Electrostatic Neutralization

A Key to Accurate & Repeatable PM Filter Weighing

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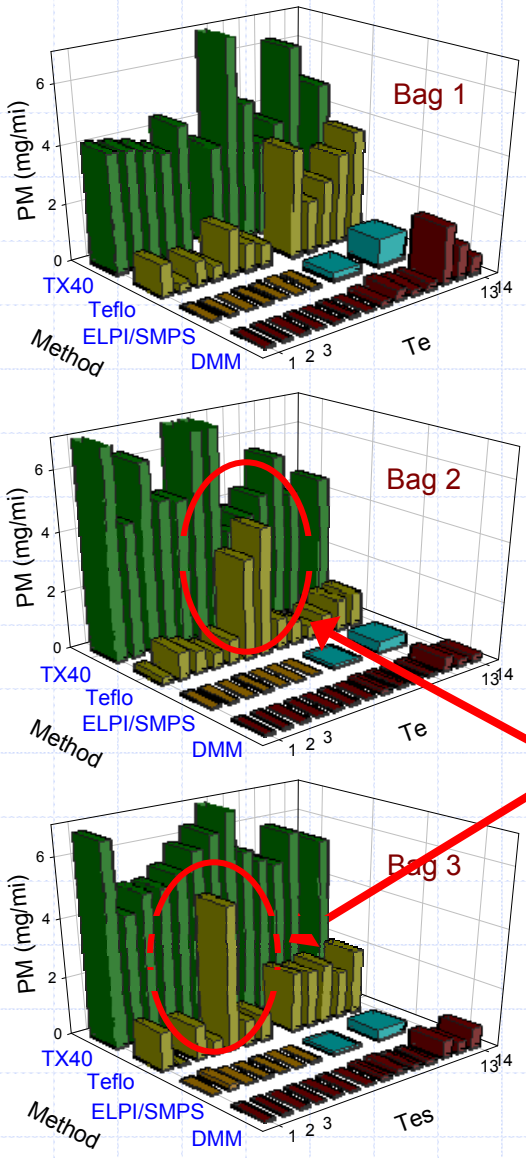
Outline

- Regulations require filter weighing for measuring PM
- Filter can acquire electrostatic charge, which affects balance measurements
- Electrostatic charge can be neutralized
- Un-neutralized charge can be detected
- Summary

Artifact study: weighing outliers

- Regulations: <10 mg/mile
- Particle counting (ELPI, DMM) showed little PM
- TX40 had large organic vapor artifact 4-7 mg/mile); Teflo had less
- Teflo data contained notable outliers – incomplete charge neutralization



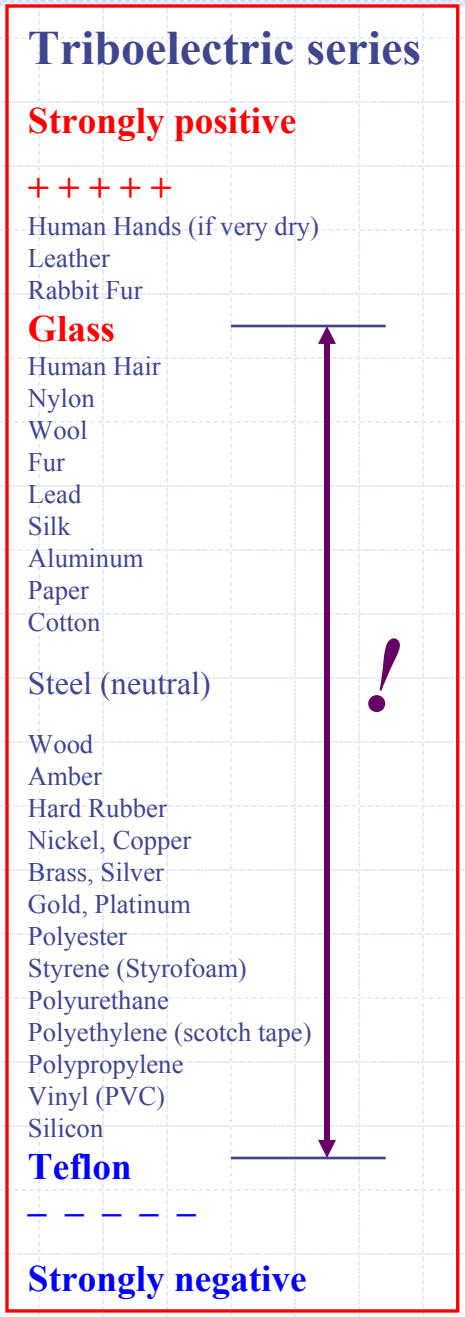
14 FTP Tests

Note

(from SAE 2004-01-0967)

Electrostatic charge

- Recall triboelectric series
- Recognize dilemma – Teflon filters should ***not*** touch glass during repeat weighing
- Neutralize filters on bottom (where charge is more likely to collect), as well as on top.
- Design improved neutralization station & apply to process



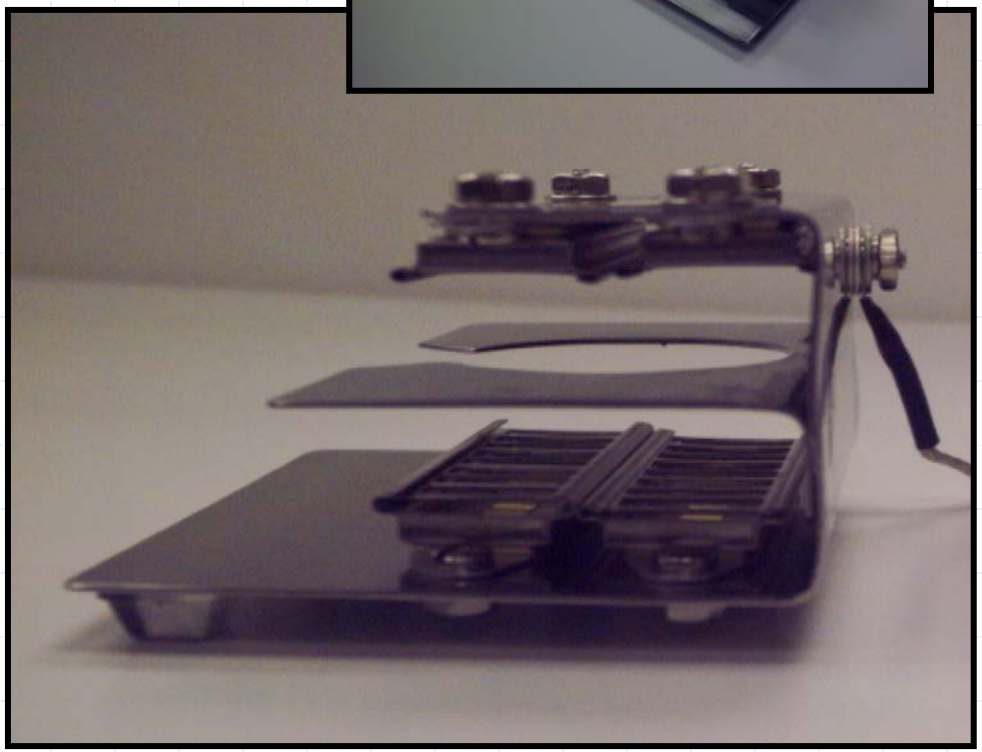
Glass is readily charged + + +

by Teflon which charges - - -

EDP – Electrostatic Discharge Platform

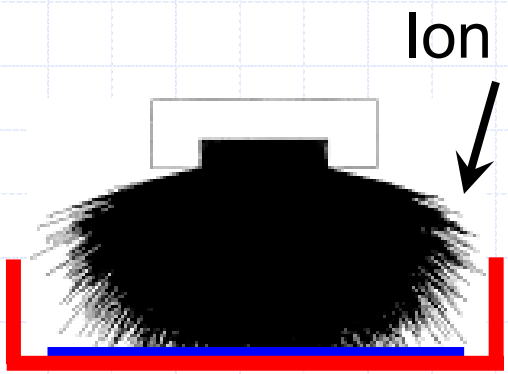
- Filter sits on polished stainless steel
- Filter-source distances optimum
- Filter neutralized above & below.
- Filter surrounded by ground planes.
- 4 times more Po^{210} bars than previous

Version 1

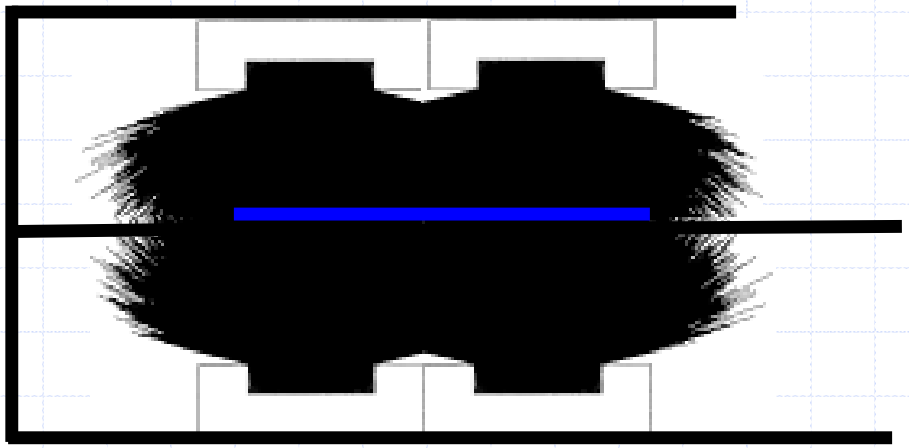


EDP *vs.* Petri dish

- Use EPD before & between weighings instead of awkward Petri dish

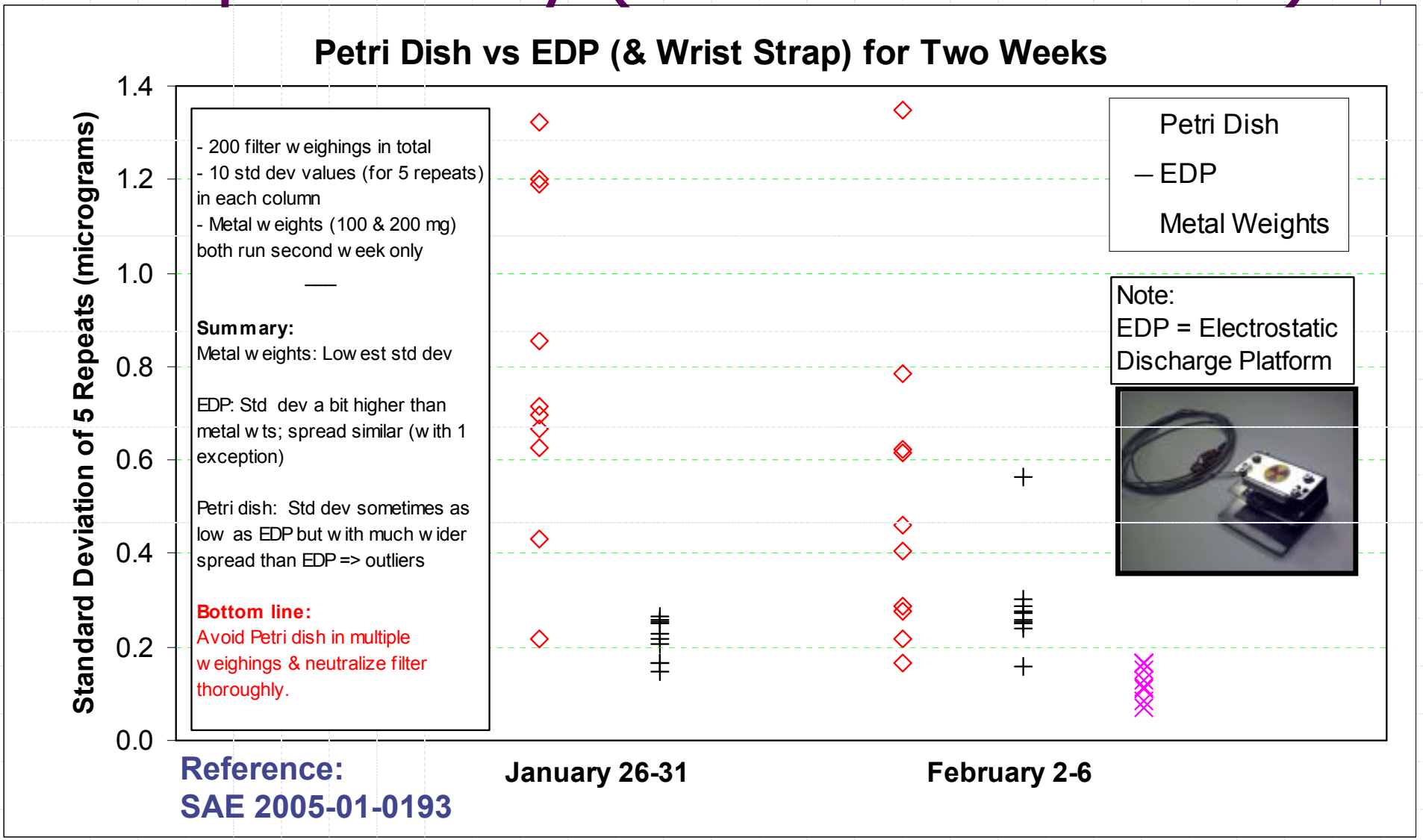


Filter in nonconductive, floating glass Petri dish



Filter in conductive, grounded Electrostatic Discharge Platform (EDP)

Repeatability (standard deviation)



Problems with EDP I

- Charge implantation
  - Po^{210} emits α's at ~5 MeV that travel in air ~3.8 cm (~1.5 inch)
  - α-particles penetrate filter material only ~50μm at 5 MeV, but they do penetrate and deposit charge
  - Change orientation to expose only filter edge
- Efficiency of ionization
  - Change orientation so ion clouds intersect with each other & not the filter surface, which ends ionization
- Ease of use
  - Ionizing bars above the sample make view difficult
  - Change orientation so the bars don't block the view.

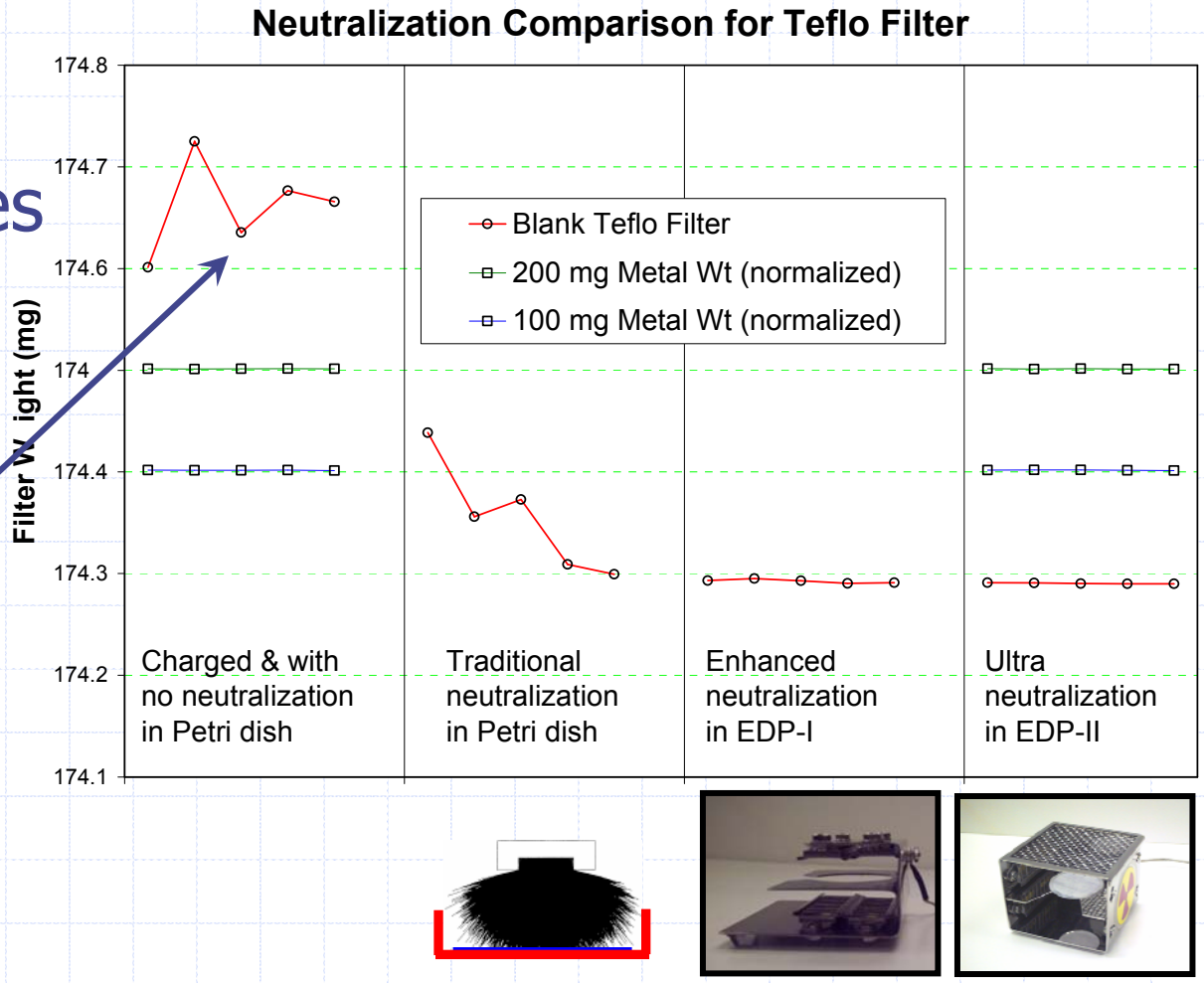
EDP II

Version 2

- Improvements
  - Stronger ion cloud near filter
  - Better visibility
  - Little chance for α implantation
- Retained
  - Ultra-neutralization above & below filter
  - Ease of access
  - Grounded stainless steel environment

EDP II Results

- Poor neutralizing causes issues
  - Larger variability
  - But also, ***offset*** to higher weight



Measuring Filter Charge

- Current Part 1065.190 language:
  - "use a device to monitor the static charge of PM sample media surfaces . . . neutralize PM sample media to within +2.0 V of neutral"
  - Revision to regulatory language needed to provide robust advice
- Electrostatic measurements depend on nearly everything –
  - What kind of instrument you use
  - Where you place the probe and the object
  - What conductors are nearby, if they are grounded, . . .

Should you measure the surface potential of the filter?

- No, probably not. Surface potential is well-defined only for a conducting surface
- Filters are insulators – surface potential varies across filter, but meters still show a reading
- Electric field can be measured, but results depend critically on filter location relative to conductors.
- The number you get depends on where you put the filter . . .

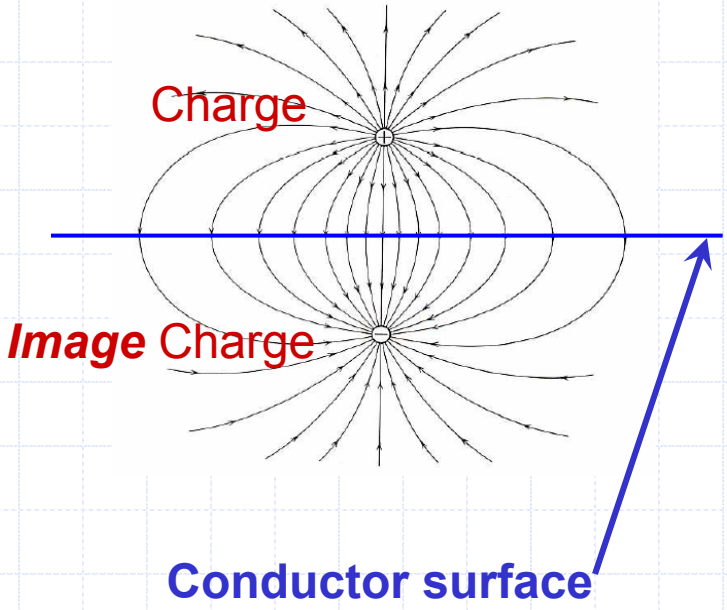
Charges Near Conductors

- Charges on conductors rearrange
- **E** field lines end on charges
- **E** field lines must end perpendicular to surface
- Result same as equal & opposite ***image charge*** below surface
- Image charge partially cancels **E** field above

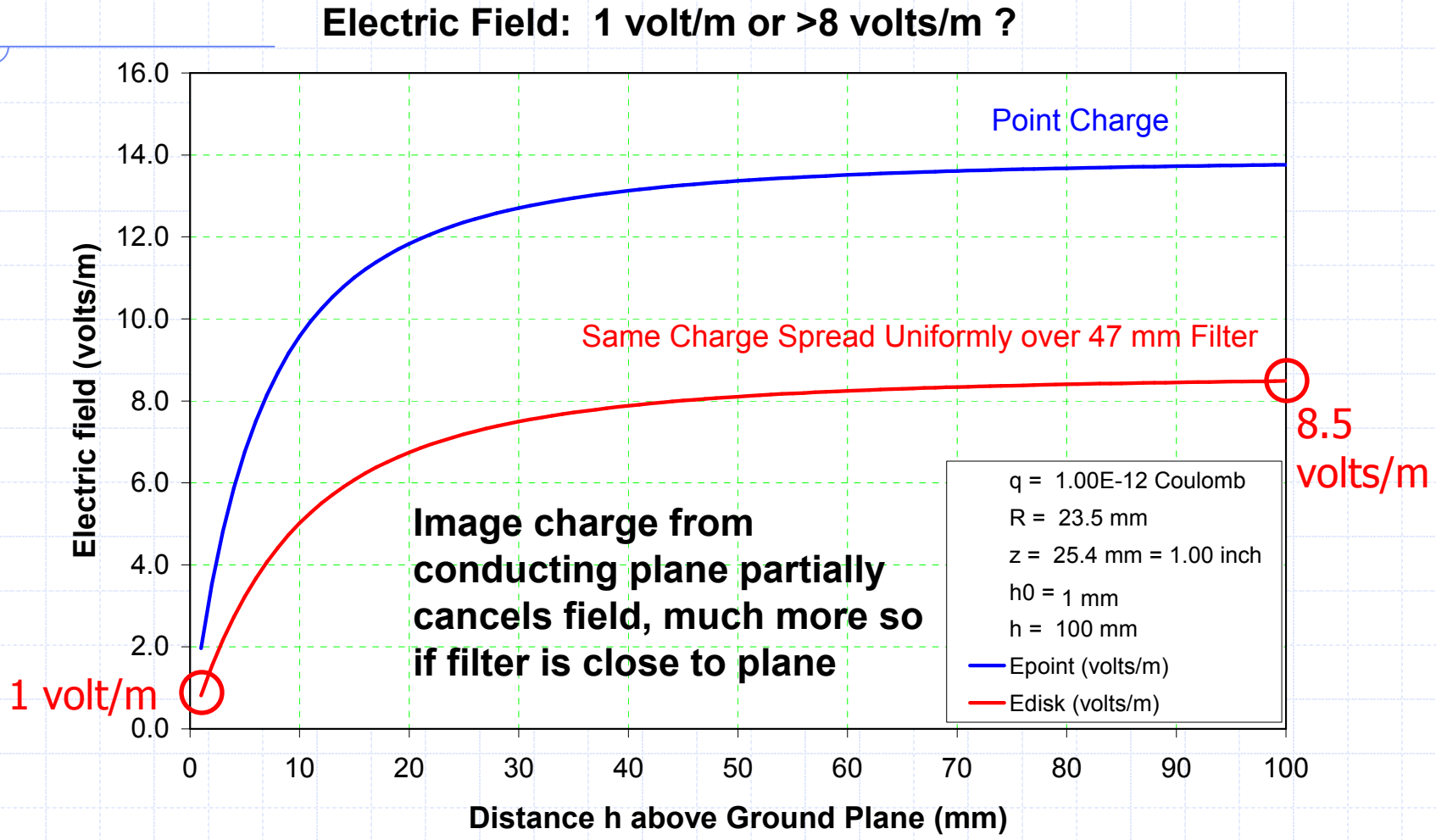
X (Meas. Pt.)

Electric field is lower here because of image charge.

Cancellation becomes complete as charge approaches surface.



Field Meter Measurements



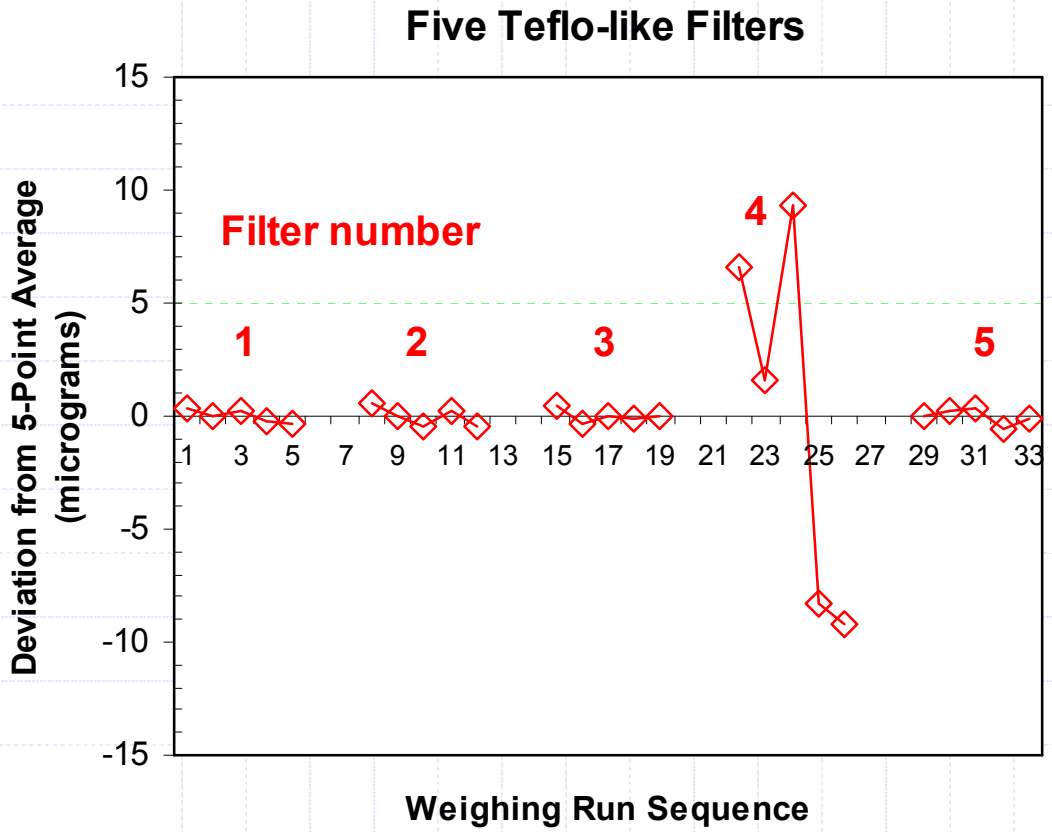
Bottom line: Locate filter >100 mm (4”) from nearest ground plane.

Can charging be found by weighing alone?

- Yes! One of five filters retained a charge.

These Teflo-like filters have thicker Teflon membranes and rings of a Teflon-like material (not polymethylpentene).

It is possible that the ring is more easily picking up a charge generated by contact.

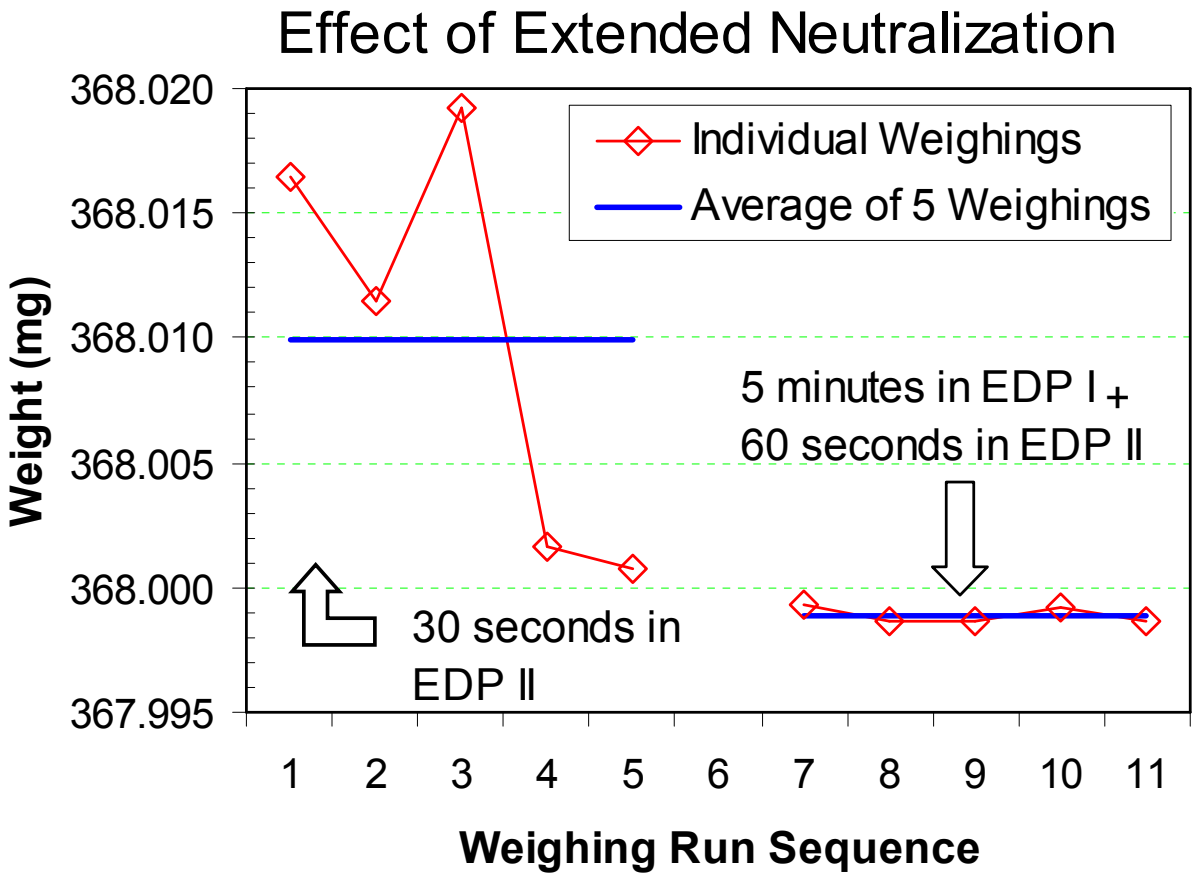


Can charging be fixed?

- Yes! Longer neutralization is effective.

Charging causes

- Increased variability
- Downward trend in the run sequence (as neutralization acts over longer times)
- Offset to higher weights



Summary

- Filter charging increases weight & variability
- Effective method of neutralizing charge found
- Residual charge can be detected, but care must be taken if electrostatic measurements are to be used.

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