ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION
WASHINGTON, D.C. 20460

June 22, 2026

Mr. Anthony Ferro
Owner/Managing Member
Opacity Vision VR, LLC
1604 NE Jaclyn Drive
Grain Valley, Missouri 64029

Dear Mr. Ferro,

I am writing in response to your February 17, 2026, letter to the U.S. Environmental Protection Agency (EPA) seeking approval of a virtual reality (VR) Method 9 training system for use as described in alternative test method 152 (ALT-152). ALT-152 was approved on August 22, 2023, as a broadly applicable alternative test method to the certification procedures required for opacity observers under section 3.2 of Method 9 – Visual Determination of the Opacity of Emissions from Stationary Sources (40 CFR part 60, Appendix A). The EPA's Office of Air and Radiation is the delegated authority for determinations on any major alternatives to test methods and other compliance determination procedures required under 40 CFR parts 59, 60, 61, 63, and 65.

Based on a thorough review of the information provided by Opacity Vision VR, LLC, the EPA concludes that the alternative method yields observers that are capable of conducting opacity observations with equivalent or better accuracy than those certified using the existing Method 9 procedures. Therefore, the use of the VR headset-based alternative method described in the enclosures is approved for conducting Method 9 plume demonstrations and certification as described in ALT-152. A copy of this letter will be posted as ALT-152C on the EPA website at https://www.epa.gov/emc/broadly-applicable-approved-alternative-test-methods.

If there are additional questions regarding this approval, please contact the Measurement Technology Branch at emc@epa.gov.

Sincerely,

Aaron Szabo
Assistant Administrator
Office of Air and Radiation

Enclosure(s) –

1. Request Correspondence of February 17, 2026
2. Details Regarding the Use of this Alternative Test Method
3. ALT-152 VR Method 9 Observer Training and Certification - Group Study & EPA Approval Submission

cc:

Gregory Fried, EPA
Gerri Garwood, EPA
Regional Testing Contacts

Enclosure 1: Request Correspondence of February 17, 2026

Enclosure 2: Details Regarding the Use of this Alternative Test Method

On August 22, 2023, the U.S. Environmental Protection Agency (EPA) approved ALT-152 to allow a novel approach for certification of candidate Method 9 observers that relies on the use of a virtual reality (VR) headset. The EPA determined that the VR headset-based alternative method for conducting Method 9 plume demonstrations and certification yields observers that are capable of conducting opacity observations with equivalent or better accuracy as observers certified using the existing Method 9 procedures.

ALT-152 requires other entities seeking to conduct Method 9 observer training and certification according to specifications in the alternative to:

- Have a documented certification system that meets all the criteria contained in ALT-152, including the attachment, and provide a demonstration to the EPA's Measurement Technology Branch (formerly the Measurement Technology Group); and
- Have performed and submitted to the EPA's Measurement Technology Branch for review and approval a successful demonstration of the VR training system according to EPA-650/4-75-009 (Evaluation and Collaborative Study of Method for Visual Determination of Opacity of Emissions from Stationary Sources).

On February 17, 2026, Opacity Vision VR, LLC submitted a report containing the results of the demonstration of a VR Method 9 training system according to EPA-650/4-75-009. Opacity Vision VR, LLC also provided a criteria list detailing how the system meets or surpasses the criteria contained in ALT-152. Additionally, Opacity Vision VR, LLC provided the EPA's Measurement Technology Branch access to its domain to allow for evaluation of the VR Method 9 training system.

Applicable Regulations and Relevant References

- 40 CFR part 60, Appendix A, Method 9: Visual Determination of the Opacity of Emissions from Stationary Sources.
- U.S. Environmental Protection Agency. (1975). *Evaluation and Collaborative Study of Method for Visual Determination of Opacity of Emissions from Stationary Sources* (Report No. EPA-650/4-75-009). https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100AVLQ.PDF

Enclosure 3: ALT-152 VR Method 9 Observer Training and Certification - Group Study & EPA Approval Submission

02/17/2026

Kim Garnett

U.S. Environmental Protection Agency

Office of Air Quality Planning and Standards

Measurement Technology Group (C439-02)

109 T.W. Alexander Drive

Research Triangle Park, NC 27711

RE: Request for Approval of VR-Based Method 9 Certification System Under ALT-152

Dear Ms. Garnett,

Opacity Vision VR, LLC respectfully submits this request for approval of its virtual reality–based Method 9 observer training and certification system under Alternative Test Method 152 (ALT-152).

The enclosed submission documents the design, operation, and validation of the Opacity Vision VR Method 9 Certification System, including:

- Complete system specifications for video capture, processing, and VR presentation
- Results of a collaborative group study with 10 observers demonstrating equivalency to traditional Method 9 certification
- Detailed compliance documentation for all ALT-152 technical requirements

Our study results demonstrate that observers trained and certified using the Opacity Vision VR system achieve accuracy levels consistent with or exceeding historical Method 9 benchmarks using the same group-mean deviation methodology established in EPA-650/4-75-009.

Respectfully submitted,

_____

Anthony Ferro

Owner / Managing Member

Opacity Vision VR, LLC

1604 NE Jaclyn Drive

Grain Valley, MO 64029

Email: anthony@opacityvision.com

Enclosures:

- ALT-152 Submission Report
- Attachment A: ALT-152 Criteria Compliance Matrix
- Attachment B: Deviation Data Tables
- Attachment C: Test Conditions

ALT-152 VR Method 9 Observer Training and Certification

Group Study & EPA Approval Submission

Opacity Vision VR, LLC

Submitted to:

U.S. Environmental Protection Agency

Office of Air Quality Planning and Standards

Measurement Technology Group

Submission Date: _____02/17/2026_____

Applicant Information

Field	Information
Applicant Organization	Opacity Vision VR, LLC
System Name	Opacity Vision VR Method 9 Certification System
Primary Contact	Anthony Ferro, Owner / Managing Member
Co-Owner	Bradley Singleton (Singleton Smoke School)
Address	1604 NE Jaclyn Drive, Grain Valley, MO 64029
Email	anthony@opacityvision.com
Phone	816-605-8765
Submission Date	01/29/2026

1. Purpose of Submission

This document is submitted in support of a request for approval of a virtual reality (VR)–based Method 9 observer training and certification system pursuant to Alternative Test Method 152 (ALT-152), as an alternative to the certification procedures specified in Section 3.2 of Method 9 – Visual Determination of the Opacity of Emissions from Stationary Sources (40 CFR Part 60, Appendix A).

The purpose of this submission is to document:

- The design and operation of the VR-based training and certification system
- Compliance with all technical, procedural, and data-retention requirements of ALT-152
- Results of a group study demonstrating equivalency to traditional Method 9 certification conducted using a smoke generator and transmissometer consistent with EPA-650/4-75-009

2. System Overview

2.0 Ownership and Development Structure

Opacity Vision VR, LLC is a standalone legal entity jointly owned by Anthony Ferro and Bradley Singleton. The company is independent of, and separate from, both Opaque Smoke School and Singleton Smoke School.

The Opacity Vision VR Method 9 Certification System was jointly developed by the owners leveraging their respective experience operating independent Method 9 smoke school programs. While development incorporated operational knowledge from both Opaque Smoke School and Singleton Smoke School, all VR system assets, software, certification workflows, and compliance responsibilities reside with Opacity Vision VR, LLC.

Approval of this system is requested solely for Opacity Vision VR, LLC as the applicant entity under ALT-152.

2.1 Description of the VR Certification System

The Opacity Vision VR Method 9 Certification System replaces the traditional in-person smoke school plume demonstrations with a virtual reality–based presentation of recorded black and white smoke plumes of known and unknown opacity.

Candidate observers utilize a VR headset to:

- View standard opacity reference plumes
- Participate in practice observations
- Complete a certification test consisting of 25 black smoke plumes and 25 white smoke plumes presented in randomized order

Except for the method of plume presentation and test administration, all certification criteria remain identical to those specified in Section 3.2 of Method 9.

2.2 Certification Criteria

To qualify as a certified observer, candidates must:

- Assign opacity values in 5 percent increments
- Demonstrate no single-reading deviation exceeding 15 percent opacity
- Demonstrate an average deviation not exceeding 7.5 percent opacity for each smoke color
- Complete the full 50-reading test sequence within the allowed time of 90 minutes.

Failure of the certification test requires repetition of the complete 50-reading sequence.

3. Video Capture and Processing Methodology

3.1 Source Video Capture

3.1.1 Camera Geometry, Distance, and Viewing Angle

All smoke plume video recordings were conducted with camera positioning and geometry consistent with Method 9 observer requirements and ALT-152 specifications. Camera setup parameters were documented for each recording session and retained as part of the permanent source archive.

Parameter	Implementation
Camera-to-Stack Distance	45–85 feet, depending on site constraints and background availability
Horizontal Viewing Angle	≤18° between camera lens axis and stack exit
Sun Position	Within 140° sector behind camera lens
Stack Exit Position	Nominally centered in frame during recording
Field of View	Adjusted to ensure full plume visibility with clear background
Background Selection	Blue sky, white cloud, or vegetative background consistent with Method 9 guidance

Camera distance, direction (azimuth), and sun angle relative to the stack were recorded for each capture session.

3.1.2 Background Selection by Smoke Color

Backgrounds selected for plume recording were chosen to provide sufficient and appropriate contrast for each smoke color in accordance with Method 9 guidance and ALT-152 requirements.

- **Black smoke plume recordings** utilize backgrounds consisting of a consistent gray/bluish sky or blue sky with broken white cloud cover. These conditions provided clear plume edge visibility and stable contrast while avoiding glare or solar washout.
- **White smoke plume recordings** utilize darker natural backgrounds, including dense pine and deciduous tree cover, to ensure adequate contrast between the plume and background.

In all cases, background conditions provided sufficient contrast for clear plume visibility. Background type was documented for each recording session.

3.1.3 Trailer-Based System Configuration and Calibration

All plume recordings were conducted using a trailer-mounted smoke generator and measurement system calibrated and verified in accordance with Method 9, Section 3 requirements. Prior to each filming session, zero and span calibration checks were performed using the SmokeVision DAQ system implemented on a custom Arduino-based platform.

Calibration and verification data, including zero opacity voltage, span (100%) voltage, filter calibration values, timestamps, and associated session metadata, were digitally recorded by the Arduino system and transmitted to the SmokeVision DAQ database. These records are retained as part of the permanent calibration and audit trail and are available for EPA review upon request.

The trailer-based configuration ensures stable camera positioning, consistent sensor alignment, and repeatable geometry between filming sessions. Calibration verification was performed immediately prior to plume recording to ensure compliance with Method 9 Section 3 measurement specifications and data integrity requirements.

Black and white smoke plume videos were recorded using a Method 9–compliant smoke generator with simultaneous transmissometer measurements. Data acquisition and synchronization were performed using a custom Arduino-based data acquisition system developed by Ferro Consulting LLC

3.1.4 Camera System Specifications

Component	Specification
Camera Body	Canon R5 (video capture for plume library)
Lens	Canon EF 70–200mm f/2.8L IS III USM
Recording Format	RAW / visually lossless codec
Color Depth	≥12-bit
Resolution	4096 × 2160 (DCI 4K)
Frame Rate	29.97 fps (Canon native frame rate)
Timecode	Per-frame timecode recorded

3.1.5 DAQ / Transmissometer System Specifications

Component	Specification
DAQ Platform	Arduino Uno R4 WiFi (custom SmokeVision DAQ firmware: Agamotto 5.5.3.z)
ADC Resolution	14-bit hardware ADC (analogReadResolution(14))
Analog Front-End	On-board OPAMP utilized for signal conditioning (OPAMP high-speed mode)
Sampling Rate	1 sample every 50 ms (~20 Hz target); sample validation yields 13–20 validated samples per second.
Opacity Logging Window	15.3 seconds recorded per capture; trimmed to 6–7 second usable clips representing stable opacity for certification
Timestamping	NTP-synchronized UTC time; per-sample time recorded at 0.1 s resolution or better
Data Storage	Local SD logging (text + JSONL + per-sample CSV/flat files) with redundant digital archive
Connectivity	WiFi multi-SSID failover; WebSocket telemetry to SmokeVision DAQ server
Camera Trigger Sync	Opto-isolated camera trigger control (OPTO_PIN) with start/stop pulse control

3.1.6 Capture and Measurement Sequence

When a test point is initiated, the system triggers the camera via opto-isolated control while simultaneously sampling opacity at approximately 20 Hz for 15.3 seconds. The system validates each sample, yielding an effective rate of 13–20 samples per second. Final logged opacity is computed using a constrained rolling and statistical processing method, with both summary-level and per-sample data recorded. Source recordings are then trimmed to 6–7 second usable clips representing stable opacity conditions for certification testing.

A white balance reference was recorded in each frame during capture. Source video files and synchronized transmissometer data are archived and retained in accordance with ALT-152 requirements.

3.2 Processed Certification Videos

Processed videos used for certification testing:

- Maintain full DCI 4K resolution (4096 × 2160)
- Frame rate of 29.97 fps
- Encoded at an average bitrate of ~100-160 Mbps, exceeding the ALT-152 minimum requirement of approximately 25.6 Mbps for DCI 4K resolution
- Remove all audio and visual aids
- Represent a single opacity value per clip
- Maintain opacity accuracy within ±2.5 percent based on a rolling average

White balance references recorded during capture are preserved in source footage. During certification testing, the application's response grid overlays the reference area to eliminate visual cues while preserving full-resolution video integrity.

4. VR Application and Test Administration

4.1 Application Features

The VR application used for training and certification:

- Displays standard reference opacities for both smoke colors
- Provides optional practice tests
- Presents 5–10 seconds of continuous smoke per observation
- Records each observer response prior to advancing
- Randomizes plume selection from a library of at least 600 clips per smoke color
- Ensures a test sequence repeat probability greater than one in one million
- Requires observer attestation that responses are their own

4.2 VR Headset Specifications

The VR headset used for training and certification was the Meta Quest 3. Specifications were verified against manufacturer documentation and in-application performance testing.

Requirement (ALT-152 Minimum)	Meta Quest 3 Implementation
Refresh rate >60 Hz	90 Hz
Horizontal field of view >90°	~110° (manufacturer specification)
Horizontal pixels per degree >17	~25 PPD (manufacturer specification)
Ambient light blocking	Full light isolation via facial interface
Head tracking	Full 6DOF head tracking (yaw, pitch, roll)

5. Group Study Design

5.1 Participant Selection

The group study included 10 adult participants. Participants:

- Had no prior Method 9 certification
- Had no prior opacity observation experience unless otherwise noted
- Were trained exclusively using the Opacity Vision VR training system prior to field observations

Participants are identified by numeric identifier only (Observer 1, Observer 2, etc.). No personally identifiable information, resumes, or employment history are included.

Because EPA-650/4-75-009 reports group-mean results for nine observers, comparisons were conducted at the group-mean level rather than individual observer matching.

5.2 Training Procedure

Participants completed:

- VR-based instructional content covering Method 9 principles
- Standard opacity reference demonstrations
- Optional practice observations
- VR-based certification testing prior to field participation

6. Field Observation Testing

6.1 Test Setup

Following successful VR-based training and certification, All ten VR-certified participants completed live field opacity observations using a Method 9–compliant smoke generator and transmissometer. No participant received in-person smoke school instruction prior to VR training or certification.

Observers were recruited on a volunteer basis at multiple locations across the United States during scheduled smoke school travel between January 4th and January 28th, 2026. Participants were selected opportunistically from individuals with no prior Method 9 certification and no professional opacity observation background, providing a geographically and experientially diverse study group.

Live field testing was conducted for the purpose of post-certification validation and consisted of:

- 20 runs of white smoke
- 16 runs of black smoke
- 25 consecutive opacity readings per run
- All live field observations were conducted under conditions consistent with traditional Method 9 evaluations.

6.2 Test Conditions

Detailed test conditions including dates, times, weather data, and observer positioning are documented in Attachment C.

7. Data Analysis Methodology

Observer readings were compared to transmissometer measurements in accordance with EPA-650/4-75-009. Accuracy was assessed as the absolute deviation between each observer's reported opacity and the true opacity measured by the transmissometer.

For each observer and each smoke color:

- The range of mean absolute deviation values observed during VR-based testing was recorded
- A midpoint value was calculated for internal comparison purposes
- Live field results were summarized using group mean absolute deviation

Results were compared to the historical group mean absolute deviation reported in the EPA collaborative study (EPA-650/4-75-009), which serves as the established in-person smoke school benchmark. Because the original EPA collaborative study reports group mean deviation values only, comparisons to traditional in-person performance were conducted at the group-mean level.

8. Results Summary

8.1 Individual Observer Results (VR-Based Certification)

Observer ID	VR Deviation Range – White (%)	VR Deviation Range – Black (%)	White Midpoint (%)	Black Midpoint (%)
1	2.50–2.65	2.65–3.10	2.58	2.88
2	2.45–2.65	2.75–2.95	2.55	2.85
3	2.55–2.75	2.70–2.90	2.65	2.80
4	2.60–2.80	2.80–3.00	2.70	2.90
5	2.50–2.62	2.30–2.50	2.56	2.40
6	2.60–2.80	2.80–3.00	2.70	2.90
7	2.65–2.85	2.85–3.05	2.75	2.95
8	2.60–2.80	2.80–3.00	2.70	2.90
9	2.80–3.00	2.75–2.95	2.90	2.85
10	2.70–2.90	2.90–3.10	2.80	3.00

All observers met Method 9 certification criteria, including:

- No single-reading deviation exceeding 15%
- No average deviation exceeding 7.5% for either smoke color
- Minor differences in absolute average deviation values reflect dataset scope and environmental variability between VR-based certification testing and live field observations

8.2 Live Field Observation Results (Post-VR Validation)

Following VR certification, the same observers completed live field opacity observations. The group mean absolute deviation from transmissometer values during live field testing was:

White Smoke (Live Field): 2.30%

Black Smoke (Live Field): 2.83%

8.3 Comparative Results

Comparison of VR-based certification results and subsequent live field performance indicates:

- VR midpoint deviation values closely align with live field group mean values for both smoke colors

- Differences between VR-based and live field results were less than 1%
- Both VR-based and live field results demonstrate lower deviation than the historical in-person benchmark reported in EPA-650/4-75-009

These findings indicate strong transfer of training from VR certification to live field observation and demonstrate that VR-based Method 9 training produces observer accuracy consistent with real-world performance.

8.4 Comparison to EPA-650/4-75-009 Benchmark

Metric	EPA-650/4-75-009	Opacity Vision VR
White Smoke Group Mean Deviation	3.74%	2.30%
Black Smoke Group Mean Deviation	3.33%	2.83%

9. Data Collection and Retention

9.1 Application Versioning

The VR certification application version, firmware version, and VR headset operating system version used during each certification test are digitally recorded and retained as part of the permanent certification record.

Component	Version
VR Application Version	1.0
DAQ Firmware Version	Agamotto 5.5.3.z
VR Headset Model	Meta Quest 3
VR Headset OS Version	Horizon OS v81.0 (at the time of testing)

9.2 Data Retention Policy

All data associated with video capture, training, certification, and field testing are retained for a minimum of five (5) years, including:

- Source video files
- Transmissometer data
- Observer responses
- Grading results

- Test timestamps
- Application and headset version information

Attachment A – ALT-152 Criteria Compliance Matrix

The following tables document compliance with each ALT-152 requirement and indicate where the Opacity Vision VR system meets or exceeds the specified criteria.

A.1 Video Recording Requirements

ALT-152 Requirement	Opacity Vision VR Implementation	Status
Sun position within 140° sector behind camera	Documented for each recording session; verified prior to capture	**Meets**
Camera-to-stack angle ≤18°	≤18° maintained; angle recorded per session	**Meets**
White balance reference in each frame	Recorded in every source frame	**Meets**
Color depth ≥12-bit	≥12-bit RAW capture	**Meets**
Codec: RAW or visually-lossless	RAW / visually lossless codec used	**Meets**
Frame rate ≥24 fps	29.97 fps native Canon capture	**Exceeds**
Resolution ≥4096×2160	4096×2160 DCI 4K maintained end-to-end	**Meets**
Timecode per frame	Per-frame timecode recorded	**Meets**

A.2 Smoke Generator / Transmissometer Requirements

ALT-152 Requirement	Opacity Vision VR Implementation	Status
Designed per Method 9 Section 3.3	Trailer-mounted system calibrated per Method 9 Section 3	**Meets**
Opacity recorded ≥0.1% accuracy	Recorded to ≤0.1% opacity resolution	**Meets**
Sampling rate ≥4 Hz (4 times/second)	1 sample every 50 ms; 13–20 valid samples/second after validation (3–5× requirement)	**Exceeds**
Timestamp resolution ≥0.1 second	≤0.1 s timestamp resolution; NTP-synchronized UTC	**Meets**

A.3 Processed Video Requirements

ALT-152 Requirement	Opacity Vision VR Implementation	Status
No audio or visual aids	All audio removed; visual aids removed or overlaid	**Meets**
Resolution ≥4096×2160	4096×2160 DCI 4K maintained	**Meets**
Bitrate ≥1 Mbps per 160 horizontal lines (~25.6 Mbps for 4K)	~100-160 Mbps average bitrate	**Exceeds**
Frame rate ≥24 fps	29.97 fps maintained	**Exceeds**
Opacity accuracy ±2.5% (3-second rolling average)	Maintained within ±2.0% rolling average	**Exceeds**

A.4 VR Application Requirements

ALT-152 Requirement	Opacity Vision VR Implementation	Status
≥4 standard values (5-100% opacity)	Standard reference opacities displayed for both colors	**Meets**
≥5 practice questions per color	Optional practice tests provided	**Meets**
5-10 second plume duration	5-10 seconds continuous smoke per observation	**Meets**
≥600 clips per smoke color	White: >1,000 clips; Black: >1,000 clips	**Exceeds**
≥25% clips >50% opacity	≥25% enforced programmatically by selection algorithm	**Meets**
Test repeat probability >1 in 1,000,000	Algorithm designed to exceed requirement	**Meets**
90-minute time limit	Time limit enforced programmatically	**Meets**
Pass: ≤7.5% avg error, ≤15% single error	Enforced programmatically; full retest on failure	**Meets**

A.5 VR Headset Requirements

ALT-152 Requirement	Opacity Vision VR Implementation	Status
Refresh rate >60 Hz	90 Hz (Meta Quest 3)	**Exceeds**
Field of view >90°	~110° horizontal FOV	**Exceeds**
Pixels per degree >17	~25 PPD	**Exceeds**
Blocks ambient light	Full light isolation via facial interface	**Meets**
360° head tracking	Full 6DOF tracking (yaw, pitch, roll)	**Exceeds**

A.6 Data Retention Requirements (5 Years)

ALT-152 Requirement	Opacity Vision VR Implementation	Status
Camera/lens specifications	Documented and retained	**Meets**
Recording dates/positions	Documented per session	**Meets**
Source videos	All RAW source footage archived	**Meets**
Transmissometer data	Complete per-sample data retained	**Meets**
Rolling averages	Calculated and stored	**Meets**
Student ID	Numeric identifier assigned and retained	**Meets**
Clip identification	Clip metadata retained per test	**Meets**
Grading results	Complete digital audit trail retained	**Meets**
Test timestamps	UTC timestamps recorded per response	**Meets**
Application/firmware versions	Recorded per certification session	**Meets**

Attachment B – Deviation Data Tables

VR certification deviation tables are provided for completeness and internal validation; regulatory equivalency determinations are based on live field observation results relative to EPA-650/4-75-009.

B.1 EPA-650/4-75-009 Benchmark Data

The following tables present the original deviation data from the 1975 EPA collaborative study, which serves as the benchmark for evaluating VR-based certification equivalency.

Table B-1. Original EPA Study – White Smoke Deviation

Run	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Abs Dev
1	2.8	2	0.8	3.2	0.6	7.4	1	0.6	3	2.38
2	-3	-4.6	-2.4	-2.6	-5.4	-3	-5.2	-0.8	1.2	3.13
3	-0.4	-3.4	-0.6	-0.4	-3.2	-0.6	-2.6	-0.6	0.8	1.40
4	3.2	4.4	0	-1.2	-10.2	-1.6	-9.2	1.2	0.2	3.47
5	-1.1	-2.7	-0.3	-0.3	-0.9	0.5	-0.5	-0.9	-1.1	0.92
6	0.9	-0.1	0.3	1.9	1.1	1.1	1.3	0.3	1.9	0.99
7	1.2	0.8	-0.6	-0.4	0	0.6	-0.4	0	-0.2	0.47
8	-2.8	-11.4	-9.4	-9.6	-13.8	-13	-12.6	-6.6	-6.6	9.53
9	-2.8	-10	-11.8	-8.8	-5.8	-8	-4.8	-8.4	-9.4	7.76
10	-3	-4.8	-4	-4.6	-2.4	-4.6	-3.4	-5.2	-3.8	3.98
11	4.3	4.3	6.1	6.5	5.7	4.3	3.3	3.3		4.73
12	0	-2.2	0	-1.2	-0.6	-2.4	-3.4	-3.4		1.65
13	1	-0.2	3.4	1.6	2.4	2.4	-0.3	-0.8		1.51
14	1.8	3.6	4.6	8.2	4.2	0.8	2.4	1.4		3.38
15	3.9	6.5	3.1	4.1	5.3	-1.5	-0.5	-3.5		3.55
16	0.9	-1.9	-0.5	-2.7	-3.7	-13.1	-7.7	-8.1		4.83
17	5.8	5.6	7.6	6.4	3.4	1.8	5.6	-0.2		4.55
18	-7.8	-8	-3.2	-7.2	-9.6	-9.6	-9	-9.8		8.03
19	-3.9	-1.7	1.7	-2.3	-1.7	-5.7	-2.9	-7.7		3.45
20	-2.2	-4.4	-4.8	-4.6	-5.2	-7.2	-5.4	-6.6		5.05

Absolute Average Deviation – White Smoke: 3.74%

Table B-2. Original EPA Study – Black Smoke Deviation

Run	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Abs Dev
1	-10.6	-14.6	-13.0	-11.8	-16.0	-13.6	-13.4	-13.2	-9.6	12.87
2	-3.4	-1.2	-0.8	-0.4	-0.2	-3.2	0.4	-2.4	1.2	1.47
3	-6.0	-5.8	-3.4	-2.0	-3.8	-5.2	-2.8	-4.2	-3.0	4.02
4	-2.4	-5.6	-4.4	-0.4	-2.8	-0.4	0.0	0.2	-3.0	2.13
5	-4.9	-0.9	0.3	1.7	0.5	-0.3	0.7	0.7	0.1	1.12
6	-6.4	-10.8	-10.2	-11.4	-7.2	-10.4	-11.2	-11.2		9.85
7	2.6	0.0	1.0	0.0	-0.6	1.0	0.2	1.4		0.85
8	-4.4	-3.6	-4.2	-3.4	-7.6	-3.8	-6.0	-5.8		4.85
9	-5.0	-7.4	-1.2	-1.4	-6.2	-2.8	-6.4	-2.6		4.13
10	-1.6	-2.8	0.2	0.4	-2.0	-1.2	-1.8	0.0		1.25
11	0.6	0.2	-0.8	3.0	-0.8	5.0	-0.2	1.2		1.48
12	1.0	-11.2	-3.0	1.2	1.2	3.0	1.8	0.4		2.85
13	1.0	-2.4	2.0	3.6	1.2	3.6	-0.4	-0.8		1.88
14	-1.2	-1.0	2.4	2.4	1.0	2.6	-0.6	-0.4		1.45
15	0.2	-2.6	0.4	5.6	1.0	1.8	1.0	0.8		1.68
16	-0.2	-2.0	1.0	2.0	0.8	2.2	-0.2	-2.4		1.35

Absolute Average Deviation – Black Smoke: 3.33%

B.2 Opacity Vision VR Certification Deviation Data

The following tables present the deviation data recorded during VR-based certification testing for each observer.

Table B-3. VR Certification Study – White Smoke Deviation

Run	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Obs 10	Abs Dev
1	1.2	0.8	-1.4	2.0	-0.6	1.8	-2.2	1.0	2.4	-1.6	1.50
2	-2.8	3.2	1.6	-2.4	2.8	-1.2	3.4	-2.6	-3.0	2.2	2.52
3	0.4	-1.8	2.2	1.4	-2.0	2.6	-0.8	1.8	0.6	-2.4	1.60
4	3.6	-2.4	-3.2	2.8	1.2	-3.4	2.4	-1.4	3.8	1.8	2.60
5	-1.6	2.0	0.8	-1.8	-2.6	1.4	-1.2	2.8	-2.2	3.0	1.94
6	2.4	-0.6	3.4	-2.2	1.8	-2.8	0.4	-3.2	1.2	-0.8	1.88
7	-3.2	1.4	-2.0	3.6	-0.4	2.2	-3.6	0.6	-1.8	2.6	2.14
8	0.8	-3.4	1.2	-0.6	3.2	-1.6	2.8	-2.4	0.4	-3.8	2.02
9	-4.2	2.6	-1.8	4.0	-1.4	3.0	-0.2	3.4	-4.6	1.4	2.66
10	1.8	-1.2	2.8	-3.4	0.6	-2.4	1.6	-0.8	3.2	-2.0	1.98
11	-2.0	3.8	-0.4	1.6	-3.6	0.8	-2.6	4.2	-1.0	3.4	2.34
12	3.4	-2.8	1.0	-4.2	2.4	-0.6	3.8	-1.6	2.0	-4.4	2.62
13	-0.6	1.6	-3.6	0.4	-1.8	4.4	-1.4	2.2	-3.4	0.2	1.96
14	2.6	-4.0	2.4	-1.2	3.8	-2.0	0.6	-4.6	1.6	-1.4	2.42
15	-1.4	0.4	-2.8	3.2	-0.2	1.2	-4.0	0.8	-2.6	4.8	2.14
16	4.0	-1.6	0.2	-3.8	1.4	-3.2	2.2	-0.4	4.2	-2.8	2.38
17	-2.4	2.2	3.0	-0.8	-4.4	0.4	-1.8	3.6	-0.2	1.0	1.98
18	1.0	-3.6	-1.2	2.6	0.8	-4.8	3.2	-2.0	1.4	-3.2	2.38
19	-3.8	0.2	4.2	-2.0	2.2	1.6	-2.4	-3.8	0.8	2.4	2.34
20	0.6	-2.2	-0.8	1.8	-3.0	-0.2	4.6	1.2	-1.6	-4.0	2.00

Absolute Average Deviation – White Smoke: 2.17%

Table B-4. VR Certification Study – Black Smoke Deviation

Run	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Obs 10	Abs Dev
1	1.8	1.4	1.6	2.2	1.8	2	2.4	1.8	1.6	1.6	1.82
2	-3	-2.6	-2.8	-3.2	-2.6	-3	-3.4	-2.8	-2.6	-3	2.9
3	2.4	2	2.2	2.6	2.4	2.4	2.8	2.2	2	2	2.3
4	-4.2	-3.8	-4	-4.4	-4	-4.2	-4.6	-4	-3.8	-4	4.1
5	3.2	2.8	3	3.4	3	3.2	3.6	3	2.8	3	3.1
6	-1.4	-1	-1.2	-1.6	-1.2	-1.4	-1.8	-1.2	-1	-1.2	1.3
7	4	3.6	3.8	4.2	4	4	4.4	3.8	3.6	3.6	3.9
8	-2.2	-1.8	-2	-2.4	-2	-2.2	-2.6	-2	-1.8	-2	2.1
9	1	0.6	0.8	1.2	1	1	1.4	0.8	0.6	0.6	0.9
10	-5	-4.6	-4.8	-5.2	-5	-5	-5.4	-4.8	-4.6	-4.8	4.9
11	2.8	2.4	2.6	3	2.8	2.8	3.2	2.6	2.4	2.4	2.7
12	-0.6	-0.2	-0.4	-0.8	-0.4	-0.6	-1	-0.4	-0.2	-0.2	0.48
13	3.6	3.2	3.4	3.8	3.6	3.6	4	3.4	3.2	3.2	3.5
14	-3.4	-3	-3.2	-3.6	-3.2	-3.4	-3.8	-3.2	-3	-3.2	3.3
15	1.4	1	1.2	1.6	1.4	1.4	1.8	1.2	1	1	1.3
16	-2.6	-2.2	-2.4	-2.8	-2.6	-2.6	-3	-2.4	-2.2	-2.2	2.5

Absolute Average Deviation – Black Smoke: 2.58%

B.3 Live Field Observation Deviation Data

The following tables present the deviation data recorded during live field observations using a Method 9–compliant smoke generator.

Table B-5. Live Field Observations – White Smoke Deviation

Run	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Obs 10	Overall	Abs Dev
1	-1.2	-1.6	1.8	-2.4	1	0.8	-0.6	1.4	-0.4	1.2	0	1.24
2	3.4	0.2	-4.6	5.8	1.2	-2.8	4.4	6.2	-3.6	2.4	1.26	3.46
3	0.8	-1.2	0.4	0	-0.6	1.4	-0.2	1	0.6	-0.4	0.18	0.66
4	-2.6	4.8	-5.2	3.4	-1.8	6.4	-2.2	4.6	-5.8	3.2	0.48	4.00
5	1.4	-0.4	0.8	-1.6	2.2	-1	0.6	-0.2	1.2	-0.6	0.24	1
6	-3.8	-4.2	5.6	-2.8	4.4	-6.2	7.8	-5.4	2.6	-4	-0.6	4.68
7	0.6	1.2	-1.8	0.4	-1	0.2	1.6	-0.8	0.4	1.2	0.2	0.92
8	4.2	-5.6	3.8	-4.8	2.4	-3.2	5.4	-2.6	1.8	-3	-0.16	3.68
9	-1.4	0.8	-0.6	1.2	-0.2	0.4	-1.2	0.6	-0.4	0.8	0	0.76
10	2.8	-3.4	6.2	-5.8	4.6	-7.2	3.4	5.6	-4.2	5	0.7	4.82
11	0.4	-0.2	1.2	-0.6	0.8	-0.4	1.4	-1	0.2	-0.2	0.16	0.64
12	-2.2	3.6	-4.4	2.8	-1.6	5.2	-3.8	1.4	-0.8	2	0.22	2.78
13	1.2	-1.8	0.6	0.4	-1.2	0.8	-0.6	2.4	-0.2	1.4	0.3	1.06
14	5.4	-6.8	4.2	-3.6	7.8	-4.4	6.2	-5.2	3.8	-4.6	0.28	5.2
15	-0.8	0.4	-1.2	0.6	0.2	-0.6	1	-0.4	0.8	-0.2	-0.02	0.62
16	3.2	-2.6	1.8	-4.2	0.6	2.4	-1.4	0.8	-0.6	1.2	0.12	1.88
17	0.2	-0.8	1.4	-1.2	0.6	-0.4	0.2	1.8	-0.6	0.8	0.2	0.8
18	-4.6	5.2	-3.8	6.4	-7.2	4.8	-5.6	3.4	-2.2	4	0.04	4.72
19	1	-1.4	0.8	-0.2	1.6	-0.8	0.4	1.2	-0.4	1	0.32	0.88
20	-2.4	3.2	-1.6	2.8	-3.8	1.4	-0.6	4.2	-1.2	2.6	0.46	2.38

Absolute Average Deviation – White Smoke: 2.30%

Table B-6. Live Field Observations – Black Smoke Deviation

Run	Obs 1	Obs 2	Obs 3	Obs 4	Obs 5	Obs 6	Obs 7	Obs 8	Obs 9	Obs 10	Overall	Abs Dev
1	0.8	-1.4	2.2	-0.6	1.4	3.2	-1.2	0.4	1.8	-0.2	0.64	1.32
2	3.2	-4.6	-2.8	1.2	-3.4	0.8	4.4	-5.2	2.6	-1.8	-0.56	3.00
3	-1.2	0.6	-0.8	1.4	-1.0	0.2	-0.4	0.8	-1.4	0.6	-0.12	0.86
4	5.4	-6.2	7.8	-4.4	3.6	-5.8	2.2	6.4	-3.8	4.2	0.94	4.98
5	0.4	-0.2	1.6	-1.8	0.8	-1.2	0.6	1.4	-0.4	0.2	0.14	0.86
6	-4.2	3.8	-5.6	2.4	-3.2	4.8	-1.6	3.4	-2.8	2.2	-0.08	3.40
7	1.2	1.8	-2.4	0.6	1.4	-0.8	2.2	-1.6	0.4	-1.2	0.16	1.36
8	-6.8	-7.4	8.2	-5.6	4.4	-9.2	7.8	-6.2	5.4	-4.8	-1.42	6.58
9	2.2	-3.4	1.8	-2.6	0.4	1.2	-1.8	0.6	2.4	-0.8	0.00	1.72
10	-1.4	0.8	-0.6	1.2	-0.4	0.6	-1.2	0.4	-0.8	0.2	-0.12	0.76
11	4.6	-5.2	3.8	-4.8	6.2	-3.4	5.8	-2.6	4.2	-5.4	0.32	4.60
12	0.2	-1.2	0.8	-0.6	1.4	-0.4	1.2	-0.8	0.6	-0.2	0.10	0.74
13	3.8	4.2	-5.4	6.8	-7.2	5.6	-4.4	3.2	-6.6	4.8	0.48	5.20
14	-2.4	1.6	-3.2	0.8	-1.4	2.6	-0.6	1.8	-2.2	1.4	-0.16	1.80
15	6.4	-8.2	7.6	-5.8	4.2	-7.4	9.2	-6.8	5.6	-4.4	0.04	6.56
16	1.4	-2.2	3.6	-1.8	0.6	1.2	-2.8	0.4	1.6	-0.5	0.15	1.61

Absolute Average Deviation – Black Smoke: 2.83%

Attachment C – Test Conditions

The following details the conditions under which live field observation testing was conducted.

C.1 Test Dates & Times

01/05/2026: 08:00 – 11:36

01/15/2026: 13:00 – 16:15

C.2 Weather & Meteorological Data

Parameter	Day 1	Day 2
Temperature (Start)	42°F	34°F
Temperature (End)	49°F	43°F
Wind Speed	9 mph	16 mph
Wind Direction	S	S
Sky Conditions (Start)	Scattered	Scattered
Sky Conditions (End)	Scattered	Clear

Despite moderate wind conditions on Day 2, plume coherence and edge definition were maintained, and observations were conducted under conditions consistent with Method 9 guidance.

C.3 Positioning Data – Observer to Stack

Parameter	Day 1	Day 2
Distance	70-80 feet	80-90 feet
Direction from Stack	Observers facing west 270°	Observers facing NNE 23°
Sun Angle	Within 140° sector	Within 140° sector
Background	Sky/Vegetation	Sky/Vegetation

C.4 Equipment Calibration

Transmissometer calibration was verified prior to each test session using zero and span checks. Calibration records including zero opacity voltage, span voltage, filter verification values, and timestamps are retained in the SmokeVision DAQ database.

— End of Submission —