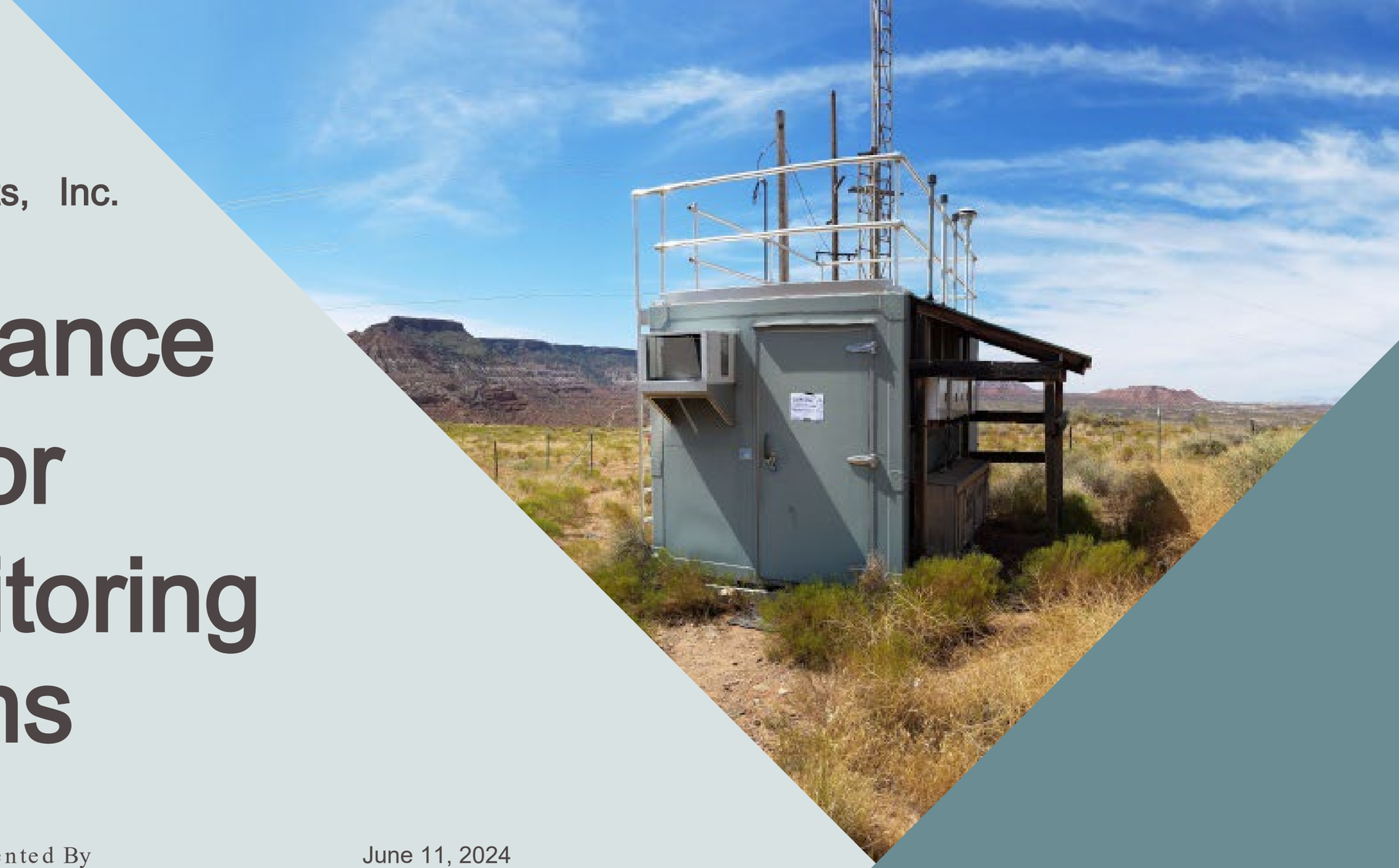
Air Resource Specialists, Inc.

Performance Audits for Air Monitoring Programs



Presented By
Christian Kirk

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What are performance audits?

Equation 1

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

40 CFR Part 58 Appendix A 4.1.1

- Independent Quality Assurance(QA) activities used to assess bias
  - 40 CFR Part 58 App A 1.3(c)Bias. The systematic or persistent distortion of a measurement process which causes errors in one direction.
- The measured response from an instrument undergoing the audit is compared to a known value

PQAO Independence Requirements

“Shall” or “Must” is a requirement

“Should” is a recommendation

“May” is optional or discretionary

- Personnel conducting audit “ **should** ” not be the routine site operator
- Personnel conducting audit “ **should** ” be trained and experienced
- Standards and equipment “ **must** ” not be those used for routine operations and measurements

Types of Common Performance Audits

TYPE OR AGENCY	AUDITS PERFORMED	REFERENCE 40 CFR Part 58 Appendix A
Internal / Primary Quality Assurance Organization (PQAO)	**Annual Performance Evaluation for SO_2, NO_2, O_3 and CO**	3.1.2
	Semi-Annual Flow Rate Audit for $PM_{2.5}$	3.2.2
	Semi-Annual Flow Rate Audit for PM_{10}	3.3.3
	Semi-Annual Flow Rate Audit for Lead	3.4.3
	Audits for Meteorological Measurements	QA Handbook Volume IV
NPAP - EPA	**National Performance Audit Program for SO_2, NO_2, O_3, and CO**	3.1.3
PM2.5 PEP – EPA	**PM2.5 Performance Evaluation Program**	3.2.4
Lead PEP – EPA	Pb Performance Evaluation Program	3.4.7

Annual Performance Evaluation for SO_2, NO_2, O_3 and CO

- The PQAO or their contractor is responsible for performing these audits
- NIST-traceable O3 transfer standards are required for O_3 audits
- EPA protocol gas cylinders are required for SO_2, NO_2, and CO audits
  - Cylinder contents are diluted to known concentrations using a gas dilution calibrator with NIST-traceable calibrations and a zero-air supply
- Minimum of 25% of network sites needs to be audited quarterly or each site once per year for networks smaller than 4 sites

Annual Performance Evaluation for SO_2, NO_2, O_3 and CO

Audit level	Concentration Range, ppm			
	O_3	SO_2	NO_2	CO
1	0.004-0.0059	0.0003-0.0029	0.0003-0.0029	0.020-0.059
2	0.006-0.019	0.0030-0.0049	0.0030-0.0049	0.060-0.199
3	0.020-0.039	0.0050-0.0079	0.0050-0.0079	0.200-0.899
4	0.040-0.069	0.0080-0.0199	0.0080-0.0199	0.900-2.999
5	0.070-0.089	0.0200-0.0499	0.0200-0.0499	3.000-7.999
6	0.090-0.119	0.0500-0.0999	0.0500-0.0999	8.000-15.999
7	0.120-0.139	0.1000-0.1499	0.1000-0.2999	16.000-30.999
8	0.140-0.169	0.1500-0.2599	0.3000-0.4999	31.000-39.999
9	0.170-0.189	0.2600-0.7999	0.5000-0.7999	40.000-49.999
10	0.190-0.259	0.8000-1.000	0.8000-1.000	50.000-60.000

- Known concentrations of 3 audit levels must be used:
  1. 2-3 times the MDL
  2. <= 99th percentile of data
  3. At the NAAQS or highest 3-year concentration
- A 4th audit level is encouraged
- Typical audit levels used in EPA Region 8 are highlighted

Annual Performance Evaluation for SO_2, NO_2, O_3 and CO

Audit level	Acceptance Criteria			
	O_3	SO_2	NO_2	CO
1	±15% or 1.5 ppb	±15% or 1.5 ppb	±15% or 1.5 ppb	±15% or 0.030 ppm
2				
3	±15%	±15%	±15%	±15%
4				
5				
6				
7				
8				
9				
10				

- Failures at audit level 1 and 2 are not “punitive”
- Failures at low levels are usually the results of zero response offsets
- A zero challenge should be included in the audit

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

Annual Performance Evaluation for SO_2, NO_2, O_3 and CO

- Audits are typically conducted by introducing the known concentrations at the back of the analyzer (BOA)
  - Analyzer is in “normal” sampling mode, and all filters, scrubbers, conditioners, etc, must be included (3.1.2.3)
- It is recommended to “flood” your sampling manifold to test the integrity of as much of the sampling system as possible
  - Multiple gas analyzers can be audited simultaneously

Semi-Annual Flow Rate Audit for $PM_{2.5}$ and PM_{10}

- The PQAO or their contractor is responsible for performing these audits
- NIST-traceable flow standards are required
- Every site is audited twice per year with 5 -7 months between audits
- Audits can occur more frequently (recommended)
- Instrument temperature and pressure measurements should also be audited with NIST-traceable standards
- Applies to FRM and FEM instruments

Semi-Annual Flow Rate Audit for $PM_{2.5}$ and PM_{10}

Parameter	Comparison	Acceptance Criteria
Temperature	Audit temperature to sampler temperature	≤ ± 2 °C
Barometric Pressure	Audit barometric pressure to sampler pressure	≤ ±10mm Hg
$PM_{2.5}$ Flow	Audit flow to actual sampler flow	≤ ± 4%
	Design criteria flow to audit flow	≤ ± 5%
PM_{10} Flow (low-volume)	Audit flow to actual sampler flow	≤ ± 10%
	Design criteria flow to audit flow	≤ ± 10%
PM_{10} Flow (high-volume)	Audit flow to actual sampler flow	≤ ± 7%
	Design criteria flow to audit flow	≤ ± 10%

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

For design criteria flow calculations, use the equation above and substitute the design flow for the audit flow

Design flow is critical for size-selective inlets (PM_{10} inlet, $PM_{2.5}$ VSCC)

Semi-Annual Flow Rate Audit for $PM_{2.5}$ and PM_{10}

EXAMPLE –

A Met One BAM-1020 PM_{10} is being audited

- Instrument Flow = 15.0 LPM
- Audit Standard = 15.0 LPM
- (15.0 - 15.0) x 100 / 15.0 = 0% Great, right?

However…….

- The design flow for the Met One BAM-1020 PM_{10} is 16.7 LPM
- (15.0 – 16.7) x 100 / 16.7 = -10.2% Audit failure!

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

Semi-Annual Flow Rate Audit for Lead (Pb)

- The PQAO or their contractor is responsible for performing these audits
- NIST-traceable flow standards are required
- Every site is audited twice per year with 5 -7 months between audits
- Audits can occur more frequently
- Pb monitoring is a filter -based method that can use a low -volume PM_{10} sampler (16.7 LPM) or high -volume TSP sampler (1.1 – 1.70 m^3/min)

Semi-Annual Flow Rate Audit for Lead (Pb)

Parameter	Comparison	Acceptance Criteria
Temperature	Audit temperature to sampler temperature	≤ ± 2 °C
Barometric Pressure	Audit barometric pressure to sampler pressure	≤ ±10mm Hg
Pb PM_{10} Flow (low-volume)	Audit flow to actual sampler flow	≤ ± 4%
	Design criteria flow to audit flow	≤ ± 5%
Pb TSP Flow (high-volume)	Audit flow to actual sampler flow	≤ ± 7%

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

For design criteria flow calculations, use the equation above and substitute the design flow for the audit flow

Total suspended particulates (TSP) has no size-selective inlet - therefore, no design flow calculation

EPA National Performance Audit Program (NPAP)

- Each EPA Region or their contractor is responsible for performing these audits
- NIST-traceable O3 transfer standards are required for O_3 audits
- EPA protocol gas cylinders are required for SO_2, NO_2, and CO audits
  - Cylinder contents are diluted to known concentrations using a gas dilution calibrator with NIST -traceable calibrations and a zero -air supply
- Minimum of 20% of network sites needs to be audited annually, and 100% of the network every 6 years

EPA National Performance Audit Program (NPAP)

Audit level	Concentration Range, ppm			
	O_3	SO_2	NO_2	CO
1	0.004-0.0059	0.0003-0.0029	0.0003-0.0029	0.020-0.059
2	0.006-0.019	0.0030-0.0049	0.0030-0.0049	0.060-0.199
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4	0.040-0.069	0.0080-0.0199	0.0080-0.0199	0.900-2.999
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8	0.140-0.169	0.1500-0.2599	0.3000-0.4999	31.000-39.999
9	0.170-0.189	0.2600-0.7999	0.5000-0.7999	40.000-49.999
10	0.190-0.259	0.8000-1.000	0.8000-1.000	50.000-60.000

- Audit levels are selected similarly to APE performed by PQAOs
- EPA will perform Level 1 or Level 2 as one the audit levels

EPA National Performance Audit Program (NPAP)

Audit level	Acceptance Criteria			
	O_3	SO_2	NO_2	CO
1	**±10%** or 1.5 ppb	±15% or 1.5 ppb	±15% or 1.5 ppb	±15% or 0.030 ppm
2				
3	**±10%**	±15%	±15%	±15%
4				
5				
6				
7				
8				
9				
10				

- Failures at audit level 1 and 2 are not “punitive”
- Ozone requirements are tighter than APEs performed by PQAOs

$$d_i = \frac{meas - audit}{audit} \cdot 100$$

EPA National Performance Audit Program (NPAP)

- Audits are conducted through -the-probe (TTP), and challenge the entire sampling system
- Auditors attend training annually and are certified by EPA

EPA $PM_{2.5}$ Performance Evaluation Program ($PM_{2.5}$ PEP)

- Each EPA Region or their contractor is responsible for performing these audits
- A $PM_{2.5}$ FRM (filter-based) is collocated with the site PM $_{2.5}$ instrument.
- The 24-hour concentrations from the audit FRM and site PM $_{2.5}$ instrument are compared
- PQAOs with 5 or less $PM_{2.5}$ sites will be audited 5 times
- PQAOswith more than 5 PM $_{2.5}$ sites will be audited 8 times
- 100% of the network needs to audited every 6 years

EPA $PM_{2.5}$ Performance Evaluation Program ($PM_{2.5}$ PEP)

- Only audits with concentrations >= 2 $\mu g/m^3$ are valid
- Many $PM_{2.5}$ regulation changes were promulgated on May 6, 2024

Equation 8 to Section 4.2.5 of Appendix A

$$100 \times \frac{\sum_{i=1}^{n} s_i}{n\sqrt{NAAQS\ concentration}} \quad \text{where} \quad s_i = \frac{meas - audit}{\sqrt{audit}}$$

What about other measurements?

- Other networks have their own audit requirements, which are described in their Quality Assurance Project Plans (QAPP)
- It is advised that PQAOs have performance audits for measurements not directly addressed by EPA regulation or guidance
  - H_2S, methane/non-methane analyzers, etc

Example of other networks

EPA Chemical Speciation Network

IMPROVE Network

National Air Toxics Trends Sites

References

- 40 CFR Part 58 Appendix A
- EPA QA Handbook Volume II
- EPA Quality Assurance Project Plan for the Federal National Performance Audit Program (NPAP) for Criteria Pollutant Gases
- EPA Quality Assurance Project Plan for the Federal $PM_{2.5}$ Performance Evaluation Program ($PM_{2.5}$-PEP)