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Standard Practice for PM Detector and Bag Leak Detector Manufacturers to Certify Conformance with Design and Performance Specifications for Cement Plants[1]

This standard is issued under the fixed designation D7392; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the procedure for certifying particulate matter detectors (PMDs) and bag leak detectors (BLDs) that are used to monitor particulate matter (PM) emissions from kiln systems at Portland cement plants that burn hazardous waste. It includes design specifications, performance specifications, test procedures, and information requirements to ensure that these continuous monitors meet minimum requirements, necessary in part, to monitor reliably PM concentrations to indicate the need for inspection or corrective action of the types of air pollution control devices that are used at Portland cement plants that burn hazardous waste.

1.2 This practice applies specifically to the original manufacturer, or to those involved in the repair, remanufacture, or resale of PMDs or BLDs.

1.3 This practice applies to (*a*) wet or dry process cement kilns equipped with electrostatic precipitators, and (*b*) dry process kilns, including pre-heater pre-calciner kiln systems, equipped with fabric filter controls. Some types of monitoring instruments are suitable for only certain types of applications.

NOTE 1—This practice has been developed based on careful consideration of the nature and variability of PM concentrations, effluent conditions, and the type, configuration, and operating characteristics of air pollution control devices used at Portland cement plants that burn hazardous waste.

1.4 This practice applies to Portland cement kiln systems subject to PM emission standards contained in 40 CFR 63, Subpart EEE.

NOTE 2—The level of the PM emission limit is relevant to the design and selection of appropriate PMD and BLD instrumentation. The current promulgated PM emission standards (70 FR 59402, Oct. 12, 2005) are: (*a*) 65 mg/dscm at 7 % O_2 (0.028 gr/dscf at 7 % O_2) or approximately 30 mg/acm (0.013 gr/acf) for "existing sources" and (*b*) 5.3 mg/dscm at 7 % O_2 (0.0023 gr/dscf at 7 % O_2) or approximately 2.5 mg/acm (0.001 gr/acf) for "new sources." On March 23, 2006 (71 FR ~~14665)~~ 14665), EPA proposed to revise the PM standard for new cement plants to 15.9 mg/dscm at 7 % O_2 (0.0069 gr/dscf at 7 % O_2), or about ~~6-9~~ 6–9 mg/acm ~~(0.0026-0.0039~~ (0.0026–0.0039 gr/acf). The emission standards may change in future rulemakings, so users of this practice should check the current regulations. Some types of monitoring instruments are not suitable for use over the range of emissions encountered at both new and existing sources.

1.5 The specifications and test procedures contained in this practice exceed those of the United States Environmental Protection Agency (USEPA). For each monitoring device that the manufacturer demonstrates conformance to this practice, the manufacturer

[1] This practice is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.03 on Ambient Atmospheres and Source Emissions.

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may issue a certificate that states that monitoring device conforms with all of the applicable design and performance requirements of this practice and also meets all applicable requirements for PMDs or BLDs at 40 CFR 63, Subpart EEE, which apply to Portland cement plants.

NOTE 3—40 CFR 63.1206 (c)(8) and (9) requires that BLDs and PMDs "be certified by the manufacturer to be capable of detecting particulate matter emissions at concentrations of 1.0 milligrams per actual cubic meter unless you demonstrate under §63.1209(g), that a higher detection limit would routinely detect particulate matter loadings during normal operations." This practice includes specific procedures for determination and reporting of the detection limit for each PMD or BLD model.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate ~~safety~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D6216 Practice for Opacity Monitor Manufacturers to Certify Conformance with Design and Performance Specifications

D6831 Test Method for Sampling and Determining Particulate Matter in Stack Gases Using an In-Stack, Inertial Microbalance

2.2 *U.S. Environmental Protection Agency Documents:*[3]

40 CFR 63, Subpart EEE National Emission Standards for Hazardous Air Pollutants: Final Standards for Hazardous Air Pollutants for Hazardous Waste Combustors

2.3 *Other Documents:*[4]

ISO/DIS 9004 Quality Management and Quality System ~~Elements-Guidelines~~Elements – Guidelines

ANSI/NCSL Z 540-1-1994 Calibration Laboratories and Measuring Equipment ~~-~~– General Requirements

3. Terminology

3.1 For terminology relevant to this practice, see Terminology D1356.

3.1.1 Definitions for transmittance measurement equipment (that is, opacity monitors) are provided in Practice D6216.

3.2 *Definitions of Terms Specific to This Standard:*

Analyzer Equipment

3.2.1 *bag leak detector [BLD], n*—an instrument installed downstream of a fabric filter control device that interacts with a PM-laden effluent stream and produces an output signal of sufficient accuracy and repeatability to track changes in PM control device performance and, together with appropriate data analysis, indicates the need to inspect the fabric filter as referenced in the Federal Register, 40 CFR 63, Subpart EEE. BLDs are used to track rapid changes in PM concentration and must have sufficient dynamic range to track both "peaks" and baseline PM levels and include provisions for adjusting the averaging period, alarm delay, and alarm set point appropriate for source-specific conditions. BLDs must also include provisions to detect faults or malfunctions of the measurement system.

3.2.2 *particulate matter detector [PMD], n*—an instrument that interacts with a PM-laden effluent stream and produces an output signal of significant accuracy and repeatability so as to indicate significant changes in the concentration of particulate material entrained in the effluent downstream of an electrostatic precipitator or fabric filter as referenced in the Federal Register, 40 CFR

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20004, http://www.epa.gov.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

63, Subpart EEE. PMDs are used to track changes in PM concentrations using six-hour rolling averages, updated each hour with a new one-hour block average. PMDs must also include provisions to activate an alarm and detect faults or malfunctions of the measurement system.

3.2.2.1 *Discussion—*
PMDs and BLDs are inherently inferential monitoring devices that sense some parameter which, in the absence of interfering effects, is directly related to PM concentrations.

3.2.2.2 *Discussion—*
This practice does not discriminate between measurement techniques but instead provides design specifications and performance standards that all devices must satisfy to be acceptable as a PMD or BLD for a cement kiln that burns hazardous waste. Techniques for continuously measuring PM include optical transmittance ("opacity"), dynamic opacity ("scintillation"), optical scatter (side, forward and back scatter), and probe electrification (sensors based on induction, contact charge transfer, or combination of effects).

NOTE 4—Extractive systems using Beta attenuation to sense PM deposited on filters are used as PM CEMS but can not meet the sampling and analysis frequency required by EPA regulations for PMDs and BLDs.

3.2.2.3 *Discussion—*
PMD and BLD instruments that conform to the requirements of this practice include automated internal mechanisms that are used to verify proper performance of the measurement device on a daily basis, or more frequent basis if recommended by the manufacturer. PMD instruments include mechanisms to facilitate external periodic audits of the measured parameter.

3.2.3 *light-scatter, n*—the extent to which a beam of light is reflected, refracted, or diffracted via interaction with PM in a medium such that a measurable portion of the original beam's energy is redirected outside the original angle of projection.

3.2.3.1 *Discussion—*
Back-scatter is generically defined as scattering in excess of 150 degrees from the direction of the original projected beam, side-scatter is generically defined as scattering between 30 degrees and 150 degrees from the original direction, and forward-scatter is generically defined as scattering of less than 30 degrees from the projected beam.

3.2.3.2 *Discussion—*
Because the correlation between the intensity and angular distribution of light scattering and the actual PM mass concentration is dependent on factors such as particle size, particle shape, wavelength of light, particle density, etc., this practice is limited to: (*a*) verification of the stability, linearity, and interference rejection of the measurement of scattered light, and (*b*) verification of the instrument sensitivity and detection limit. This practice does not recommend any specific light-scattering technology, and leaves the evaluation of the application to the discretion of the user of a BLD or PMD.

3.2.3.3 *Discussion—*
A light-scatter BLD or PMD may include the following: (*a*) sample interface equipment such as filters and purge air blowers to protect the instrument and minimize contamination of exposed optical surfaces, (*b*) shutters or other devices to provide protection during power outages or failure of the sample interface, and (*c*) a remote control unit to facilitate monitoring the output of the instrument, initiation of zero and upscale calibration checks, or control of other BLD or PMD functions.

3.2.4 *dynamic opacity, n*—the amount of light variation caused by particles traversing a cross-stack beam of transmitted light.

3.2.4.1 *Discussion—*
Dynamic opacity instruments measure the alternating component of the transmitted light and are sometimes referred to as scintillation instruments.

3.2.4.2 *Discussion—*
In certain dynamic instruments the measured alternating signal (light variation) is divided by the average transmitted light intensity signal to provide a ratio measurement. This ratio is unaffected by optics contamination.

3.2.5 *probe electrification, n*—methods by which the charge carried on PM creates a signal in a grounded sensing rod through charge induction, contact, or combination.

3.2.5.1 *Discussion—*
Probe electrification instruments measure the current produced by charged particles passing or impacting a grounded sensing rod. Certain instruments measure the DC component of the signal, the AC component of the signal or both the DC and AC components of the signal.

3.2.5.2 *Discussion—*
Probe electrification instruments can be used after fabric filters where the particle charge is relatively constant. The influence of changing velocity should be considered when considering using probe electrification devices in applications with variable speed fans or variable flow.

3.2.6 *BLD or PMD measuring volume, n*—the spatial region in which the particles interact with the instrument to produce a measurable signal.

3.2.6.1 *Discussion*—
For light scattering or transmittance instruments, the measuring volume is the spatial region where the projected light and the field of view of the detector optics overlap in which the PM concentration can be detected via scattering of light or reduction of transmittance. For probe electrification instruments, the measuring volume is the area near the sensing probe.

3.2.7 *nominal full scale, n*—the default, as-shipped full scale calibration of a BLD or PMD, based on standard gains and offset settings established during field performance tests under Section 7.

3.2.7.1 *Discussion*—
The nominal full scale (NFS) will be determined by the manufacturer by means of data taken as part of the verification of instrument sensitivity and detection limit on at least one representative cement kiln installation.

3.2.8 *BLD or PMD model, n*—a specific BLD or PMD configuration identified by the specific measurement system design, including: (*a*) the use of specific source, detector(s), lenses, mirrors, and other components, (*b*) the physical arrangement of principal components, (*c*) the specific electronics configuration and signal processing approach, (*d*) the specific calibration check mechanisms and drift/dust compensation devices and approaches, and (*e*) the specific software version and data processing algorithms, as implemented by a particular manufacturer and subject to an identifiable quality assurance system.

3.2.8.1 *Discussion*—
Minor changes to software or data outputs that do not affect data processing algorithms or status outputs are not be considered as a model change provided that the manufacturer documents all such changes and provides a satisfactory explanation in a report.

3.2.8.2 *Discussion*—
Software installed on external devices, including external computer systems, and used for processing of the PMD or BLD output to generate average values or activate alarms is not considered part of the PMD or BLD monitoring device.

3.2.8.3 *Discussion*—
For the purposes of this practice, the BLD or PMD includes the following components which are described in subsequent sections: (*a*) internal zero and upscale performance check devices to evaluate instrument drifts while installed on a stack or duct; (*b*) apparatus and means to quantify, independent of the internal zero and upscale performance check devices, the degree to which the response of the BLD or PMD has changed over a period of time.

Analyzer Zero Adjustments and Devices

3.2.9 *external zero audit device, n*—an external device for checking the zero alignment or performance of the measurement system either by simulating with a surrogate the zero-PM condition for a specific installed BLD or PMD or by creating the actual zero-particulate condition.

3.2.10 *internal zero performance check device, n*—an automated mechanism within a BLD or PMD that simulates a zero PM condition while the instrument is installed on a stack or duct using a surrogate appropriate to the measurement technique.

3.2.10.1 *Discussion*—
The internal zero performance check device may be used to check zero drift daily, or more frequently if recommended by the manufacturer, and whenever necessary (for example, after corrective actions or repairs) to assess BLD or PMD performance.

3.2.10.2 *Discussion*—
The proper response to either the external zero audit device or the internal zero performance check device are established with the PMD set up in a clean environment and in such a way that no interference or stray signal reaches the detector. The internal zero performance check device thereby provides the surrogate, simulated zero PM condition while the PMD is in service and the external zero audit device provides a check, which is independent of the internal zero performance check, of the proper performance of the PMD.

3.2.11 *zero alignment, n*—the process of establishing the quantitative relationship between the internal zero performance check device and the zero PM responses of a PMD.

3.2.12 *zero compensation, n*—an automatic adjustment of the BLD or PMD to achieve the correct response to the internal zero performance check device.

3.2.12.1 *Discussion*—
Zero compensation adjustment is fundamental to the BLD or PMD design and may be inherent to its operation (for example,

continuous adjustment based on comparison to reference values/conditions, use of automatic control mechanisms, rapid comparisons with simulated zero and upscale calibration drift check values, and so forth) or it may occur each time a control cycle (zero and upscale performance check) is conducted by applying either analog or digital adjustments within the BLD or PMD.

3.2.13 *zero drift, n*—the difference between the BLD or PMD responses to the internal zero performance check device and its nominal value after a period of normal continuous operation during which no maintenance, repairs, or external adjustments to the BLD or PMD took place.

3.2.13.1 *Discussion*—
Zero drift may occur as a result of changes in the energy source, changes in the detector, variations in internal scattering, changes in electronic components, or varying environmental conditions such as temperature, voltage or other external factors. Depending on the design of the BLD or PMD, PM (that is, dust) deposited on optical surfaces or surface of a probe may contribute to zero drift. Zero drift may be positive or negative. The effects (if any) of dust deposition on optics or deposits on probes will be a monotonically increasing or decreasing function depending on the type of instrument. Particular designs may separate dust compensation and other causes of zero drift.

3.2.14 *light trap, n*—A device used to absorb the projected light from a light scattering BLD or PMD, so as to eliminate false optical scattering due to reflections from the inner walls of a duct or stack.

Analyzer Upscale Calibrations and Adjustments

3.2.15 *internal upscale performance check device, n*—an automated mechanism within a BLD or PMD that (*a*) simulates an upscale value of the parameter sensed by the BLD or PMD while the instrument is installed on a stack or duct and (*b*) provides a means of quantifying consistency or drift in the BLD or PMD response.

3.2.15.1 *Discussion*—
The internal upscale performance check simulates the parameter sensed by the PMD that is related to dust concentration and provides a check of all active analyzer internal components including optics, active electronic circuitry including any light source and detectors, electric or electro-mechanical systems, and hardware, or software within the nominal operating ranges of the instrument.

3.2.15.2 *Discussion*—
The internal upscale performance check for a BLD may include one or a series of checks in order to evaluate all of the active components of the measurement device and provide for the detection of conditions that adversely affect the measurement system performance.

3.2.16 *external upscale audit device, n*—an external device for verifying the stability of the upscale calibration of the BLD or PMD by applying a reference signal or condition independent of the internal simulated upscale calibration device.

3.2.17 *reference signal source, n*—a device that can be used to simulate a signal that the PMD measures, corresponding to a given PM concentration, as established when testing to set up the NFS. In the case of a BLD, the reference signal source may be one or a combination of test signals/conditions that are applied and, taken together, provide a comprehensive test the correct operation of the instrument.

3.2.17.1 *Discussion*—
For a light scattering instrument, the reference signal may be a glass or grid filter that reduces the transmittance of light, or a reflective target of defined reflectivity, such as a photographer's standard, commercially available photo-gray material, or an adjustable iris, or any combination of such elements, that can be used to simulate a given intensity of scattered light corresponding to a given concentration of PM, as established when testing to set up the NFS. Care should be taken to select materials with properties that are not affected by aging.

3.2.17.2 *Discussion*—
The PMD reference signal source or attenuator, components need not be NIST-traceable materials, but need to be commercially available and subject to testing and verification for consistency.

3.2.17.3 *Discussion*—
The PMD external zero audit device and the external upscale audit device may be combined into one device, where the use of design-appropriate PMD reference signal source are used both to create a zero-PM condition and to simulate two or more upscale conditions. For light scattering instruments, the external upscale audit device or combination device may generate the required reference signals by utilizing one or more attenuators, reflectance targets, or other reference materials in any combination to change the intensity of the projected light, or the scattered light reaching the detector.

3.2.17.4 *Discussion*—

The key attributes of the PMD audit device are that: (*a*) it uses the same active components as are used for making the PM measurement; (*b*) it is capable of monitoring any credible change in instrument response not caused by changes in determinant or stack conditions; and (*c*) it checks the instruments components in the same physical and measurement condition as that in making the PM measurement.

3.2.17.5 *Discussion—*

The reference signals applied to the BLD must challenge all of the key active components of the instrument. They are not necessarily a surrogate for dust (as in a PMD), but the reference signals must check the correct operation of the instrument.

3.2.18 *calibration drift, n*—the difference between the BLD or PMD responses to the internal upscale performance check device and its nominal value after a period of normal continuous operation during which no maintenance, repairs, or external adjustments to the BLD or PMD took place.

3.2.18.1 *Discussion—*

Calibration drift may be determined either before or after determining and correcting for zero drift.

3.2.19 *linearity error, n*—the differences between the BLD or PMD readings and the values of two reference signal sources under zero-PM conditions, using the external zero and upscale audit device(s).

3.2.19.1 *Discussion—*

The linearity error indicates the fundamental calibration status of the BLD or PMD.

3.2.20 *instrument response time, n*—the time required for the electrical output of a BLD or PMD to achieve greater than 95 % of a step change in the parameter sensed.

4. Summary of Practice

4.1 This practice provides a comprehensive series of specifications and test procedures that BLD and PMD manufacturers must use to certify systems prior to shipment to the end user. The specifications are summarized in Table 1. Certification of conformance with the requirements of this practice requires providing information or test results, or both, in four parts.

4.2 To satisfy the certification requirements of Part 1 "Manufacturer's Disclosure," the manufacturer is required to provide certain information about the monitoring equipment and written procedures for certain activities to the end user. The specific requirements are included in Section 6.

4.3 To satisfy the certification requirements of Part 2, "Field Demonstration" the manufacturer must conduct a one-time field test at a Portland cement plant for each model (and whenever there is a change in the design that may significantly affect performance) and demonstrate that the BLD or PMD monitoring equipment meets the applicable specifications as provided in Section 7.

4.4 To satisfy the certification requirements of Part 3, "Design Specifications" the manufacturer must certify that the BLD or PMD design meets the applicable requirements for (*a*) measurement output resolution, (*b*) measurement frequency, (*c*) data recording and data averaging, (*d*) internal zero and upscale performance checks, (*e*) external zero audit device, (*f*) external upscale audit capability, and (e) status indicators. In addition, the manufacturer must demonstrate conformance with design specifications for thermal stability, insensitivity to line voltage variation, and insensitivity to ambient light (optical systems) by testing a representative instrument annually (and whenever there is a change in the design, manufacturing process, or component that may affect performance) and demonstrate that the BLD or PMD monitoring equipment meets the applicable specifications as provided in Section 8.

4.5 To satisfy the certification requirements of Part 4 "Performance Specifications" the manufacturer must demonstrate conformance with specifications provided in Section 9 for instrument response time, linearity error and calibration device repeatability by testing each BLD or PMD instrument prior to shipment to the end user. The manufacturer must include procedures for establishing the value for the PMD internal upscale performance check device.

4.6 Guidance and recommendations for determining PMD 15-minute averages, one-hour block averages, and six-hour rolling averages are provided in Appendix X1.

4.7 Guidance and recommendations for setting BLD averaging period, alarm delay, and alarm levels are provided in Appendix X2.

TABLE 1 Summary of Manufacturer's Specifications and Requirements

Specification	Requirement	~~PMD~~	~~BLD~~
~~**Part 1 Manufacture's Disclosure**~~		~~Subsections~~	
Part 1 Manufacture's Disclosure		PMD Subsections	BLD
~~Provide written description of monitor principles, internal calibration checks procedure and limitations, and external audit procedures and limitations~~	~~Provide non-proprietary information for review by users~~	~~6.1~~	~~6.1~~
Provide written description of monitor principles, internal calibration checks procedure and limitations, and external audit procedures and limitations	Provide non-proprietary information for review by users	6.1	6.1
~~Provide written operation, maintenance and quality assurance recommendations~~	~~Provide information for review and reference by users~~	~~6.2~~	~~6.2~~
Provide written operation, maintenance, and quality assurance recommendations	Provide information for review and reference by users	6.2	6.2
~~Provide written procedures for setting BLD alarms~~	~~Provide information for review and reference by users~~	~~NA~~	~~6.3~~
Provide written procedures for setting BLD alarms	Provide information for review and reference by users	NA	6.3
Part 2 Field Demonstration (Test each model once)	90 days field test at cement plant	PMD Subsections	BLD
~~Availability (excluding start-up period)~~	~~≥95 % of source operating time~~	~~7.3~~	~~7.3~~
Availability (excluding start-up period)	≥95 % of source operating time	7.3	7.3
~~Internal Zero Drift~~	~~≤2 % NFS or manufacturer's specification, whichever is most restrictive~~	~~7.4~~	~~7.4~~
Internal Zero Drift	≤2 % NFS or manufacturer's specification, whichever is most restrictive	7.4	7.4
~~Internal Upscale Drift~~	~~≤2 % NFS or manufacturer's specification, whichever is most restrictive~~	~~7.4~~	~~7.4~~
Internal Upscale Drift	≤2 % NFS or manufacturer's specification, whichever is most restrictive	7.4	7.4
~~Repeatability (comparison of two instruments)~~	~~STD of paired differences ≤ 10 % of mean or ≤ 3 % NFS, whichever is least restrictive~~	~~7.5~~	~~7.5~~
Repeatability (comparison of two instruments)	STD of paired differences ≤ 10 % of mean or ≤ 3 % NFS, whichever is least restrictive	7.5	7.5
~~External Zero and Upscale Audit Error~~	~~≤3 % NFS or manufacturer's specification, whichever is most restrictive~~	~~7.6~~	~~7.6~~
External Zero and Upscale Audit Error	≤3 % NFS or manufacturer's specification, whichever is most restrictive	7.6	7.6
~~Analytic Function (comparisons to co-located gravimetric test method results during the first and last month of test period)~~	~~PMD Correlation Coefficient ≥0.85~~ ~~BLD Correlation Coefficient ≥0.75~~ ~~Confidence Interval ≤1 %~~ ~~Tolerance Interval ≤25 %,~~	~~7.7.10~~	~~7.7.10~~
Analytic Function (comparisons to co-located gravimetric test method results during the first and last month of test period)	PMD Correlation Coefficient ≥0.85 BLD Correlation Coefficient ≥0.75 Confidence Interval ≤1 % Tolerance Interval ≤25 %	7.7.10	7.7.10
	~~Optional Specification 1 (when test concentrations are limited by operational constraints):~~ ~~Relative Accuracy ≤20 %~~	~~7.7.11~~	~~7.7.11~~
	Optional Specification 1 (when test concentrations are limited by operational constraints): Relative Accuracy ≤20 %	7.7.11	7.7.11
	~~Optional Specification 2 (when the mean test concentrations are less than 5 mg/acm [0.002 gr/acf]):~~ ~~Correlation Coefficient ≥0.75~~	~~7.7.12~~	~~7.7.12~~
	Optional Specification 2 (when the mean test concentrations are less than 5 mg/acm [0.002 gr/acf]): Correlation Coefficient ≥0.75	7.7.12	7.7.12
~~Field Detection Limit~~	~~Determine and report as specified:~~ ~~Noise Limited Detection Limit~~ ~~Observed Detection Limit~~	~~7.8~~	~~7.8~~
Field Detection Limit	Determine and report as specified: Noise Limited Detection Limit Observed Detection Limit	7.8	7.8
Part 3 Design Specifications (Test representative instrument once per year for each model)		PMD Subsections	BLD
~~Measurement output resolution~~	~~≥0.5 % NFS~~	~~8.2~~	~~8.2~~
Measurement output resolution	≥0.5 % NFS	8.2	8.2
~~Measurement frequency~~	~~15 seconds~~	~~8.2~~	~~8.2~~
Measurement frequency	15 seconds	8.2	8.2
~~Data recording~~	~~60 seconds~~	~~8.2~~	~~8.2~~
Data recording	60 seconds	8.2	8.2
~~PMD data averaging~~	~~15 minute periods and hourly averages (External devices may be used for averaging and recording data)~~	~~8.2~~	~~NA~~
PMD data averaging	15 minute periods and hourly averages (external devices may be used for averaging and recording data)	8.2	NA
~~BLD data averaging~~	~~Manufacture to specify based on alarm procedure~~	~~NA~~	~~8.2~~
BLD data averaging	Manufacture to specify based on alarm procedure	NA	8.2
~~Internal zero performance check device~~	~~Automated mechanism required~~	~~8.3.1~~	~~8.3.3~~
Internal zero performance check device	Automated mechanism required	8.3.1	8.3.3

Specification	Requirement	~~PMD~~	~~BLD~~
~~Internal upscale performance check device~~	~~Automated mechanism required~~	~~8.3.2~~	~~8.3.3~~
Internal upscale performance check device	Automated mechanism required	8.3.2	8.3.3
~~External zero audit device~~	~~Required~~	~~8.4~~	~~8.4~~
External zero audit device	Required	8.4	8.4
~~PMD external upscale audit device~~	~~Must provide upscale check of parameter sensed by PMD at two levels and include source, detector, and all active measurement components~~	~~8.4~~	~~NA~~
PMD external upscale audit device	Must provide upscale check of parameter sensed by PMD at two levels and include source, detector, and all active measurement components	8.4	NA
~~BLD external upscale audit device~~	~~A check, or series of checks when combined, which test the status of the upscale response and integrity of measurement device~~	~~NA~~	~~8.4~~
BLD external upscale audit device	A check, or series of checks when combined, which test the status of the upscale response and integrity of measurement device	NA	8.4
~~External audit device repeatability~~	~~±2.0 % NFS~~	~~8.4~~	~~8.4~~
External audit device repeatability	±2.0 % NFS	8.4	8.4
~~Status indicators~~	~~Manufacturer to identify and specify~~	~~8.5~~	~~8.5~~
Status indicators	Manufacturer to identify and specify	8.5	8.5
~~Insensitivity to supply voltage variations~~	~~±1.0 % NFS change over specified range of supply voltage variation, or ±10 % variation from the nominal supply voltage~~	~~8.6~~	~~8.6~~
Insensitivity to supply voltage variations	±1.0 % NFS change over specified range of supply voltage variation, or ±10 % variation from the nominal supply voltage	8.6	8.6
~~Thermal stability~~	~~±2.0 % NFS change per 22ºC (40°F) change over specified operational range~~	~~8.7~~	~~8.7~~
Thermal stability	±2.0 % NFS change per 22ºC (40°F) change over specified operational range	8.7	8.7
~~Insensitivity to ambient light (optical instruments only)~~	~~±2.0 % NFS max. change for solar radiation level of ≥900 W/m²~~	~~8.8~~	~~8.8~~
Insensitivity to ambient light (optical instruments only)	±2.0 % NFS max. change for solar radiation level of ≥900 W/m²	8.8	8.8

Part 4 Performance Specifications (Test Each Instrument)		PMD Subsections	BLD
~~PMD instrument response time~~	~~≤15 seconds to 95 % of final value~~	~~9.3~~	~~NA~~
PMD instrument response time	≤15 seconds to 95 % of final value	9.3	NA
~~BLD instrument response time~~	~~≤1 second to 95 % of final value~~	~~NA~~	~~9.3~~
BLD instrument response time	≤1 second to 95 % of final value	NA	9.3
~~Linearity error~~	~~≤3 % NFS for two upscale values~~	~~9.4~~	~~9.4~~
Linearity error	≤3 % NFS for two upscale values	9.4	9.4
~~Calibration device repeatability~~	~~≤1.5 % NFS~~	~~9.5~~	~~9.5~~
Calibration device repeatability	≤1.5 % NFS	9.5	9.5

~~"NFS" is nominal full scale as defined 3.2.6.2~~
"NFS" is nominal full scale as defined 3.2.7.1.

4.8 This practice establishes appropriate guidelines for QA programs for manufacturers of BLDs and PMDs. These guidelines include corrective actions when information provided by the manufacturer is determined to be incorrect or non-representative based on field applications, or when non-conformance with specifications is detected through periodic tests. Non-conformance with the design or performance specifications requires corrective action and retesting of the affected model(s)

5. Significance and Use

5.1 EPA regulations require Portland cement plants that burn hazardous waste to use BLDs or PMDs to provide either a relative or an absolute indication of PM concentration and to alert the plant operator of the need to inspect PM control equipment or initiate corrective action. EPA and others have not established for these applications specific design and performance specifications for these instruments. The design and performance specifications and test procedures contained in this practice will help ensure that measurement systems are capable of providing reliable monitoring data.

5.2 This practice identifies relevant information and operational characteristics of BLD and PMD monitoring devices for Portland cement kiln systems. This practice will assist equipment suppliers and users in the evaluation and selection of appropriate monitoring equipment.

5.3 This practice requires that tests be conducted to verify manufacturer's published specifications for detection limit, linearity, thermal stability, insensitivity to supply voltage variations and other factors so that purchasers can rely on the manufacturer's published specifications. Purchasers are also assured that the specific instrument has been tested at the point of manufacture and shown to meet selected design and performance specifications prior to shipment.

5.4 This practice requires that the manufacturer develop and provide to the user written procedures for installation start-up, operation, maintenance, and quality assurance of the equipment. This practice requires that these same procedures are used for a field performance demonstration of the BLD or PMD monitoring equipment at a Portland cement plant.

5.5 The applicable test procedures and specifications of this practice are selected to address the equipment and activities that are within the control of the manufacturer.

5.6 This practice also may serve as the basis for third party independent audits of the certification procedures used by manufacturers of PMD or BLD equipment.

6. Manufacturer's Disclosure

6.1 The equipment manufacturer shall provide a written statement and relevant information for each BLD or PMD model as part of the manufacturer's certification of conformance with this practice in response to the issues identified below. (In the event the manufacturer has no reliable information about a particular area, the certification shall explicitly state that it is "unknown" or information is "not available.")

6.1.1 Measurement principle description and specific parameter(s) monitored. (For example, a light transmittance measurement system may be used and the optical density output may be monitored.)

6.1.2 Nominal PM concentration measurement range(s) (in units of mg/acm) over which monitoring device can meet all specifications in this practice and corresponding instrument output units. The minimum detection limit, minimum practical quantification level, and nominal maximum PM concentration level should be indicated.

6.1.3 *Analytic Function*—Linear or other output that can be corrected to provide a linear system response.

6.1.4 Description of internal zero and upscale performance checks. Identification of components or influences excluded from these checks and explanation of the underlying assumptions, and other relevant limitations.

6.1.5 Description of external audit capabilities and audit materials that can be used for periodic independent checks. Identification of components or influences excluded from such external audits and explanation of the underlying assumptions, and other relevant limitations.

6.1.6 Identification and description of known uncontrollable effluent or PM variables that affect the PMD or BLD response. Quantitative information should be provided if available from the manufacturer conducted tests or appropriately referenced based on TUV, MCERTS, or other similar tests or evaluations, if available.[5]

6.1.7 A description of cross sensitivities and interferences due to changing effluent conditions that are expected to occur when monitoring kiln emissions at cement plants burning hazardous waste. This shall include statements regarding the PMD or BLD response to changes in effluent (*a*) flow rate or velocity at the point of measurement, (*b*) effluent temperature, (*c*) effluent moisture content, (*d*) effluent gas composition, and (*e*) other known factors, if any. Table 2 provides nominal measurements and effluent values and ranges of variation for several representative applications at Portland cement plants.

6.1.8 Explicit statements regarding the applicability of the monitoring device (*a*) downstream of electrostatic precipitators, (*b*) downstream of fabric filters, (*c*) where water droplets or condensed mists are present at the monitoring location, or (*d*) other applicable limitations.

6.2 The manufacturer shall provide written procedures for installation, start-up, operation and maintenance, and quality assurance of BLDs and PMDs. The manufacturer shall identify those activities, ~~and/or~~or QA check/maintenance intervals, or both, or other factors that may need to be adjusted based on site-specific conditions.

6.3 BLD manufacturers shall provide detailed written procedures for establishing alarm levels for BLDs including provisions for adjustment of the averaging period, alarm delay, and alarm set point, and any other parameters appropriate for source-specific conditions. The manufacturer shall specify the minimum (or range) BLD monitoring period necessary to establish the alarm set point. The manufacturer shall provide criteria for re-setting the alarm point.

[5] (Note: TÜV (Technischer Überwachungs Verin) is an internationally recognized certification and testing organization in the Federal Republic of Germany (with offices word wide) that performs laboratory and field tests of environmental monitoring instrumentation for TUV approaval. MCERTS is the Monitoring and Certification Scheme of the United Kingdom and includes laboratory and field testing of environmental monitoring systems.)

TABLE 2 Typical Portland Cement Effluent Characteristics

Wet process cement kiln with ESP control	
PM concentrations	10–40 mg/acm (0.004–0.017 gr/acf) with short term variability due to rapping in ESP
Six-Minute Opacity	4–20 % opacity
~~Moisture Content~~	~~30 % (water droplets may be present during start-up or while shutting down.~~
Moisture Content	30 % (water droplets may be present during start-up or while shutting down)
Effluent Temperature (at stack testing location)	180–232ºC (350–450°F)
Flow Rate	80 000–100 000 acfm Varying ±10 % and proportional to production rate (except for start-up and shut down, or waste fuel cut off transients)
SO_2	300–800 ppm (2–10 ppm H_2SO_4)
NO_x	300–1200 ppm
HCl	1 to 13 ppm
NH_3	1–10 ppm

Contemporary pre-heater pre-calciner kiln system with in-line raw mill		
	Mill On (90 % of operating time)	Mill Off (10 % of operating time)
PM concentrations	3–8 mg/acm (0.0013–0.0034 gr/acf)	4–10 mg/acm (0.0017–0.0043 gr/acf)
6-Minute Opacity	2–20 % opacity	2–20 % opacity
Moisture Content	12–18 %	May decrease 1–2 % H_2O
Effluent Temperature (at stack testing location)	120–180ºC (250–350°F)	May increase 30ºC (50°F)
Flow Rate	400 000 acfm	May increase 5–15 %
SO_2	200–300 ppm (2–3 ppm H_2SO_4)	May increase 50–100 ppm
NO_x	200–400 ppm	200–400 ppm
HCl	2–50 ppm	10–60 ppm
NH_3	1–10 ppm	May have five fold transient increase when mill shuts down
May have co-mingled emissions from coal mill, alkali bypass, or clinker cooler PM control systems at kiln system test location.		

7. Field Demonstration

7.1 *Representative Instrument*—Perform the field performance specification verification procedures in this section for each representative model or configuration involving substantially different sources, detectors, active components, electronics, or software and include the results in a report. Perform the tests on a representative instrument installed to monitor kiln emissions at a Portland cement plant.

7.2 *Operational Period*—Operate the BLD or PMD for a period of at least 90 days in accordance with the manufacturer's written installation, operation and maintenance procedures, as provided in response to the requirement in 6.2 during the test program.

7.3 *Monitor Availability*—Report all malfunctions or breakdowns, maintenance and corrective actions performed during the test period. After completing all BLD or PMD start-up activities (not to exceed 14 days), calculate and report the percent monitor availability achieved (excluding, all invalid data, monitor downtime, monitor maintenance time, etc.) as a fraction of source operating hours during the test period. Percent monitor availability ≥95 % is acceptable.

7.4 *Drift Test*—Perform internal zero and upscale performance check cycles daily, or more frequently if recommended by the manufacturer's written procedures, for at least seven consecutive days and verify that the instrument drift (difference between current value and reference value) is within ±2 % NFS or the manufacturer's published specification, whichever is more restrictive. Intrinsic and automatic adjustments may be performed at any time, and prescribed maintenance may be performed in accordance with the manufacturer's written procedures.

7.5 *Repeatability Test*—Perform a repeatability test by installing two PMDs or two BLDs of the same model at sampling locations expected to provide comparable results. Summarize the concurrent one-hour average outputs (or other representative period) of the two instruments recorded at approximately eight-hour intervals (three times per day) for a period including at least 60 days of concurrent operation. Reject non-representative data, missing pairs of data during maintenance or other downtime. The repeatability is acceptable if the standard deviation of the differences between the monitor responses is less than 10 % of the average of the two instruments, or 3 % of NFS, whichever is less restrictive.

7.6 *External Audit*—Conduct audits of the installed BLD(s) or PMD(s) using the external audit device two or more times at least 30 days apart during the field test. Verify that the linearity error at zero and two upscale levels during the external audits is ≤3 % NFS or the manufacturer's published specification, whichever is more restrictive.

7.7 *Analytic Function Testing*—Conduct independent PM concentration tests to verify the ability of the BLD or PMD to indicate PM Concentrations. Using Test Method D6831 is strongly recommended, especially for sources with low PM concentrations and sources with significant temporal variability as indicated by the PMD or BLD. Other in-stack filtration manual test methods may be used, such as 40 CFR 60, Appendix A, Method 17, or EN 13284-1, etc. These methods may provide acceptable comparisons for sources with emissions above 20 mg/acm (0.0086 gr/acf). However, the apparent acceptability of the monitoring instrument may be adversely affected by the test method limitations, including poor precision at low concentrations and as well as actual PM concentration variability during the sample run. Out-of-stack filtration methods, such as 40 CFR 60, Appendix A, Method 5 or 5I may also be used. However, these methods are subject to the same limitations as Method 17 and may also result in the measurement of condensable or reactive compounds that are not present in the effluent stream as PM. For example, gaseous ammonia may react with HCl or sulfur compounds and form PM that is not present in the effluent stream and thus not seen by the PMD or BLD.

7.7.1 *Discussion*—Test Method D6831 can resolve in-situ PM concentrations of 0.5 mg/acm (0.0002 gr/acf). If actual PM concentrations during the test are below 5 mg/acm (0.002 gr/acf), it is very likely that measurement error will adversely affect any attempt to establish a statistical correlation. In these cases, extra care is required in performing the tests.

7.7.2 *Filter Temperature*—Operate the Test Method D6831 with the filter temperature 5°C (9°F) above the effluent temperature.

7.7.3 *Sampling Points*—Co-locate the Test Method D6831 sampling probe as close as practical to the BLD or PMD sampling point, volume, or path, as applicable. For path measurement devices, perform a stratification traverse parallel to the BLD or PMD path. If stratification is indicated, select multiple measurement points (four or more evenly spaced traverse points) to represent the average PM concentration along the measurement path.

NOTE 5—The purpose of the test is to determine the analytical function of the PMD or BLD relative to the PM concentration passing through the measurement volume. Therefore, the reference sampling probe is positioned as close as practical to the measurement volume and traverses of the stack cross-section are not performed.

7.7.4 Conduct tests during periods that are representative of the normal range of emissions, and normal range of process and control equipment operations (raw mix or slurry feed rate, raw mix or slurry composition, waste feed rate, waste feed composition, dust re-injection, etc.) as selected by the plant operator. For plants with ESP controls, conduct tests at two or more ESP power settings. For plants with in-line raw mills, conduct testing under both "mill on" and "mill off" conditions.

7.7.5 Select sample run durations to provide representative measurement results as indicated by the variability of emissions on the Test Method D6831 instrument's real-time output. Typically, sample run durations range from 5 to 20 minutes. Multiple consecutive test runs can be performed without removal of the microbalance from the duct or stack and without filter replacement. For high level emissions, sample periods may range from 1 to 3 hours before filter replacement is necessary. For low level emissions, sampling may be performed for 8 hours, or longer before filter replacement is necessary.

7.7.6 If upset or transient conditions occur during a particular test period, discard the Test Method D6831 data and the concurrent BLD or PMD data for those sample runs or periods, or adjust the run start and stop times to avoid including the emission anomaly in the comparison.

7.7.7 For sources without water droplets, perform the comparison of the Test Method D6831 results and BLD or PMD data without desiccation of the filter. Perform filter stabilization and nozzle recovery procedures only between consecutive sampling