

TECHNICAL BULLETIN

Standards Development Branch

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TECHNICAL METHODS FOR OPACITY under O. Reg. 419

EXECUTIVE SUMMARY

This bulletin is to assist Ontario industries in understanding the technical issues regarding opacity measurements conducted for regulatory purposes (e.g. compliance with conditions in Environmental Compliance Approvals (ECAs), compliance with provisions in orders, and compliance with regulations).

In Ontario, any facility responsible for opacity discharges is required to comply with the opacity requirements set out in section 46 of O. Reg. 419: *Air Pollution – Local Air Quality* (hereafter referred to as the “Regulation”). The Regulation regulates opacity discharges into the air (i.e. out of stack). In addition to meeting the requirements of section 46, some ECAs issued to the facility under section 9 of the *Environmental Protection Act* (EPA) may require in-stack measurements for certain industrial processes.

This bulletin is categorized into the following topics:

- Background information;
- Identification and description of opacity monitoring;
- Clarification of averaging period over which opacity limits are assessed;
- Start-up, shut-down and maintenance;
- Alternative methods; and
- Clarification of reporting provisions

1. BACKGROUND INFORMATION

Opacity is the degree to which an emission obstructs the passage of light. Opacity measurements of the visible plumes can be made, either continuously by instrumentation or by a human observing the plume at regular intervals. Measurements are reported based on the percentage of light blocked (i.e. from 0% to 100%). In this context, water vapour is not considered when measuring the opacity of an emission.

Emissions that exceed an opacity limit may: (i) be aesthetically offensive; (ii) be used as an indicator of poor combustion; or (iii) have the potential to cause environmental and health effects, depending on the constituents in the plume and their concentrations.

In general, subsection 46(1) of the Regulation states that opacity is not to exceed 20 per cent. However, the Regulation allows an emission with an opacity of up to 40 per cent but only for combustion of fuels with high ash content where an emission lasts for a period of not more than a total of 6 consecutive minutes in any 30-minute period. Fuels with high ash content include items such as wood, coal and black liquor from Kraft mills.

2. IDENTIFICATION AND DESCRIPTION OF OPACITY MONITORING

For the purposes of section 46 of the Regulation, opacity can be measured by:

1. In-stack opacity – Instrumentation using Continuous Opacity Monitoring System (COMS);
2. Out-of-stack opacity – Instrumentation (e.g. Light Detection and Ranging (LIDAR)); and
3. Human observations (e.g., United States Environmental Protection Act (US EPA) Method 9 visual observation method).

A 6 minute averaging period (block average) is used for any opacity monitoring method (visual assessment methods as well as continuous opacity monitors (COMS)).

The common methods used for determining the opacity of the visible emissions are described below. There are other methods under development which are not covered in this bulletin.

2.1 Continuous Opacity Monitoring System (COMS):

The Ministry of Environment and Climate Change (Ministry) requires certain facilities to install and use a Continuous Opacity Monitoring System (COMS) in their stacks to measure opacity continuously. It is generally expected that facilities having COMS use the system to assess opacity. COMS can create a continuous and permanent record of opacity.

COMS measure in-stack opacity and may be required by way of ECA conditions. If a facility is required by the Ministry to install an opacity monitor, the minimum specification requirements by the Ministry for the monitor can be found in the attached document^{A1}. The Regulation governs out-of-stack opacity. In general, in-stack opacity data from a properly installed COMS will be considered representative of out-of-stack opacity. In a few instances, this is not the case. For example, where there are chemical reactions occurring in the air, a COMS may indicate low in-stack opacity while out-of-stack opacity greater than 20% is occurring.

In general, the Ministry uses performance specifications and operating procedures for COMS that closely follow those of the US EPA. COMS that meet the requirements of performance specifications of the US EPA 40 CFR Part 60, Appendix B¹ would generally satisfy the requirements of the Ministry. The US EPA Method 203² sets out a method to determine the opacity of emissions from stationary sources using COMS which include the following:

- Minimum quality control (QC) and quality assurance (QA) requirements are specified to assess the quality of COMS performance.
- Daily zero and span checks, quarterly performance audits, and annual zero alignment checks are required in order to ensure the proper functioning of the COMS and the accuracy of the COMS data.

In operating COMS for in-stack opacity measurements, the following should be considered:

- COMS should be used with precaution where water droplets are present in the effluent being measured for opacity. If water droplets are present, there may be a need to install a bypass so that the water in the effluent can be evaporated by heating;
- Physical limitation of the stack:
 - If the shape of the stack is not circular, there may be a need to calculate the equivalent diameter, e.g. for a stack with rectangular cross section;
- Location of the monitor:
 - If the monitor is located in a section of the stack where the diameter is different from the emission outlet, there will be a difference between the monitor path length and the emission outlet path length; this will affect the perceived opacity. The following equation should be used for the path correction:
$$\log (1 - Op_2) = (L_2/L_1) * \log (1 - Op_1)$$

Where:

Op₁ = Opacity of the effluent based on L₁;
 Op₂ = Opacity of the effluent based upon L₂;
 L₁ = Monitor path length; and
 L₂ = Emission outlet path length.

- Install the monitor at a location where the opacity measurements are representative of the total emissions from the affected source. The following requirements should be met:
 - Measurement location. Select a measurement location that is (a) at least 4 duct/stack diameters downstream from all particulate control equipment or flow disturbance; (b) at least 2 duct/stack diameters upstream of a flow disturbance; (c) where condensed water vapour is not present; and (d) accessible in order to permit maintenance.
 - Measurement path. The primary concern in locating a monitor is determining a location of well-mixed stack gas. Select a measurement path that passes through a centroidal area equal to 25 percent of the cross section of stack/duct. Additional requirements should be considered:
 - If the location is in a straight vertical section of stack/duct and is less than 4 equivalent diameters away from a bend, use a path that is in the plane defined by the affecting bend.
 - If the location is in a horizontal section of stack/duct and is at least 4 diameters downstream from a vertical bend, use a path in the horizontal plane that is between one-half and two-thirds the distance up the vertical axis from the bottom of the stack/duct.
- Double versus single pass:
 - Double pass would provide a higher accuracy than a single pass. Double pass transmissometer is even more sensitive to the alignment of a transceiver (including both light source and detector components) and a reflector mounted on opposite ends of the measurement path.

2.2 Visual Determination:

Out-of-stack opacity can generally be determined through visual observations by people who have been trained and certified as Visible Emission Observers³.

US EPA Method 9

US EPA Method 9³ is a visual observation method and a valid means by which to assess opacity. The disadvantage to this method is that the results are one time readings and are not available for night time observations. If there is an exceedence of the opacity limit as set out in the Regulation or Environmental Compliance Approval, this must be reported to the Ministry (see Subsections 46(9) to 46(11) of Reg.419 and Part 2.5 of this bulletin).

The opacity of emissions from sources of contaminant can be determined visually by an observer certified to use Method 9. Although it is required that persons use the official version of Method 9, the key requirements of Method 9 are summarized as follows:

- Position – The observer shall stand at a distance sufficient to provide a clear view of the emissions with the sun oriented in the 140-degree sector to the observer's back. The observer must make opacity observations from a position such that the line of vision is approximately perpendicular to the plume directions;
- Observations – The observer shall make opacity observations at the point of greatest opacity in that portion of the plume where condensed water vapour is not present. The observer must not look continuously at the plume, but, instead, observe the plume momentarily at 15-second intervals;

- Recording Observations – The observer shall record the opacity observations to the nearest 5 percent. Each momentary observation recorded is deemed to represent the average opacity of emissions for one 15-second period. The average of 24 successive readings for a continuous period of six minutes (24 readings x 15 seconds/reading = 360 seconds = 6 minutes) is deemed to represent the opacity of the plume;
- Certification:
 - To receive certification as a qualified observer, a candidate must be tested and demonstrate the ability to assign opacity readings in 5 percent increments for 25 different black plumes and 25 different white plumes, with an error not to exceed 15 percent opacity on any one reading and an average error not to exceed 7.5% opacity in each category; and
 - The certification shall be valid for a period of 6 months. To retain certification, the qualification procedures must be repeated.

For measurement of out-of-stack opacity, the following should be considered:

- Attached steam plumes – When condensed water vapour is present within the plume as it emerges from the emission outlet, the observer must make opacity observations beyond the point in the plume at which condensed water vapour is no longer visible;
- Detached steam plumes – When water vapour in the plume condenses and becomes visible at a distinct distance from the emission outlet, the observer must evaluate the opacity of emissions at the emission outlet prior to the condensation of water vapour; and
- The observer must make opacity observations at the point of greatest opacity in that portion of the plume where condensed water vapour is not present.

2.3. Clarification of Averaging Period over Which Opacity Limits are Assessed

The following Questions & Answers provide clarifications on the issue of averaging periods.

1. My ECA requires me to meet a 20% opacity limit using a COMS but does not specify an averaging period. What is the averaging period for measurements of opacity?

Subsections 46(1, 2, 3) of O. Reg. 419 state:

46. (1) No person shall cause or permit an emission into the air that, during a period of six consecutive minutes, obstructs the passage of light at any point by an average of more than 20 per cent.

(2) Subsection (1) does not apply to an emission from a source of combustion that uses fuel with high ash content, if,

(a) during the six-minute period referred to in subsection (1), the passage of light was not obstructed by an average of 40 per cent or more at any point;

(b) the six-minute period referred to in subsection (1) was part of a period of 30 consecutive minutes in which there were four periods of six consecutive minutes during which the person complied with subsection (1); and

(c) the four periods referred to in clause (b) did not overlap with each other and did not overlap with the six-minute period referred to in subsection (1).

(3) If an environmental compliance approval prohibits a person from causing or permitting an emission into the air that obstructs the passage of light at any point by a percentage that is less than 20 per cent, that prohibition applies instead of subsection (1).

The 6 minute averaging period will be applied to all measurements of opacity (including Method 9 and COM). The same averaging period allows for comparison of results from COMS with that of US EPA Method 9 (in which opacity of a visible emission is assessed over a continuous six-minute interval).

The 6 minute averaging period is also applicable for the assessment of both the 20% limit and 40% opacity exception for fuels with high ash content.

2. How does Reg.419 address fuel with high ash content?

Subsection 46(2) of O. Reg. 419 states:

“Subsection (1) does not apply to an emission from a source of combustion that uses fuel with high ash content, if

- (a) During the six-minute period referred to in subsection (1), the passage of light was not obstructed by an average of 40 per cent or more at any point;***
- (b) The six-minute period referred to in subsection (1) was part of a period of 30 consecutive minutes in which there were four periods of six consecutive minutes during which the person complied with subsection (1); and***
- (c) The four periods referred to in clause (b) did not overlap with each other and did not overlap with the six-minute period referred to in subsection (1).”***

Subsection 46(2) provides for an exception to the 20% opacity requirement in subsection 46(1) provided the provisions set out in 46(2) a, b, and c are met. The exception to the opacity limit is applicable to situations where the source of combustion burn fuels with a high ash content. For example, boilers could have ashes deposited on the surface of their tubes; these tubes need to be cleaned. Such cleaning involves blowing periodic bursts of compressed air or steam. During such short periods, opacity can increase. In these situations, the Regulation allows an exception of the 20 percent opacity limit. The exception is up to 40 per cent where an emission lasts for a period of not more than a total of 6 consecutive minutes in any 30-minute period. This exception applies to recovery boilers in the Pulp & Paper mills (high ash content fuel). It is a good practice for the operator to schedule these periodic bursts for ash cleaning such that the total time of increased opacity meets the requirements of subsection 46(2).

2.4 Alternative methods

Opacity is a simple and inexpensive measure that is a useful indicator of good combustion and how well a process is operating. The Regulation allows opacity monitoring to evolve with technical advancements in methods that will minimize opacity emissions. The Regulation provides the Director the ability to allow an alternative method for the purpose of minimizing the opacity of emissions. There are two possible avenues to request an alternate method for opacity. They are:

- (1) An ECA

Subsection 46(4) states that: Subsection (1) does not apply to a person if,

- (a) At the time of the emission, the person was using a device or equipment for the purpose of minimizing the opacity of emissions;***
- (b) The use of the device or equipment is required or authorized by an environmental compliance approval; and***
- (c) The Director is satisfied that the device or equipment effectively minimizes the opacity of emissions.***

(2) A notice

Subsection 46(5) states that the Director may, on the request of a person, give the person a notice requiring the person to use a device or equipment specified in the notice for the purpose of minimizing the opacity of emissions if,

- (a) The person has provided the Director with such information about the use of the device or equipment as the Director may require; and*
- (b) The Director is satisfied that use of the device or equipment in accordance with the notice will be at least as effective as subsection (1) in minimizing the opacity of emissions.*

Some examples of alternative methods that may minimize the opacity of emissions based on the U.S. Maximum Achievable Control Technology (MACT) Rules⁴ are as follows:

- If the unit is controlled with a fabric filter, the facility may elect to operate the fabric filter using a bag leak detection system such that corrective actions are initiated within 1 hour of a bag leak detection system alarm and the facility operate and maintain the fabric filter such that the alarm is not engaged for more than 5 percent of the total operating time in a 6 month period.
- For boilers and process heaters with fabric filters in combination with wet scrubbers for control of particulates emissions, the facility must measure the pH, pressure drop and liquid flow rate of the wet scrubber during the performance test. Furthermore, the fabric filter must be operated such that the bag leak detection system does not sound more than 5% of the operating time during any 6-month period.
- For boilers and process heaters with electrostatic precipitators (ESP) in combination with wet scrubbers for control of particulates emissions, the facility must measure the pressure drop, and liquid flow rate of the wet scrubber during the performance test. The facility must also measure the voltage and secondary current of the ESP collection plates or total power input during the PM performance test.

2.5 Clarification of Reporting Provisions

Section 46 of O. Reg. 419 states:

“(9) A person who contravenes subsection (1) shall notify a provincial officer in writing as soon as practicable after the contravention occurs of the contravention and of the source of the emission.

(10) If a person contravenes subsection (1) more than once in a 24-hour period, the person may, instead of complying with subsection (9), notify a provincial officer in writing as soon as practicable after the end of the 24-hour period of the number of contraventions that occurred during the period and of the source of the emission.

(11) If a person contravenes subsection (1), the Director may give the person written notice requiring the person to give notice to a provincial officer in writing and in accordance with the notice, at such regular intervals as may be specified by the Director and for such period of time as may be specified by the Director, of such information as may be specified by the Director.

(12) Before the Director gives a person a notice under subsection (11), the Director shall give the person a draft of the notice and an opportunity to make written submissions to the Director during the period that ends 15 days after the draft is given.”

Reporting of an incident (i.e. exceedence of opacity in a 6 minute period) is a regulatory requirement. Reporting of an incident should be made as soon as practicable in writing to the local District Office unless otherwise specified by the District. If more than one incident occur in a day (i.e. 24 hour period), the Ministry allows reporting to be done once per day (i.e. end of 24 hour period).

2.5.1 Start-up, shut-down and maintenance

Opacity exceedences due to start-up, shut-down and maintenance do not have to be reported if the facility has a plan on site to minimize conditions that lead to high opacity. The Director can ask for a copy of the plan and require changes to the plan if necessary.

Section 46 of O. Reg. 419 states:

“(14) Subsections (9) and (10) do not apply to the following contraventions of subsection (1), if the person who contravenes subsection (1) has implemented a plan to minimize the opacity of emissions during those contraventions:

- 1. A contravention that occurs when the operation of a source of emission is increased from an inoperative state to normal operating conditions.***
- 2. A contravention that occurs when the operation of a source of emission is decreased from normal operating conditions to an inoperative state.***
- 3. A contravention that occurs when the source of emission undergoes routine maintenance.***

(15) A person who has a plan referred to in subsection (14) shall keep the most recent copy of the plan at the facility and, on the request of the Director or a provincial officer, shall immediately provide the Director or provincial officer with a copy of the plan.

(16) The Director may give a person who has a plan referred to in subsection (14) a notice requiring the person to revise the plan in accordance with the notice if the Director is of the opinion that the plan does not effectively minimize the opacity of emissions during contraventions referred to in that subsection.” While section 34(14) provides relief from reporting to the Director under these specific conditions, it does not absolve the facility from meeting the opacity limit set out in this Regulation.

2.6 Other Legal Requirements

Please note that there are other provisions in the Regulation and EPA which may be applicable and should be considered. Specifically, section 47 of the Regulation prescribes reporting of exceedences of the opacity limit that may occur under certain circumstances.

A full copy of the [Regulation](#) can be found on e-laws

For those notifying the Ministry, further information can be found on the [ministry website](#).

REFERENCES

1. [US EPA Part 60 – Standards of Performance for New Stationary Sources.](#)
2. US EPA Method 203 - [Determination of the Opacity of Emissions from Stationary sources by continuous opacity monitoring systems.](#)
3. US EPA Method 9 - [Visual Determination of the Opacity of Emissions from stationary sources.](#)
4. US EPA 40 CFR Part 63 – [National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters:](#) Final Rule.

ATTACHMENTS

- A1. Minimum Specification Requirements for Opacity Monitors

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PARAMETER: Opacity

INSTALLATION:

The continuous Opacity Monitor shall be installed at an accessible location where the measurements are representative of the actual opacity of the gases leaving the Equipment and shall meet the following design and installation specifications.

| PARAMETERS | SPECIFICATION |
|---|---------------|
| 1) Wavelength at Peak Spectral Response (nm): | 500 - 600 |
| 2) Wavelength at Mean Spectral Response (nm): | 500 - 600 |
| 3) Detector Angle of View: | ≤ 5 degrees |
| 4) Angle of Projection: | ≤ 5 degrees |
| 5) Range (percent of opacity): | 0 - 100 |

PERFORMANCE:

The Continuous Opacity Monitor shall meet the following minimum performance specifications for the following parameters.

| PARAMETERS | SPECIFICATION |
|---|--|
| 1) Span Value (percent opacity): | 2 times the average normal opacity of the source |
| 2) Calibration Error: | ≤ 3% opacity |
| 3) Attenuator Calibration: | ≤ 2% opacity |
| 4) Response Time (95% response to a step change): | ≤ 10 seconds |
| 5) Schedule for Zero and Calibration Checks: | daily minimum |
| 6) Procedure for Zero and Calibration Checks: | all system components checked |
| 7) Zero Calibration Drift (24-hours): | ≤ 2% opacity |
| 8) Span Calibration Drift (24-hours): | ≤ 2% opacity |
| 9) Conditioning Test Period: | ≥ 168 hours without corrective maintenance |
| 10) Operational Test Period: | ≥ 168 hours without corrective maintenance |

CALIBRATION:

The monitor shall be calibrated, to ensure that it meets the drift limits specified above, during the periods of the operation of the Equipment. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER:

The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 30 seconds or better.

RELIABILITY:

The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 95 percent of the time, on a monthly basis, when the Equipment is in operation.