شرکت کنترل کیفیت هوا
وابسته به شهرداری تهران

دانشگاه صنعتی امیرکبیر
(پلی تکنیک تهران)

اصول اندازه‌گیری آلودگی هوا

احمد طاهری

مدیر شبکه سنجش کیفیت هوا، شرکت کنترل کیفیت هوا (شهرداری تهران)

رئیس کمیته فنی کیفیت هوا (TC 146)، سازمان ملی استاندارد

دانشجوی دکتری مهندسی عمران، گرایش محیط زیست، دانشگاه صنعتی امیرکبیر

هفتمین همایش مدیریت آلودگی هوا و صدا

زمستان ۹۷

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Outline:

1- Air Quality monitoring in Iran

2- Air Quality Monitoring in Tehran

3- Air Quality Monitoring in AQCC

4- Air Quality Monitoring Principles

5- Calibration Principles for Gases Analyzers

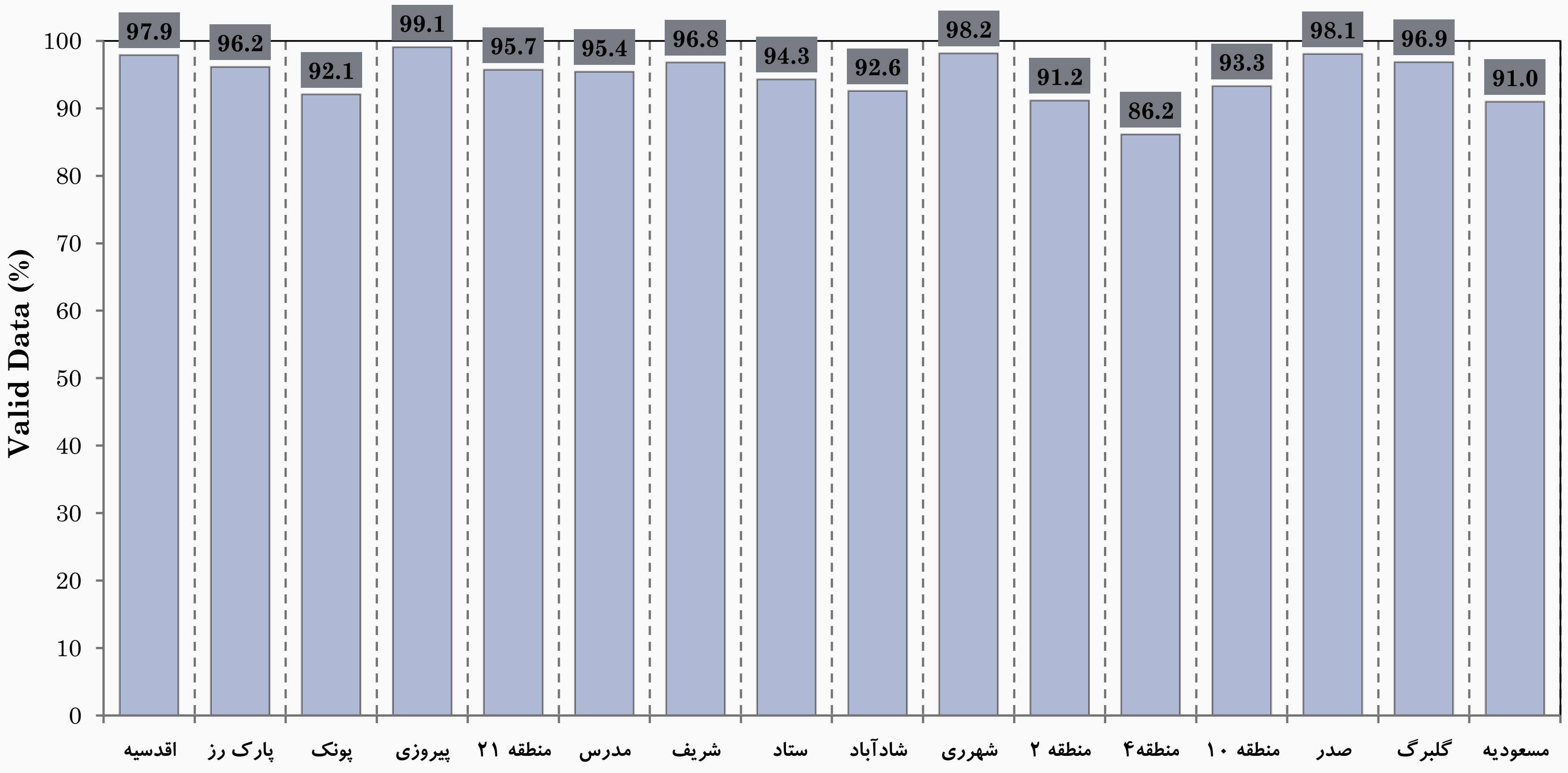
6- Calibration Principles for PM Analyzers

7- Air Quality Monitoring Assessment and Design

8- Sampling Systems Criteria

9- Data Validation and Verification

Data Validity of AQCC AQMS, 1396



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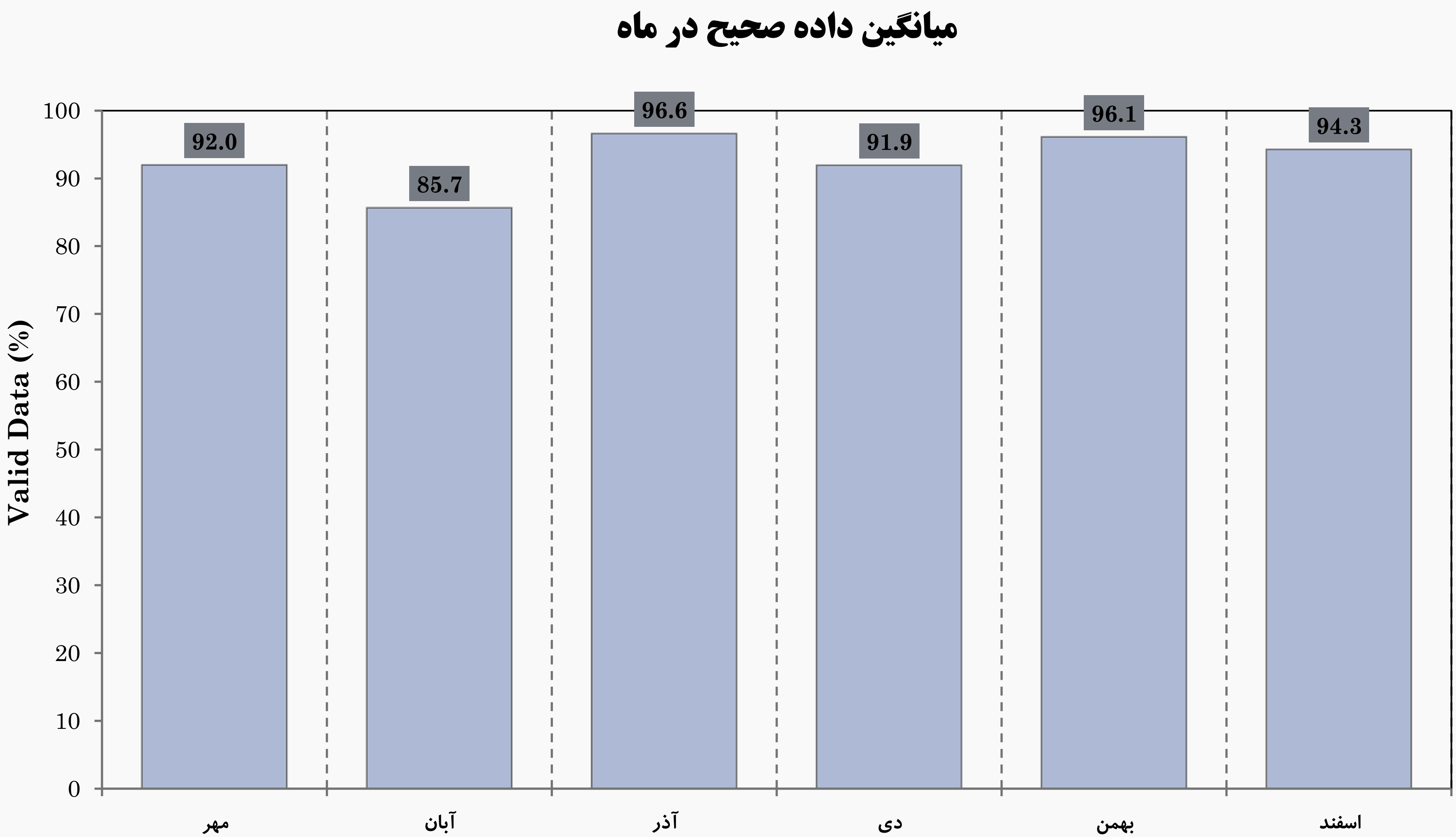
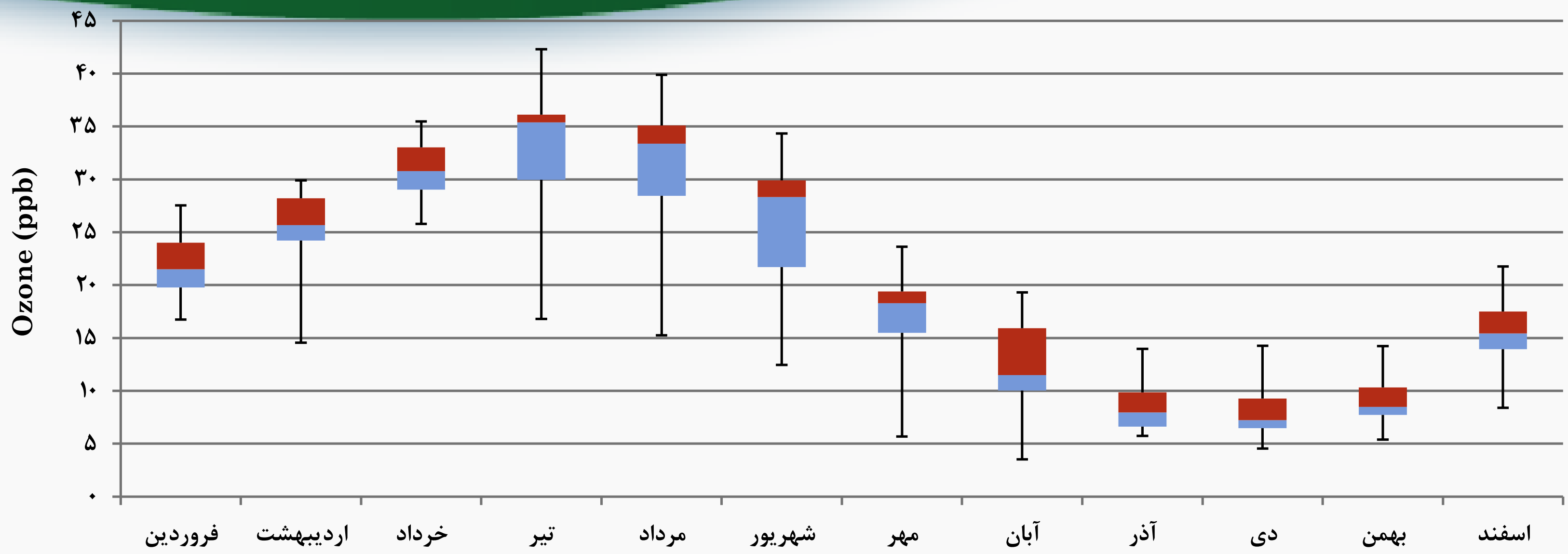
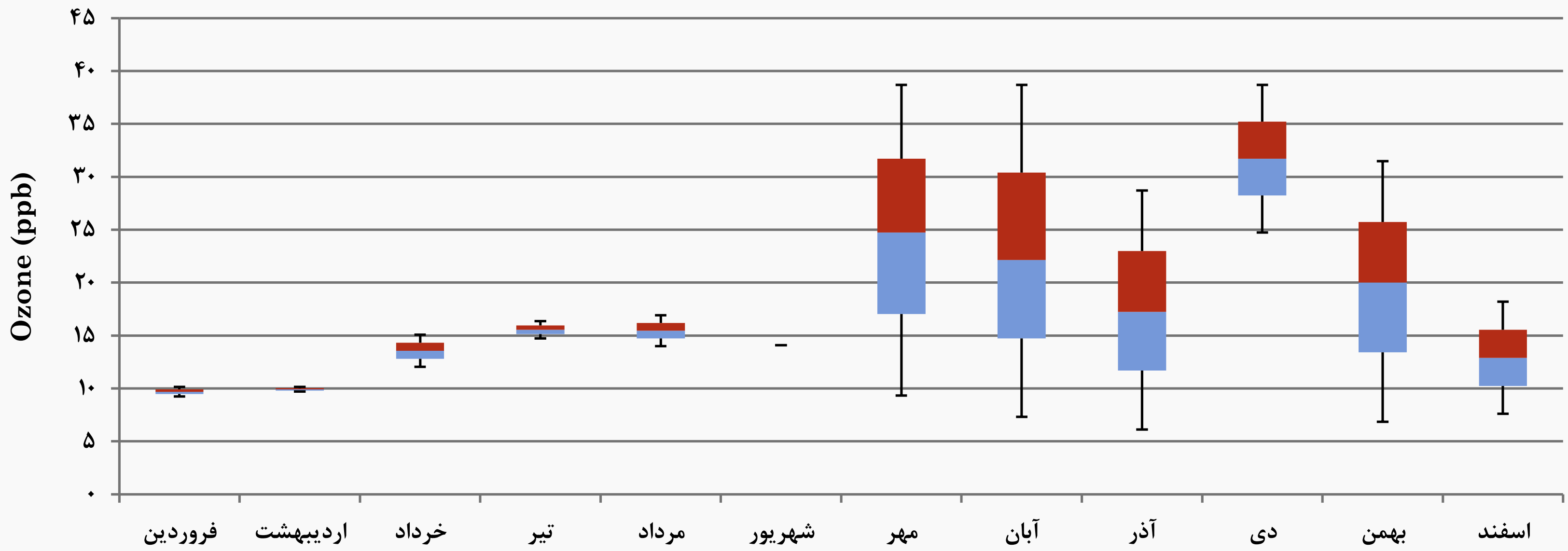


Data Validity AQMS, 1396





Data Evaluation

منشا آلاینده ازن؟!
- اکسیدهای نیتروژن
- ترکیبات آلی فرار

منشا ذرات معلق؟
- ذرات اولیه
- ذرات ثانویه

دلایل افزایش ازن؟
- افزایش انتشار اکسیدهای نیتروژن و ارتباط آن با ذرات تولیدی؟
- افزایش انتشار اکسیدهای نیتروژن و ارتباط آن با ذرات ثانویه؟

Environnement S.A L'instrumentation de l'environnement	**FICHE DE CONTROLE CO12M** ***CHECK LIST FOR CO12M***	Validé le : 10/07/02 Signature Par : P. ANTHOINE Date d'application : 10/07/02

Réglages E2POT
E2POT settings

Signal MES : **6095 / 1**
MES signal

Signal REF : **4377**
REF signal

Keiichi Takahashi:
I believed that the life time of an analyzer is 8 years. But, the AQCC maintenance performance changed my mind.

Tehran AQI, 96-97

- At least every two-weeks zero/span check
- At least every six-month multipoint calibration ($R^2 > 0.9995$)
- At least every month flow calibration check for PM analyzers
- Regular MFC flow calibration check by primary standards (ref lab)
- Regular calibration gas check in ref lab
- PM offset measurement (36 hour test)
- Sampling system check by gas injection
- Etc.

Monitoring Regulations

According to **40 CFR – Part 58 (1965-2018)**

CFR: Code of Federal Regulations

Title 40: Protection of Environment

Part 58: AMBIENT AIR QUALITY SURVEILLANCE

Gaseous Pollutants

O_3,CO, NO_2 and SO_2

According to 40 CFR
Part 58

Station Requirements

- Temperature (CFR Part 53.32)
- Power (CFR Part 53.32)
- Data System
- Isolation and Mounting
- Access
- Labeling

Temperature

•Required 20-30Deg.C

range-and stable(+/-2Deg) within that range, especially for low level!!!

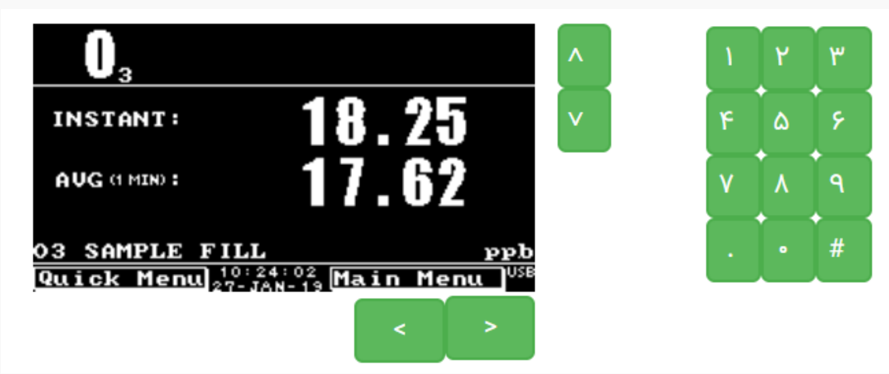
•Problems can occur, especially if T changes during measurement; PV=nRT Rules!

•Need AC

Data System

AQCC system

- Online continuous data logger system
- Concentration, Temperature, Humidity, UPS status, etc.
- Data logger redundant system
- Remote access to analyzers
- Calibration control mode



Probes, Manifolds, Lines, etc.

- For Reactive Gases, need Sampling Flowpath made of Non-reactive materials
- FEP Teflon or Borosilicate Glass; most ¼” (PTFE not mentioned but allowed!)
- Minimize turns fittings, that increase resistance, change P
- Use 316 SS for reactive gases only when P too high for Teflon
- Use SS for reactive gas regulators
- Brass Regulators OK for UP air, CO

Standards and Calibrators

- EPA Protocol Gas in Cylinders
- NIST SRPs*
- Zero Air
- Calibrations
- Calibrators

These items are used to calibrate test gas analyzers a

generate audit test gases.

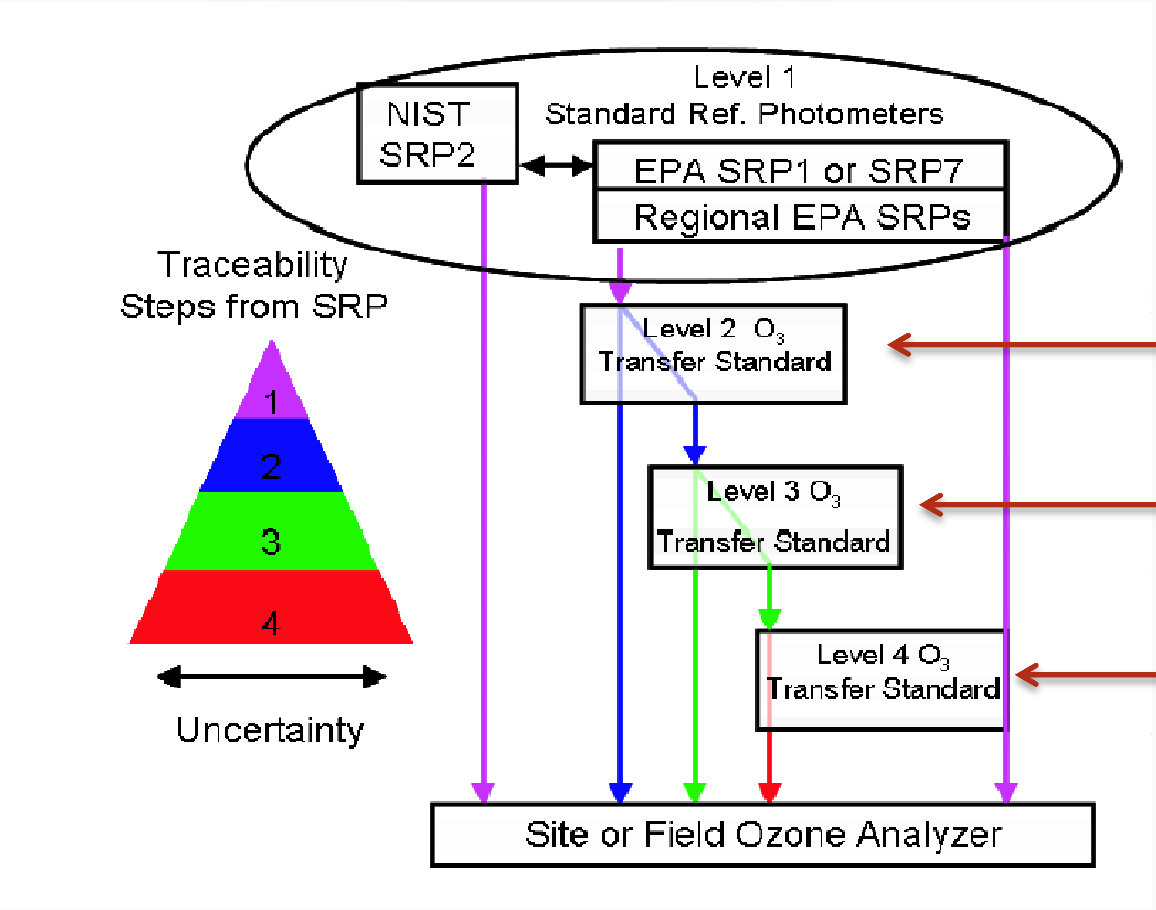
EPA Protocol Gas in Cylinders

- NIST SRMs and NIST Traceable NAAQS CO, SO_2 and NO in commercial compressed gas cylinders (2000 psig or 150 bar in N_2 or air)

How to have SRM for Ozone?

How to have NIST Traceable calibration gas for CO, NO and SO_2?

EPA Protocol for Ozone transfer standard



"Local primary standard"

"Audit or field standard"

"Field standard"

Levels 2 – 4 ozone standards are all transportable devices, but the Level 2 standard should remain stationary

Standard Reference Photometer (SRP)

•NIST Traceable NAAQS O-3 Use a UV wavelength in a NIST or commercial-made device (can’t bottle ozone)

2 •NIST SRPs in RTP vs 2 NIST SRPs

1 •NIST SRP in 8 of 10 EPA Regions

- All SLT “primary” commercial devices must be compared /1yr to Regional SRPs

Challenges of Calibration gases in Iran

- Sanctions and difficulties for purchasing gases
- So Expensive!
- Take lots of time
- Hard to refill
- Non-consumable bottles
- Short shelf life

Reference Laboratory

Reference Laboratory

- ✓ First and Only Reference Laboratory for Ambient Air Quality Monitoring
- ✓ ISO 17025 Certificate
- ✓ Accredited by Department Of Environment (DOE)
- ✓ First and Only Primary Standard for Ozone in Iran
- ✓ Calibration chain traceable to NIST for SO_2, CO, NOx
- ✓ Primary Standard for **Flow**, Pressure, and Temperature
- ✓ SOP According to EN Standards

Reference Laboratory

- ✓ Verification and Calibration of Ozone Generators and Analyzers
- ✓ Verification of SO_2, CO, NOx Calibration Gases
- ✓ Verification and Calibration of Mass Flow Controllers (MFC) of Calibrators
- ✓ Verification and Calibration of Maintenance Instruments, such as Flow Meter, Barometer, Thermometer, etc.
- ✓ Verification and Calibration of Gases Analyzers

Zero Air (ZA)

Zero Air

- Part 58 AppB,sect.2.6.1,Gas..Audit Standards must be NIST-traceable; but, no NIST Zero
- Part 50, Appendices for gases: must be free of contaminants which will cause a detectable response on the analyzer; or react with the gas being analyzed

Zero Air

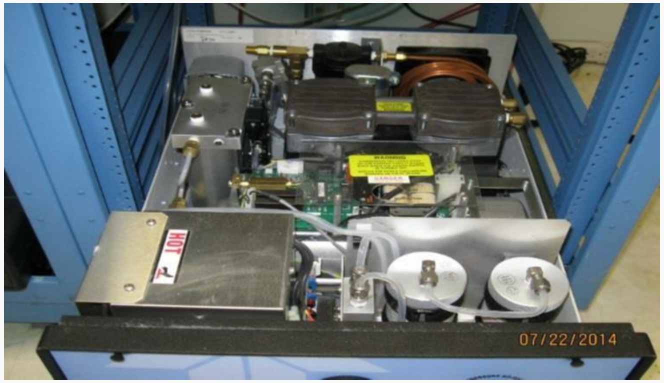
- ZA role: used to zero analyzers; dilute hi conc.to make ambient concentrations and make and dilute ozone
- Sources: zero air generator (ZAG-ambient air scrubbers), or commercial cylinders.
- Best ZAG Feature: Regeneration Cycle
- So, sources vary a lot. So, need to document
  ALL info about your ZA

Zero Air

- Use same “0” for all 4 –CO, SO_2, NO_2 and O_3

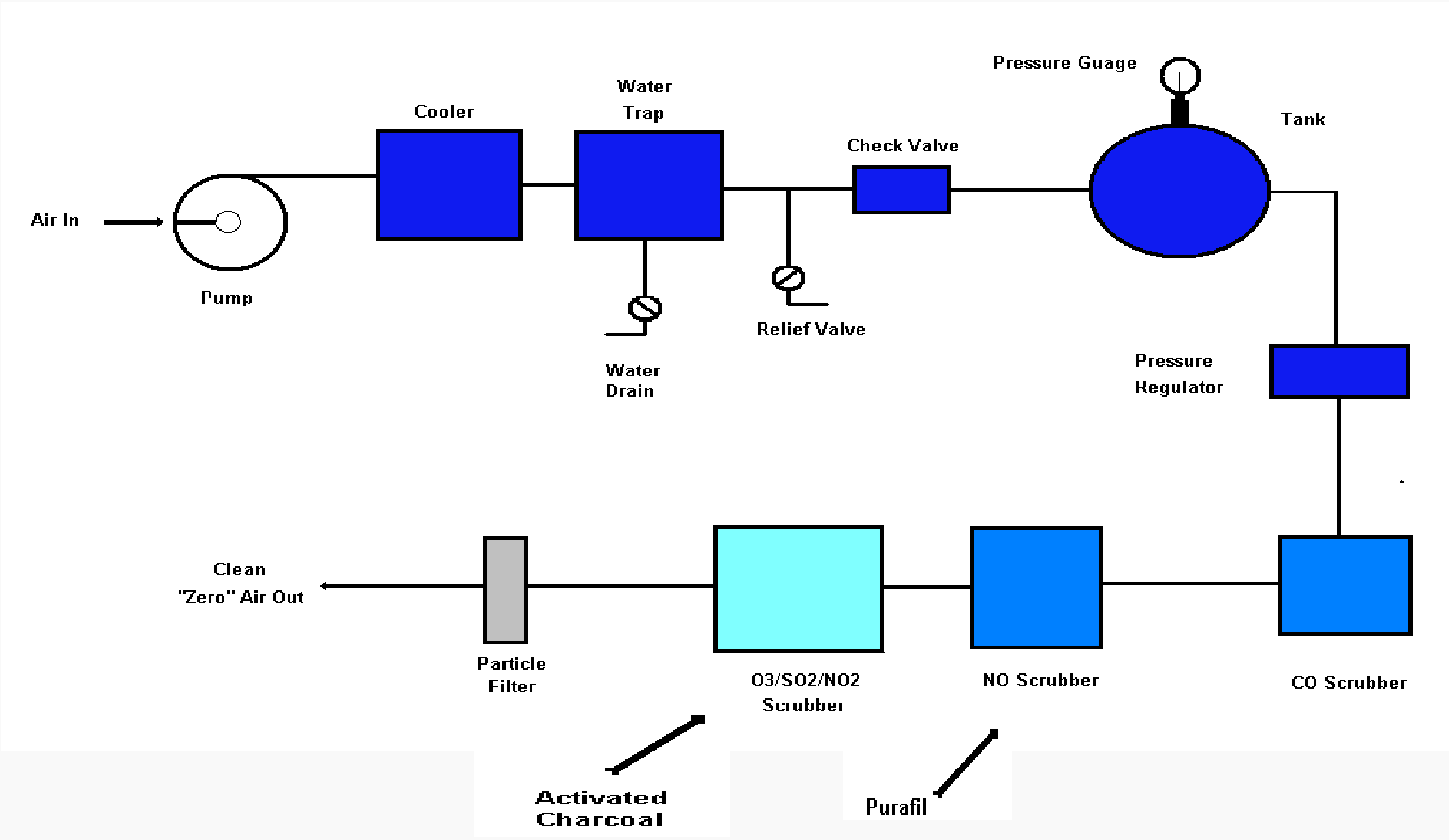
- Should identify ZA Acceptance criteria

- Can control problems by checking ZAG vs Air Cylinder, since ZAG can change, cylinder is less likely to; if ZAG “0” is “better,” use ZAG for your zero; and Document!



Zero Air

Zero Air Systems - Features



Zero Air

Zero Air Source - Issues

- The air system should be able to provide clean air below the stated Lower Detection Limits (LDL) of the instruments you are operating at maximum required flow rates (up to 20 l/min)
  - NO: 50 ppt
  - SO2: 100 ppt
  - CO: 40 ppb (20 ppb is better)
- Check the specifications before you purchase
- Regularly maintain/replace scrubbing materials

Zero Air Generation - Issues

Ultra Pure Cylinder Air vs. Zero Air Generators

Trade off:

Quantity Used vs. Costs for cylinders

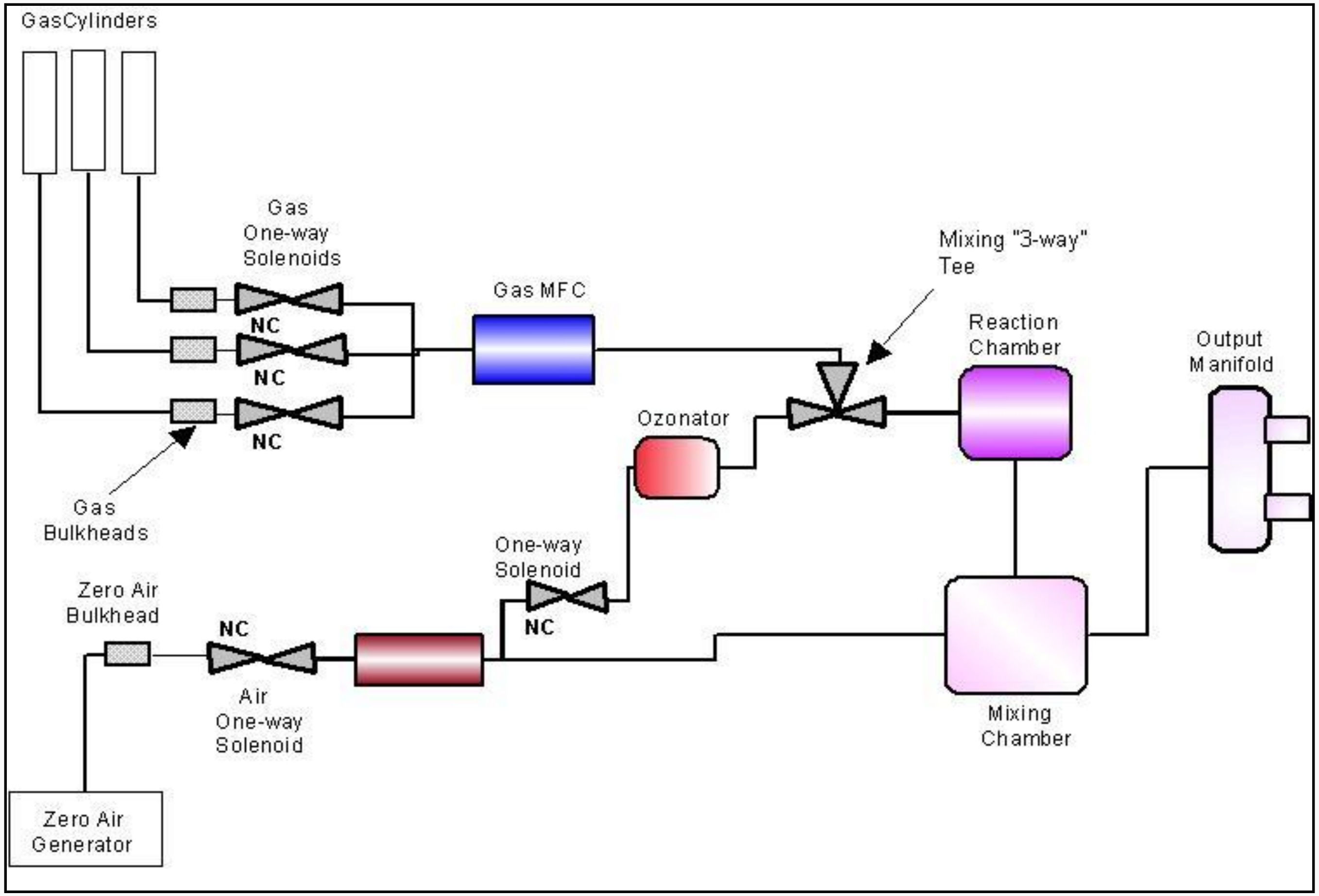
- High flow rates
- Humidity issues
- Purity of air generated
- Use Ultra Pure Cylinder air to verify Generator purity (recommended)

Calibrators

- Vary between vendors. Some (more than 1) vendors can add a 3rd MFC to the regular range device that only has 2. Set up for Gas Phase Titration(GPT).
- Trace will need a 3rd MFC, compared to the 2 needed for regular range
- Regular range Calibrators may contain O3 Generators designed for regular range. Can/may need to be adjusted for lower level concentrations.

Calibrators

Typical Mass Flow Controller (MFC) Theory Calibrator Diagram



Calibrators

CALIBRATOR CRITICAL SPECIFICATIONS

- Gas Flow – 0 to 100 cc/min
- Air Flow – 0 – 20 L/min
- Multiple Gas ports - optional
- Built in traceable ozone generator
- Accuracy +/- 1% Full Scale
- Precision +/- 1% Full Scale
- Linearity +/- 1% Full Scale

Calibrators

Calibrator Specification Matrix (EPA Research 2006)

Calibrator	Gas* Flow	Air* Flow	Gas input Ports	Ozone Gen.	Flow Accuracy	Flow Precision	Linearity
Ecotech 1100	0-500 sccm	0-20 lpm	4 Std.	Yes, 0 – 1ppm	+/- 1.0% Full Scale	+/- 0.15% Full Scale	0.15% Full Scale
Environics 9100	0-100 sccm	0-20 lpm	2 Std.	Yes, 0.5 – 1.25 ppm	+/- 1.0% Full Scale	+/- 1.0% Full Scale	1.0% Full Scale
Sabio 4010L	0-1000 sccm	0-20 lpm	Yes	Yes, 0 – 2 ppm	+/- 1.0% Full Scale	+/- 0.15% Full Scale	0.5% Full Scale
Tanabyte 300	0-100 sccm	0-10** lpm	Yes	Yes, 0 – 2 ppm	+/- 0.5% Full Scale	+/- 0.1% Full Scale	0.5% Full Scale
Teledyne-API 700E	0-200 sccm	0-20 lpm	4 Std.	Yes, 0.1 – 10 ppm	+/- 1.0% Full Scale	+/- 0.2% Full Scale	0.5% Full Scale
Thermo 146C	0-200 sccm	0-20 lpm	NA	Yes	+/- 1.0% Full Scale	+/- 1.0% Full Scale	1.5% Full Scale

Calibrators

Calibrator Critical Features

- Option for multiple gas flow controllers to expand dynamic dilution range
  - Want to stay away from flows less than 10% or greater than 90% of MFC full scale
- Internal calculation of MFC flow response
- Programmable scheduled tasks
- Remote access and control ready (accept direct digital commands)
- Digital Inputs – controlled by remote access
- Digital Outputs – signals to remote device
- Capability to directly control solenoids without external power supplies

Calibrators

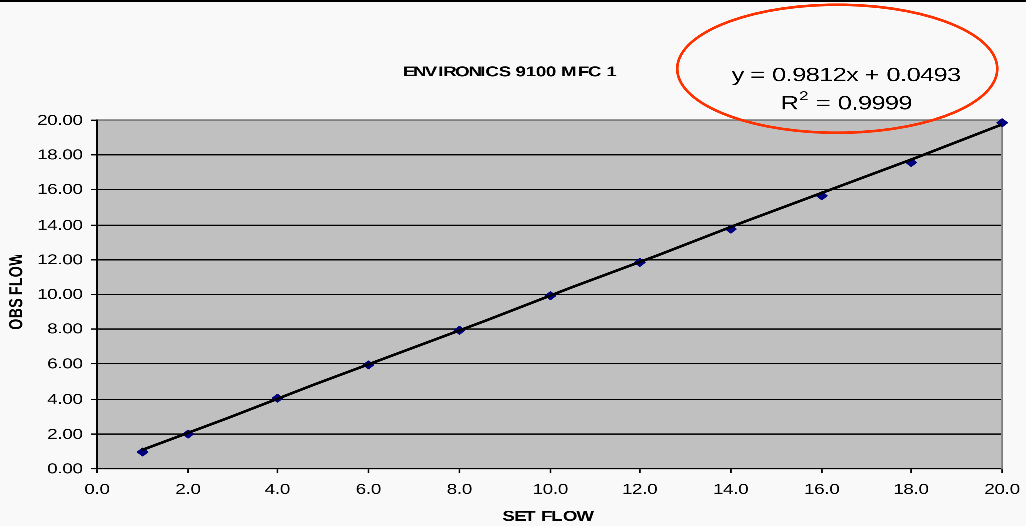
Certifying your Calibrator Flows

- Initial calibration should be provided with purchase – always recheck after delivery
- Certify flow controllers against a NIST traceable flow device **NIST Traceable flow device should be certified annually** (or if you suspect a problem)
- **Perform quarterly or semi-annual checks of your MFCs**
- Calculate observed flow vs set points at STP (25 degrees Celsius and 760 mm Hg)

Calibrators

MFC Calibration (Environisc)

ZERO AIR FLOW CONTROLLER MFC1 LAST CERTIFICATION: 8/21/2006							
		L/M (5 REPLICATES PER READING)					
POINT#	DISPLAY/SET	DRYCAL1	DRYCAL2	DRYCAL3	DRYCAL4	DRYCAL5	AVERAGE
1	20.0	19.90	19.80	19.82	19.81	19.80	19.826
2	18.0	17.58	17.60	17.61	17.58	17.58	17.590
3	16.0	15.67	15.68	15.67	15.68	15.67	15.674
4	14.0	13.71	13.72	13.74	13.74	13.72	13.726
5	12.0	11.82	11.83	11.84	11.83	11.82	11.828
6	10.0	9.90	9.91	9.92	9.91	9.91	9.910
7	8.0	7.95	7.95	7.94	7.94	7.94	7.943
8	6.0	5.98	5.98	5.98	5.98	5.98	5.980
9	4.0	4.01	4.01	4.01	4.01	4.00	4.008
10	2.0	1.99	2.00	1.99	1.99	2.00	1.994
11	1.0	0.976	0.987	0.976	0.981	0.978	0.980



Looking for a slope near 1.0000 and an R-square of ≥ 0.9990

Calibrations

- 40CFR Part 50, Appendices' sections on calibration, for 20-80% Full Scale (from 70's)
  - May not be appropriate for current ambient concentrations
  - Recent data challenges – "Calibration should have one point in the range of monitors concentrations"
- The QC (Sect. 9) and calibration section of the QA Handbook (Sect. 12) address the issue.
  - Using term "calibration scale" vs. "full scale"
- Ozone proposal will revise Part 50 to describe calibration scale (expected to be out for review by the end of CY(2014

1Point Precision Check vs.Cal.

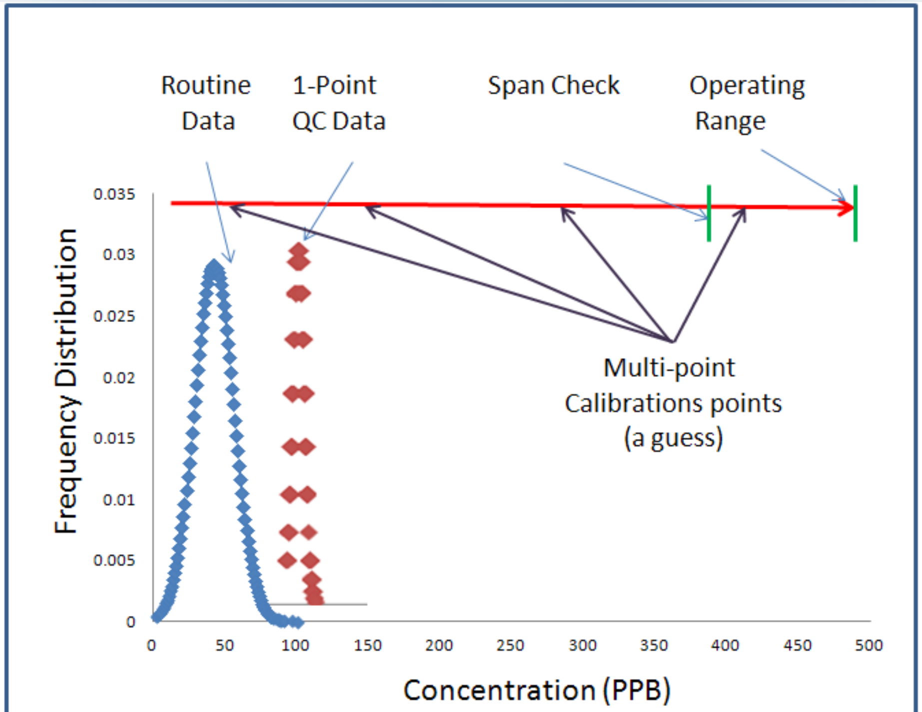
- ’1970s (to Present) Part 50 Calibration Requirements vs 1 Pt. Check requirements are inappropriate for the 1 pt check, because CFR Calibration requires no points lower than % 20FS. But many recent monitoring data are below 20% FS- especially for O3 (“low level!”)

Lowering 1-Point QC Check Concentration Range

- CO
  - Current: 1-10 ppm
  - Proposed: 0.5-5.0 ppm

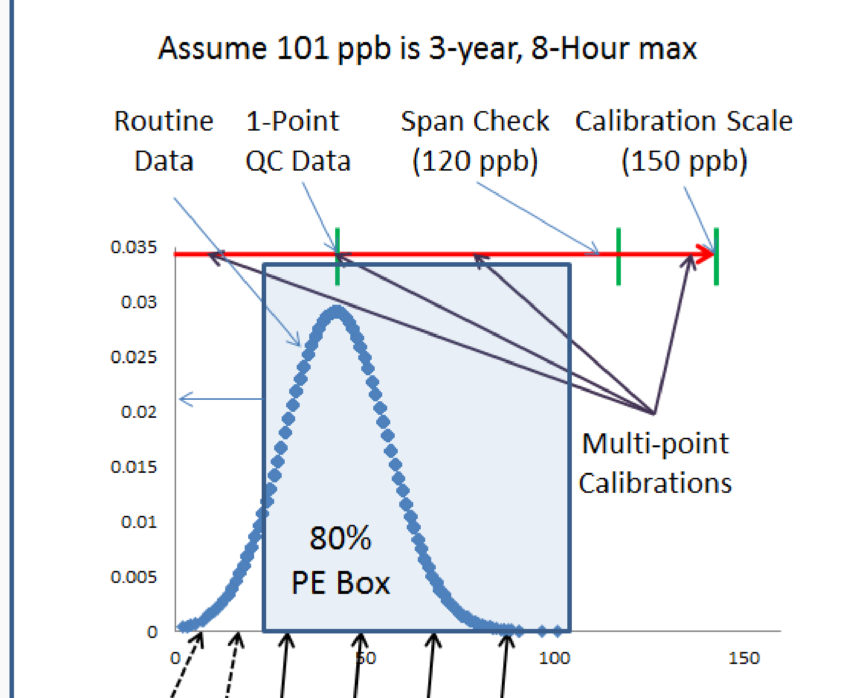
- SO_2, NO_2, and O_3
  - Current: 0.01-0.1 ppm (10-100 ppb)
  - Proposed: 0.005-0.08 ppm (0.5-80 ppb)

Full Scale (Operating Range) vs. Calibration Scale (or calibration range)



Historical Approach
(real data example)

New Thinking



PE Audit Levels (ppb)									
1	2	3	4	5	6	7	8	9	10
4.0-5.9	6.0-19	20-39	40-69	70-89	90-119	120-139	140-169	170-189	190-259

Gas Phase Titration (GPT)-EN

1- Calibration of both channels of the analyzer with NO at 50 % to 80 % of the certification range of NO (~480 nmol/mol– 770 nmol/mol NO)

2- Application of 50 % of the NO certification range until a stable signal is obtained (at least 12 min) (~480 nmol/mol NO- no NO_2)

3- Addition of O_3 at the level of 50 % of the certification range of NO_2 (~480 nmol/mol NOx, of which ~131 nmol/mol is NO_2) until a stable signal is obtained (at least 12 min);

Gas Phase Titration (GPT)-EN

4- Switch off addition of O_3. Application of 50 % of the NO certification range until a stable signal is obtained (at least 12 min) (~480 nmol/mol NO, no NO_2);

5- Addition of O_3 at the level of 95 % of the certification range of NO_2 (~480 nmol/mol NOx, of which ~248 nmol/mol NO) until a stable signal is obtained (at least 12 min);

6- Switch off addition of O_3. Application of 50 % of the NO certification range until a stable signal is obtained (at least 12 min) (~480 nmol/mol NO, no NO_2)

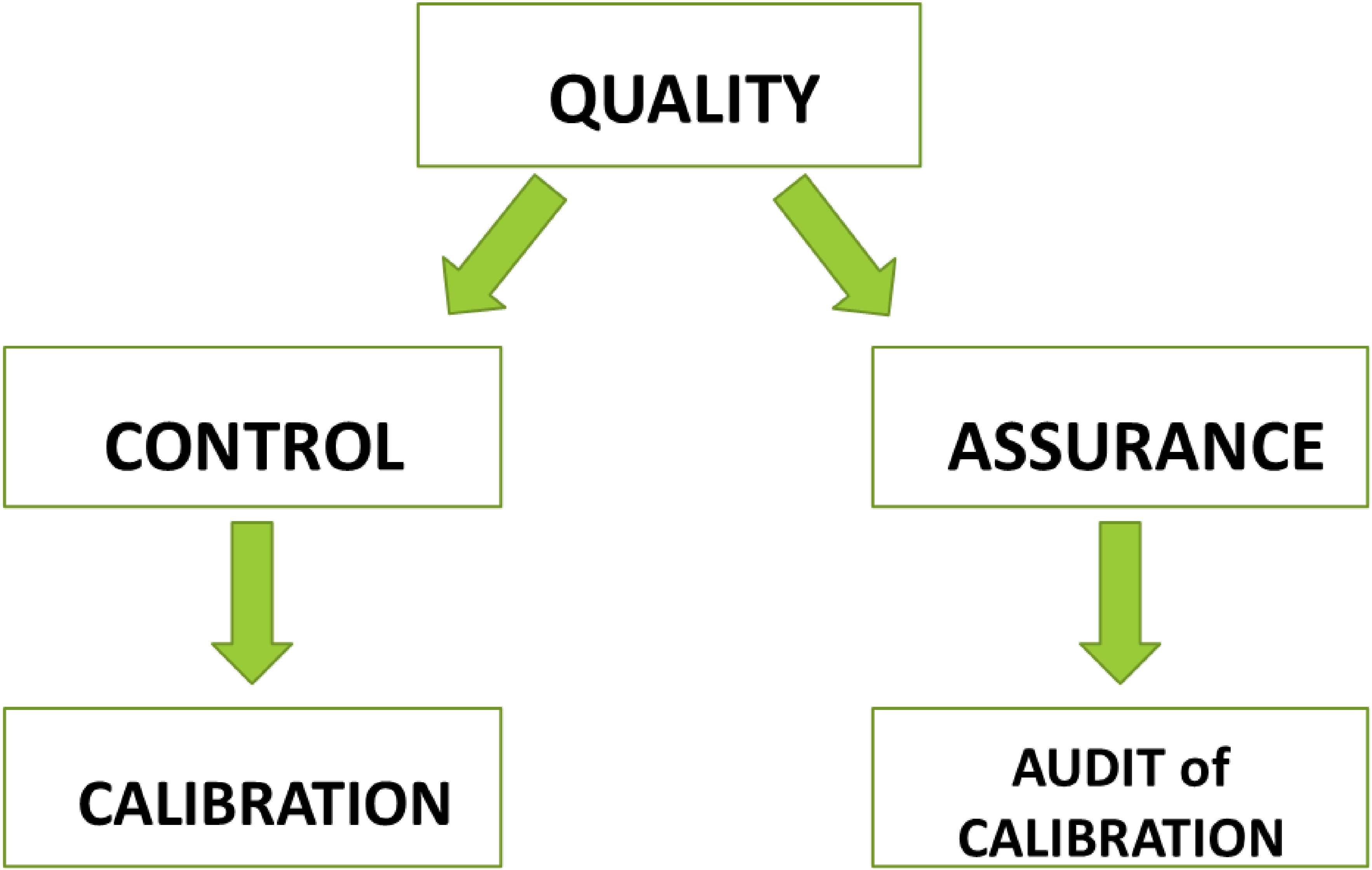
Gas Phase Titration (GPT)-EN

$$E_c = \left(1 - \frac{C_{NO_x,init} - C_{NO_x,fin}}{C_{NO,init} - C_{NO,fin}}\right) \times 100$$

E_c	converter efficiency in %
$C_{NO_x,init}$	average of the **four individual measurements**
$C_{NO_x,fin}$	average of the **four individual measurements** after applying O_3
$C_{NO,init}$	average of the **four individual measurements**
$C_{NO,fin}$	average of the **four individual measurements** after applying O_3

$$E_c \geq 98\%$$

QA/QC Standards


QUALITY
CONTROL
ASSURANCE
CALIBRATION
AUDIT of
CALIBRATION

40 CFR Part 58, Appendix A, §2.1

All (Primary Quality Assurance Organizations) PQAOs must develop a **quality system** that is **described and approved** in quality management plans (**QMPs**) and quality assurance project plans (**QAPPs**) to ensure that the monitoring results:

- Meet a well-defined need, use, or purpose;
- Provide data of adequate quality for the intended monitoring objectives;
- Satisfy stakeholder expectations;
- Comply with applicable standards specifications;
- Comply with statutory (and other legal) requirements; and,
- Reflect consideration of cost and economics.

QA / QC Standards

•For NAAQS monitoring, QA / QC standards must meet NIST traceability specifications found in 40 CFR Part 58, Appendix A

•Quality / sensitivity of the standards procured depends on the monitoring objectives (i.e., intended use)

•Examples:

- •Ncore: **National Core (NCore) Network**
- •SLAMS: **State or Local Air Monitoring Stations (SLAMS) Network**
- •NATTS: **National Toxics Trends Network**
- •CASTNET: **Clean Air Status and Trends Network**
- •NADP: **National Atmospheric Deposition Network**

etc.

Types of Standards

- Photometers
- Mass reference standards (i.e., check weights)
- Calibration gases (cylinders)
- Calibrator Mass Flow Controllers (MFCs)
- Other **flow rate** devices
- Thermometers
- Barometers
- Others

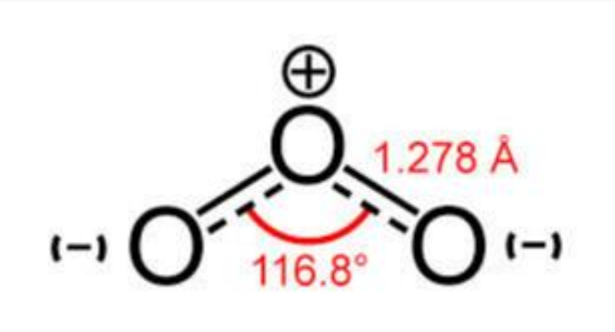
Gaseous & Flow Rate Audit Standards

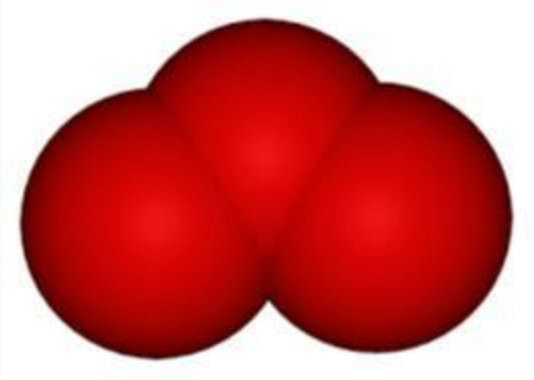
40 CFR Part 58, Appendix A, §2.6.1:

Gaseous pollutant concentration standards used to obtain test concentrations for CO, SO_2 , NO, NO_2 **must be traceable** to either a NIST-Traceable Reference Material or a NIST-Certified Gas Manufacturer's Internal Standard

40 CFR Part 58, Appendix A, §2.6.2:

Test concentrations for ozone (O_3) must be obtained in accordance with the ultra violet photometric calibration procedure specified in Appendix D to Part 50, and by means of a **certified O_3 transfer standard**





Gaseous & Flow Rate Audit Standards

40 CFR Part 58, Appendix A, §2.6.3

Flow rate measurements **must** be made by a flow measuring instrument that is **traceable** to an authoritative volume or other applicable standard

What is traceability?

Traceability

Traceability – 40 CFR Part 50

40 CFR 50.1(h):

"**Traceable** means that a **local standard** has been compared and certified either directly or via not more than one **intermediate standard**, to a **primary standard** such as a National Bureau of Standards* Standard Reference Material (NBS SRM), or a USEPA/NBS-approved Certified Reference Material (CRM)."

*NBS is now NIST

Traceability

Traceability – 40 CFR Part *58

40 CFR 58.1:

"**Traceable** means that a **local standard** has been compared and certified either directly or via not more than one **intermediate standard**, to a **NIST-Certified primary standard** such as a NIST-Traceable Reference Material or a NIST-Certified Gas Manufacturer's Internal Standard."

*Revised in 2016

Traceability

Standard traceability is the process of transferring the accuracy or authority of a primary standard to a field-useable standard.

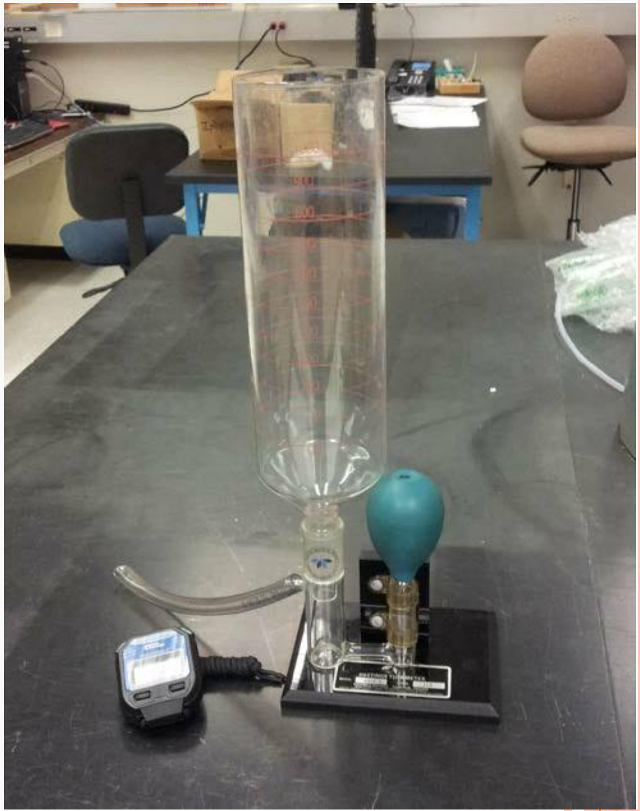
Primary Standard

- By definition, a primary standard is an accurate standard that is not calibrated by or subordinate to other standards

- Primary standard meters are those whose volumes can be determined by measurement of internal physical dimensions alone

Primary Standard

- Usually expensive
- Should be maintained, stored, and handled in a manner that maintains its integrity
- Should be kept under secure conditions
- Often used to calibrate, develop, or assay working of subordinate standards

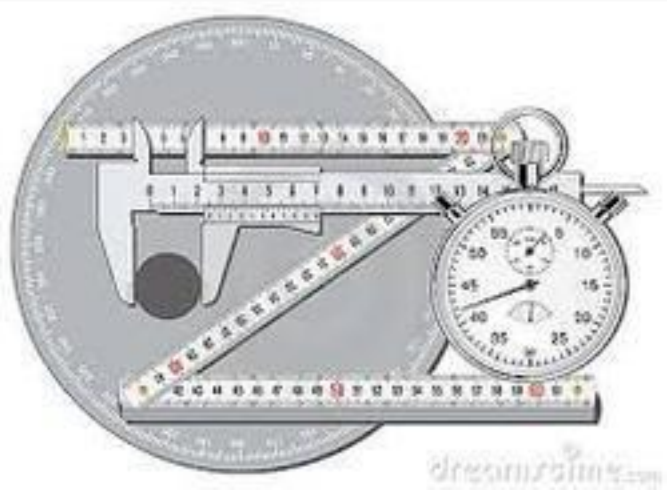


Transfer Standards

- Term used to describe where traceability to a higher standard has been "**transferred**" to a subordinate standard
- Also described as a **transportable device**
- Transfer standards are certified against a NIST / primary standard
- Term refers to a variety of different devices (e.g., ozone transfer standard, flow transfer standard (FTS), among others)
- May also be referred to as Levels 2, 3, or 4 standards in other EPA guidance documents

Calibration

- **Calibration** = Instrument response is changed through an **adjustment**
- **Verification** = Done **without** making adjustments to instrument response
- Calibrations should include adjustment, followed by multi-point verification
- Calibrations should be **documented**, with equipment identification included to show the **traceability** to NIST



Calibration

Calibration Challenges

- Operating analyzers on lower ranges where ambient data are more affected by instrument drift and interferences
  - Old CO range 0 – 50 ppm for NAAQS compliance
  - Typical NCore CO range 0 – 5 ppm or even lower
- More frequent QC checks advised so calibration automation is important
- Integration of data systems and calibrators important for QC validation and timely reporting of problems
- Calibration standard certification periods are shorter for lower concentration standards
- Zero air purity is more critical than ever
- **Reviewing your calibrator capabilities and potentially upgrading hardware may be the most important part of designing and implementing a successful NCore gas monitoring system**

Calibration

NCore Calibration and QC Check Requirements

- QC Checks (Precision):
  - Required (40 CFR 58 Appendix A)
  - Minimum: Once every two weeks – daily is recommended
  - Daily Level 1 Zero and Spans recommended

- Multi-point calibrations:
  - Quarterly (according to TAD) or if drift is an ongoing issue
  - Draft MQO Table - 1 in 6 months, upon instrument startup, repair, or exceeded drift tolerance

Calibration

Calibration and QC Check Concentrations

Item	CO	SO2	NOy
Full Scale Range	0 to 5000 ppb	0 to 100 ppb	0 to 200 ppb
Cylinder concentration	200 – 300 ppm	10 - 15 ppm	10 – 30 ppm
Calibration ranges			
Zero (action tolerance)	± 40 ppb	± 0.100 ppb	± 0.050 ppb
Level I Span (action tolerance)	4500 ppb ± 10%	90 ppb ± 10%	180 ppb ± 10%
Mid Point Span	2500 ppb	50 ppb	100 ppb
Precision Level	250 - 500 ppb	5 - 10 ppb	20 - 40 ppb
Measurement Uncertainty Goal	10% upper 90 percent confidence limit for CV	10% upper 90 percent confidence limit for CV	10% upper 90 percent confidence limit for CV

Traceable Calibrations: Ozone

- **Certified photometer:**
  - Can be a stand-alone device, or contained within a calibrator
  - Maintain records of all photometer certifications
  - Paperwork should show a "chain" back to the Standard Reference Photometer
- **Zero air supply**
  - Does not have to be NIST-traceable, but should be checked annually
  - Document and track zero air testing and maintenance

Traceable Calibrations: SO_2 , CO, NO

- **EPA Protocol Gas Cylinder:**
  - Certificates of Analysis should specify valid certification period & traceability
  - Maintain these records in the central office!
- Gas Dilution Calibrator
  - Annual certifications of **Mass Flow Controllers (MFCs)** using traceable flow standard
- Zero air supply
  - Does not have to be NIST-traceable, but should be checked annually (document!)

Traceable Calibrations: Particulates

- **Certified Flow Standard:**
- Typically performed by an accredited vendor, but can be performed in-house against NIST-traceable flow standards
- Some flow devices contain temperature / barometric pressure sensors that also require recertification*

- **Support Equipment:**
- *Flow standard-dependent**
- Manometer
- Thermometer
- Barometer

PM QA Requirements

Requirements in 40 CFR

- FRM requirements in Part 50 Appendices:

1. Appendix B ……. TSP
2. Appendix J ……. PM-10 (note refers to Appendix L for low-volume measurements)
3. Appendix L …… $PM_{2.5}$

- FEMs performance specifications and testing requirements are listed in Part 53

- Lab climate and filter conditioning requirements: Part 50

Requirements in 40 CFR

But there is more ! – The Part 58 appendices

1. Appendix A and B
2. Appendix C ARMs and Exceptions to Pb-TSP samplers
3. Appendix D Network Design:
   a) Geospatial scale
   b) Siting criteria
   c) Monitoring objectives

Requirements in 40 CFR

And there is still more! –Part 58 appendices

Appendix E: Monitoring Path Siting Criteria for Ambient Air Quality Monitoring

- Horizontal and Vertical Placement
- Spacing from Minor Sources
- Spacing From Obstructions
- Spacing From Trees
- Spacing From Roadways

Overall Requirements For PM

- ***Field QA***
  - ***Flow Verifications and Audits***
  - ***NIST-traceable Parametric measurement devices***

- ***Lab QA***
  - ***Climate and Static controls***
  - ***Balance checks, blanks and Audits***

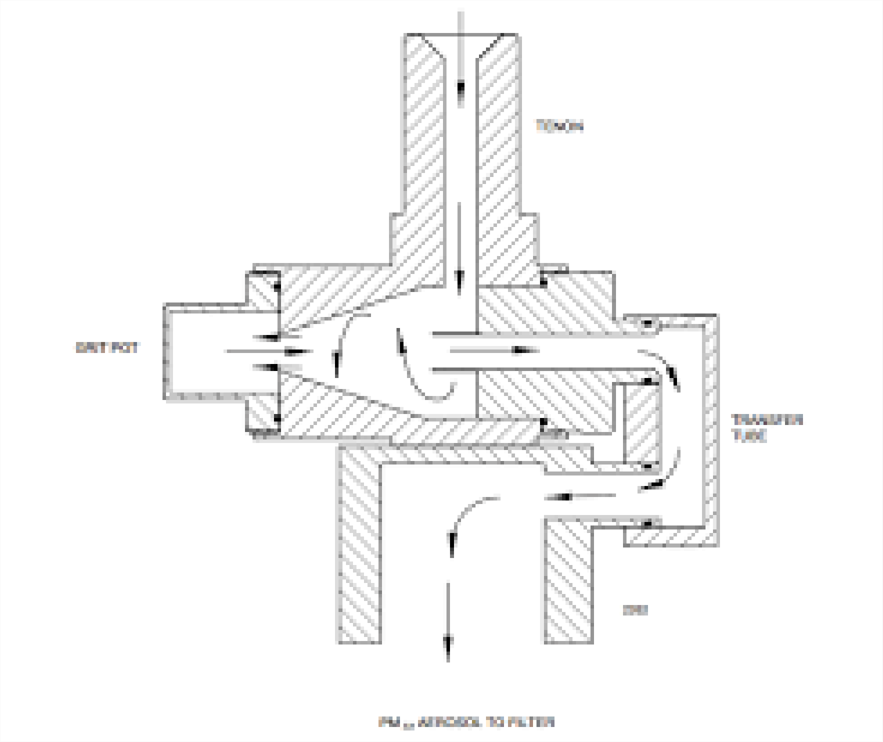
- ***Overall QA***
  - ***Precision***
  - ***Bias***

PM Flow Rate Verifications and Audits

You might ask "why are these important?"

- ***The cut point of the PM separators (size of the particles collected) are dependent on the flow rate***

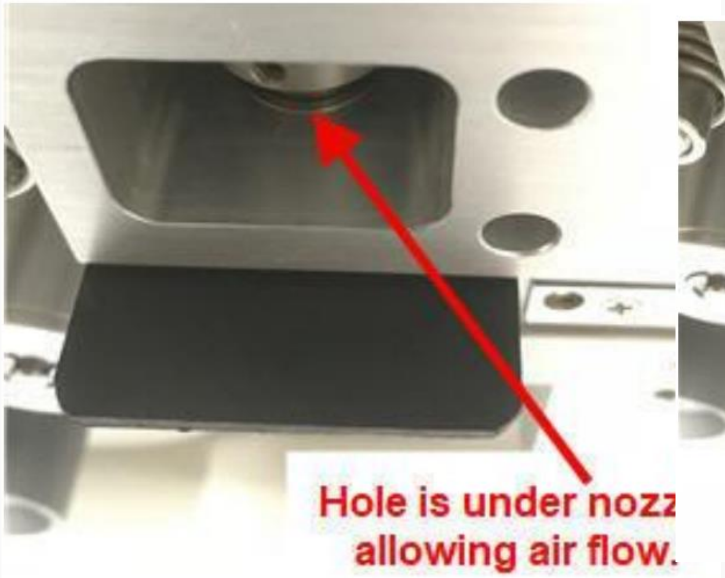
- ***The final concentration value is directly influenced by the flow rate, i.e., 24-hour sample volume***



PM Leak Check

Why is it important?
- Different flow path
- Filter punching

Criterial:
- If the flow rate is 1.5 LPM or less, the leak check is satisfactory
- If the flow rate is greater than 1.5 LPM, the leak check fails



PM and AQI

Appendix G to 40 CFR Part 58 – Uniform Air Quality Index and Daily Reporting Levels are based on 24 hours

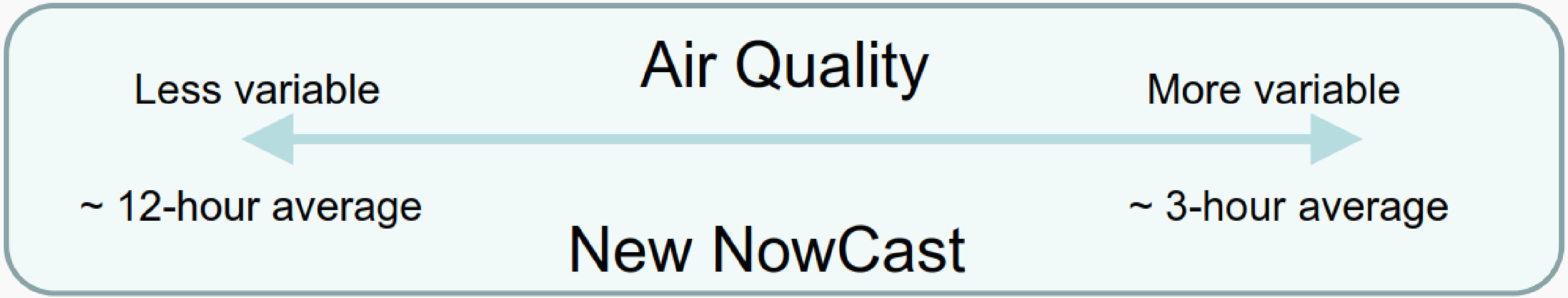
AQI Level	Descriptor	Color	$PM_{2.5}$ Breakpoints (µg/m³)	PM_{10} Breakpoints (µg/m³)
0 to 50	Good	Green	0.0 – 12.0	0 – 54
51 to 100	Moderate	Yellow	12.1 – 35.4	55 – 154
101 to 150	Unhealthy to sensitive groups	Orange	35.5 – 55.4	155 – 254
151 to 200	Unhealthy	Red	55.5 – 150.4	255 – 354
201 to 300	Very Unhealthy	Purple	150.5 – 250.4	355 – 424
301 and above	Hazardous	Maroon	250.5 – 350.4 350.5 – 500.4	425 – 504 505 - 604

PM and AQI

How to handle real-time reporting of the AQI when there are changes in $PM_{2.5}$ concentrations throughout the day?

NowCast:

- AirNow uses a combination of monitor data and air quality projections to show current air quality in the 24-hour AQI form.
- In August 2013 the AirNow program updated the NowCast so it is more responsive to rapidly changing air quality conditions.



Computing the NowCast (As used in AIRNow)

.1 Compute the concentration range (max-min) over the last 12 hours. This tells us how much the air has changed, but relative to what? We need to scale it.

Example 12-hour period

13 16 10 21 74 64 53 82 90 75 80 50

Range = 90-10 = 80 ug/m3

.2 Divide the range by the maximum concentration in the -12hour period

Scaled rate of change is .80/90

.3 Compute the weight factor by subtracting the scaled rate of change from 1. The weight factor must be between .5 and 1. The minimum limit approximates a 3-hour average. If the weight factor is less than .5 then set it equal to ..5

Weight factor is 1 – 80/90 = .11 → less than .5, so use .5

.4 Multiply each hourly concentration by the weight factor raised to the power of how many hours ago the concentration was measured (for the current hour, the factor is raised to the zero power)

… + $(5.)^0$*74 + $(5.)^1$*21 + $(5.)^2$*10 + $(5.)^3$*16 + $(5.)^4$*13

.5 Compute the NowCast by summing these products and dividing by the sum of the weight factors raised to the power of how many hours ago the concentration was measured.

$(5.)$*13^0 … + $(5.)^1$*74 + $(5.)^2$*21 + $(5.)^3$*10 + $(5.)^4$*16 +

… + $(5.)^0$ + $(5.)^1$ + $(5.)^2$ + $(5.)^3$ + $(5.)^4$

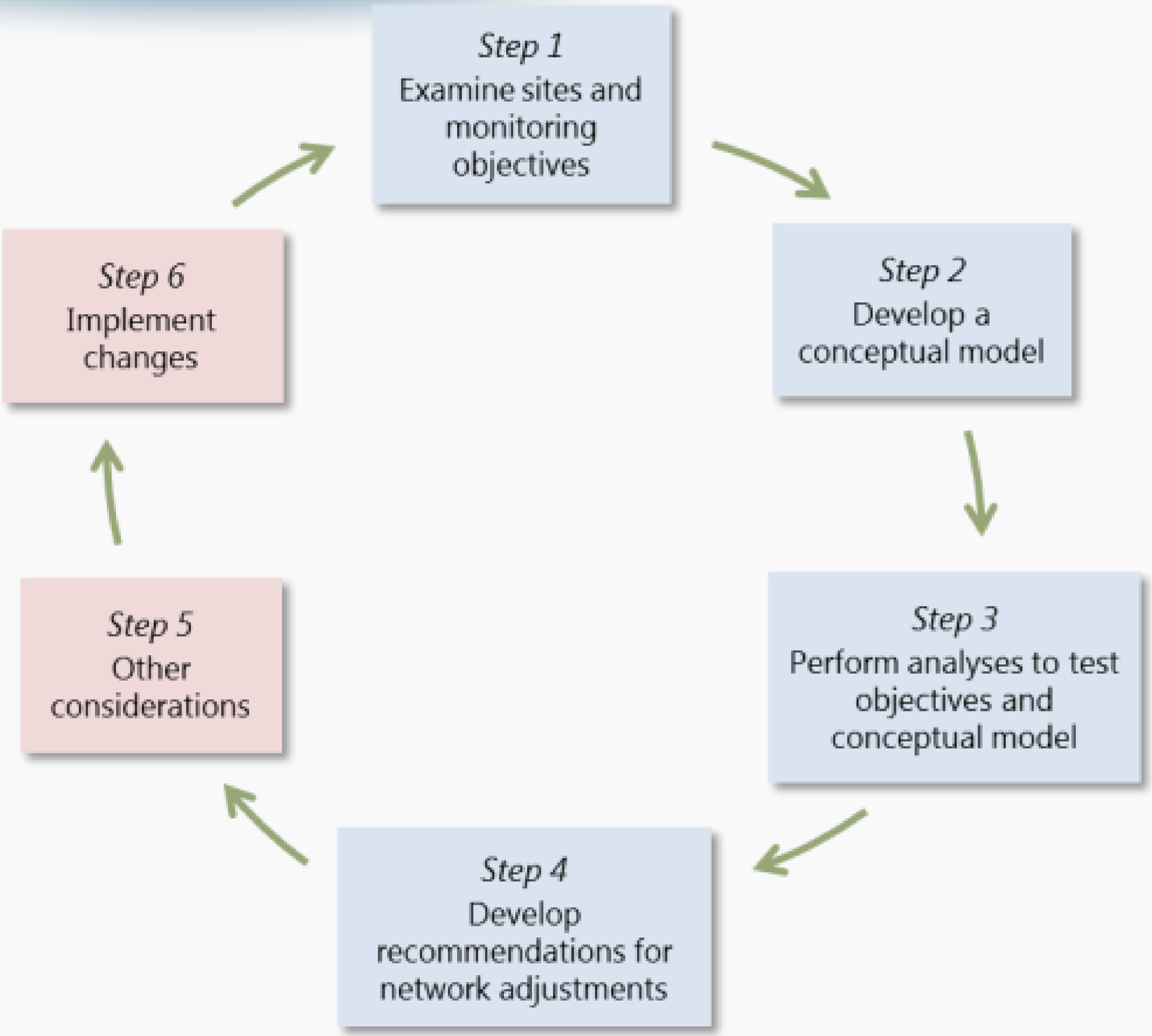
17.4 =ug/m3

Network Assessment and Design

Regulatory Text

*"The State, or where applicable local, agency shall perform and submit to the EPA Regional Administrator an assessment of the air quality surveillance system **every 5 years** to **determine**, **at a minimum**, **if the network meets the monitoring objectives** defined in appendix D to this part, whether **new sites are needed**, whether existing sites are **no longer needed** and can be terminated, and where **new technologies** are appropriate for incorporation in the ambient air monitoring network. The network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma), and, for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies. **For PM2.5, the assessment also must identify needed changes to population-oriented sites**. The State, or where applicable local, agency must submit a copy of this 5-year assessment, along with a revised annual network plan to the Regional Administrator. The first assessment is due July 1, 2010."*

Network Assessment and Design



Conceptual Model:

- Review sites, monitoring objectives, and supporting data
- Synthesize data to form a conceptual model of the existing monitoring network and its ability to meet the monitoring objectives

A conceptual model is a mental model used to represent our understanding of the network. The model forms the basis for a preliminary set of network recommendations.

Correlation Analysis (Ozone)

	شریف	پیروزی	اقدسیه	پونک	م۲	گلبرگ	مسعودیه	م۴	ری	ستادبحران	م۱۶	م۲۱	فتح	شادآباد	تربیت مدرس	پارک رز
شریف	1															
پیروزی	0.90002385	1														
اقدسیه	0.91560111	0.88990864	1													
پونک	0.88151288	0.86469033	0.91090612	1												
م۲	0.91453098	0.88657685	0.93812879	0.92264878	1											
گلبرگ	0.90297747	0.9170753	0.92272922	0.85917731	0.8926037	1										
مسعودیه	0.85882686	0.86870234	0.87115377	0.84557239	0.8457706	0.88412197	1									
م۴	0.81068963	0.82371024	0.89100212	0.79289295	0.8447381	0.81354327	0.81369789	1								
ری	0.89692296	0.89807948	0.86546578	0.84201023	0.8623456	0.86957232	0.8469	0.804187	1							
ستادبحران	0.94739378	0.91494944	0.93359686	0.88733508	0.9361005	0.94464886	0.87359763	0.841671	0.889419	1						
م۱۶	0.86312349	0.85027919	0.78583477	0.76404032	0.7939236	0.848523	0.81544267	0.61469	0.83953	0.85903388	1					
م۲۱	0.9515186	0.90834455	0.91532894	0.89825158	0.9260715	0.92046289	0.86706711	0.887019	0.929131	0.95295898	0.809757	1				
فتح	0.94747053	0.88219129	0.89531614	0.84457902	0.8795196	0.90078572	0.85036689	0.746413	0.911869	0.93576817	0.838021	0.967697	1			
شادآباد	0.91564471	0.87620348	0.88023504	0.84598602	0.8774632	0.89640148	0.84248676	0.772084	0.875431	0.92117667	0.869587	0.937166	0.9085451	1		
تربیت مدرس	0.9736417	0.92112442	0.93237127	0.90334461	0.9434165	0.94625084	0.88070355	0.899862	0.926308	0.98073749	0.857347	0.967594	0.9655046	0.9383938	1	
پارک رز	0.59093295	0.56426891	0.57273718	0.59290122	0.6143883	0.54611728	0.58490121	0.504557	0.53789	0.56455038	0.434498	0.518082	0.5063408	0.5627615	0.5616623	1

Correlation Analysis ($PM_{2.5}$)

	شریف	پیروزی	اقدسیه	پونک	م۲	گلبرگ	مسعودیه	م۴	ری	ستاد بحران	م۱۰	م۱۱	م۲۱	شادآباد	تربیت مدرس	پارک رز
شریف	1															
پیروزی	0.75409	1														
اقدسیه	0.51434	0.5649	1													
پونک	0.69317	0.7296	0.4684	1												
م۲	0.57893	0.5521	0.4814	0.617	1											
گلبرگ	0.60837	0.7175	0.5209	0.525	0.4725	1										
مسعودیه	0.59262	0.5759	0.4536	0.457	0.386	0.549	1									
م۴	0.50781	0.5995	0.4586	0.498	0.3969	0.503	0.39345	1								
ری	0.7508	0.7153	0.3992	0.583	0.4274	0.606	0.51198	0.483	1							
ستادبحران	0.80896	0.7873	0.562	0.704	0.5578	0.638	0.54967	0.578	0.7036	1						
م۱۰	0.87089	0.7616	0.4955	0.694	0.5694	0.647	0.584	0.531	0.7615	0.80292	1					
م۱۱	0.64471	0.6159	0.4145	0.508	0.3898	0.53	0.51644	0.51	0.5961	0.617228	0.66	1				
م۲۱	0.7271	0.6865	0.4465	0.604	0.4331	0.566	0.47911	0.468	0.6953	0.641914	0.704	0.5495	1			
شادآباد	0.77402	0.7121	0.4537	0.653	0.4733	0.586	0.50587	0.504	0.6937	0.669963	0.734	0.6168	0.7538	1		
تربیت مدرس	0.86635	0.8023	0.4788	0.738	0.5533	0.624	0.53141	0.567	0.7555	0.84207	0.832	0.6431	0.7059	0.7382	1	
پارک رز	0.54804	0.6155	0.4334	0.611	0.3672	0.468	0.41093	0.345	0.4514	0.543307	0.522	0.419	0.5028	0.5556	0.5657947	1

Correlation Analysis (CO)

	شریف	پیروزی	اقدسیه	پونک	م۲	گلبرگ	مسعودیه	م۴	ری	ستادبحران	م۱۶	م۱۱	م۱۹	م۲۱	فتح	محلاتی	شادآباد	تربیت مدرس	پارک رز
شریف	1																		
پیروزی	0.339748	1																	
اقدسیه	0.195767	0.550721	1																
پونک	0.279757	0.248512	0.207186	1															
م۲	0.439092	0.279965	0.527129	0.3247704	1														
گلبرگ	0.418446	0.702665	0.6481	0.0867617	0.44488	1													
مسعودیه	0.334773	0.565209	0.422871	0.2797733	0.326812	0.498105	1												
م۴	0.253475	0.474428	0.447227	0.3541681	0.261354	0.380361	0.3887681	1											
ری	0.611117	0.544759	0.345728	0.2158377	0.310124	0.537758	0.4772488	0.4218	1										
ستادبحران	0.626639	0.455538	0.370393	0.1670223	0.445598	0.570116	0.3908835	0.3714	0.65548	1									
م۱۶	0.462059	0.3494	0.275183	0.4700944	0.337052	0.303077	0.3280214	0.41101	0.57292	0.463153	1								
م۱۱	0.577452	0.508248	0.373068	0.0486631	0.398405	0.615085	0.4847522	0.22821	0.629043	0.555009	0.274935	1							
م۱۹	0.537219	0.572369	0.459079	0.2483984	0.445008	0.607818	0.4650383	0.46722	0.775055	0.691735	0.645119	0.708828	1						
م۲۱	0.310309	0.563575	0.46623	0.224386	0.315767	0.528101	0.441454	0.45481	0.559217	0.535263	0.441917	0.52455	0.623825	1					
فتح	0.621564	0.501212	0.340325	0.2046692	0.343489	0.510251	0.3951584	0.47202	0.684398	0.632875	0.430461	0.642821	0.718933	0.549785	1				
محلاتی	0.421239	0.612433	0.385306	0.0241493	0.333305	0.58227	0.4972332	0.16918	0.421193	0.374606	0.138709	0.542167	0.351205	0.309845	0.457118	1			
شادآباد	0.642184	0.475586	0.323948	0.3229751	0.435083	0.50756	0.4257622	0.43455	0.616992	0.618489	0.484229	0.638503	0.592091	0.521449	0.738046	0.504963	1		
تربیت مدرس	0.719008	0.529236	0.373359	0.2721888	0.488813	0.566755	0.4595535	0.40574	0.73123	0.768795	0.496434	0.6572833	0.701876	0.529376	0.746693	0.404954	0.6462	1	
پارک رز	0.164913	0.196239	0.226558	0.081833	0.202515	0.238128	0.1362185	0.15351	0.170409	0.229522	0.110684	0.091537	0.196256	0.130062	0.081524	0.198362	0.157328	0.169461	1

If it is not documented, it did not happen!