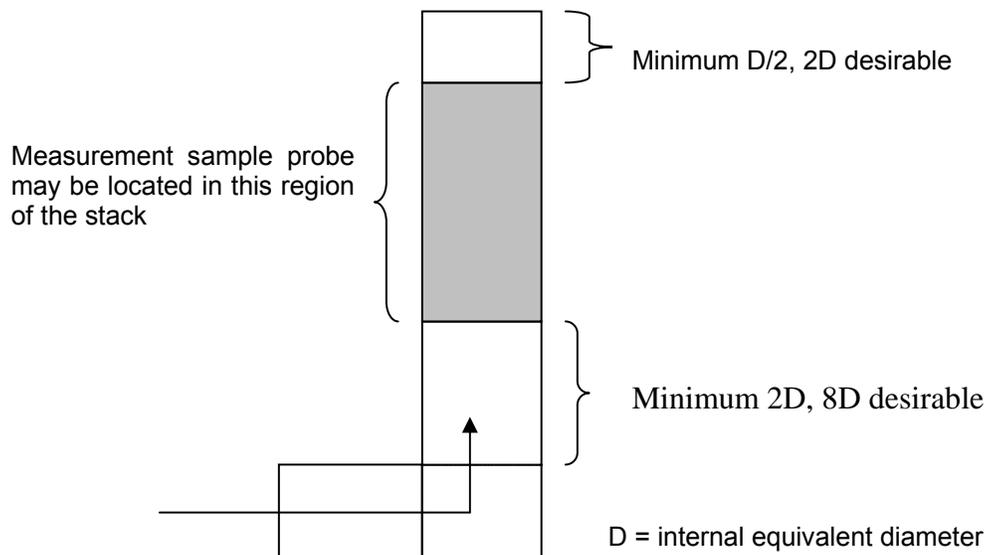


Figure 4-1: Measurement of Sampling probe location

After choosing the measuring location for sampling probes or monitors, the measurement point of the CEM system sample location must be no closer to the stack wall than 30% or farther than 45% of the stack diameter. The sampling point must be within the central area of the stack / duct cross-sectional area.

The Malaysian Standard MS 1596:2003 defines the selection of suitable sampling location to be the section of straight stack / duct at least seven (7) hydraulic diameters long, to ensure sufficiently homogeneous gas velocity distribution.

- a) At a distance of five (5) hydraulic diameters from the inlet and the distance to the stack / duct top should also be five (5) hydraulic diameters.
- b) Choose a section where the distribution of particles is reasonably uniform.

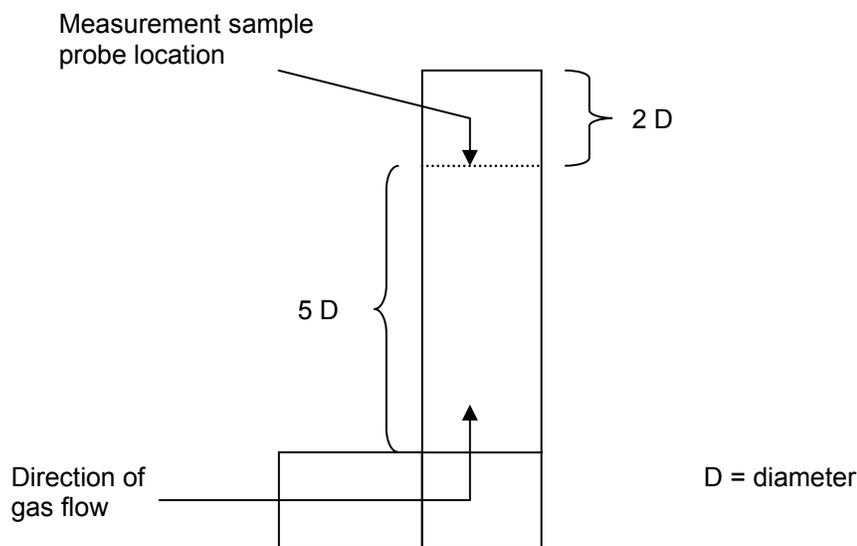


Figure 4-2: Position of sampling probe location

NOTE:

The Malaysian Standard MS 1596:2003 specifies a manual method for the measurement of the concentration and mass flow rate of particulate matter only in a gas stream from stacks / ducts.

The opacity / dust (in-situ system) installation specification (as provided by US EPA 1991c):

- a) The monitor is to be placed in a location where the opacity measurements are representative of the total emissions. Locations where the stack gas is well-mixed are considered primarily.
- b) The monitor is to be accessible to permit routine maintenance, such as window cleaning and blower maintenance. Accessibility is also important for the performance of calibration audits and alignment checks.
- c) The monitor is to be located downstream from all particulate control equipment.
- d) Water droplets (condensed water vapor) are not to be present at the monitoring location.
- e) If the monitor responds to ambient light, it is to be located at a point where ambient light is not present (away from either the top of the stack or where light leaks into the ductwork).

4.3 Quality Assurance / Quality Control

A Quality Assurance Plan (QAP) must be written, implemented, maintained and followed. It must include and describe a complete program of activities to be implemented that will ensure that the data generated by the CEMS is complete, accurate, precise, traceable and reliable. The QAP must satisfy the requirements as listed and any other requirements which are necessary to ensure accuracy, precision, traceability and reliability of the data and information.

- a) *Operational checks* are those procedures that are performed on a routine basis, generally daily, to determine whether the system is functioning properly. These procedures include daily zero and calibration checks and visual checks of system operating indicators and so on.
 - i. Daily calibrations & span checks shall be made using procedures recommended by the manufacturer.
 - ii. Daily records must be kept and adjustments shall be made if the drift is greater than 10% of the calibration gas value.
 - iii. For extractive systems, the calibration gases are to be introduced upstream of all filters and sample conditioning system as close to the tip of the probe as possible.
 - iv. For opacity monitors daily drift is limited to +/-2% opacity
 - v. For PM's the daily drift is limited to +/-3% of span
 - vi. For flow monitors the daily drift is limited to +/-3% of span
- b) *Routine maintenance* is performed at regular intervals. These activities include replacing filters, replacing bearings on motors cleaning pumps, etc. as a monthly task and leak checks, linearity check on instruments, etc. as quarterly task.
- c) *Performance Specification Audits* provide a check of system operation that can identify problems, identify the need to improve preventive maintenance procedures or alert the operator to the need for corrective maintenance. Each CEM system shall be audited by independent third party at least once each calendar quarter. A Relative Accuracy Test Audit (RATA) shall be conducted at least once every four calendar quarters.
 - i. An alternate relative accuracy test, the Cylinder Gas Audit (CGA) may be conducted in three of the four calendar quarters in place of conducting a Relative Accuracy Test Audit (RATA), but in no more than three quarters in succession.
 - ii. Performance Specification Tests and Audits shall be conducted so that the entire continuous emission system is concurrently tested.
- d) *CEMS Monitoring Plan* shall contain the following at the minimum:
 - i. A general description of the source or process including fuel
 - ii. An organizational chart outlining the responsibilities and authorities of key individual.
 - iii. Training of personals.
 - iv. All factors which may affect the operation/maintenance of the CEMS
 - v. Specific monitoring requirement in the permit or regulation
 - vi. Proposed milestone dates & time line for CEMS procurement, installation, testing, certification, etc.
 - vii. Provide detailed description of all parameters to be monitored and their expected normal & maximum values to be measured.

When the quality assurance (QA) assessment activities indicate that the data quality is inadequate, the quality control (QC) efforts must be increased until the data quality is acceptable. If it is determined that data quality is inadequate, then appropriate corrective action shall be determined and implemented as soon as possible.

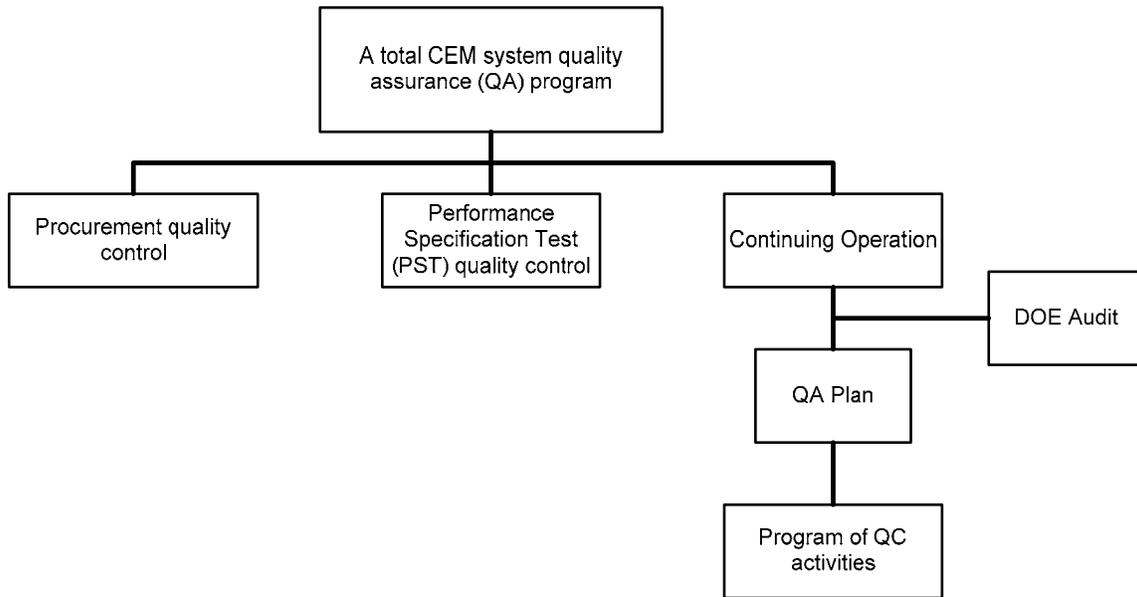


Chart 4-1: Framework of Quality Control Activities in CEM Program

Testing & Auditing Requirements

5.1 CEM System Test

The initial test for gas and opacity/dust monitors, the performance specification test or certification test, have two major criteria that CEM systems must meet: 1) calibration drift and 2) relative accuracy,

- a) **Calibration drift** "The difference in the CEM system output readings from the established reference value after a stated period (usually one week) of operation." The calibration test is conducted by introducing calibration gases into the CEM system, to examine the system's ability to hold its calibration over a period of time.
- b) **Relative accuracy** "The absolute mean difference between the gas concentration or emission rate determined by the CEM system and the value determined by the reference methods (US EPA) plus the 2.5% error confidence coefficient of a series of tests, divided by the mean of the reference method tests." That is,

$$RA (\%) = \frac{|d| + |CC|}{RM} \times 100$$

Where, |d| = the mean difference between the reference method result and the CEM result

|CC| = the confidence coefficient

RM = the average of the reference method values obtained in the test series

The principal sampling strategy for the relative accuracy test is to take CEM readings and reference method samples at the same time.

5.2 CEM System Audits

The principle objective of an audit is to determine how well the system is working. There are two basic sets of audit:

- 5.2.1 The systems audit, an inspection of system operation and system management practices. This audit includes the following:
 - a) Tour of the CEM system installation to review system configuration and condition
 - b) Evaluation of the CEM system operational status
 - c) Review of data and records
- 5.2.2 The performance audit, involves testing the system using manual reference methods (MS 1596:2003) to provide an independent assessment of the systems accuracy; using the following:
 - a) Relative accuracy test audit (RATA) – a repeat of the relative accuracy test or
 - b) Cylinder gas audit (CGA) – a challenging of the monitoring system with cylinder gas of known concentration or
 - c) Relative accuracy audit (RAA) – an audit similar to the RATA, except that only three sets of measurement data (instead of nine) are taken.

The CEM system test and audit guidelines can be found in the US EPA 40 CFR 60 Appendix B (Instrument Performance Specifications) and 40 CFR 60 Appendix F (Quality Assurance Procedures) documents for further reference.

Reporting

6.1 Record Keeping

All industrial premises / facility subject to CEMS requirements must maintain a file of:

- a) All pertinent information, manufacturer literature, phone logs, meeting notes;
- b) Operations and maintenance;
- c) Emission measurements, system performance specification test data and field accuracy tests, calibration checks;
- d) Excess emission reports, instrument logbooks, downtime, adjustments and maintenance.

These records must be retained and made available to DOE for inspection upon request.

6.2 Reports

- a) Performance Specification Test Report: This test is to be conducted by the person responsible for the installation. A copy of the test results to be furnished to the DOE upon completion.
- b) Report of Excesses:
 - i. Reporting Requirements: Any indicated excess of any emission standard to which the stationary source is required to conform, as indicated by the monitoring device, shall be reported by the operator of the source by telephone to the state DOE within 1 hour of such occurrence.
 - ii. An indicated excess will be considered to have occurred if the daily average concentration of the gaseous and total PM pollutant over any clock hour exceeds the emission standard, and no half-hour average exceeds twice the emission standard.
 - iii. An indicated excess will be considered to have occurred if any cumulative period of 15 minutes in any period of twenty-four hours was in excess of the opacity or PM emission standard.
- c) Daily Monitoring Data Transfer Reports: Please refer to Volume 2 of this guideline for details on formats and unit of standards.
- d) Monthly Monitoring Report: The monthly report to the DOE shall include:
 - i. All daily mean value emission data, related to the daily operating time derived from the half-hourly mean values for gases & Total PM and one minute values for smoke.
 - ii. The date and time identifying each period the system was inoperative, and the nature of repairs.
To include in CEM instrument downtime summary
 1. Duration of downtime
 2. Reasons for the downtime
 - iii. A summary of the excesses/ Excess Emission Report.
 1. Date of excess emission
 2. Start and end time excess emission
 3. Magnitude of excess emissions
 4. Reason or cause for the excess emissions
 5. Corrective actions taken or measures taken to minimize emissions

- iv. Zero / span calibration records.
 - v. A record of any on-stack maintenance of CEMS monitors / probes.
- e) Quarterly Monitoring Report: The quarterly report shall include; besides the monthly task:
- i. Leak check on flow results
 - ii. Instrument linearity check results
 - iii. Cylinder Gas Audit (CGA) report (if any)
- f) Annual Report: All the monthly and quarterly tasks plus:
- i. Leak check on sample system
 - ii. Instrument linearity check results
 - iii. Relative Accuracy Test Audit (RATA) report

Monthly reports must be received by the DOE within 15 calendar days after the end of the month and quarterly reports must be received by DOE within 7 days of each calendar quarter.

6.3 Reporting Requirements

- a) Report to the state DOE, within 1 hour after the occurrence, the violation of any emission standard to which the source is required to conform.

Refer to Appendix 1 and 2 for samples of the Monthly and Excess Emission reporting format.

Enquiry

For any enquiry, kindly contact:

Air Division
Department of Environment
Ministry of Natural Resources and Environment
Level 1 - 4, Podium 2 & 3,
Wisma Sumber Asli,
No. 25, Persiaran Perdana, Precint 4,
Federal Government Administrative Centre
62574 Putrajaya.

Tel : 03 – 8871 2000 / 8871 2200
Fax : 03 – 8889 1973 / 8889 1975

APPENDIX 1

MONTHLY CONTINUOUS EMISSION MONITORING REPORT

A. General

| | |
|--------------------------------------|---|
| Company Name: | Source: |
| Address: | Pollutants: |
| Plant Name: | Permit No: I/D: |
| Operating Times: Hours | Reporting Period: From: To: |

B. Continuous Monitor Information

| Continuous Monitor | Manufacturer | Model & SN | Type: | Range | Location |
|---|---------------------|-----------------------|--------------|--------------|-----------------|
| H₂O (Water Vapor) | | | | | |
| O₂ | | | | | |
| CO₂ | | | | | |
| NO₂ | | | | | |
| SO₂ | | | | | |
| CO | | | | | |
| Total PM | | | | | |
| Opacity | | | | | |

C. Emission Data

| Day | H ₂ O % | O ₂ % | CO ₂ % | NO ₂ ppm | SO ₂ ppm | CO ppm | Total PM mg/m ³ | Smoke Level % |
|-----|-----------------------|---------------------|----------------------|------------------------|------------------------|-----------|-------------------------------|------------------|
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NOTE:

1. Gases: 24 hour average concentration derived from the half-hourly mean values.
2. Total PM: Maximum 30 min concentration
3. Smoke: Maximum level

D. Statement of Excess Emission

| Date | Start Time | End Time | Duration | Remarks / Reasons |
|------|------------|----------|----------|---------------------------|
| | | | | Startup / shutdown |
| | | | | Soot blowing |
| | | | | Control Equipment Problem |
| | | | | Process Problem |
| | | | | Other known cases |
| | | | | Unknown cases |

E. CEM System Malfunction

| Date | Time | Duration | Problem | Corrective Action |
|------|------|----------|-----------------------------------|-------------------|
| | | | Monitor Equipment Malfunction | |
| | | | Non-monitor Equipment Malfunction | |
| | | | QA calibration error | |
| | | | Other known causes | |
| | | | Unknown causes | |

I certify that the information contained in this report is true, accurate and complete.

Name:

Position:

Signature:

Date:

APPENDIX 2

EXCESS EMISSION REPORT

A. General

| | |
|----------------------|----------------------------|
| Company Name: | Source: |
| Address: | Pollutants: |
| Plant Name: | Permit No: I/D: |

B. Statement of Excess Emission

| Date | Start Time | End Time | Duration | Remarks / Reasons | Action |
|------|------------|----------|----------|---------------------------|--------|
| | | | | Startup / shutdown | |
| | | | | Soot blowing | |
| | | | | Control Equipment Problem | |
| | | | | Process Problem | |
| | | | | Other known cases | |
| | | | | Unknown cases | |

I certify that the information contained in this report is true, accurate and complete.

Name:

Position:

Signature:

Date: