Aethalometer® Training Course:
Magee AE33 / TAPI-633

Instructor:
George Allen, NESCAUM
gallen (at) nescaum . org

Portions of this material are from Aerosol and TAPI manuals and service documents

Updated: November 5, 2015

Course Overview

Magee AE33 and TAPI 633 are the same instrument.
Made at Aerosol in Slovenia

Method principle and history

Routine Operation and Maintenance, Things you need to know

Troubleshooting and Repair

Data Logging, Processing and Validation, Data Mashers

Discussion/Q&A

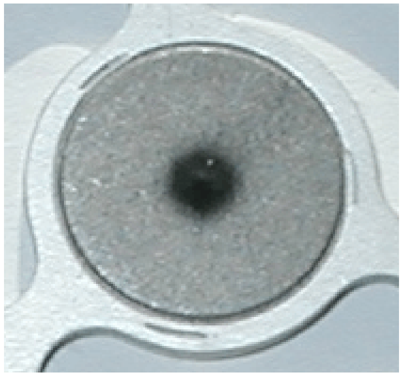
All Training Materials: tinyurl.com/AethTraining

Black Carbon (BC): what is it?

EPA Report to Congress on Black Carbon (2012):
"BC is defined as the carbonaceous component of particulate matter that **absorbs** all wavelengths of solar radiation"

http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryID=240148
(388 pages...)

"Stuff that looks black" when collected on a filter or impaction surface (think FRM WINS):



Source in ambient air: Primary product of combustion (example: diesel)
Directly emitted - not secondary
Nearly all BC mass < 1 μm diameter

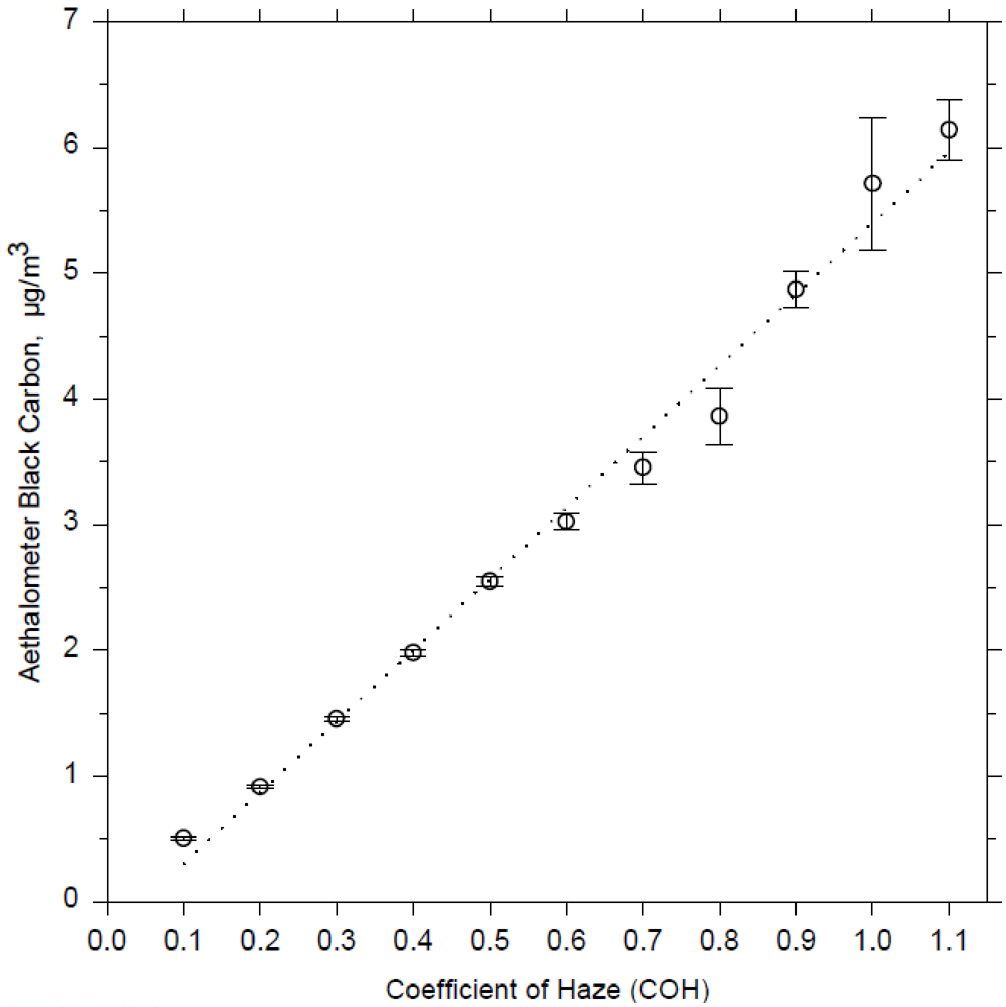
BC is related to "elemental carbon" (EC)

- Usually highly correlated
- Relationship is EC method dependent (TOR/TOT, NIOSH-5040, ...)
  - CSN/STN TOR EC: ~ Aethalometer BC
  - Sunset/NIOSH EC: ~ 1/2 Aethalometer BC

Similar to classic Coefficient of Haze (COH) measurement:

Average black carbon concentration as a function of coefficient of haze. The circles represent the average BC concentration at each COH level, and the error bars represent the standard error. Only COH levels which occurred three times or more during the study period are included. Regression of average BC on COH (dotted line) yields an R2 of 0.988, a slope of 5.66, and an intercept of -0.26.

Allen et al., Atmos. Env. 33:5 (Feb1999)



BC physical characteristics.

BC typically < 10% of PM2.5

Usually not well correlated with PM2.5

Exception: when BC source dominatesPM2.5 (near-road event)

BC particle size: ~ 0.15 to 0.3 µm diameter

Smaller than other typical components of PM2.5 (OC, SO4, NO3)

==> thus higher surface area per unit of PM

This size: effectively penetrates deep into the lung

Not too big, not too small (just right)

BC particle surface can carry other reactive stuff

an effective "delivery vehicle" to target lung tissues

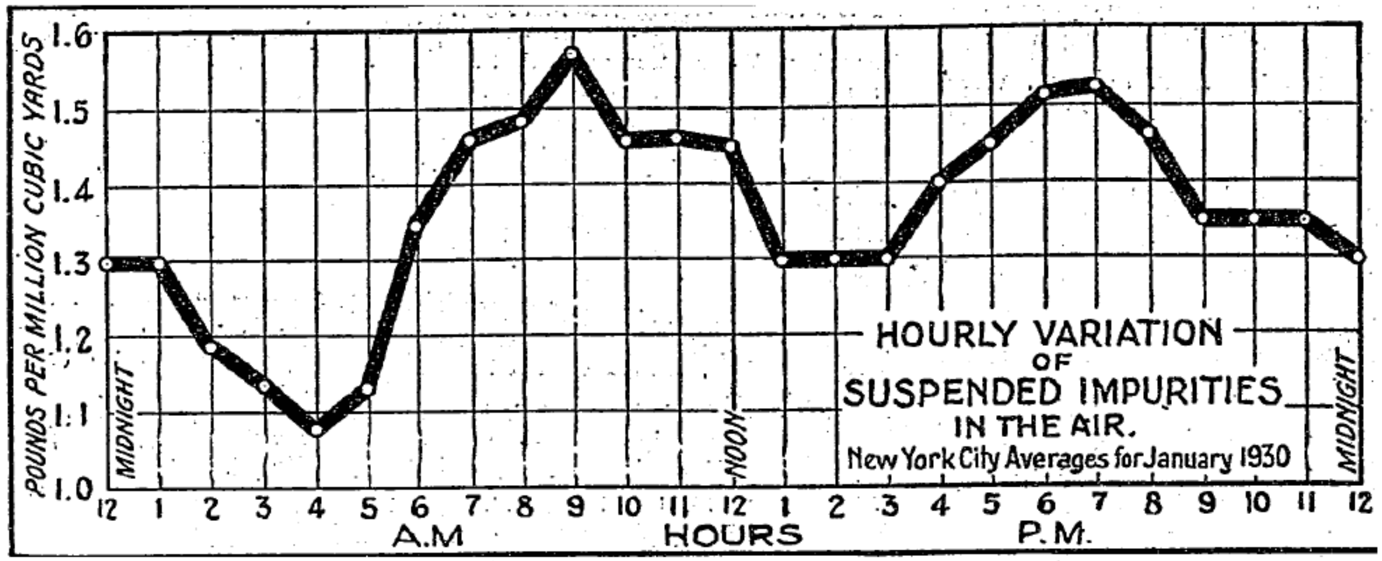
NYC: 1930 NY Times Article. ~ 800 µg/m^3 PM
COH/Aethalometer-type measurement every 15-minutes.

FINDS CITY'S AIR PUREST AT 4 A. M.

Device That 'Breathes' in Park Records 9 A. M. as Hour of Greatest Pollution.

WORKS EACH QUARTER HOUR

61,199 Dust Particles Per Cubic Foot Is Average for January, Against 50,524 in Same Month of 1929.



HOW THE CITY'S AIR POLLUTION FLUCTUATES HOURLY.

Chart Prepared by New York Meteorological Observatory in Central Park Based on January Averages Shows the Rise in the Air's Dust Content From the Low Point at 4 A. M. to the Peak at 9 A. M.

Using a new apparatus that "breathes" the city air and registers its dust and smoke content every fifteen minutes, the New York Meteorological Observatory in Central Park has found that every million cubic yards of New York's atmosphere contained, during January, an average of 1.35 pounds of impurities. The instrument, which was installed on Jan. 1, showed the city's air to be purest at 4 A. M. and most polluted at 9 A. M., according to a report of the first month's operation made public yesterday by David R. Morris, meteorologist.

The apparatus, which is known as the Owens automatic air filter and is much used in England, keeps an automatic record throughout the day and night. It was lent by the Stevens Institute of Technology. Samples of air examined each noon by another instrument, in use at the observatory for a year, showed a higher dust content this January than last year. This year the average for the month was 61,199 particles per cubic foot, compared to 50,524 last year. January is usually the dirtiest month of the year.

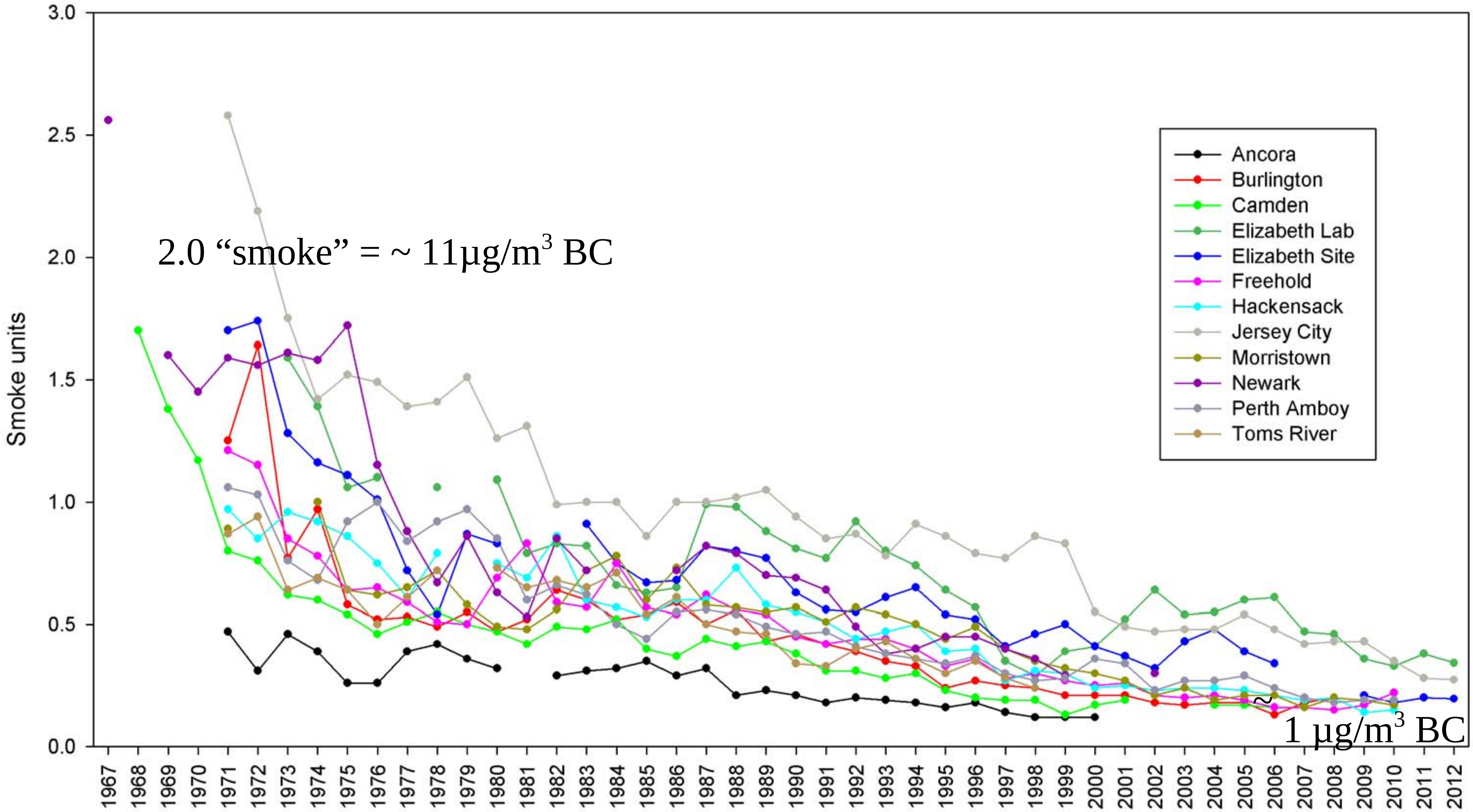
The pollution of the air shown by the Owens filter varied during the month from 0.27 pound of impurities per million cubic yards, registered on Jan. 11, to 2.70 pounds on Jan. 27.

Mr. Morris has prepared a chart showing the average variation during the day, in January, of the air pollution. Starting from the low point at 4 A. M., when the air is at its purest, the curve gradually rises, as fires are made in homes and offices, until it reaches its peak at 9 A. M. It declines until after noon, and does not begin to rise again until 3 o'clock, probably because the home fires are started up again in preparation for the evening. The second peak is reached at 7 P. M., and thereafter the curve declines almost steadily, with a slight retardation between 9 and 11.

The air filter "breathes in" two liters of air every fifteen minutes. The air is sucked in through a small tube which hangs out the window. It passes through filter paper, leaving its dust and smoke in a small, round mark the size of a small pea.

Ninety-six of these marks are left around the edge of a circular filter paper. They are compared with a series of sixteen standard shades, each of which represents a certain percentage of impurity, and the amount of dust per million cubic yards is then calculated.

COH measurements ("smoke shade") show BC trend back 50+ years for multiple NJ-DEC sites – Annual Means, 1967 through 2012:



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BC Measurement Theory (Collaud-Coen et al., AMT, 2010)

The light attenuation (ATN) through the aerosol-laden section of a filter spot is defined as

$$\text{ATN} = \ln\left(\frac{I_0}{I}\right) \tag{1}$$

where I_0 is the intensity of light passing through a pristine portion of the filter and I the intensity passing through the loaded filter. The particles embedded in the filter during a time interval Δt will increase ATN, so that the nth measure of the aerosol attenuation coefficient ($b_{\text{ATN},n}$) of the filtered aerosol particles is obtained from

$$b_{\text{ATN},n}(\lambda) = \frac{(\text{ATN}_n(\lambda) - \text{ATN}_{n-1}(\lambda))}{\Delta t} \cdot \frac{A}{V} \tag{2}$$

where A is the area of the sample spot and V the volumetric flow rate. The corrections discussed below are then applied to infer the true aerosol absorption coefficient $b_{\text{abs},n}$ of airborne particles from $b_{\text{ATN},n}$.

www.atmos-meas-tech.net /3/457/2010/

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From the AE33 Manual:

Optical attenuation: → $ATN = -100 * \ln(I/I_0)$ — I_0=reference signal;

$\ln(I/I_0)$ is negative; -100 factor makes ATN 'nice' — I=spot signal

Flow: $F_{in} = F_{out} * (1 - \zeta)$ — F_{out}=measured flow

ζ=leakage factor

Attenuation coefficient: $b_{atn} = \frac{S*(\Delta ATN/100)}{F_{in}\Delta t}$ — S=spot size; t=time

Absorption coefficient: $b_{abs} = \frac{b_{atn}}{C}$ — C=multiple scattering parameter (Weingartner et al. 2003)

Black carbon concentration: $BC = \frac{b_{abs}}{\sigma_{air}}$ — σ_{air}=mass absorption crossection

Loading effect compensation: → $BC = BC_{measured}/(1 - k * ATN)$

when k or ATN are small, correction is ~1 — k=compensation parameter

when k & ATN are large, correction is > 1

Final equation: $BC = \frac{S*(\Delta ATN_1/100)}{F_1(1-\zeta)*\sigma_{air}*C*(1-k*ATN_1)*\Delta t}$

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History of the Aethalometer.

Tony Hansen

Science of the Total Environment, 1984.

The Science of the Total Environment, 36 (1984) 191—196 191
Elsevier Science Publishers B.V., Amsterdam — Printed in The Netherlands

THE AETHALOMETER — AN INSTRUMENT FOR THE REAL-TIME MEASUREMENT OF OPTICAL ABSORPTION BY AEROSOL PARTICLES*

A.D.A. HANSEN, H. ROSEN, and T. NOVAKOV
Applied Science Division, Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720, USA

ABSTRACT

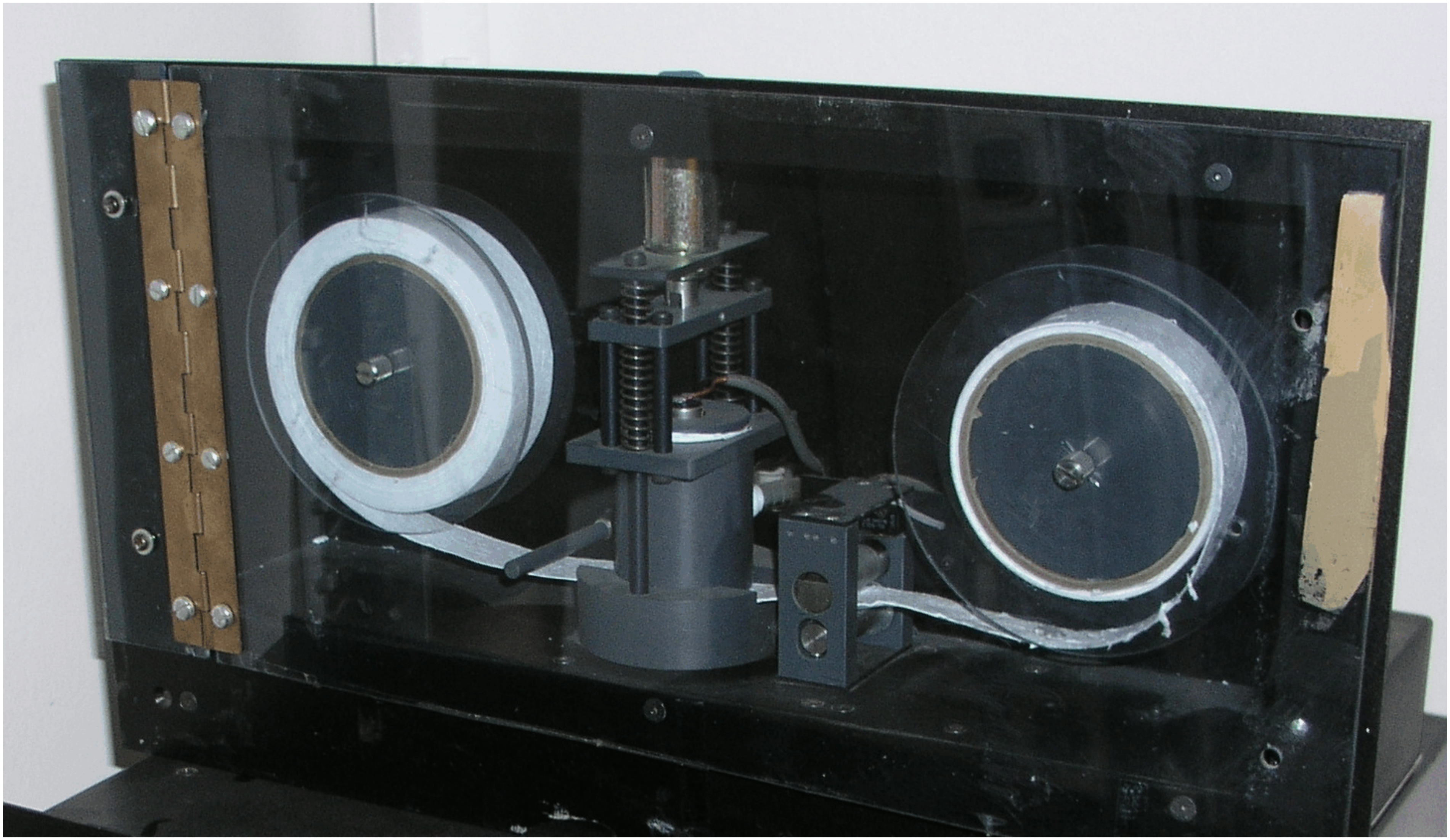
We describe an instrument that measures the concentration of optically absorbing aerosol particles in real time. This absorption is normally due to black carbon, which is a good tracer for combustion emission. The minimum resolving times range from seconds in urban environments to minutes in remote locations. We present results obtained during operation on an aircraft. Due to the time resolution capability, we can determine the spatial distributions of absorbing aerosol. From the Greek word "αιθαλουν," "to blacken with soot," we have named this instrument the aethalometer.

INTRODUCTION

Aerosol particles emitted from combustion sources contain many different carbonaceous compounds and structures. One of these components is carbon in a microcrystalline graphitic form (ref.1), which, due to its strong optical absorption, is termed "black carbon." This material can only be produced by incomplete combustion: there are no secondary mechanisms known for its production from airborne precursors. It is also inert to transformation in the atmosphere and therefore possesses qualities that make it a good tracer for combustion emissions. Chemical techniques (ref.2) for the determination of the black carbon content of aerosol samples collected on filters are generally complex and time consuming. In contrast, optical measurements are often simple and rapid.

AE-9 (1990) - my first Aethalometer! Manual 47 mm quartz filter.

AE-1x (AE-14, 16 ...) prototype, automatic tape advance version.



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Timeline of current Aethalometer lineage:

~ 1997: AE20 first 2-channel (UV) Aethalometer with Hg lamp.

~ 2000 AE-16/AE-21 single/2-channel UV LED version

~ 2004 AE21-ER (extended range): "big spot"

~ 2007 AE-22 – incremental improvements / updates

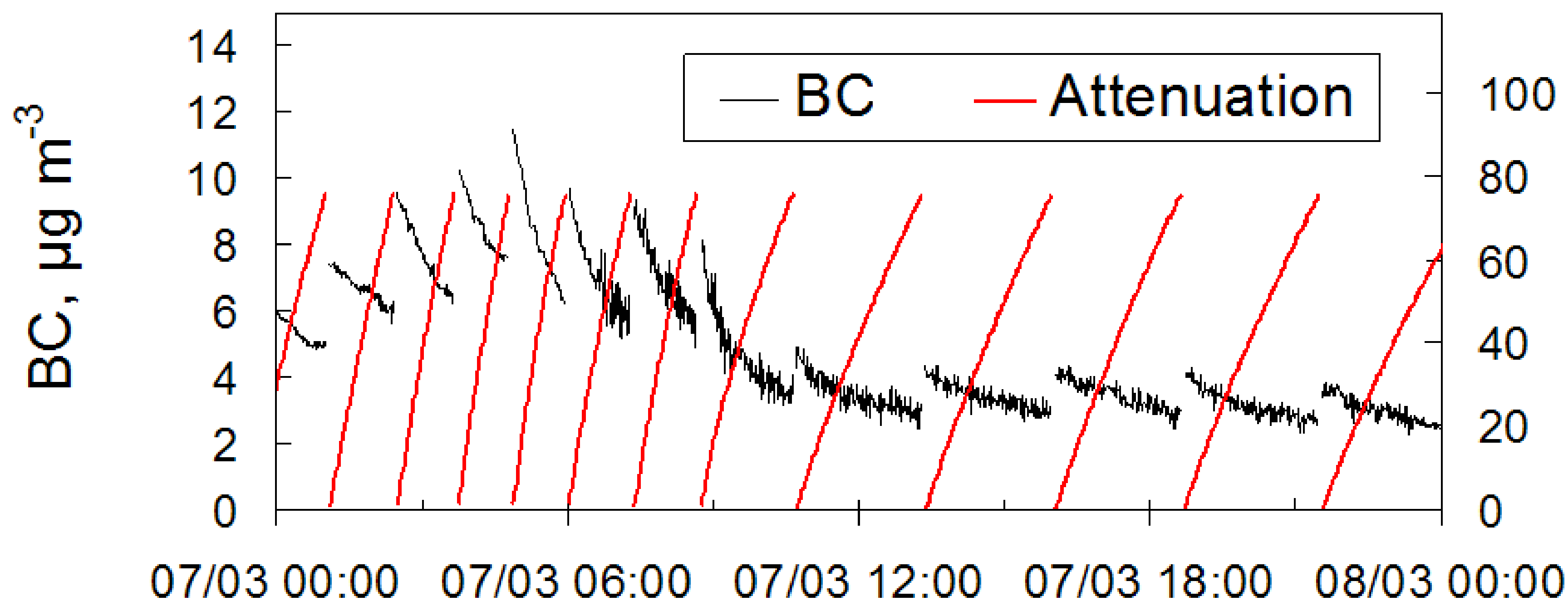
~ 2011/2012 "Next-Gen" AE33 prototypes
Introduction of "dual-spot"™ measurement method

2013: AE33 (TAPI 633) routine shipments

Saturation (spot loading) data quality issue

with Legacy Aethalometers, other optical BC methods

Reported BC decreases as spot loading increases:

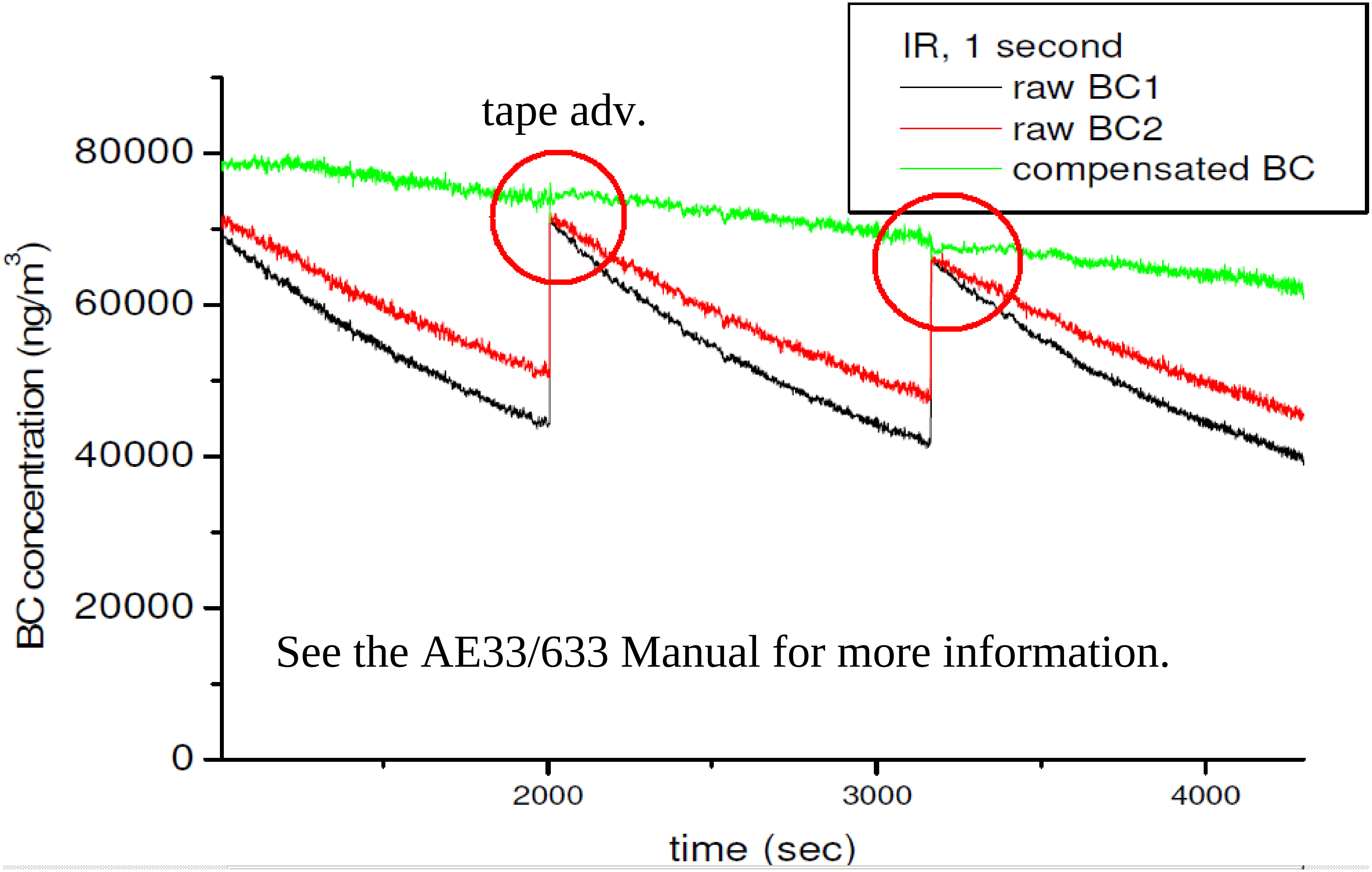


Virkkula et al., JAWMA 2007: subway diesel soot.

Effect is large when sample is all fresh soot.

Small when sample is mostly "white" aerosol with some aged soot.

Solution to spot loading artifact: DualSpot™ measurement used in AE33



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The “K” loading correction factor:

generated dynamically by the AE33 from 2 spot data
one K value for each channel (K1...K7)

BC_reported = BC_sen1 * [1/(1-K*ATN)]

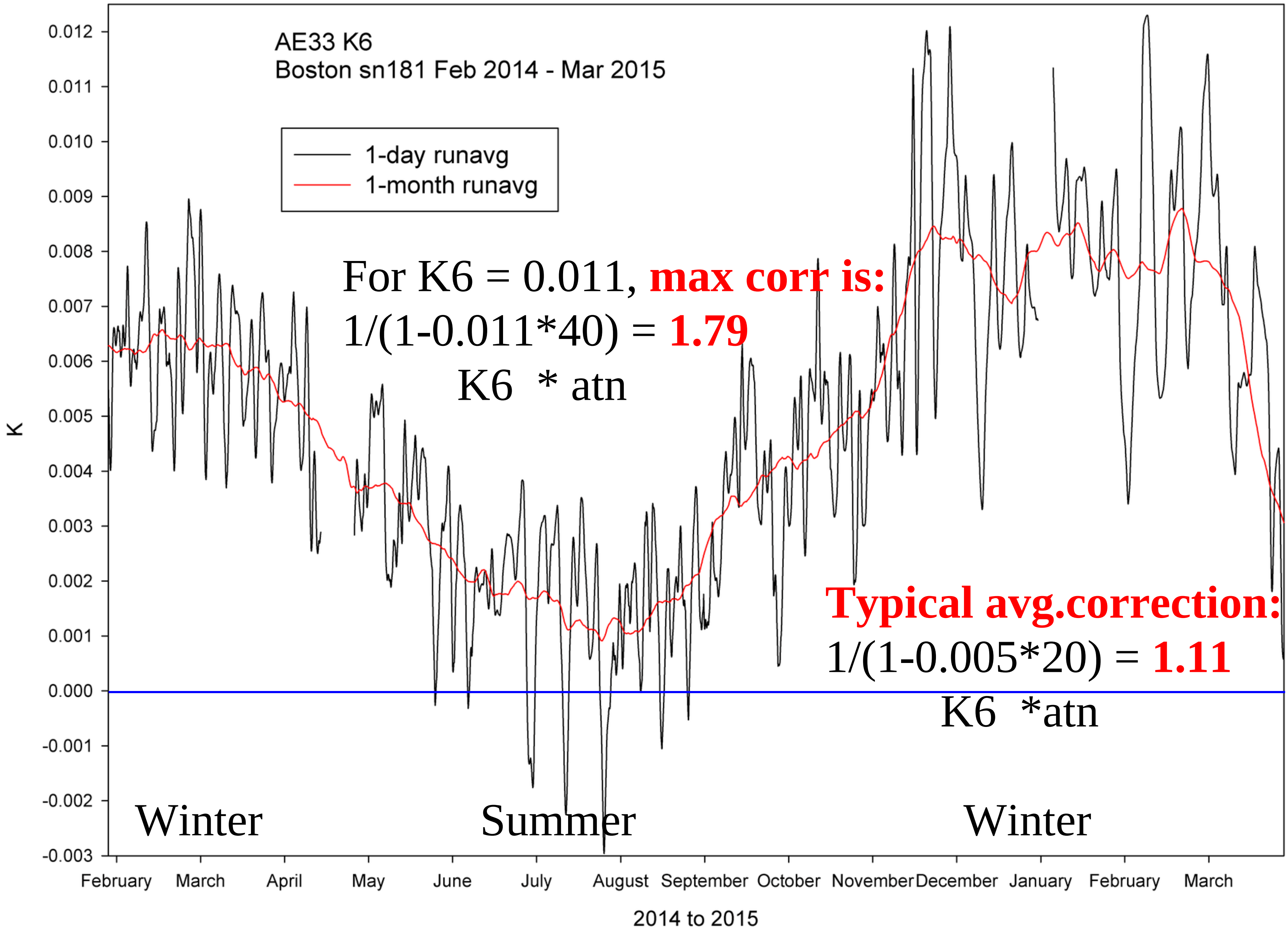
BC_sen1 is uncorrected data **from the higher flow spot** – BC11...BC71
ATN is the channel-specific attenuation for each minute of data

ATN ~ 0-40 for BC6 (880 nm) – Classic BC channel
ATN = 0-120 for BC1 (370nm) – Classic UVC channel

Typical K values:
0.000 to 0.010 for K6
0.002 to 0.006 for K1

correction explodes if K1 > ~ 0.008
divide by 0 at max-atn (120) when K1=.00833

Example of seasonal variation in K6 (BC 880 K) – Boston MA



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Installation Info

Keep inlet line as short as practical (< 3 to 4 meters)

Use black conductive tubing supplied by TAPI/Magee

www.freelin-wade.com/static-dissipative-polyurethane-p-1668-l-en.html

Part # 1J-405-01 blk 85a pur fre-stat, 3/8 x 1/4" x 100 ft: $150

Keep instrument and inlet line out of air conditioner airflow

Use inlet cyclone: PM2.5 or PM1.0 (BGI photometer cyclones)

Now Mesa Labs: bgi.mesalabs.com /environmental-cyclones

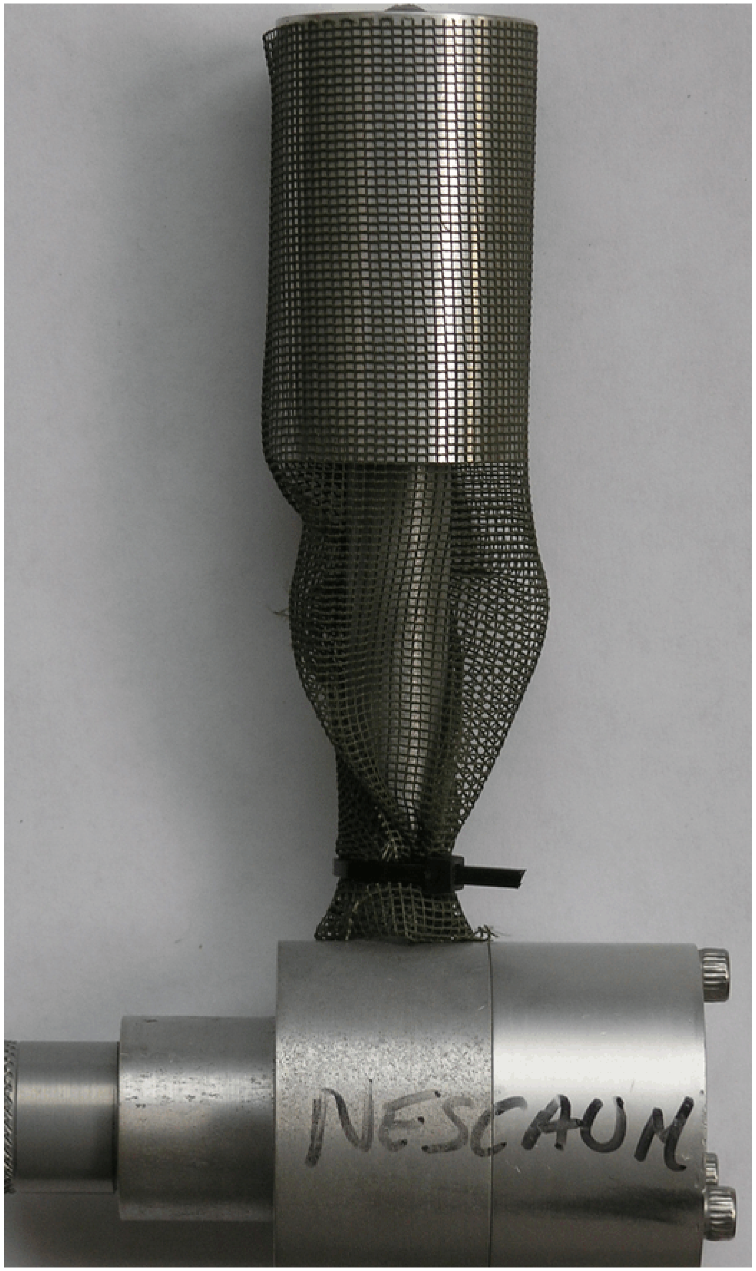
Cover inlet with bug-screen! [next page]

Bug webs in cyclone = particle filter

Clean cyclone routinely: procedure in section 5.1 of TAPI 633 manual

1-2x/year with screen? monthly/bimonthly without screen

Cyclone Bug Screen:



Seating tubing in quick-connect adaptor: beware!

Very difficult with soft tubing.

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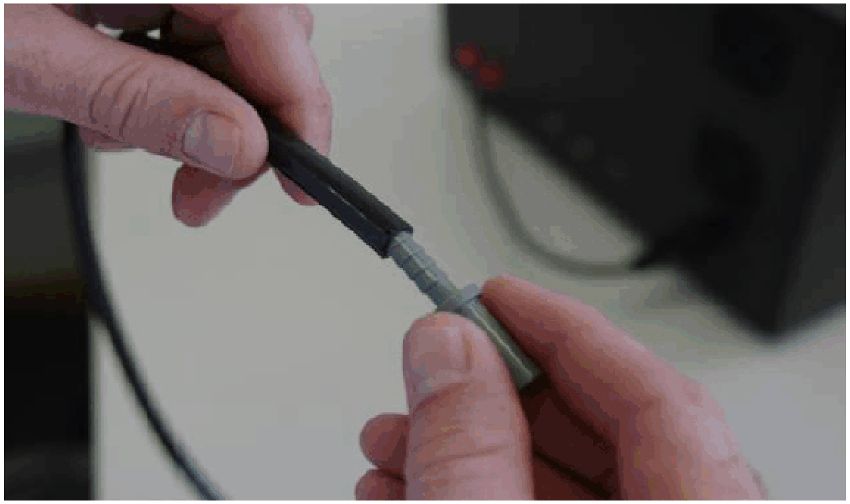
Quick-Connects and soft conductive tubing: bad combo

Very easy to not seat properly!! → 3/4" rule

TAPI supplies barb adaptors - use them (on inlet cyclone too)

barb to QC:
McMaster p/n
51055K65



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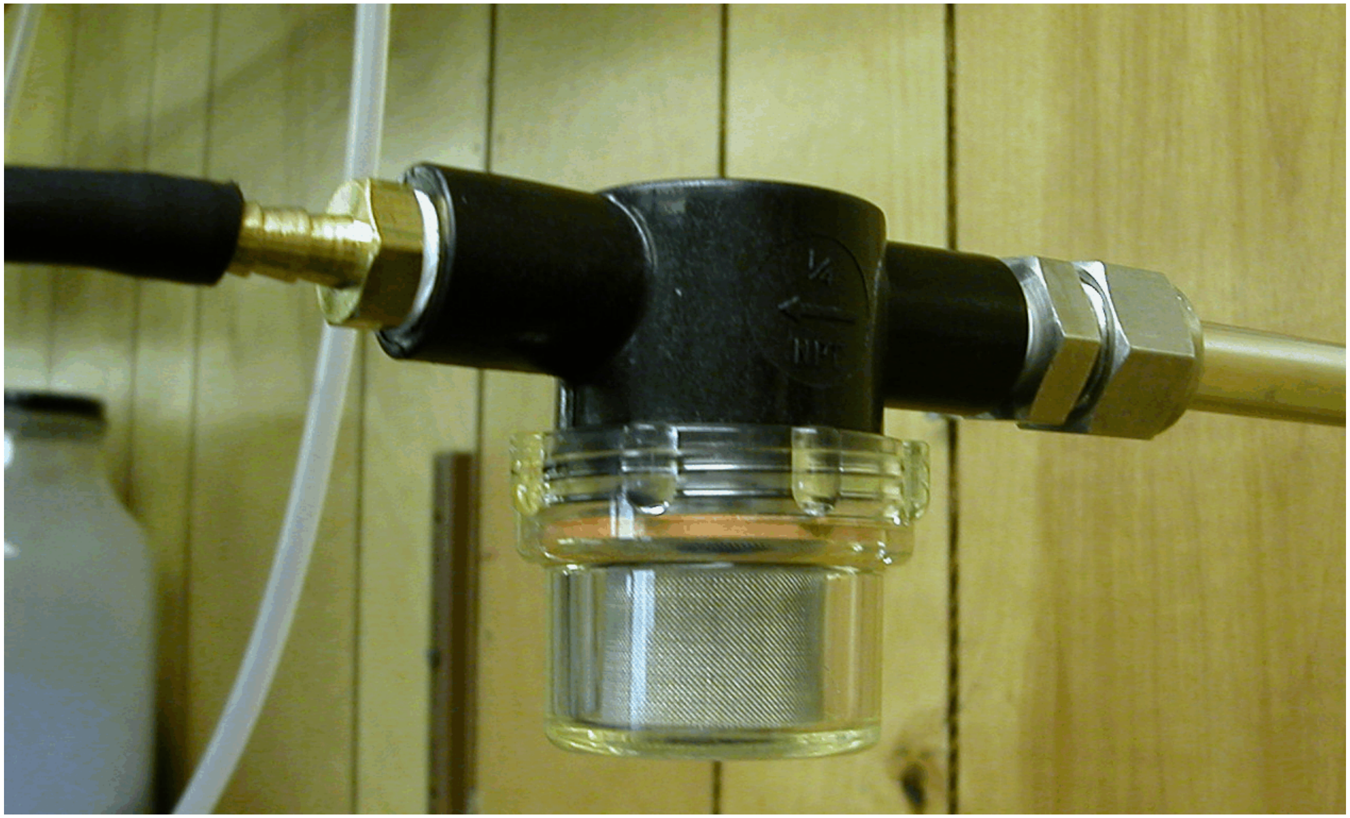
Use water trap on inlet! Heavy/windy rain can get up into cyclone...



Supplied by TAPI

Critical to use!!!

Inspect/clean regularly.

Trap: McMaster-Carr p/n 98775K41 (same as 98775K413)
Polypro T-Strainer Clear Bowl, 80 Mesh, 1/4 NPT Female, 3" Length

Can also serve as bug trap

screen on cyclone inlet is still good idea; keeps cyclone cleaner

Instrument Settings

1. Timebase: 1-minute (default), never 1-second
2. Max Attn: 120 (default)
3. Flow: usually 5 lpm (with BGI 1.829 cyclone for PM2.5) - default
   2 lpm: BGI 0.732 cyclone gives 1.0 µm cutpoint

4. Other settings (see setup file)
   "DST off" is important, DateFormat=US
   "Measure Time Stamp" = before
   Recommend 1-minute "warmup" (default is 3)
   Flow Standards for reporting data
   use EPA "STP" (25C) unless t/p sensors in use
   defaults are AMCA (70F or 21.1 C)

==> Settings are not saved until you start a run
Prompt to save changes

Operation, Advanced menu: Time Settings and Biomass Burning (%)

Date format		☑ US	☐ EU
Measure time stamp		☑ Before	☐ After
Home display		☑ UVPM	☐ Proc BB
Display	☐ ON	☑ Saver	☐ Auto OFF

HOME

BC	4536	ng/m^3
BIOMASS BURNING	7.6	%
REPORTED FLOW (AMCA)	5.0	LPM
TIMEBASE	60	s
TAPE ADV. LEFT	152	
STATUS	✓	0

Woodsmoke Indicator

BB (%): the percentage of BC created by biomass burning determined by the Sandradewi model (qualitative estimate).

http://dx.doi.org/10.1016/j.atmosenv.2007.09.034

Alternative to “Delta-C”:
UVC - BC
(BC1 - BC6)

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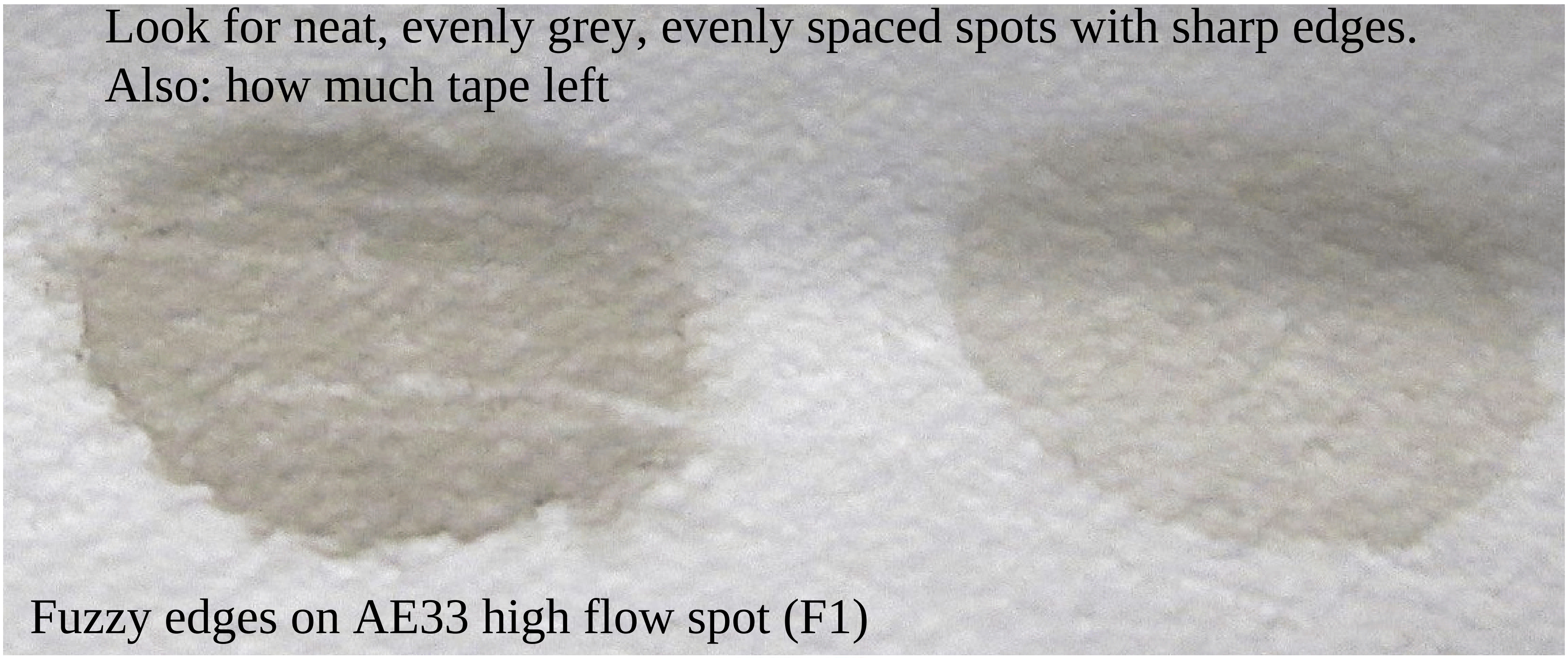
Operational Checks

1. Instrument date/time check/set: monthly and after power failure
   SET clock monthly even if time is ok
   Time may change on reboot -- backup clock vs. Windows clock

2. Tape visual inspection check: at least monthly (each flow/leak test?)
   Look for neat, evenly grey, evenly spaced spots with sharp edges.
   Also: how much tape left



Fuzzy edges on AE33 high flow spot (F1)

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3. USB thumb drive data download:
    Monthly or more often: even if connected to logger!
        QC files can be useful (log [FVRF], FV, LT, setup, etc)
    Data/Export menu, enter date of last download
    Thumb drive must not have other files on it
        a ".exe" file in the root dir will cause the Aeth to stop
    All data are stored internally (50 years worth) on CF card

4. Flow and Leak Checks: do together
    monthly to bi-monthly (set time too)
    different procedure than used for AE2x

5. As needed: clean optical chamber and inlet cyclone
    1 to 6 months [remember the inlet screen and bug/water trap]

See also instrument manuals:
    TAPI manual checklist
    AE33 manual "Maintenance" page

Why you should open the Aethalometer door now and then...

Flow and "Filter Leak" Checks

Very different procedure from Legacy Aeth

Do NOT use "block the inlet" for leak check!

Use "Flow Verification" and "Leakage Test" procedures in software

"Filter Leakage Test" introduced in software version 1.1.4.6

– described in current Aerosol version of manual

Use flowmeter <u>without</u> pressure pulses (BGI tetraCal, TSI-4100)

For all flow verification, leak chk, flow cal: Must <u>always</u> re-enter 25C !

<u>Some leakage is normal:</u>

7% filter "lateral" leak assumed and used in data calculations

➜<u>When AE33 is running:</u>

Measured inlet flow will *always* be 3-10% less than display flow!

Does NOT mean a flow cal is needed

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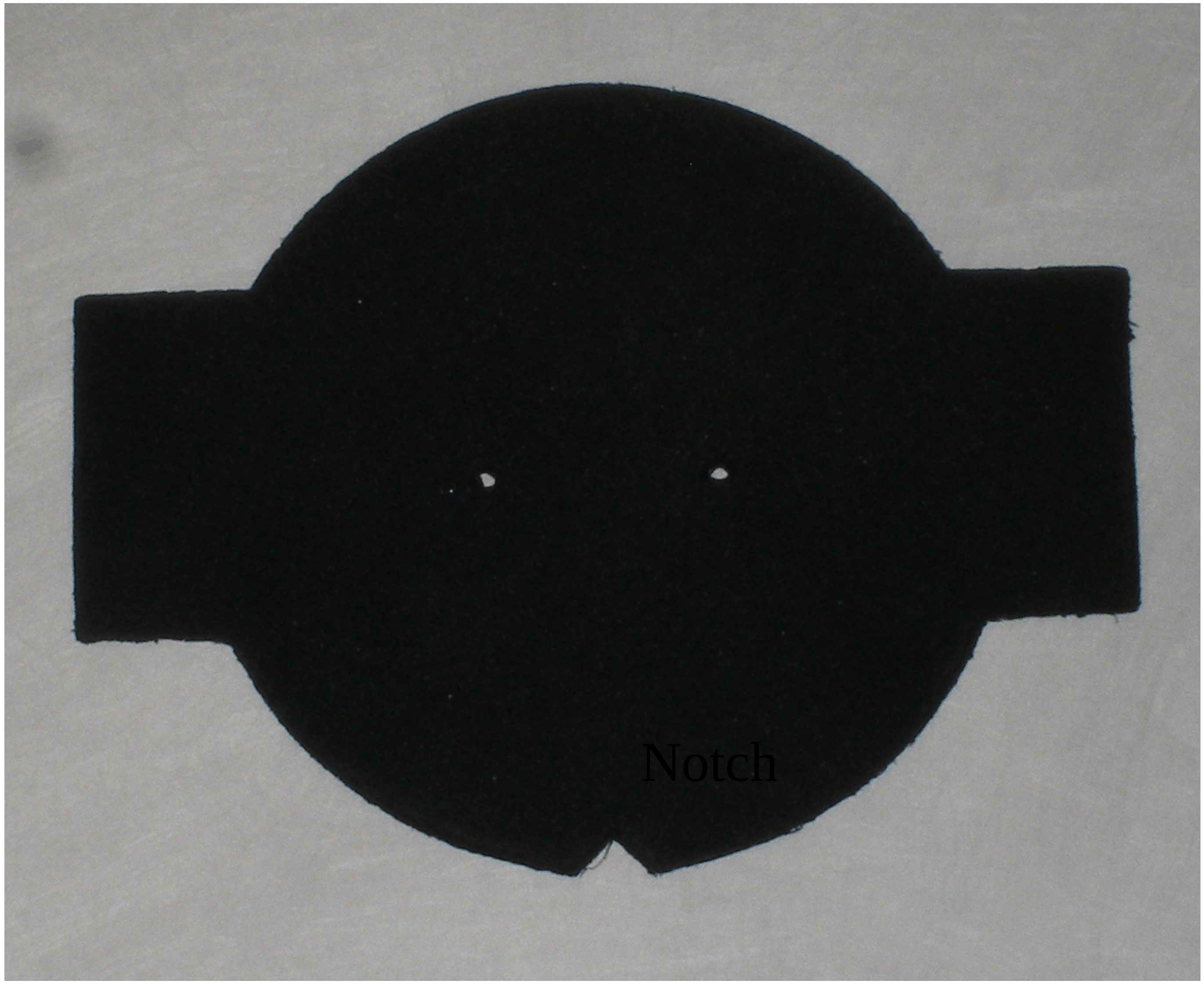
AE33 Flow Pad: goes in with notch facing out
[towards you]
per TAPI

Does it matter?



Example of filter leak test report (LT*.dat file)

Software ver 1.1.4.6 and later

```
Manual leakage test report
Serial number: AE33-S02-00181
Date and time: 06 Mar 2015 10:12:15
Selected flow: 5000 mlpm
Flow through tape: 4920
Flow through calibration pad: 5140
Instrument leakage is: 4.3 %
```

Result should be ~3 to 7%

> 10%: corrective action [new tape roll, mechanical problems?]

Run test a few times - variable results

==> <u>MUST</u> enter flow in mL/min, not LPM

Run leak test <u>whenever</u> a new roll of tape is installed!

also with each Flow Verification and Flow Cal

filter leak varies - spot to spot and roll to roll

AE33 Flow Check and Calibration

LT: Leak Test
FV: Flow Verification

Flow Cal procedure does not report “as found” or “post-cal” flow errors
- Do “as found” LT and FV before any Flow Cal
- Do “post-cal” FV after Flow Cal

Order of tests: ==> LT, FV, Flow Cal, FV
- Do all FV / Flow cals at EPA STP!
- Enter 25 C each time!

FV “Trigger” for Flow Cal:
- Recommend FCal if any flow >5% in FV summary (my limit)
- Mfg suggests 10%

Note: all flows must be entered in cc/m (ml/min), not LPM

Leak-Test and Flow Verification Demo...

Example of AE33 / 633 Flow Verification result.
These results are in the FV log files.

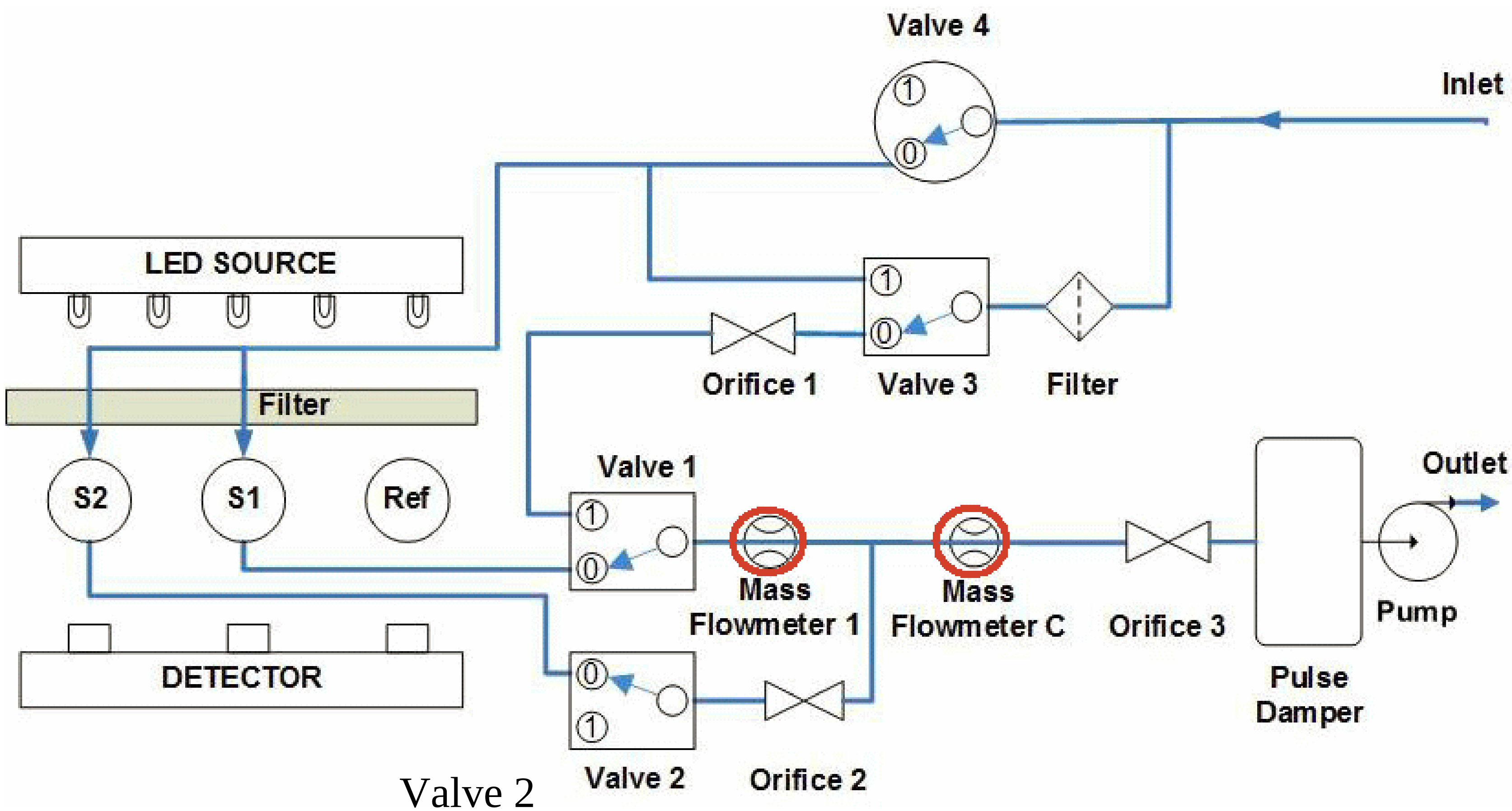
“Fin” is external flow measurement (at the INlet)
“F1” is flow for sensor 1 (higher loading)
“Fc” is total (“control”) flow, or “Flow ∑” – controls the pump

```
Flow reporting standard:  EPA  101325 Pa  25 °C
```

Fin	F1	(%)	Fc	(%)
736	746	(101)	742	(101)
2470	2394	(97)	2387	(97)
4120	4190	(102)	4190	(102)

Explaining F1 and Fc: instrument flow diagram

AE33 / 633 Flow Diagram: valves shown in operating mode



Valve 2
=1 for flow cal (adjustible - sets F2/F1 ratio)

Note location of F1 and Fc flowmeters (in series for flow cal) - red circles

Fc is controlled to total flow setpoint

Spot 2 (Sensor 2) flow not measured directly! (only used for K calc)

Another QC parameter: Face Velocity Ratio Factor (FVRF)

Introduced with software 1.1.7.1; Important for K calculation

Used in data calculation; Corrects for differential error between F1 and F2

See Drinovec et. al AMT AE33 paper (open source) for details:

http://www.atmos-meas-tech.net/8/1965/2015/amt-8-1965-2015.html

FVRF reported in log file (not data file) after each tape advance entry:

```
12/Sep/2015 07:36:18 Tape Advance number:  512 Number of steps:  527

12/Sep/2015 07:38:00 ATN1zero(1): 35.3942 ATN2zero(1): 31.4476
       [etc etc.....]

12/Sep/2015 19:14:00 FVRF value is: 0.852 ← ←

16/Sep/2015 03:22:00 TapeAdvance procedure started.
```

Nominal value: 1.00   Range: +/- 10%

If consistently out of range: perform a flow verification and calibration

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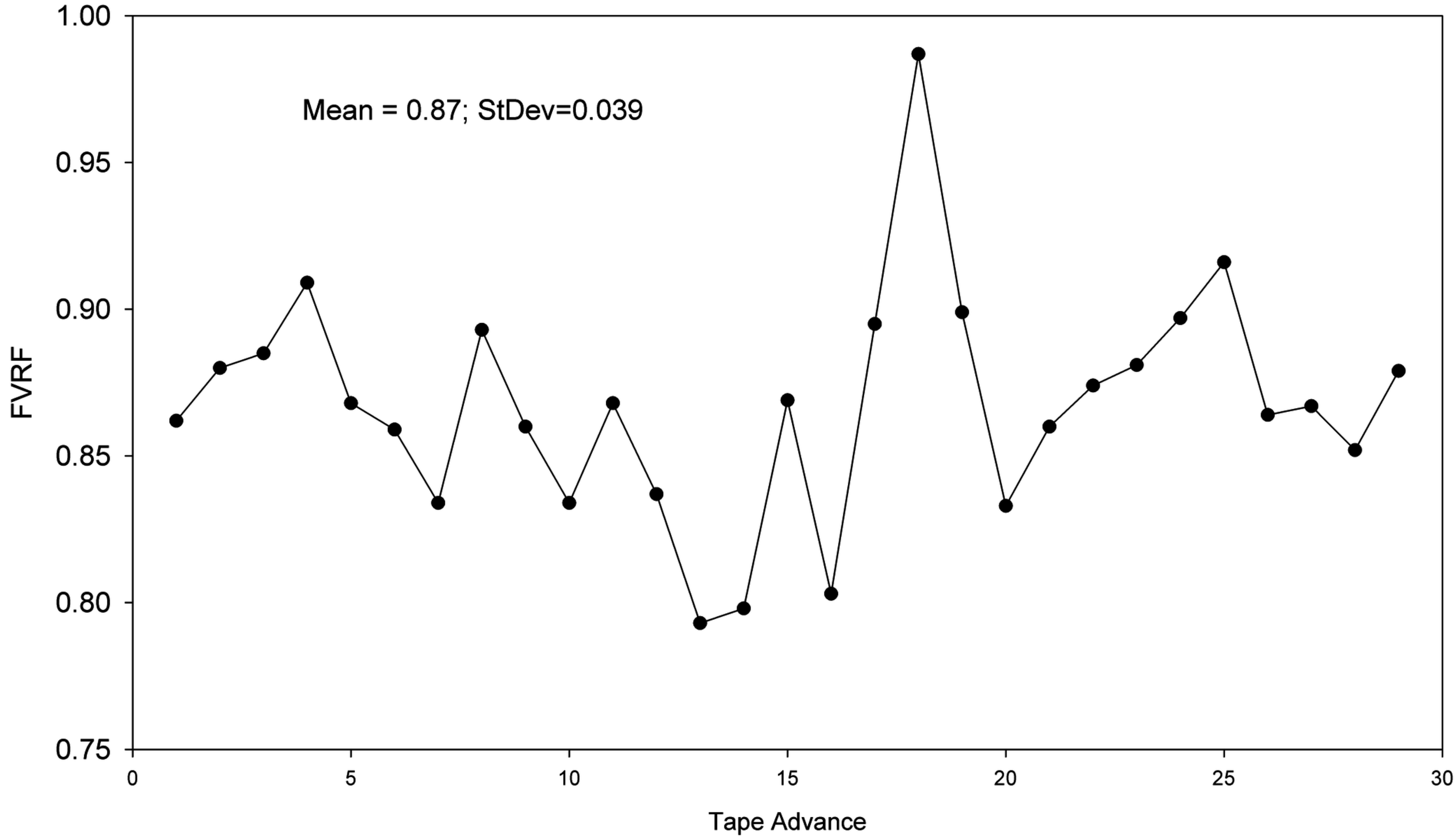
Example of FVRF spot to spot variability:



Range is 0.79 to 0.99; mean = 0.87

Flow cal needed for this instrument

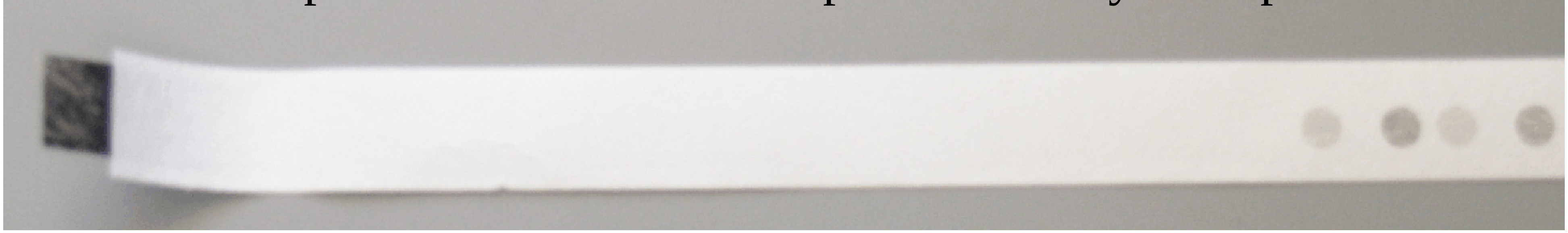
Tape Changes: things to check

Cardboard spool hubs: not too tight on spools; tape should feed out freely
Be sure to thread under tape guides
Use tape change procedure in software

- **Must do** leak test with every new tape roll (rogue rolls?)
- Document tape lot # when installed

“Spots Left” # can be misleading - look when < 30!
~ 230 tape advances per roll

Instrument stops as soon as the black tape is “seen” by the tape sensor.



There is no way to tell how much tape is left remotely

- Status indicator gives some information (<30, <5 spots left) [?]
- “TapeAdvCount” in data record is LIFETIME # of spots

AE33 / 633 Optical Chamber Cleaning

Easy, Important

- AE33 is more sensitive to “stuff” in chamber
- Interferes with K calculations (see example)

Step by Step Instructions:

- TAPI 633 Manual, section 5.6

Recommended Interval: 2 months and as needed

- Include as part of Flow Verification routine

BIG Caution: Chamber can be put back on incorrectly!

- White marker line: left of center when seating chamber

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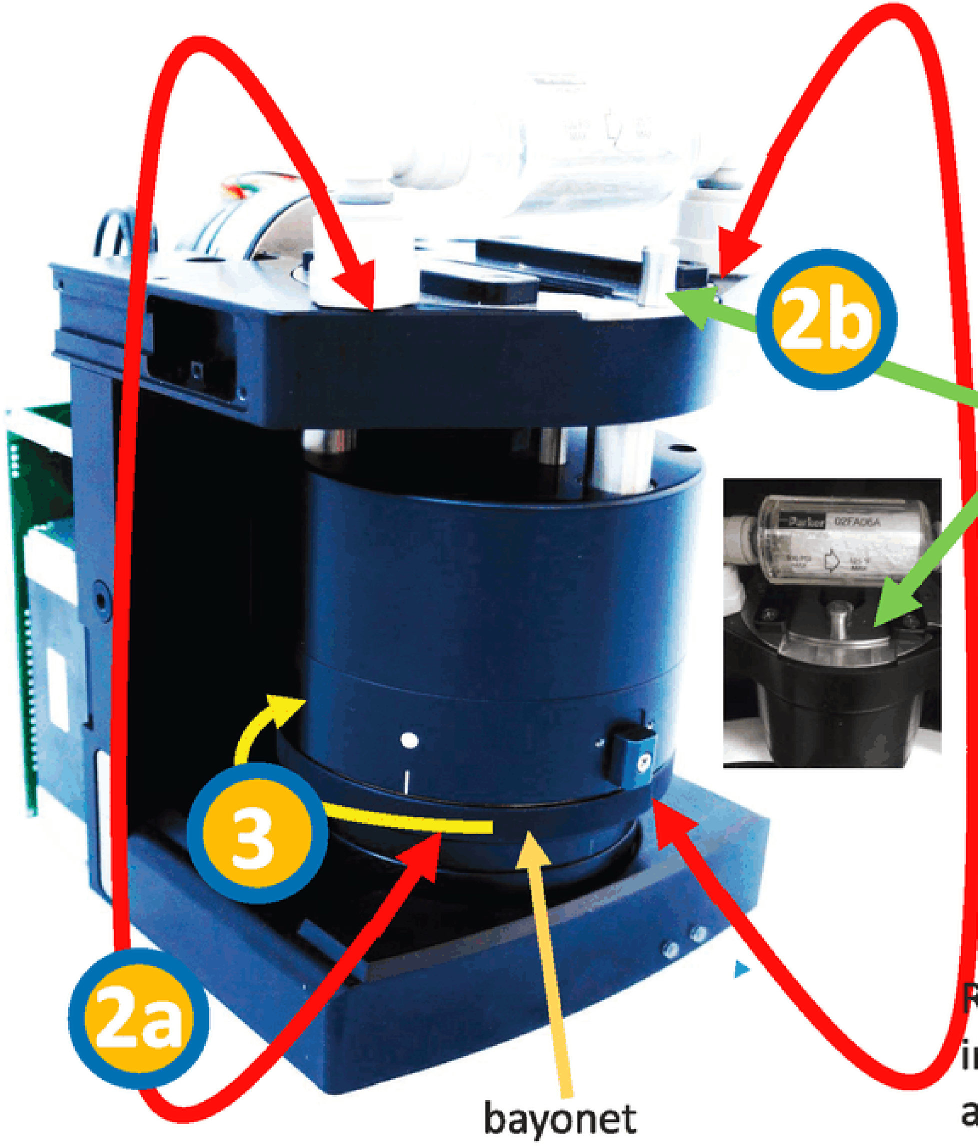
AE33 – cleaning the optical chamber

Aerosol MAGEE SCIENTIFIC



1.Stop the measurement

2.Lock the chamber into the upper position

a) squeeze firmly from both sides

b) lock the slider on the top

Press the release button and

3.Hold the bayonet tightly and rotate it clockwise. You will feel when it will be released.

Remove the bayonet and inspect the interior. If you have acess to compressed air, blow inside to remove any dust or other deposited material.

Re-assemble the chamber in revers order.

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AE33 things you need to know: software and manual

AE33 user manual: Many changes since March 2014 TAPI manual
Detailed flow diagram, reflects many software changes

Software version: current version in header of every data file
==> **must update** if < 1.1.4.6 (new leak check procedure)
1.1.0.0 has daylight time bug (TAPI CF card update spring 2014)
Current version: 1.1.7.2 (August 2015)

Current AE33 Manual, Software, and Firmware at:
http://tinyurl.com/AethTraining
under "AE33 Instrument Software and Manual" folder

Caution: Firmware updates are only for s/n > 90
Older instruments: FW update must be done at factory
Current software works on any FW version

Software Update Demo...

Issues with Older Data. (up to early 2014)

Data before version 1.1.0.0 should be "reprocessed"
    bug can cause K to go to the rail[s]

Aethalo33Recalculator1.3.exe
    Produces "fixed" 1-minute raw data files
    Under "AE33 Instrument Software and Manual"

Then: use AE33 masher to create 1-h average data

New Resource:

Magee support for TAPI 633 / AE33 Aethalometer

Aethalometer Users Group web registration:
http://mageesci.com/group/index.php/component/users/?view=registration
Instrument software, manuals, FAQ, how-tos, etc.

Magee Service and Support: complicated for now...
TAPI 633 users can access both TAPI and Magee / Aerosol support
"Protected" TAPI customers must use TAPI for sales/parts for now

Effective 3/12/16: all S/L agencies can purchase directly from MageeSci
Jim.Morton@MageeScientific.com http://www.mageesci.com/

Put Magee on agency contract list [parts/service]?

Additional Resource: TAPI 633 Training Manual
Under "Tapi 633 Service Notes" folder

AE33 data file format:

Date(yyyy/MM/dd); Time(hh:mm:ss); Timebase; RefCh1; **Sen1Ch1;** Sen2Ch1; RefCh2; Sen1Ch2; Sen2Ch2; RefCh3; Sen1Ch3; Sen2Ch3; RefCh4; Sen1Ch4; Sen2Ch4; RefCh5; Sen1Ch5; Sen2Ch5; RefCh6; Sen1Ch6; Sen2Ch6; RefCh7; Sen1Ch7; Sen2Ch7; Flow1; Flow2; **FlowC**; Pressure(Pa); Temperature(°C); BB(%); ContTemp; SupplyTemp; **Status;** ContStatus; DetectStatus; LedStatus; ValveStatus; LedTemp; BC11; BC12; **BC1;** BC21; BC22; BC2; BC31; BC32; BC3; BC41; BC42; BC4; BC51; BC52; BC5; BC61; BC62; **BC6;** BC71; BC72; BC7; **K1;** K2; K3; K4; K5; **K6;** K7; *TapeAdvCount*; [**LIFETIME**, not remaining!]

[and then external device status & data but without any headers]

➜ **What really matters:**

Date; Time; Flow1; FlowC; Status; BC1; BC6; K1; K6;

BC1, K1 are UV (370 nm) data: legacy UV-C channel

BC6. K6 are BC (880 nm) data: legacy BC channel

For tape advance failure screening: Sen1Ch1 (UV-C hi-flow sensor)

AE33 data format, continued.

Data are "space" delimited [not comma]

Invalid data are reported as "0" [with status flag] !!!
(See Data Handling Section)

With only 1 com port [logger] active: last 3 data columns are "5 0 0"
after tape advance count field

External t/rh/bp sensor data are appended: "5 0 1 24.4 31.5 997.7"
5=data on com1; 0=nothing on com2; 1=Ames met sensor
T=24.4 RH=31.5 BP=997.7

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Supported external devices (from the AE33 manual ver. 1.53):

AMES_TPR159 (ID = 1):
temperature and pressure for flow reporting at ambient conditions

Datalogger_AE33_protocol (ID = 5):
for data polling

Aerosol_inlet_dryer (ID = 6):
performance data from inlet dryer option

Others:

Comet_T0310 (ID = 2):	Comet temperature sensor
Vaisala_GMP343 (ID = 3):	CO2 sensor
TSI_4100 (ID = 4):	Mass flowmeter

Datalogger_BH_protocol (ID = 7)
Datalogger_Qair_protocol (ID = 8)

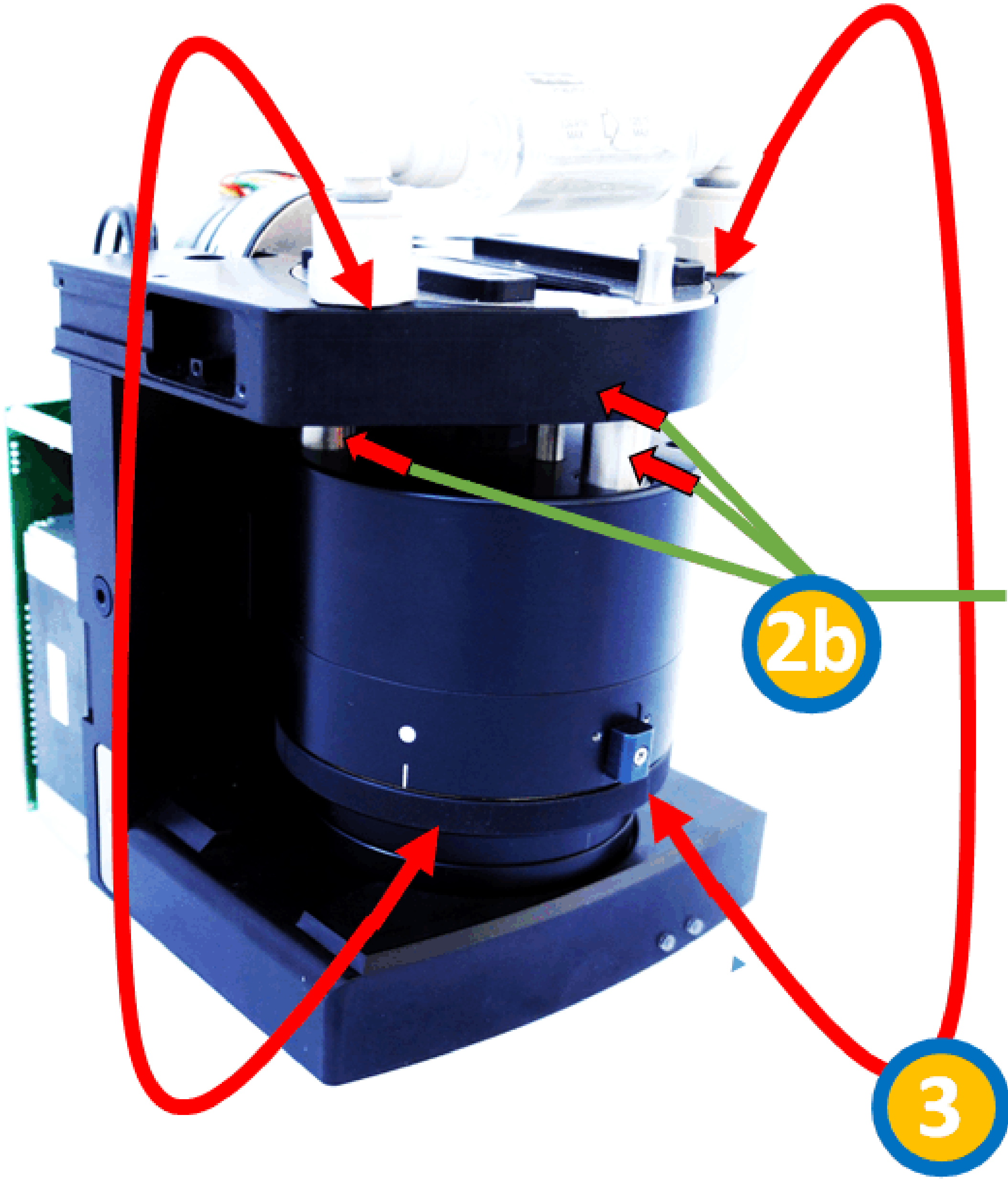
AE33 Maintenance: Lubricate sliders once/year

or when a tape advance sounds screechy

silicon grease such as
Dow Molykote 33 Light

AE33 – lubricating sliders of the optical chamber

Aerosol MAGEE SCIENTIFIC



1.Turn off the instrument

2.Leave the chamber in the bottom position

a) Put some grease on a flat stick

b) Gently apply grease on all three sliders

3. Squeeze firmly from both sides and move the middle part several times up and down.

AE33 Take Up Spool Fix Instructions:

Tape Drive Grip Spring Retrofit
sn 226 and lower
fixes "failure to advance"

See procedure:
AE33 takeup spool fix.pdf

AE33 System Restore

Used for recovery of older setup file

May fix flow cal and other odd problems

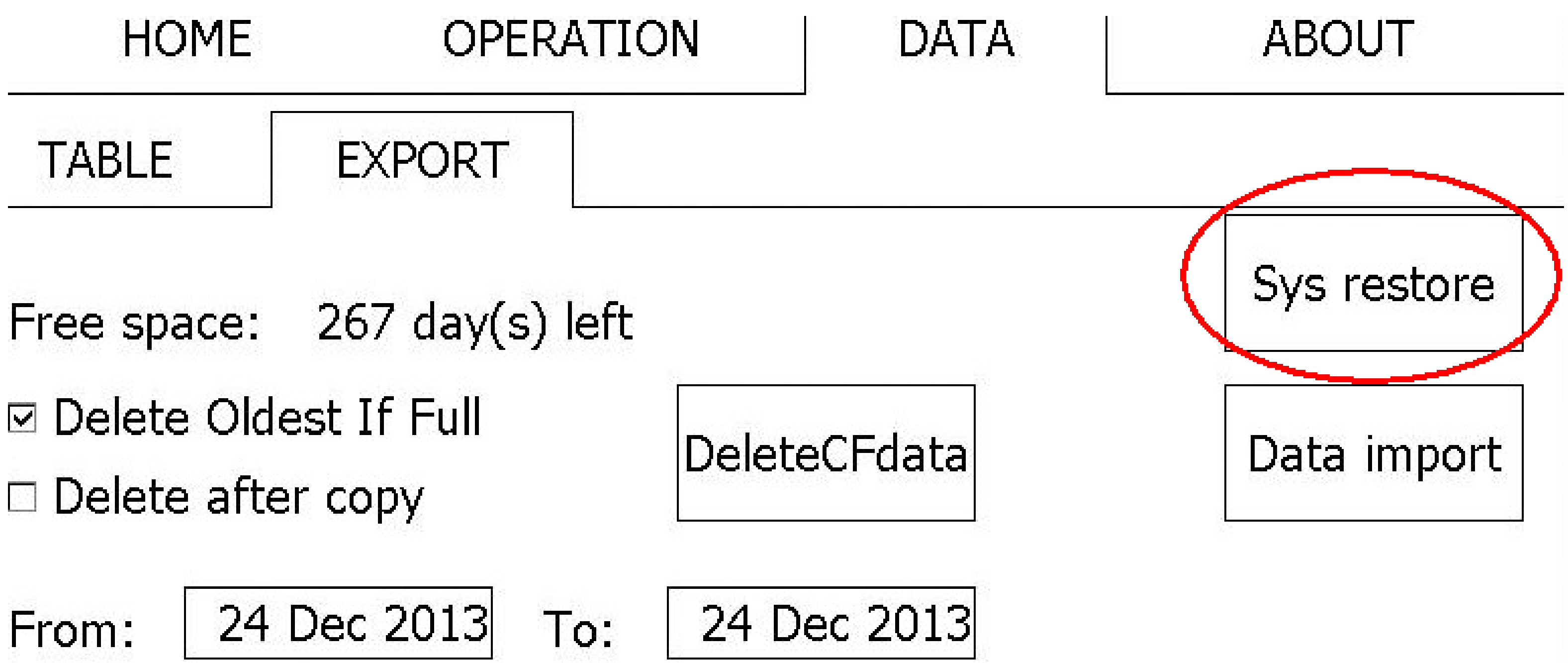
Quick diagnostic tool

Choose a setup file from when the AE33 was running ok

select the setup file by the date/time in filename:

AE_SETUP_AE33-S02-00181_20150305_123323.xml

date is when it was archived (replaced by a new one)



AE33 flow ratio: affects quality of K calculation

Too high: K becomes unstable
Too low: K becomes noisy, less dynamic
- Valid data limits for F2/F1: 0.2 to 0.75
- Invalid data flag is same as total flow error (status 4 or 12)

Advanced Operation Display shows Fc (Σ) and F1
- F2 not shown on display - only in raw data file

Sweet spot flow ratio is between 0.4 and 0.5
- **F1 for 5 LPM inlet flow: target ~ 3500 cc/m**
- between ~3325 and 3575 cc/m

Trigger for adjustment: ratio outside of 0.3 - 0.6
- F1 outside of 3125 to 3850 cc/m

Flow Ratio Adjustment: only for experienced personnel!!

Examples of F1 and Fc and flow ratio:

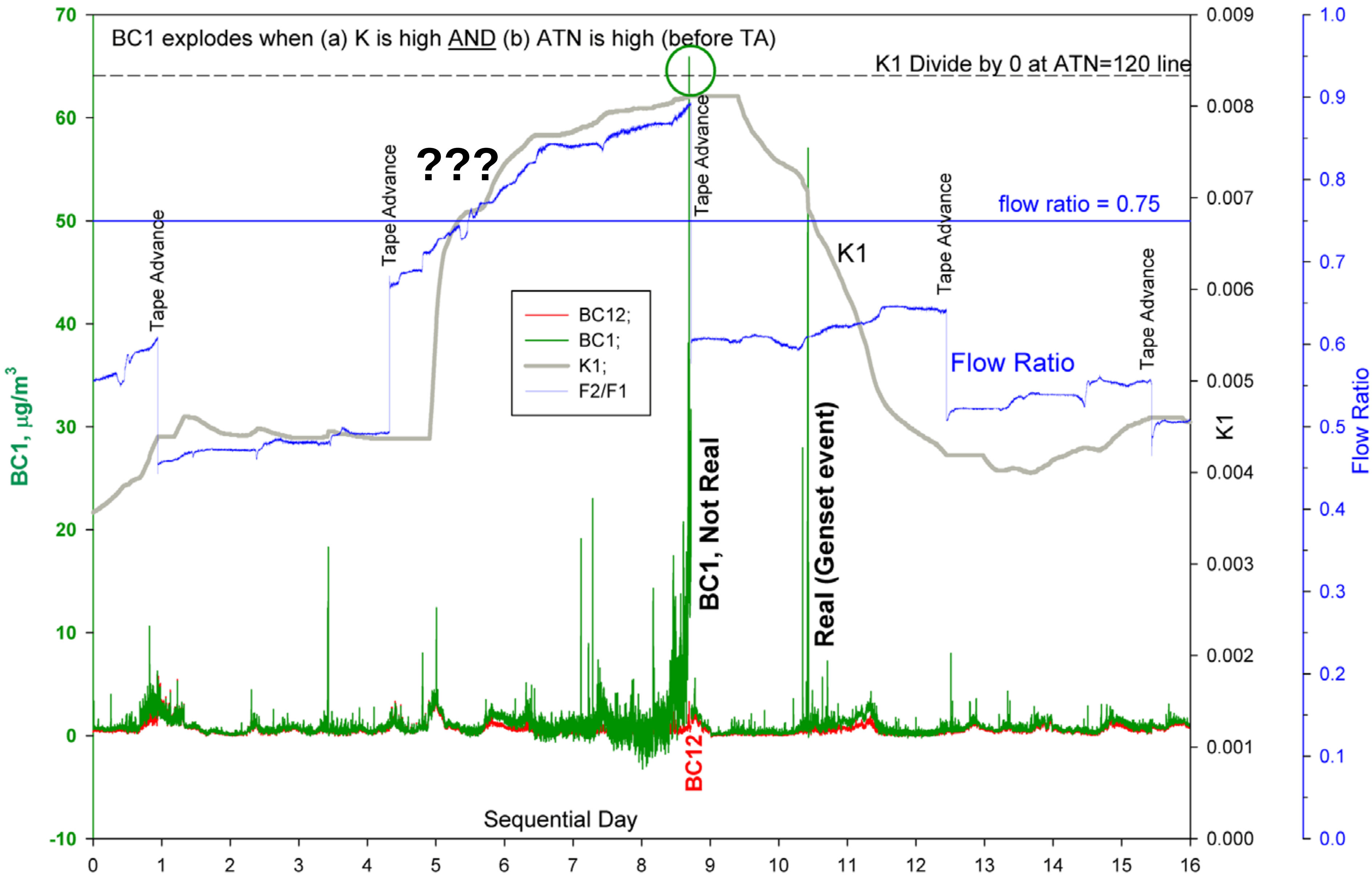
Fc	F1	F2	F2/F1
5000	4200	800	0.19
5000	4000	1000	0.25
5000	3850	1150	0.30
5000	3500	1500	0.43
5000	3250	1750	0.54
5000	3125	1875	0.60
5000	3000	2000	0.67
5000	2800	2200	0.79

5000 and 3500 are target Fc and F1 flows for 5 LPM

Ratio varies somewhat from spot to spot
look at ratio over several spots

AE33 Data Masher outputs flow ratio (voids data when out of range)

K and flow ratio: a case study   Boston, January 2015, 1-minute data
Flow induced exploding BC1



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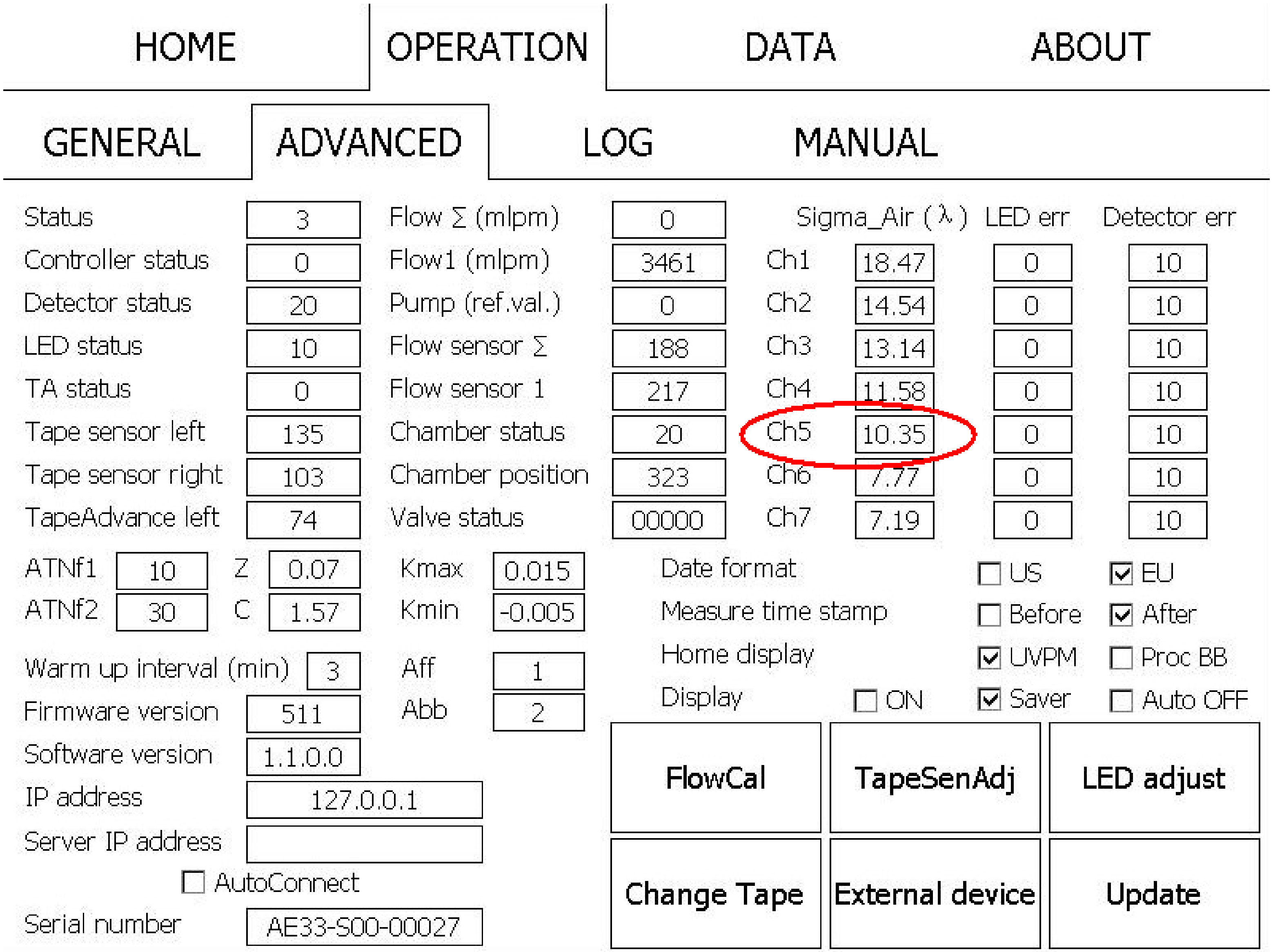
Channel 5 “Sigma” value: should be 10.35 (was 9.85)
a minor tweak that doesn’t effect most users



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AE33 / 633 QC Suggestions - Collocation

Co-location of Aeths:

- Very important if mix of legacy and 633 models
- Preserve spatial patterns / temporal trends

Not important if no other BC or EC measurements in airshed

- e.g., a single Aeth, no CSN etc

633 BC6 (880) expected to read higher than AE21/22 BC

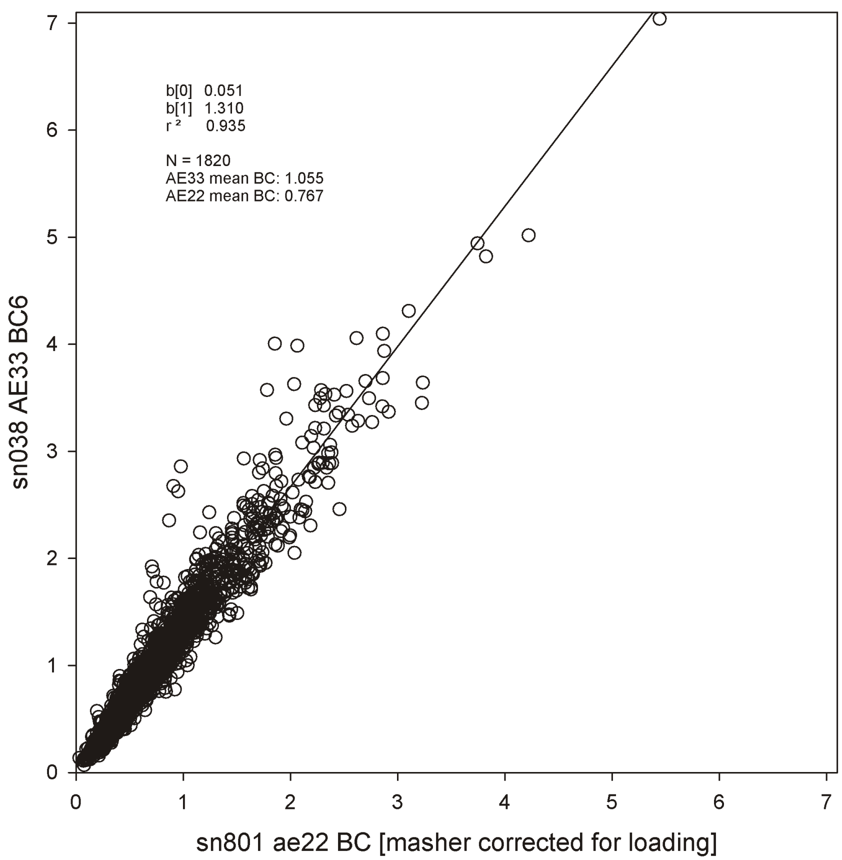
- ~10 to 15%
- compared to uncorrected legacy BC (880)
- site and season-specific

May read substantially higher ~30% [??]

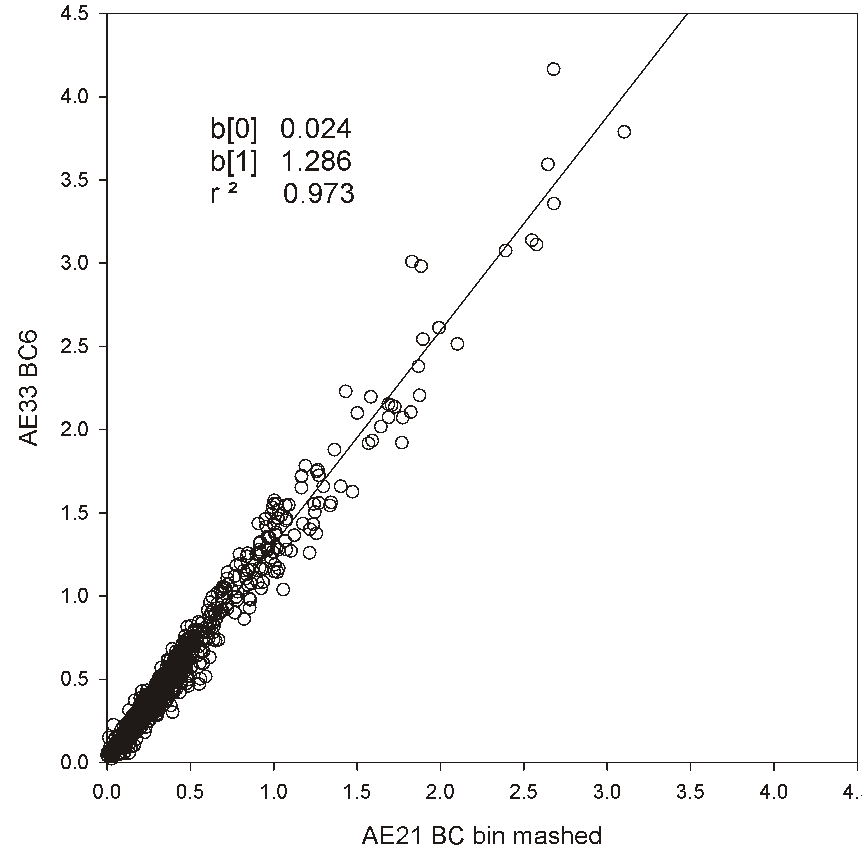
- or may not...

Examples of 633 BC6 vs. AE2x Legacy “corrected” BC(880): Roxbury/Boston MA (MassDEP), and Rochester NY (NY-DEC)

Roxbury/Boston: slope=1.31



Rochester, NY: slope=1.28



Add another ~ 10% if AE2x data not corrected for spot loading artifact

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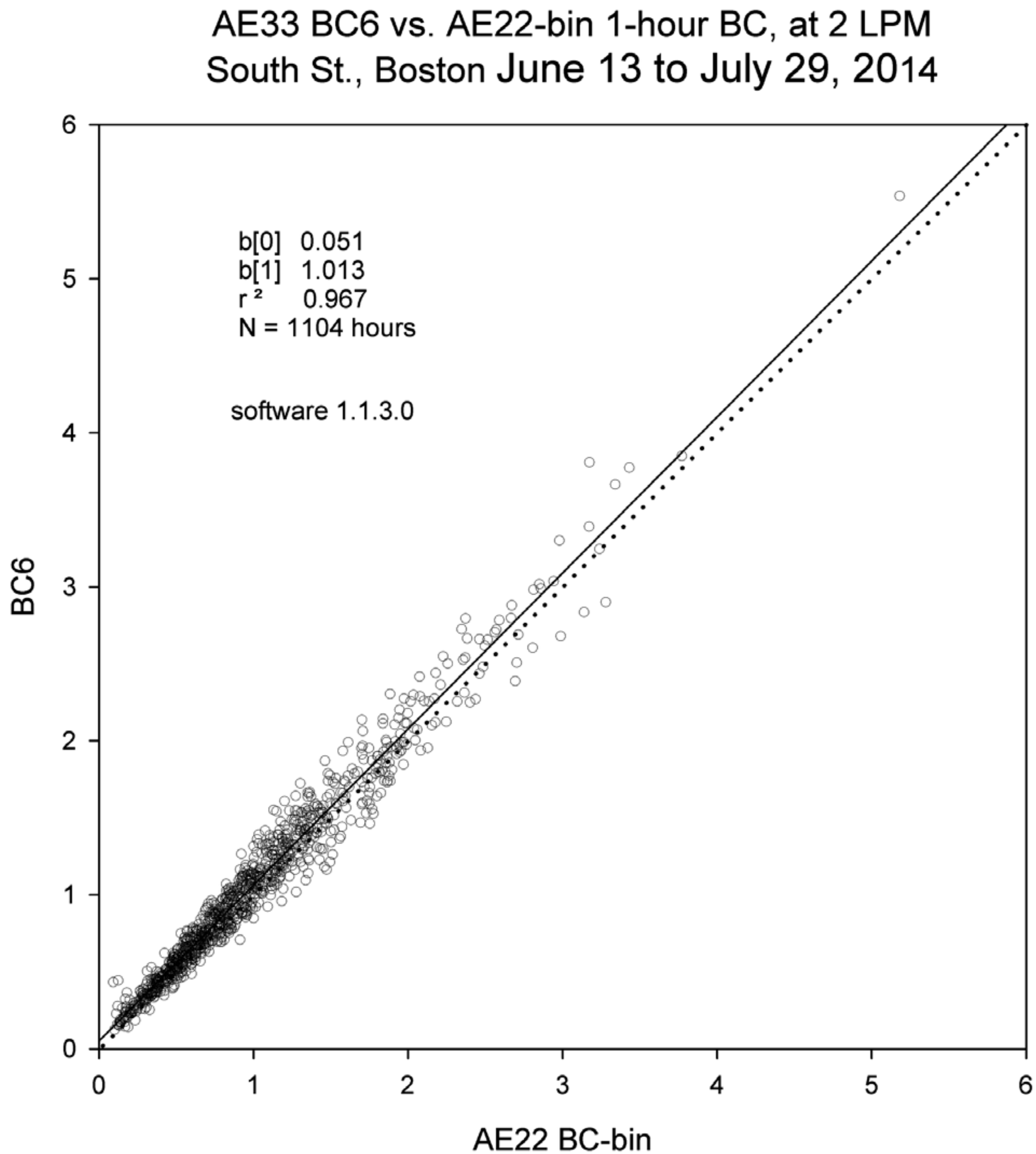
But... more recently w/ newer HW, newer software, 2-LPM:

Excellent agreement at my Boston site

No idea why different from 2013 results



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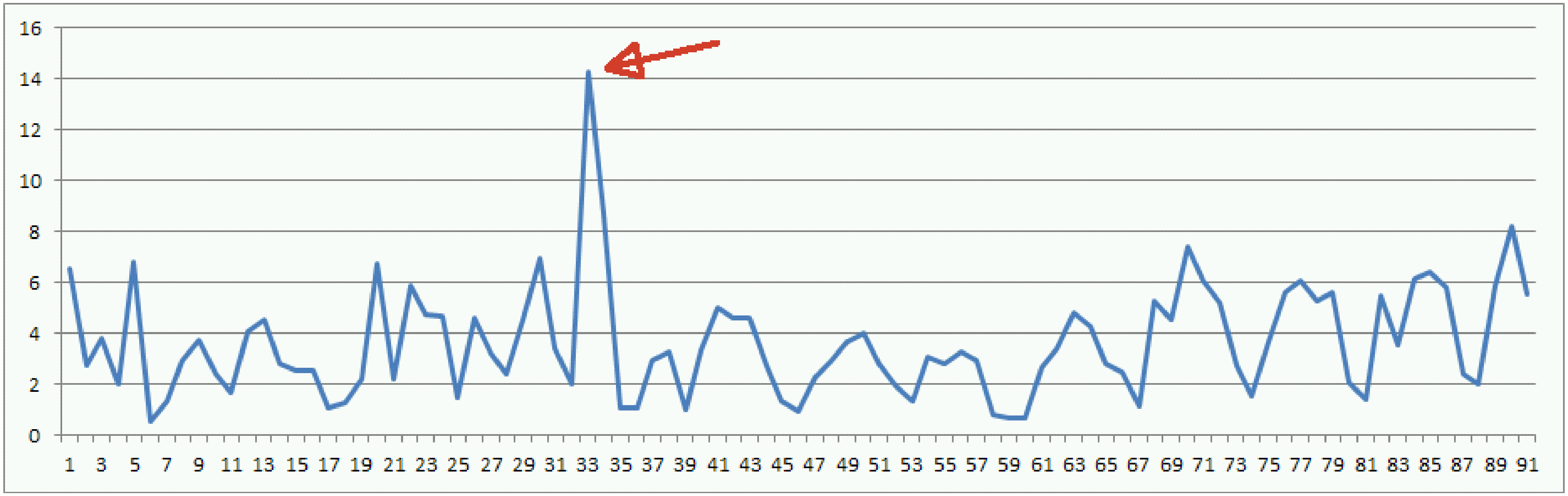
AE33 / 633 QC Suggestions - Data Screening

BC time-series at 1-min. and/or 1-hour level

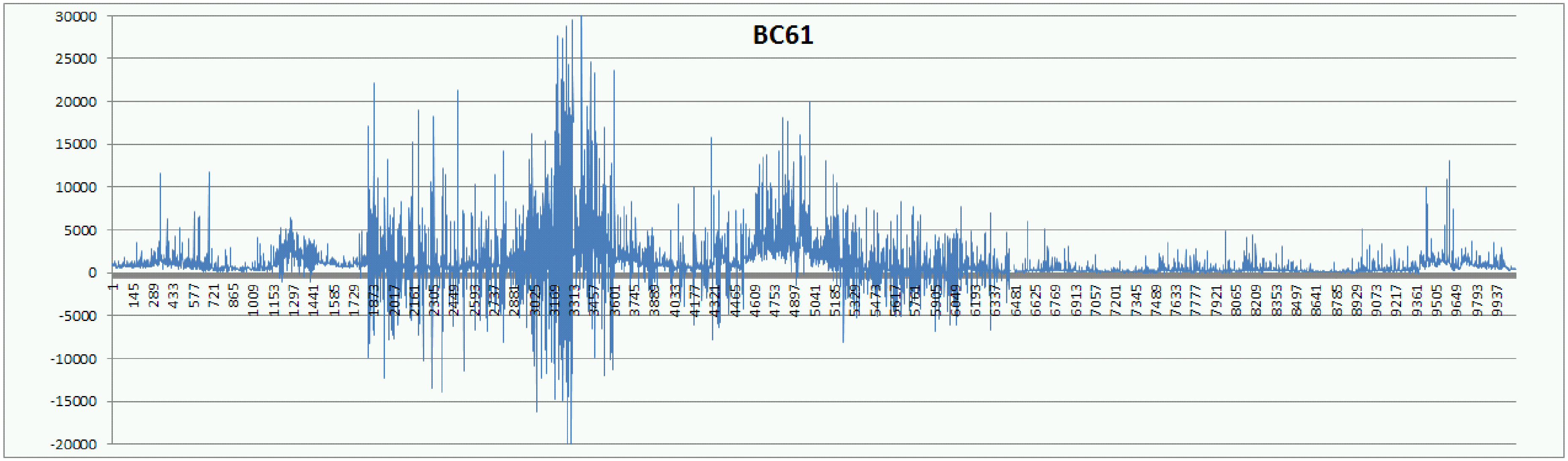
Noise, Extreme values

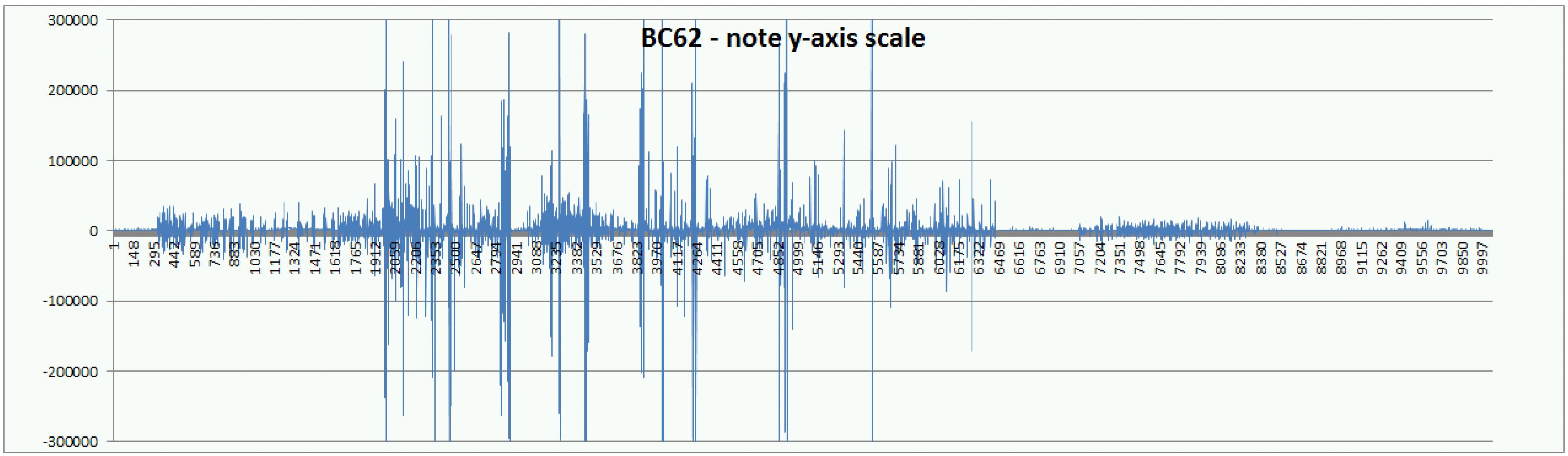
Real-World Case Study: Daily Max 1-h BC from AirNowTech (3-months)



14 μg/m^3 1-h BC6? Investigate...

Quick QC plot of 1-minute BC6 data for 1-week period in question:





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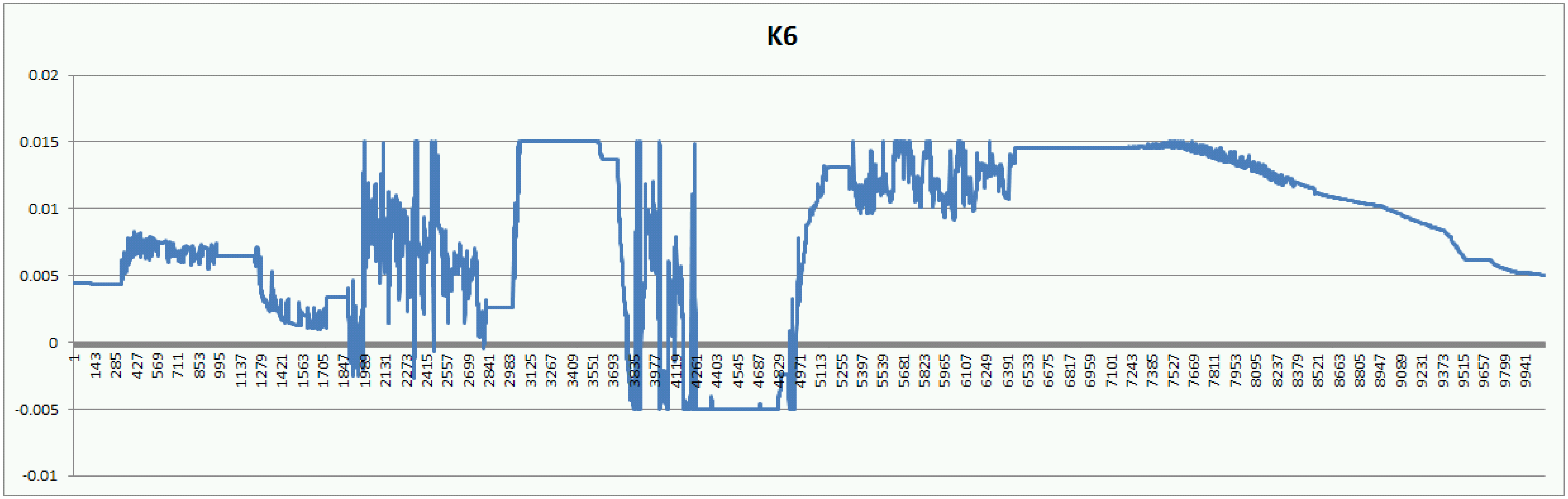
K6 for this 1-week period:



Indicates serious operational problem (invalid data)!

K6 is normally between 0.000 and 0.010

Default K Min/Max: -0.005 to + 0.015

Cause: junk on spots [bugs can get past cyclone]

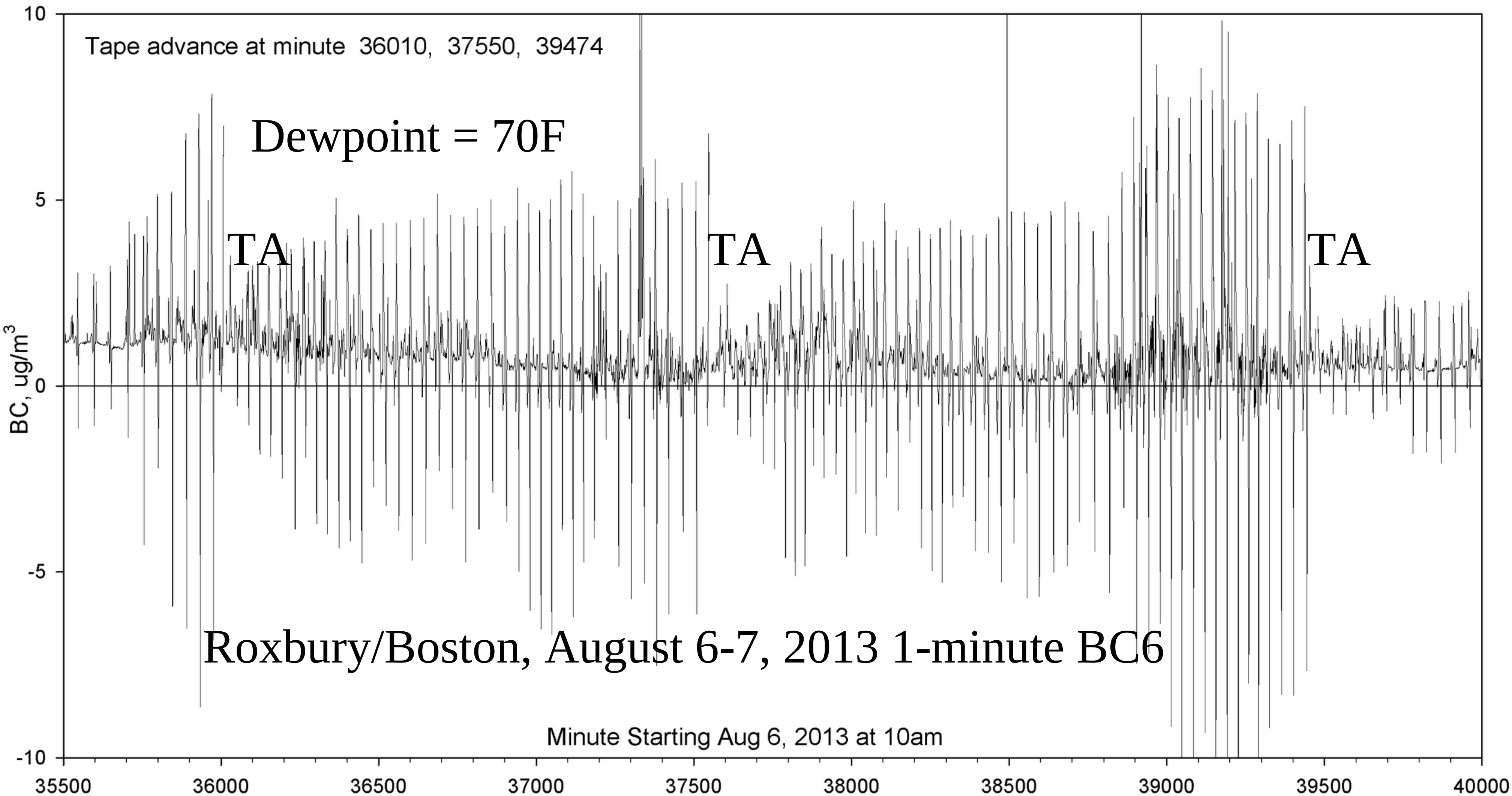
High BC6 K (+0.015) results in over-correction of data

<u>Not obvious</u> from casual review of 1-hour average data

<u>RH cycling effect</u> (from air conditioner shelter temperature cycling)

Teflon tape fixes media effect; still have aerosol effect in 1-min. data

- Hourly data are ok -- but ONLY IF negative data are included
- A Nafion sample dryer option is now available from Magee



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Data Handling

Updated EPA-AQS method/param codes spreadsheet:
 Aeth AQS codes JRice EPA-6Feb15.xlsx

AE33 Data Acquisition: digital only

"Pull" com port - no push
 must set up instrument com port
 same data format as USB data file

Invalid data reported as "0" (even when instrument is stopped)
 status value is complicated - more than just valid or not

DRDAS and Agilaire have 633 modules
 May or may not handle data status codes properly
 See: Agilaire Application Note_633_25March2015.pdf
 and DrDAS D23-TAPI-633.pdf

Other Data Acq option

RealTerm: Windows freeware that can poll and log AE33 data to a file

RealTerm AE33 logger.zip

USB to Com port cable: Sabrent SBT-FTDI ($20)

also need “null modem” cable crossover adaptor/cable

Aethalometer Data Processor ("Masher")

Stand-alone Windows software (Turner/Allen)

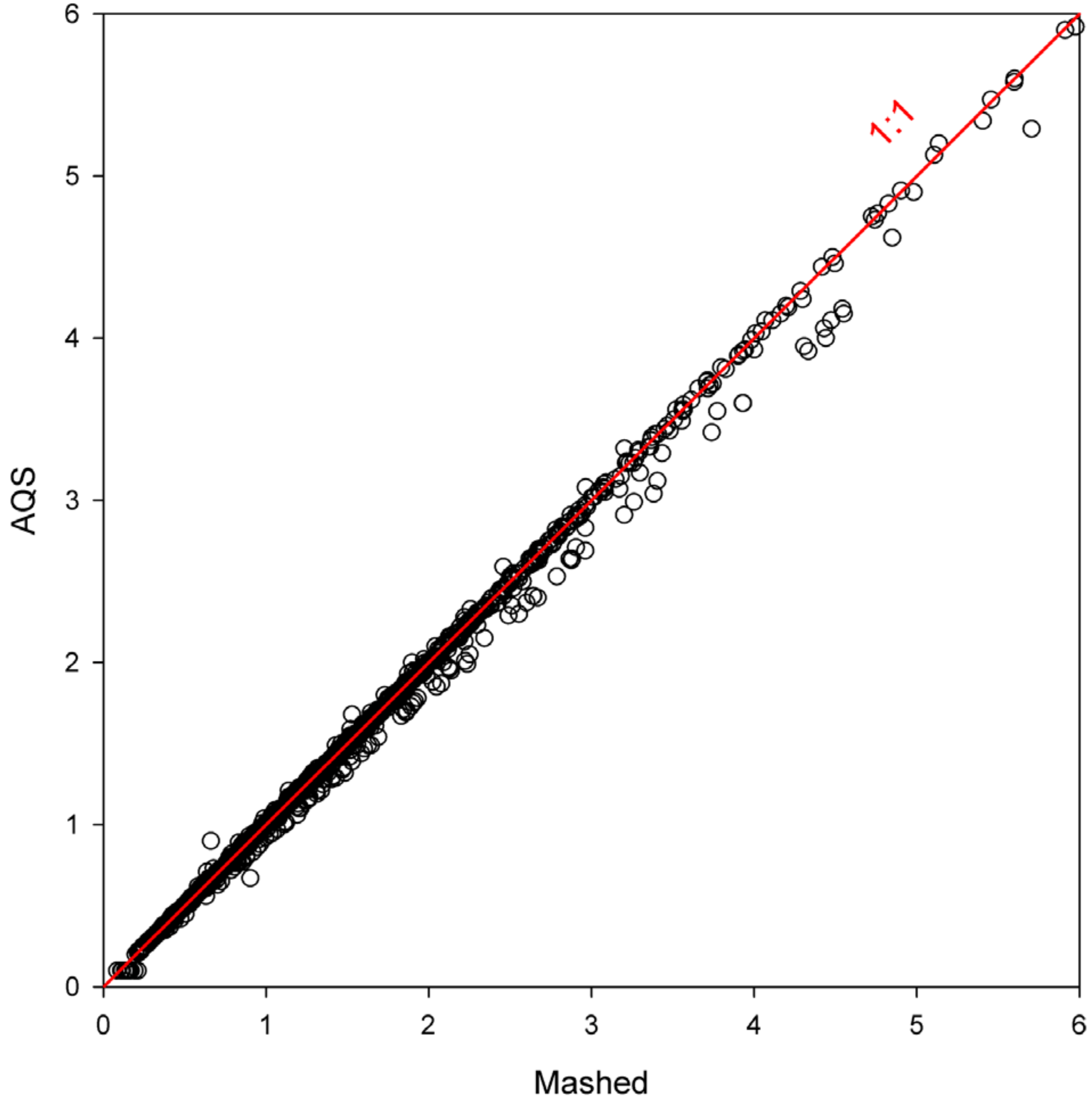
- Logger validation or primary data pathway
- Ingest raw data files
- Outputs cleaned up 1-hour average data
- Files under: "Data Mashers"

==> There is no spot loading correction or other data correction!

Masher data validation:

- Reports K values, flow ratio
- Incorporates screening for bad K, flow ratios, etc.

AQS vs. Mashed BC Example:
Jan-Feb 2015 1-hour BC, Tape Advance "0" data included in AQS



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AE33 / 633 Masher (continued)

Output fields (1, 5, and 60 minute averages):
Date/Time, N(880), BC1(370)...BC7(950), K1(370)...K7(950), flow ratio

Option for manual void input file

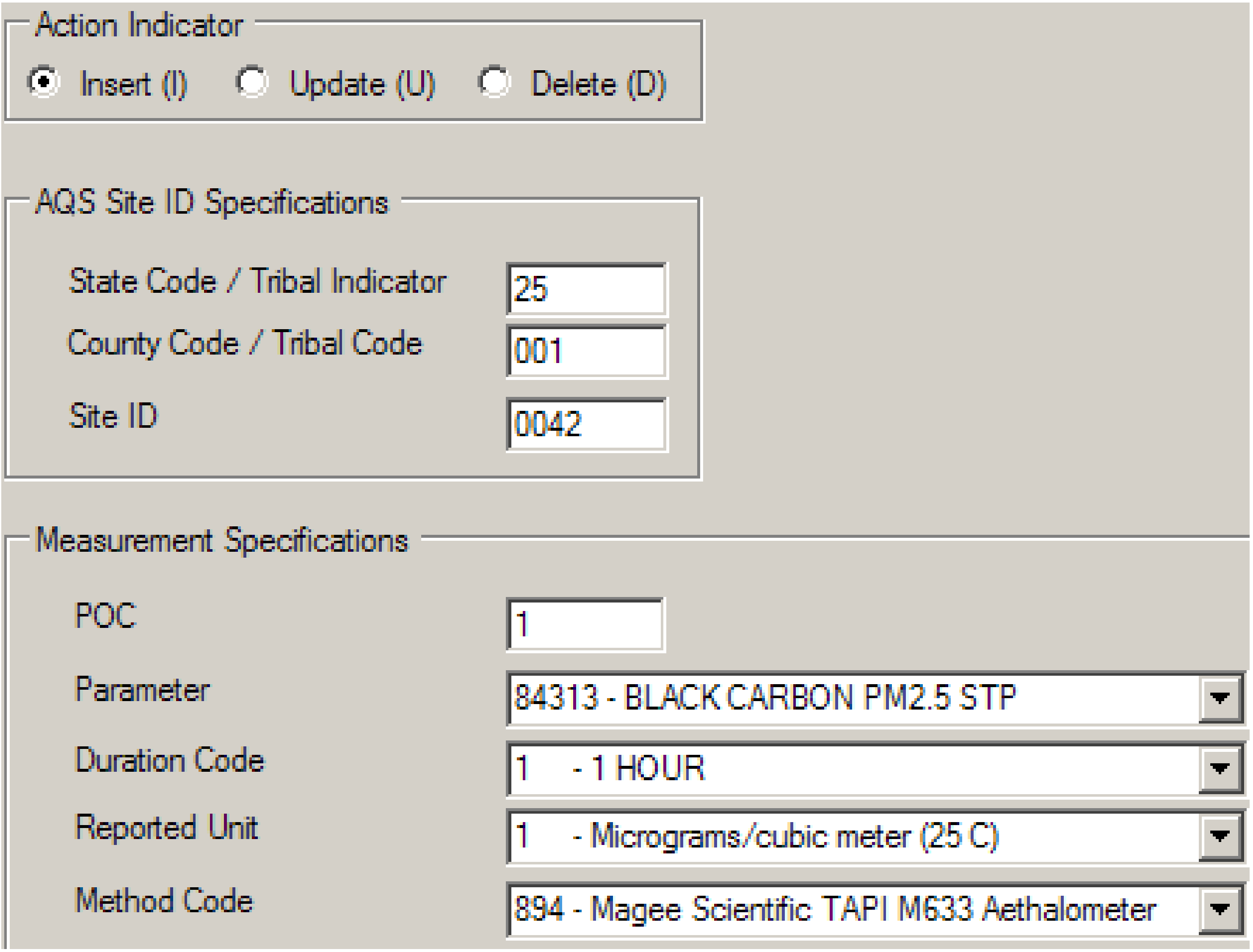
- start date time, end date time
- `8/12/2013 15:41:00, 08/12/2013 16:56:00`

Not performance optimized

- be patient - takes 7 minutes for 1/2 year of data
- 365 days of data maximum at a time

Can output AQS-ready files

Masher AQS File Builder option:



Reads in masher output file that was just run
Outputs AQS submission format

AE33 masher, continued.

Diagnostic output in log file:

```
Unique instrument serial numbers = 1
     Serial number = AE33-S02-00181
Unique application versions = 3
     Application version = 1.1.0.0
     Application version = 1.1.1.8
     Application version = 1.1.3.0
Flow Rate Ratio minimum = -3.413927
Flow Rate Ratio maximum = 22.90833
Pressure minimum (Pa) = 101325
Pressure maximum (Pa) = 101325
Temperature minimum (C) = 21.11
Temperature maximum (C) = 25
```

Ljubljana at night