

# The “Art” of Data Validation

*A holistic endeavor!*

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Holistic = emphasizing the functional relation between parts and the whole

- To produce valid air quality data, we reduce error at each stage of the monitoring process by applying best practices and measurement quality objectives then we review operations using a combination of expertise to assure expectations are being met.

## How We Do It

- Plan our work and work our plan (QAPPs)
- Develop DQOs
- Purchase qualified air monitors, samplers, analyzers, transfer standards, etc.
- Employ MQOs
- Follow good lab practices (GLP)
  - Buy approved/certified supplies
- Use accepted data management practices
- Hire skilled staff for all positions
- Keep all pertinent site records

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## Basic Rules for Data

- Review all data ASAP after collection
  - Technicians review instrument operating data
  - Staff independent of collection review all data
- Preserve raw data with all original flags, comments, other info (example: BAM tape)
- Increase scrutiny on data at each quality assurance (QA) level
- Apply QA process to all data equally
- Account for all scheduled samples

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# Documenting Field Activities

- A “field sheet” is produced for each service:
  - zero span checks
  - flow verifications
  - calibrations
  - certifications
  - PE audits
  - instrument changes
  - maintenance, etc.
- Sheets document **supporting data**:
  - time
  - pressure
  - temperature
  - flow rate
  - run times
  - run dates
  - instrument IDs
  - sample IDs, etc.

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AAAD Site#		Date	
Arizona Department of Environmental Quality Partisol 2000 FRM PM2.5 / PM10 Verification Data Sheet			
Site Name:		Instrument Model:	RoP 2000 FRM
Technician:		Equipment Number:	
Standard Model:	(TetraCal, TriCal or DeltaCal)	ADEQ Eq#:	
Certification Date:		Instrument Configuration:	
Standard T <sub>a</sub> :	° C	(Is unit a Pm10 or Pm2.5 / Primary or Secondary)	
Standard Pa:	mmHg	Sampling Method:	
Service Start Time:		Method ( Pm-2.5, RPPS-0498-117, Pm-10, RPPS-1298-126)	
Service End Time:		Instrument last calibrated:	
<b>Ambient Temperature Probe Verification</b>			
Sampler Reading	Temperature Standard (TF)	Diff. Temperature	
deg. C	deg. C	deg. C	##### ± 2 deg.C
<b>Filter Temperature Probe Verification</b>			
Sampler Reading	Temperature Standard (TF)	Diff. Temperature	
deg. C	deg. C	deg. C	##### ± 2 deg.C
<b>Pressure Sensor Verification</b>			
Sampler Reading	Pressure Standard ( Pa )	Diff. Pressure	
mm Hg	mm Hg	mm Hg	##### mm Hg ± 10 mmHg
atm	atm	atm	##### atm ± 0.13 atm
<b>External Leak Check</b> ( Vacuum Drop Difference < 126 mmHg )			
Try 1	Drop to : Stop @ : Diff	Try 2	Drop to : Stop @ : Diff
	##### mmHg/min		#VALUE! mmHg/min
Try 3	Drop to : Stop @ : Diff		
	##### mmHg/min		
<b>Flow Verification</b>			
Flow Setting	Current Flow	Standard Flowrate	Diff ( ± 3 % )
16.70 Liter/min.	L / min.		#VALUE!
		16.2 to 17.2 L / min.	
<b>Inlet / Down tube &amp; Unit Service</b>			
Det Sn #	Disassembled & Cleaned?	V.S.C.C. SN #	
	Yes No	Removed & Cleaned?	
Down-Tube Service?	Yes No	Yes No	
Air Intake Filters?	Yes No		
Filter Seals?	Cleaned Replaced		
<b>Final External Leak Check &amp; Flow Verification After Service</b>			
Drop to : Stop @ : Diff	Drop to : Stop @ : Diff	Flow Diff ( ± 3 % )	
##### mmHg/min	##### mmHg/min	( 16.2 to 17.2 )	
Flow Setting	Current Flow	Standard Flowrate	
16.70 Liter/min.	L / min.		#VALUE!
		16.2 to 17.2 L / min.	
Comments:			
mon, 8/06/2008 [R.V.L.] Reviewed By: ( AMU ) ( DM )			

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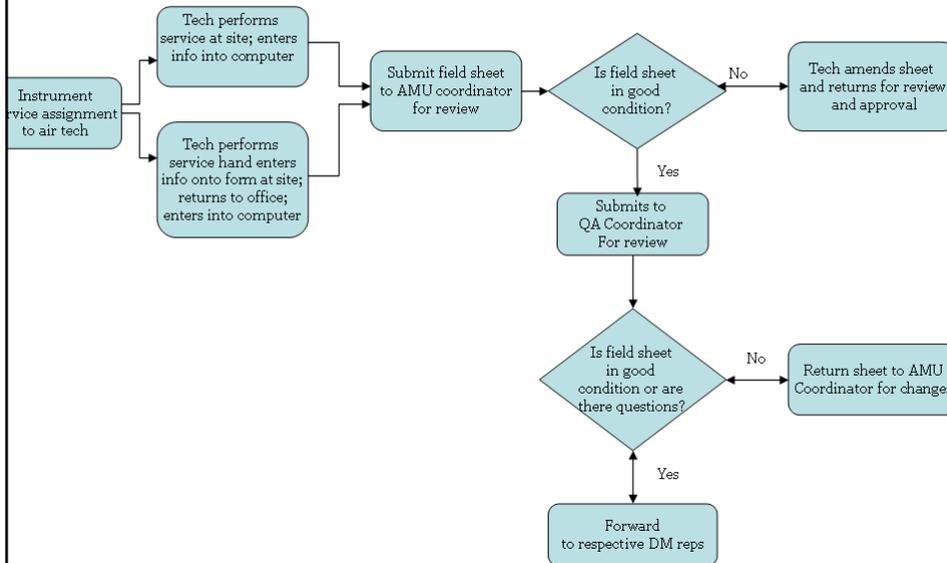
Source: EPA QA Handbook, Volume II, December 2008

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PM<sub>2.5</sub> Filter Based Local Conditions Validation Template

Criteria	Frequency	Acceptable Range	Information (CFR or Method 2.12)
<b>CRITICAL CRITERIA- PM<sub>2.5</sub> Filter Based Local Conditions</b>			
<b>Filter Holding Times</b>			
Sample Recovery	all filters	≤ 7 days 9 hours from sample end date	Part 50 App I. Sec 10.10
Post-sampling Weighing	all filters	≤ 10 days from sample end date if shipped at ambient temp, or ≤ 30 days if shipped below ave ambient (or 4° C or below for ave sampling temps ≤ 4° C ) from sample end date	Part 50 App I. Sec 8.3.6
<b>Sampling Period (including multiple power failures)</b>	all filters	1380-1500 minutes, or value if < 1380 and exceedance of NAAQS <sup>1/2</sup> midnight to midnight	Part 50 App I. Sec 3.3 Part 50, App.I. Sec 7.4.15
<b>Sampling Instrument</b>			
Average Flow Rate	every 24 hours of op	average within 5% of 16.67 liters/minute	Part 50 App I. Sec 7.4
Variability in Flow Rate	every 24 hours of op	CV ≤ 2%	Part 50, App.I. Sec 7.4.3.2
<b>Filter</b>			
Visual Defect Check (unexposed)	all filters	see reference	Part 50, App.I. Sec 10.2
<b>Filter Conditioning Environment</b>			
Equilibration	all filters	24 hours minimum	Part 50, App.I. Sec 8.2
Temp. Range	all filters	24-hr mean 20-23° C	Part 50, App.I. Sec 8.2
Temp. Control	all filters	± 2° C SD <sup>a</sup> over 24 hr	Part 50, App.I. Sec 8.2
Humidity Range	all filters	24-hr mean 30% - 40% RH or ≤ 5% sampling RH but > 20%RH	Part 50, App.I. Sec 8.2
Humidity Control	all filters	± 5% SD <sup>a</sup> over 24 hr	Part 50, App.I. Sec 8.2
Prepost Sampling RH	all filters	difference in 24-hr means ≤ ± 5% RH	Part 50, App.I. Sec 8.3.3
Balance	all filters	located in filter conditioning environment	Part 50, App.I. Sec 8.3.2
<b>* Verification/Calibration</b>			
One-point Flow Rate Verification	1/4 weeks	± 4% of transfer standard	Part 50, App. I. Sec 9.2.5 Part 58, Appendix A Sec 3.2.3 & 3.3.2
<b>OPERATIONAL EVALUATIONS TABLE PM<sub>2.5</sub> Filter Based Local Conditions</b>			
<b>Filter Checks</b>			
Lot Blanks	9 filters per lot	less than 15 µg change between weighings	Method 2.12 Sec. 7.7
Exposure Lot Blanks	3 filters per lot	less than 15 µg change between weighings	Method 2.12 Sec. 7.7
Filter Integrity (exposed)	each filter	no visual defects	Method 2.12 Sec. 8.2
<b>Filter Holding Times</b>			
Pre-sampling	all filters	< 30 days before sampling	Part 50, App.I. Sec 8.3
<b>Lab QC Checks</b>			
Field Filter Blank	10% or 1 per weighing session	± 30 µg change between weighings	Part 50, App.I. Sec 8.3
Lab Filter Blank	10% or 1 per weighing session	± 15 µg change between weighings	Part 50, App.I. Sec 8.3
Balance Check	beginning, 10th sample, end	≤ 3 µg	Method Sec. 7.9
Duplicate Filter Weighing	1 per weighing session	± 15 µg change between weighings	Method Sec 7.11
<b>Sampling Instrument</b>			

# Field Sheet Tracking



## Blending Field Activities into Data Review

- Meeting MQOs reduces measurement error from air monitoring instruments to acceptable levels
- Quality assurance reviews identify instrument, procedural, and information transfer errors that may affect the quality of **supporting** and **concentration data** by comparing:
  - Field sheets
  - Log books (site and instrument)
  - Chain-of-custody and field data forms
  - Instrument data
    - electronic communications
    - manual downloads
  - Information on site conditions

*Redundancy is your friend!*

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## Factors That Influence Air Quality Data

- Size of MO and number of air monitoring programs
  - How challenging are field operations?
  - How much data is being generated?
- Proactive or reactive approach to reviewing supporting data and concentration data
  - Are all available data and documents reviewed? When?
  - Where are records stored?
- Use of MQOs
  - Are they being applied consistently among MOs? Internally at MOs? To all procedures?
- Use of concentration data
  - Are we consistent with applying flags or validating/invalidating data?
  - Do you assess air quality data for regulated sources?
  - Do we compare outcomes to DQOs?
  - Are we discerning trends?

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# The Bottom Line

- Did we meet our data completeness requirements?  
Needed for calculating Design Values which are used for planning purposes

$$\text{Data Completeness} = \frac{\# \text{ of valid samples}}{\# \text{ of scheduled samples}}$$

- Did we produce valid and certifiable data?  
Yes → effort + expense = job well done  
No → effort + expense = nothing
- What are the consequences if certified data is found to be in error and has to be corrected and recertified at a later date?

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**Source: EPA QA Handbook, Volume II, December 2008**

**Ozone Validation Template**

Requirement	Frequency	Acceptance Criteria	Information /Action
<b>CRITICAL CRITERIA-Ozone</b>			
One Point QC Check Single analyzer	1/2 weeks	≤ ±7% (percent difference)	0.01 - 0.10 ppm Relative to routine concentrations 40 CFR Part 58 App A Sec 3.2
Zero/span check	1/2 weeks	Zero drift ≤ ± 2% of full scale Span drift ≤ ± 7 %	
<b>OPERATIONAL CRITERIA - Ozone</b>			
<b>Shelter Temperature</b>			
Temperature range	Daily (hourly values)	20 to 30° C. (Hourly ave) or per manufacturers specifications if designated to a wider temperature range	Generally the 20-30 ° C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	± 2° C SD over 24 hours	
Temperature Device Check	2/year	± 2° C of standard	
Precision (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	90% CL CV ≤ 7%	90% Confidence Limit of coefficient of variation. 40 CFR Part 58 App A sec 4.1.2
Bias (using 1-point QC checks)	Calculated annually and as appropriate for design value estimates	95% CL ≤ ± 7%	95% Confidence Limit of absolute bias estimate. 40 CFR Part 58 App A sec 4.1.3
<b>Annual Performance Evaluation</b>			
Single analyzer	Every site 1/year 25 % of sites quarterly	Percent difference of each audit level ≤ 15%	3 consecutive audit concentration not including zero. 40 CFR Part 58 App A sec 3.2.2
Primary QA Organization (PQAO)	annually	95% of audit percent differences fall within the one point QC check 95% probability intervals at PQAO level of aggregation	40 CFR Part 58 App A sec 4.1.4
Federal Audits (NPAP)	1/year at selected sites 20% of sites audited	Mean absolute difference ≤ 10%	40 CFR Part 58 App A sec 2.4
<b>State requirements</b>			
Verification/Calibration	Upon receipt/adjustment/repair/ installation/moving 1/6 months if manual zero/span performed biweekly 1/year if continuous zero/span performed daily	All points within ± 2 % of full scale of best-fit straight line Linearity error <5%	Multi-point calibration (0 and 4 upscale points) 40 CFR Part 50 App D sec 5.2.3
Zero Air		Concentrations below LDL	
Gaseous Standards		NIST Traceable (e.g., EPA Protocol Gas)	40 CFR Part 58 App A sec 2.6.1
Zero Air Check	1/year	Concentrations below LDL	

## Scenario #1

- Air monitoring implements a more stringent internal standard for an O<sub>3</sub> analyzer ZSP check (+/- 5% RPD) than required by MQOs/validation tables (+/- 7%)
- Field sheets automatically calculate pass or fail
  - Sheet shows instrument is failing when it is actually passing
  - Staff in both units had limited familiarity of MQOs/validation tables
- 2 weeks of data invalidated based on “failure”
- How could this have been prevented?
- What type of error(s) is represented?

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## Scenario #2

- A 2-month short study to determine PM concentrations arises suddenly. The project is targeting 75% data completeness. All samplers are calibrated upon installation with a one-point QC check planned for every 2 weeks in the QAPP.
- The QC checks are not scheduled at 2 weeks - instead the verifications are setup 4 weeks apart. PE audits are conducted within 2 days after setup. All samplers pass.
- The 1<sup>st</sup> QC check is performed 4 weeks later. One sampler fails a flow check. The tech does not verbally report this to anyone.
- DM&QA receives this field sheet ~ 1.5 week after the 2<sup>nd</sup> check. Seven sampling dates have passed when failure is detected and report by QA.
- Would you invalidate data? How far back?
- Can you make 75% data completeness?
- What actions could have prevented this breakdown?

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## Scenario #3

- A sample from one site shows a 24-hour  $PM_{2.5}$  exceedance. No other sites record an exceedance. Visual observation of the filter does not support a high concentration.
- All documents (FS, COC, weigh log) are carefully reviewed. Review finds a written comment from the lab tech conducting initial weighs saying that the initial filter was damaged and replaced with a new filter. The initial filter's weight had not been deleted properly from weigh records. The comment was not transferred to subsequent logs. The 2<sup>nd</sup> filter's weight was heavier than the 1<sup>st</sup>.
- Correction was applied; final concentration was close to other sites and was not an exceedance
  
- What level of QA review is represented?
- What type of error is represented?

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## Scenario #4

- A  $PM_{2.5}$  sampler is replaced with another when it fails a monthly leak check
- Tech fails to submit field sheet
- Operator logs sampler ID# on the COC
- Filter lab tech detects different sampler ID#, contacts field tech and obtains instrument change info
  
- Would this change be discovered if the lab did not cross reference documents?
- What other records could help identify the change?

*Remember - redundancy is your friend!*

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