Station Operations
High Quality Data Begins Here

About
- Intro points
  - This is not comprehensive
  - Not a substitute for SOPs, manuals, etc.
- Objectives:
  - Fill in some of the gaps in the SOPs & EPA Vol II
  - Point out common issues/mistakes (TSA)
  - Good habits
  - HIGH QUALITY, LEGALLY DEFENSIBLE DATA

Overview
Day in the life
- Starts in the office
- Review of new data
- Field
  - Site check
  - Routine operations
  - PM / Repairs / maintenance
- Particulates
- Calibrations
  - Gaseous & Particulates
Routine Office Procedures: Daily Checks

"Out-Of-Office" E-Mail Auto-Reply:

The e-mail server is unable to verify your server connection and is unable to deliver this message. Please restart your computer and try sending again.

Routine Office Procedures: Daily Checks

At the office:
- Review new data (minute and hourly), looking for:
  - Missing data (power failures, communications failures, etc.)
  - Flags / errors (equipment malfunctions)
  - High / low values (real or not)
  - Extreme values (e.g. over range values, negative values)
  - Unusual changes in values
  - Autocal results

Routine Office Procedures: Daily Checks: Strip Chart Review

Things to look for:
- Patterns
  - Normal – Could be real
  - Abnormal
    - i.e., "spiking"—both positive and negative—of pollutant values
    - Or a power issue, bad lamp, flow obstruction, etc.
Routine Office Procedures: Daily Checks: Strip Chart Review

- Instrument recovery after extended power failure:
  - Minimum of one hour
  - API Nox: 24 – 48 hours
  - API TCO: 4 – 7 days
  - Refer to Mfg. manual

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Routine Office Procedures: Daily Checks: Strip Chart Review

Things to look for:

- Wind Speed/Direction Problems:
  - Mechanical systems:
    - WD flat lining (stuck or sluggish bearings or damaged vane)
    - WD usually zero (stuck or sluggish bearings, or damaged cups)
  - Sonic systems:
    - Bird interference (blocking the signal path)
    - Precipitation/condensation interference (blocking the signal path)

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Routine Office Procedures: Daily Checks: Strip Chart Review

When path is blocked on MetOne 50.5:
- Spiking WD (full scale)
- Reports WD of 10°, 160° or 170°.

Water droplets on transducer affects readings:
- WD jumps up
- WD from ~ N, S, E, or W
- Often seen during rain or at early a.m. when dew forms
Routine Office Procedures: Daily Checks: Strip Chart Review

Shelter Temperature:
- 20 – 30 °C, or per manufacturer’s specifications if designated to a wider temperature range.
- "EPA Recommendation:
  - the standard deviation of the daily temperature values not exceed +/- 2 deg C.

• Instrument manuals and SOPs

Shelter Temperature & Pollutant Interaction
- Not correlated to pollutant concentrations

Pollutant Interaction
Pollutant / Wind interaction

E.g. At many sites, NOx should peak during a.m. and p.m. commute hours.

Deviation from typical pattern
- E.g. At many sites, NOx should peak during a.m. and p.m. commute hours.

Things to look for:
- Deviation from typical pattern
- E.g. ozone should have a diurnal pattern
**Routine Office Procedures: Daily Checks**

At the office:
- If available, review meta data (helps w/ PM)
- Lamp degradation
- Vacuum pump degradation
- Flow degradation
- BAM performance
- Voltages
- Flags, etc.
- Review schedule, looking for:
  - Upcoming / overdue routine maintenance
  - Upcoming / overdue calibrations / audits

**O3 lamp adj**

**10'Hg**

**Flow error**

**BAM alarms**

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**Routine Office Procedures: Timely Data Review**

Should be done in a timely fashion—
- The longer you wait...

- Ref: ARB QA Manual Vol. II sec 2.0.2
- NOTE: Many levels of review (1, 2, 3)
- Each level depends on the previous level

It all starts with the **Station Operator**

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**At the Station**

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Routine Procedures: Site Check

- References:
  - ARB QA Manual Vol. II, Section 2.0.1
  - EPA QA Manual Vol. II Table 11-1

- Upon arriving at site:
  - Note outside conditions
    - weather conditions, trees, roof, shelter condition, potential sources, pests ... anything abnormal!
    - E.g.: construction activity, fires nearby could interfere with measurements or even contaminate instruments and sample lines.

Routine Procedures: Site Check

Note inside conditions

- Sounds
- Odors
- Temperature
- Humidity

Routine Procedures: Site Check

Check for obvious issues:

- Instruments and computers in fault condition, crashed
- Gas lines disconnected, probes damaged
- Damaged meteorological equipment
  - Do instantaneous values in logger match what your eyes see?
  - Incorrect clocks and timers; ensure actual time is correct
  - Synch to NIST clock at time.gov
Routine Procedures: Site Check

Ensure cylinder certification has not expired (FO14)

Routine Procedures: Site Check

Check/log cylinder pressures

<table>
<thead>
<tr>
<th>Category</th>
<th>Minimum Usable Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2/CO2, CO, CH₄, calibrated zero air, hydrogen, nitrogen, compressed air</td>
<td>200 psig</td>
</tr>
<tr>
<td>NO/NOx, SO₂/SO₃, CO/CH₄/NOx/Ar, CO2/NO/SO2/Ar</td>
<td>200 psig</td>
</tr>
</tbody>
</table>

See ARE QA Man Vol II Table 2.0.1.1 for minimum usable pressures

Routine Procedures: Site Check

Check and record instrument test-values

Operational Data Review
- Gas Analyzers / Samplers: Voltages, Flows, Temperatures, Pressures.
Routine Procedures: Site Check

Keep station clean and tidy
- Stations are field laboratories
- No clutter
- Dust
- Clean floors
- 1x/year thorough cleaning

(Re)stock spares and consumables
- backup fuses
- backup fittings
- bearings
- lamps
- tubing
- filters
- gloves
- seals and O-rings
- pump rebuild kits
- paper towels, cleaning supplies
- etc.
Routine Procedures: Going Off-line

Maintenance/Repairs/Calibrations/Audits
- Document periods when instruments are offline
- You can be off-line for up to 30 minutes without losing any hourly data!
  - If possible, minimize periods of lost data by going offline in the last 15 minutes of the hour and going back online before the 15 minutes past the hour
  - Take the respective channel(s) offline at the data logger

Routine Procedures: Changing Filters
- Weekly/monthly per SOP
- Don’t handle with bare hands
  - Clean hands
  - Tweezers (plastic or rubber-tipped)
  - Latex gloves (powder free)
- Mark instrument offline during change and DOCUMENT in log
- Not right before calibration or audit

Shelter Maintenance
- Security:
  - Lock doors, windows, etc.
  - Ensure any exterior lights, motion sensors, cameras are in working order
- Building/room safety:
  - Doors, windows, stairways, interior lighting, flooring treatment are in good order
  - Safety equipment is in order
  - No leaks (Snoop)
Shelter Maintenance: Station Safety Considerations

- Fire extinguisher (A:B:C)
- Fire extinguisher (Halon)
- 1st Aid kit
- CO monitor
- Sound protection (ear plugs, etc.)
- Emergency contact information
  - Hospital Emergency room directions
  - Evacuation information (i.e., Diablo Canyon)
- MSDSs (gas cylinders, etc.)
- Heat Illness Prevention binder
- Roof safety railing
- Cylinders secure (2 straps)

Shelter Maintenance: Probe & Gas Lines

Manifold / probe / exhaust lines

References:
- 40 CFR 58 App. E, Sect. 9,
- Gases: Borosilicate glass or FEP Teflon®
- VOCs: Borosilicate glass or stainless steel
- Exhaust: most anything & away from sample port

If probe material is changed or the length or diameter is changed, send a Probe Report to ARB (MLD-5 Probe Sampler ID Report)

Gas line plumbing

- Exhaust /vent lines must exit the shelter, and have adequate diameter to prevent back pressure
  - Air in shelter must be clean and safe
- Calibration system plumbing
  - No leaks at gas cylinder, calibrator, manifold, or to the inlet port of the analyzer
  - Be mindful of back pressure
  - Observe length/diameter specs in manual
Shelter Maintenance: Probe & Gas Lines

Routinely inspect, clean, replace sample lines
- All lines (and glassware) from the inlet to the analyzers
- Run “As is” cals BEFORE cleaning / replacing sample lines
- Blast with cal gas after cleaning or replacing lines (conditioning)
- Lines can become contaminated from neighbor’s activities

What is wrong here?

Shelter Maintenance

Residence Time (FO4)
- Must be less than 20 sec for gases
- References:
  - 40CFR 58 App. E, Sect. 9
  - CARB QA Manual Vol. 1
  - Worksheet posted on ARB Web Manual page
- Post Residence Time calculation results near manifold

Recalculate whenever sample path is altered!
Preventive Maintenance

- Preventive Maintenance:
  - maintaining the equipment to prevent downtime and costly repairs and data loss
  - is an ongoing element of quality control and is typically enveloped into the daily routine
  - the responsibility of the station operator and the supervisory staff
  - not a static process; procedures must be updated

- Spare parts list, including relevant catalog numbers, is recommended

Preventive Maintenance: Gas Instruments

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>ACTION</th>
<th>WHEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>Rebuild or replace</td>
<td>Wear on diaphragms, seals, and bearings causes low/unstable vacum</td>
</tr>
<tr>
<td>Lamps</td>
<td>Adjust lamp position, drive voltage, and/or detector gain. Or replace.</td>
<td>Output decreases over time</td>
</tr>
<tr>
<td>Optics</td>
<td>Clean and/or replace windows and optical filters</td>
<td>Clouding and petting causes excessive noise, zero/span drift, low response</td>
</tr>
<tr>
<td>Chemicals &amp; scrubbers</td>
<td>Replace</td>
<td>Due to depletion of reagent or lack of scrubbing effectiveness</td>
</tr>
<tr>
<td>Critical Orifices</td>
<td>Replace orifice and associated O-rings and sintered filters</td>
<td>Critical orifices will occasionally clog up causing reduction in flow, zero/span drift, high or low response</td>
</tr>
</tbody>
</table>

Leak Checks

- Perform when a leak is suspected.
  - API says “80 – 90% of analyzer problems are due to pneumatic issues.”
  - Generally plug at sample bulkhead fitting of instrument
  - Watch the flow (and pressure) and record
  - Slowly remove the plug
  - Recheck after pneumatic maintenance
Station Records (FO1)

Air monitoring station site documentation includes:
- Instrument logs (EPA Vol II 11.2.3)
- Instrument manuals
- Instrument QC check sheets
- Station log books (EPA Vol II 11.2.3)
- Instrument utilization reports
- SOPs
- Current bulletins
- Most recent audit results
- AQS (AMP390) / ARB Site reports

All should be on-site and available to auditors!

5 minute break

PARTICULATES

Reporting:
- The State
  - Requires reporting PM$_{10}$ & PM$_{2.5}$ values in actual conditions
- US EPA
  - requires reporting PM$_{10}$ in standard conditions
  - requires reporting PM$_{2.5}$ in actual conditions
  - Standard = Actual Corrected for STP
  - STP = Volume of the Gas * (273.15 / T) * (P / 760)
- Some samplers calculate both standard and actual
Particulates:
Met One BAM 1020

Routine Maintenance:
- Clean inlet (PM2.5 head and PM2.5 cut):
  - Monthly per ARB SOP 400 & Manual.
- Clean Nozzle & Vain:
- Tape change:
  - Roll lasts ~60 days.

Particulates:
BAM Routine QC check (FO7)

- Required bi-weekly by ARB SOP 400
- EPA QA Manual Vol II requires only monthly
- Five element FB
  - Flow rate verification (details on next slide)
  - Cal manometer verification
  - Barometric pressure verification
  - Clock/Timer verification
  - Leak Check

Particulates:
Routine QC: Flow Verification

- Delta-Cal issues:
  - Inaccurate flows due to botched start-up
  - Inaccurate temperatures due to short equilibration
- Solutions:
  - No air flow during initialization (~first 30s)
  - Suggestion: leave in case during initialization.
  - Minimum warm-up/equilibration period: 10 minutes in shade
  - Record Volumetric flow (Qa), not standard flow (Qs).
Particulates: Met One BAM 1020

**Routine QC: Leak Check**
- BAM Manual recommends doing leak checks from the PUMP menu
- Perform before any cleaning
- Open and close valve slowly
- <1.0 LPM passed, <0.5 is ideal
- Minimized time that inlet is capped

**Particulates: BAM Background Test**

**72 hr Background Test:**
- Annually per manual.
- Set BKGD value to 0 before test.
- MetOne recommends using a poly sample tube and set up the system, rather than ambient air.
- Hole punchers using sample syph (inside down tubes) w/ filter
- Best if not run during moist conditions

**Particulates: Met One BAM 1020**

**More Common Considerations / Issues**
- Hole punching
- Wrong Flow Mode
- Dirty down tube – clean 1x/year
- Fluctuating station temperature (2° in 1 hour)
- Inaccurate Rh sensors
- Non-grounded BAM units & inlet tubes (all pieces)
- Non-insulated inlet tubes
- Weak pumps (re-build GAST pumps <20inHg)
- Zero background filter checks out of specifications (ARB/Met One agreement)
- Misadjusted nozzle/vane
- Poorly maintained (not cleaned) nozzle/vane/capstan roller
Particulates: FRM Issues
- Delay in sending in samples (F05)
- Scheduling make-up samples (next 3 slides) (F06)

Particulates: FRM: Make–Up samples
- No more than 5 make-up samples allowed per quarter
- Only two make-up samples are permitted each calendar month for lead; these are counted according to the month in which the miss and not the makeup occurred
  - Source: 40 CFR part 50 Appendices R (Lead)

Particulates: FRM: Make–Up Samples (F06)

Regulations:
- 40 CFR part 50 Appendices N (PM2.5) and R (Lead)
- EPA’s “Use of Make–up PM Samples to Replace Scheduled PM Samples” memo on PM2.5 samples
- 1999 Guideline on Data Handling Conventions for PM NAAQS

What they say:
- Make–up samples are either taken before the next required sampling day or exactly one week after the missed (or voided) sampling day
Particulates: Schedule

<table>
<thead>
<tr>
<th>January</th>
</tr>
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<tbody>
<tr>
<td>S M T W T F S</td>
</tr>
<tr>
<td>1 2 3 4</td>
</tr>
<tr>
<td>5 6 7 8 9 10 11</td>
</tr>
<tr>
<td>12 13 14 15 16 17 18</td>
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<tr>
<td>19 20 21 22 23 24 25</td>
</tr>
<tr>
<td>26 27 28 29 30 31</td>
</tr>
</tbody>
</table>

Meteorological Instruments: Key References

- ARB SOPs

Meteorological Instruments: Wind Sensors (Vanes / Anemometers)

Common Issues:
- Alignment
- Bird damage
- Bearings/torque

Solutions:
- At every site visit:
  - Note alignment
  - Check for damage
  - Do readings make sense?
  - Calibrations & audits

Data Review:
- Periods of WS at 0 mph
- Periods of WD not changing
Meteorological Instruments: Wind Sensors (Sonic)

Common Issues:
• Alignment
• Birds perching
• Rain interference / condensation / fog

Solutions:
• At every site visit:
  • Note alignment
  • Check for damage
  • Do readings make sense?
  • Calibrations and audits
  • Data Review

Meteorological Instruments: Ambient Temperature

Common Issues:
• Dirty Radiation Shield → increased solar heating
• Dirty Sensor Bead → slowed response
• Broken Fan / Blocked flow → increased solar heating

Solutions:
• Regular inspection and cleaning
• At each visit: Is fan running?

Warning:
• Plunging sensor from ice bath into hot water can cause damage

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Data Acquisition Systems: Data Logger

Common Signal Issues:
- **Accuracy:** How well does value recorded by logger match value reported by instrument?
  - For analog connections, problems caused by:
  - Ground loops,
  - Analog-to-digital conversion calibration,
  - Misconfiguration
  - For digital connections:
  - Clock problems, Are logger & instrument clocks in sync?

Solutions:
- Site set-up:
  - When possible use digital connections (serial port, Ethernet, MODBUS, RS-232...)
  - At every site visit:
    - Check values logged by DAS against values reported by instrument front panel.
  - When validating:
    - If possible compare analog and digital data streams. (E.g. BAM 1020).

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CALIBRATION

Calibration

- Calibrations should be carried out
  - at the field monitoring site
  - by allowing the analyzer to sample test atmospheres containing known pollutant concentrations
- The analyzer should be in operation for
  - at least several hours
  - (preferably overnight) prior to the calibration so that it is fully warmed up and its operation has stabilized
- Warm-up periods (per API):
  - 2 hours (O3)
  - 24 – 48 hours (NOx)
  - 4 – 7 days (TCO)
Calibration

- During the calibration, the analyzer should be operating in its normal sampling mode, and it should sample the test atmosphere through all filters, scrubbers, conditioners, and other components used during normal ambient sampling, and through as much of the ambient air inlet system as is practicable.

Calibration: Timing

- When to perform a calibration (EPA QA Vol II, Section 12, 3):
  - Upon initial installation
  - Following physical relocation
  - After any repairs or service that might affect its calibration
  - Following interruption in operation of more than a few days
  - Upon any indication of analyzer malfunction or change in calibration
  - At some routine interval or at minimum every 6 months (FO10)
  - Station shutdown

- Frequency of full calibration
  - Full calibration (multipoint) = 6 mo (as is / final)

Calibration: Timing

Regarding audits
  - No calibrations within 30 days before an audit (CARB QA)

Regarding pollution & meteorological conditions
  - Pollution: not during pollutant episodes, (i.e., O3 not in afternoon)
  - Met / Particulates: not during high wind conditions or adverse weather conditions due to safety
Calibration: Standards

- Traceability of Standards (EPA QA Vol II, Section 12.1.2)
- CARB Standards Lab cert. schedule:
  - http://www.arb.ca.gov/aaqm/qa/stdslab/stdslab.htm
- Ensure standards are not expired (FO14)

Calibration: Zero Air (FO13)

- Testing:
  - Frequency: 1/year (EPA QA Vol II, Section 3, Table 3.1)
  - Concentrations below LDL (EPA QA Vol II, App. D tables)
  - Protocol: more detailed procedures will be forthcoming
- Maintenance, Scrubbers, Chemicals
  - Replace per mfg. PM schedule or as needed
  - Determine if maintenance caused a change in response:
    - If “as is” zero check was ok, and “final” zero check is ok, then assume no problem.
    - If “as is” zero check was high or low and “final” zero check =0, then ok...
      if not, determine cause of discrepancy.

Calibration: Proper use of Standards

- Response plateauing
- Purging regulators
- Warm-up period
Calibration: Response Plateauing
Actual EPA Audit finding (not from California):

1. At all sites, bidirectional verification (precision) checks and performance audit procedures appear to be needed, and in many cases, stable concentrations are not achieved before analyzers are placed back on site. Commentary on the electronic chart by field technicians indicate that staff are highly concerned about data recovery generation, and therefore any of some procedures that in order to “zero data,” remove data from procedures in which concentration points have not been given ample time to stabilize is questionable at best, and therefore does not serve the purpose for which it was intended.

- General practice is to allow concentrations to stabilize (plateau) for at least 10–15 minutes
- Teledyne API Analyzers:
  Stability should be <0.5 ppb (non-trace level)

Calibration: NO₂ Example

Calibration: Purging a Regulator
Automated with Properly Purged Reg
1. Attach the regulator to the cylinder valve.
2. Open the cylinder valve to flow gas into the regulator, then immediately close the cylinder valve.
3. Increase the regulator outlet pressure by 2 or 3 PSI.
4. Then open the regulator outlet valve to vent the gas trapped in the regulator.
5. Close the regulator outlet valve.
6. Repeat steps 2 through 5 (4-5 times).

*CAUTION*: Many gas mixtures contain harmful or toxic substances. Suitable vents must be used to avoid breathing these substances.
Calibration: Other Issues

- Calibration equipment warm-up periods:
  - In general, most calibration equipment requires a minimum of 1 hour warm-up.
  - Dynamic Dilution Calibrators, Ozone transfer standards, etc.

- Calibration points (F011):
  - Minimum number of points is specified by EPA:
    - 40 CFR 50 Appendices
    - QA Manual Vol II, Appendix D
  - O3, CO, NO, SO2: Zero plus 4 upscale points
  - NO2: Zero plus at least 3 titration points

BASIC Tools for Station Operators:

- Leatherman-style multi-tool
- Box end wrenches 1/8, 1/4, 5/16, 1/2, 3/4
- Adjustable wrenches 6", 10", 12"
- Needle nose pliers
- Channellock® style pliers
- Digital volt meter
- Flat blade screw drivers
- Phillips screw drivers
- Allen wrenches (std and metric)
- Tubing cutters
- Dipped Grip 4 pc Plier Set
- Hammer
- Jeweler's Screwdriver Kit 7 pc
- Mechanical Pick-Up, Lighted, 36"
- Wire Stripper-Cutter w/o Spring
- Wire crimper / cutter
- Small file
- Small level
- Electrical tape
- Soldering iron
- Solder
- Nut drivers
- Compass
- Teflon® tape
- Maglite® flashlight
- Tube of Silicone
- Toothbrush

Station Operator's Briefcase

- Pens
- Pencil
- Highlighter
- Sharpie® Marker
- Maglite®
- Paperclips
- Business cards
- Notebook "Toolkit"
- Kitchen timer
- Jumper wire set
- Ear protection
- Scientific calculator
- Magnifying lens
- Phone contacts
- Thumb drive
- "1st aid guide
- Leatherman®
Notebook Toolkit

Google Group for Station Operators
- Email Karl Tupper (San Luis Obispo APCD)
- Email-based Discussion group
- Purpose:
  - Troubleshooting
  - Equipment recommendations
  - Equipment loans
  - Technical issues
  - Advice
- Contact Karl at ktupper@co.slo.ca.us

Station Operator Contact List
- Compiled by Wendy Caruso,
  - Air Pollution Specialist
  - North Coast Unified AQMD
  - wcaruso@ncuaqmd.org
- Download from PQAO Web Portal
  www.cce.csus.edu/ARBPQAOTraining
Wrap up

- Review:
  - Jack of all trades
  - TSA Field Operations Findings review
  - In the office: data review
  - At the station: general operations, QC, PM
  - Particulates
  - Calibrations
  - Tool kit
  - California Station Operators Google Group
  - California Station Operators Contact List

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