

High Volume PM10/TSP Calibration/Verification/Audit Guidance

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Purpose: The purpose of this guidance is to assist operators of industrial particulate samplers for particulate matter less than 10 microns in diameter (PM10) or total suspended particulate (TSP) in performing calibrations, verifications and provide better understanding of audits to ensure greater operational consistency throughout the network.

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Issue: In recent years there has been a large increase in the number of facilities and consultants operating high volume PM10 or TSP samplers. These samplers have several methods of flow controls and facilities/consultants may have their own individual procedures for flow calibration and determination. Additionally the Wisconsin Department of Natural Resources (WDNR) upgraded its network to volumetrically controlled samplers in 2012 and has updated its internal calibration, verification and audit procedures as well.

The increased number of operators and the variety of methods has resulted in some inconsistency across the industrial monitoring network and confusion about the audit procedures used to assure the data.

Use of PM10 monitors has become typical in recent years because the secondary 24-hour ambient air quality standard for TSP was suspended in Wisconsin on 12/1/2011 to become consistent with the national ambient air quality standards. However, TSP samples are still collected at some sites for secondary analysis for lead or as a surrogate for PM10.

Proposal: WDNR acknowledges that there are several accepted methods for the calibration of high volume samplers that yield similar results. WDNR recommends that all calibrations be done in terms of actual conditions. Some flexibility in calibration method is acceptable, and methods will be evaluated during annual audits that are performed with a standard method. Additionally WDNR is providing guidance for calibrations and flow calculations for common types of samplers. This guidance will include spreadsheet templates for calibrations and QC checks that can be used by facilities and consultants. Use of these templates is not a requirement; they are provided as a guide.

Temperature/Pressure

Most calibrations and flow measurements are pressure and temperature dependent. As a result, it is strongly recommended that any calibration/verification activity includes temperature and pressure measurements using annually certified standards.

Per 40 CFR Part 50 Appendix J, PM10 flow rates must be maintained within 10% of 1.13 m³/minute in local conditions for samples to be valid. Therefore most flow controls should be adjusted to meet actual conditions. However, PM10 and TSP measurements should be reported in standard conditions $\mu\text{g}/\text{std m}^3$ (760 mm Hg, 25 C/298 K). The conversion from measured flow rates in actual conditions to standard conditions is done by the equation:

$$Q_{\text{std}} = Q_{\text{a}} * (P_{\text{a}}/760) * (298/T_{\text{a}})$$

Where:

Q_{std} = flow rate in standard conditions

Q_{a} = flow rate in actual conditions

P_{a} = ambient sampling pressure (mm Hg)

T_{a} = ambient sampling temperature (K)

Ambient pressure and temperature can be measured on site, can be taken from a nearby weather station, or can be estimated using seasonal temperatures.

On site Temperature and Pressure: On-site temperature and pressure should be calibrated or verified with a certified standard. Barometric pressure should measure ambient pressure, not corrected to sea level.

Weather Station: The weather stations used for determining temperature and pressure should be identified in the cover letter of the report. CAUTION: Weather stations normally report barometric pressure corrected to sea level. If this is the case, the site operator will need to correct barometric pressure back to station pressure by correcting it for the elevation of the sampler. WDNR suggests this equation:

$$BP_{\text{station}} = BP_{\text{sea-level}} - 1.08 * (\text{elevation in feet}/1000)$$

Seasonal Temperature and Pressure: WDNR uses the following seasonal temperatures and pressures. This is subject to be updated in the future.

Wisconsin Average Temp and Pressure:

	Dec/Jan/Feb	March/Apr/May	Jun/Jul/Aug/Sept	Oct/Nov
Seasonal Average Temp South of US Hwy 8 (°C)	-8.3 °C	+6.8 °C	+18.6 °C	+6.8 °C
Seasonal Average Temp North of US Hwy 8 (°C)	-8.3 °C	+3.1 °C	+18.6 °C	+6.8 °C
Seasonal Average Barometric Pressure	744.1 mm Hg	744.1 mm Hg	744.1 mm Hg	744.1 mm Hg

Flow Calibration Standard

In all cases WDNR recommends using an orifice calibrated with a slope and intercept in actual conditions. If a flow standard with a different principle (calibrated in terms of standard or theoretical conditions) is used, it should be clearly documented and explained in the monitoring plan and should be indicated in any calibration report.

Sampler Types

Currently, there are three main types of monitors being used that differ primarily in the mechanism used for flow control and calculation: Volumetric Controlled (choked flow venturi), Mass Flow Controlled (automated MFC or rheostat) and Computer Controlled. These flow controls can be used for either PM10 or TSP samplers. Each type is described below along with WDNR recommendations for calibration methods, monthly verifications and the audit procedures that will be used by WDNR.

Suggested Action Levels

WDNR recommends the following action levels when doing checks of high volume samplers and associated equipment. These recommendations are based on criteria found in 40 CFR Part 50 Appendix J and DNR standard operating procedures.

- Orifice measured flow rate versus Instrument flow rate (may be looked up, calculated from a Dickson, or displayed depending on instrument type)
 - >5% - should result in corrective maintenance or recalibration
 - >7% - the data bracketed by the check should be considered for invalidation
- Orifice measured flow rate or Instrument flow rate versus design flow rate 1.13 m³/min (PM10 only)
 - >5% - consider corrective maintenance or recalibration
 - >10% - the data bracketed by the check should be considered for invalidation
- Temperature agreement between certified standard and sensor reading
 - > 4 °C – consider recalibrating the temperature sensor
- Barometric Pressure
 - > 10 mm Hg – consider recalibrating the pressure sensor

Volumetric Controlled High Volume Samplers

Principle: Volumetric controlled high volume samplers are controlled by a choked flow venturi. This venturi approximately limits the flow to a design value so long as there is a sufficient vacuum being drawn. The flow rate is slightly dependent on temperature and the pressure ratio before and after the venturi. A lookup table is provided specific to each venturi device or a temperature/pressure dependent equation may be used in some cases to determine the actual flow rate of the sampler. It is the opinion of WDNR that this method of flow determination is more accurate than a Dickson chart calibration and reading.

Calibration: Since the venturi is a fixed device, there is no calibration of the sampler flow rate. Instead, the user performs a flow check to verify the sampler is operating properly. It is recommended that at startup and annually a multipoint check should be done with no filter in place and a variety of stagnation pressures bracketing the normal operating stagnation pressure by approximately 5 inches of pressure (if normal stagnation pressure is 19 inches check five points from 14-24 inches of pressure). If the results of the check are poor (>5%), it is an indication of a problem with sampler such as a leak, or a weak motor not pulling enough vacuum.

Monthly: A one point flow check should be conducted monthly by the site operator. This check should be done with a filter in place, or no filter and an orifice adjusted to produce a similar stagnation pressure typically seen pre and post sampling. This check should be done using an orifice calibrated in actual conditions and taking measurements with a certified temperature and pressure standard. The flow measured using the orifice should be compared to the flow that would be determined using the venturi lookup table or equation using the same temperature and pressure.

Audit: An annual audit will be conducted by WDNR personnel with an independent flow standard in an identical fashion to the suggested monthly check. An audit will pass if the 7% and 10% flow rate invalidation criteria are not exceeded. If either of these conditions is exceeded, work will be done to try to determine the cause of the problem including cross checking the flow rate with the facility orifice, if available.

Mass Flow Controlled High Volume Samplers

Principle: Mass flow controlled high volume samplers are typically controlled by an automated mass flow controller (MFC). The MFC automatically varies the motor voltage and consequently the standard flow rate of the sampler. Some TSP units use a rheostat which is manually set to deliver a specific voltage to the motor. The sampling flow rate is measured and recorded by a calibrated Dickson chart recorder.

Calibration: A multipoint calibration should be done at startup and after any maintenance that may affect flow rate. WDNR recommends that operators utilize the calibration procedure provided in EPA Method IO-2.1I at <http://www.epa.gov/ttnamti1/files/ambient/inorganic/mthd-2-1.pdf> or the method recommended by the equipment manufacturer. This method typically uses an orifice calibrated in actual conditions and compares the measured flow rates to Dickson readings and developing a linear relationship between the two. A certified temperature and pressure standard should be used during this procedure. After the calibration is completed, a one point check at the operational flow rate is recommended to confirm the calibration and instrument setting is acceptable.

Monthly: A one point flow check should be conducted monthly by the site operator. This check should be done with a filter in place and the mass flow controller or rheostat inline. This check should be done using an orifice calibrated in actual conditions fully open or with no restrictor plate and taking measurements with a certified temperature and pressure standard. The flow measured using the orifice is compared to the flow that would be calculated from the Dickson chart reading using the same temperature and pressure.

PM10 Audit: An annual audit will be conducted by WDNR personnel with an independent flow standard in an identical fashion to the suggested monthly check. An audit will pass if the 7% and 10% flow rate invalidation criteria are not exceeded. If either of these conditions is exceeded, work will be done to try to determine the cause of the problem including cross checking the flow rate with the facility orifice, if available.

TSP Audit: An annual audit will be conducted by WDNR personnel with an independent flow standard. This audit will consist of taking the mass flow controller or rheostat out of line. No filter is used for this audit. Five points are run with either a variable orifice or fixed orifice and plates. Flow rates should bracket the operational range (approximately 1.1 to 1.7 m³/min). For each point the flow measured using the orifice is compared to the flow that would be calculated from the Dickson chart reading using the same temperature and pressure. An audit will pass as long as the overall percent difference is within 7%.

Computer Controlled High Volume Samplers

Principle: Computer controlled high volume samplers have integrated pressure and temperature sensors as well as a computer that acts as a timer control and directly provides flow and volume measurements in both actual and standard conditions to the user as well as other sampling event information. The flow control can either utilize a mass flow controller or choked flow venturi which may be transparent to the operator. This type of sampler is capable of automatically performing checks and calibrations. Currently, WDNR has limited direct experience with computer controlled high volume samplers. For this reason, WDNR recommends performing occasional manual checks to verify all components of the sampler are functioning correctly. The sampler should be set up to control the flow in actual conditions but standard sample volumes should be used for determining reporting ambient particulate concentrations.

Calibration: WDNR recommends that users follow the method recommended by the equipment manufacturer. This method typically uses an orifice calibrated in actual conditions with the pressure tap plugged into a pressure sensor. The computer runs a calibration sequence and calculates slope and intercept flow settings. It is recommended that the barometric pressure and temperature sensors be checked and calibrated as needed using certified standards. Calibrations should be done after any major maintenance including motor changes.

Monthly: A manual one point flow check should be conducted monthly by the site operator. This check should be done with a filter in place. This check should be done using an orifice calibrated in actual conditions fully open or with no restrictor plate and taking measurements with a certified temperature and pressure standard. The orifice pressure should be read by a manometer or certified pressure standard instead of the computer. The flow measured using the orifice should be compared to the actual flow displayed by the computer. Additionally the orifice flow should be converted to standard conditions and compared to the standard flow measured by the computer or converted from the actual flow using the sampler's temperature and pressure readings and checked to see if it meets the 7% criteria. It is suggested that temperature and pressure sensors are also checked against certified standards.

Audit: An annual audit will be conducted by WDNR personnel with an independent flow standard in an identical fashion to the suggested monthly check. An audit will pass if the 7% and 10% flow rate invalidation criteria are not exceeded. If either of these conditions is exceeded, work will be done to try to determine the cause of the problem including cross checking the flow rate with the facility orifice, if available.