1) Call to Order – 8:01
   a) Introductions
   b) Roll call & quorum confirmation
      Kathleen Owen, Chair Y
      Todd A McGrath, Vice Chair  NonVoting
      Leslye Sandberg, Secretary  Y
      Zied Driss Y
      Dr. Dara Marina Feddersen Y
      Kevin Kwong Y
      Dr. Sanjeev K Kingorani  Y
      Marisa Jimenez Segovia Y
      Kevin Morrow N
      Donna M Sullivan N
      Jim Rosenthal Y
      Dr Rahul Bharadwaj Y
      Robert B Burkhead  Y
      Richard K Chesson Jr, Chair Research Subcommittee Y
      Dr. Carolyn Kerr  (Gemma)  Y
      Dr. John Zhiqun Zhang N
      Joe Fly III, Organizational Vote NAFA  Y
      Len Duello  N
      13Y Voting Member present

2) Review of this agenda – ok
3) Review of “Draft” Houston 2018 Minutes – Jim Rosenthal Moved Gemma 2nd **12 Y 0 N 1 A b s t e n t i o n** – Chair nonvoting

4) Chair Remarks – if you have signed up to be a “nonvoting” member of the committee you will receive everything from the committee. Without that you will not. Also – you must update your contact information with ASHRAE to stay up to date with communications.

ISO16890 still under discussion. PM Efficiency change proposal from Mike Corbat – to be presented today.

5) Membership – NAFA organizational voting person updated. Roster changes typically take place July after summer meeting. If you want to come on as a voting member – please turn in an application. This MUST be done for chair to move you from nonvoting to voting. Committee must maintain a balance so multiple people from same company may not sit at same time. Sign in sheets are routing.

6) Website – Todd McGrath 52.2 site is up. Todd will be able to load the minutes for all to see. Other presentations will be available with the approval of presenter. See link below

   a) [http://sspc522.ashraepcs.org/](http://sspc522.ashraepcs.org/)

7) Liaison Report – none present

8) ISO 16890

   a) Changes in fibers during IPA conditioning - Crystal Jolliffe –

      Questions for further research and study:
      • What studies were done to show how isopropyl alcohol changes the media?
      • What media attributes could be studied besides efficiency?
        • Fiber size
        • Density
        • Thickness
        • Stiffness
        • Basis weight
        • Charge
        • Can the differences here be explained by variation in testing?
        • variations in the media?

      From the group: Can this be repeated? Can the samples be retested? No same samples are gone. Is the change permanent? Some of the changes may be at the fiber level - can this be tested? The effects of drying? How many fibers were evaluated? (SEM is 10K data points) Temperature changes? Vapor changes? Condensation? Instrument calibration? Has anyone else seen pressure drop changes? Were the medias similar chemical base? Change in basis weight?

      Don suggested that pressure drop changes haven’t been seen in completed filters through testing to date. Chrystal mentioned not a lot of that data is shared so an RTAR to discover wider published data is her request.

      Move by Chair to evaluate whether or not discussion of ISO16890 should still be a topic of discussion. This was the last of the formal presentations to the committee on the subject. If nobody else has discussions/presentations should the topic be tabled? Removed from the agenda?
Jim Rosenthal made a motion that we discontinue discussion on ISO16890 topic unless asked by ASHRAE. Bob Burkhead seconded. From the floor – what about others not “ASHRAE”? Jim Rosenthal withdraws the motion.

Chair will drop the topic from the agenda.

9) Open Action Items
   a) Air Density Equation addendum - went through publication for public review – no comments – it is up on the website with changes – 52.2 addendum 2017
   b) PM and OPC measurements – Vijay has done some analysis of inlet size and PM. Preliminary results suggest new avenues for calculation going forward. Not an RTAR request at this time.
   c) Improving Charge Neutralization – Bruce McDonald – presentation on neutralization. See attached presentation and support documents.
   d) PM efficiency Change Proposal –
      i) Mike Corbat – Other committees using 52.2 output and citing it in standards are not happy with MERV. They are interested in a PM2.5 efficiency number for health concerns. Note: It has been discovered that many are equating the E2 as a representation of PM 2.5 which it is not. So as a committee 52.2 is asked to come up with a PM efficiency to cite in their standards.
      ii) Discussion – Chair clarified what a change proposal was and how it works. Committee is required to respond to the proposal. Also noted that 62.1 and 62.2 have stated that they must have a ‘PM’ efficiency – those letters must be in it. They need the PM2.5 level, but would like PM10 and PM 1.0 efficiencies in addition. From the floor – the proposed MERV table doesn’t match up to the E-1 to E-3 calculation. Consensus from the floor is that the existing MERV table should remain and the PM_{EST} calculation could be the added. Per Bob Burkhead it’s easy enough put additional calculations onto a test result. Some dissension about what/how the calculation is done. Per Jim Rosenthal – if they need a way to estimate PM efficiency from the test add a calculation to the standard that everyone can use IF they want such a number.

Chair summary – feel from the room is mostly people agree that there could be a calculation added but no change to the MERV table. Flat distribution as proposed. Matt Middlebrook, Zied Driss, Bob Burkhead, Jenny Berens volunteer to work on this with Mike to revise the request.

Committee must reply formally that they accept with revisions. Barney B will help clarify and push for fast answer – need revisions do go with the acceptance form back to ASHRAE.

10) New Business
    Negative Pressure Dust Feeding Ducts – Kathleen Owen – is anyone interested in this? No response
    Bob Burkhead – chamber testing Micro balance QCM new instrument – this arena is work in progress but is likely to contribute to PM data going forward.
    Leslye Sandberg stepping down as secretary; Kevin Kwong taking the place.

11) Adjourn Main meeting Moved Jim Rosenthal Second Gemma Kerr

12) SSPC 52.2 Research – Keith Chesson – went straight into the research meeting
    a) Get ASHRAE to fund an official comparison between 52.2 and ISO16890?
Since the committee has removed from the agenda do we want to continue? Do we want an RTAR? Before spending ASHARE money should we try to get comparative data from companies just to see what is available now. Ask chair of TC2.4 Mike Corbat and Kathleen as chair of SPC52.2 to send an email to companies asking for data they can share. Camfil (Don Thornburg), Freudenberg Filtration Technologies (Jenny Berens), AAF (Jonathan Rajala), Filtration Group (Phil Winters) at the meeting have offered. If we can’t get adequate data that way, then look to research. **Keith Chesson will collect the data. Christine Sun willing to champion this project with Kathleen’s help.**

IPA Vapor changes – 2014 there was discussion on this talking about doing round robin testing. There was interest in impact on different fibers back then. Tabled while waiting for ISO standard to complete. Are we interested in reopening discussion on this topic for research? **Crystal willing to work on it but hasn’t done an RTAR proposal before...Phil Winters will help with the RTAR, Jon Rajala will help. Marquita Beard (eSpin) also volunteered.**

Another interest in 2014 comes back with Bruce’s presentation on neutralization. Bruce can help but not champion all himself. Research to improve the standard. Nobody stepped forward as champion.

Update on 1784 – Geoff – received bids for round robin on 52.2 – group will meet today to make recommendations to TC2.4 for ASHRAE on Tuesday. TC2. If funded it should start this summer.

13) Adjourn Research 11:12

### Attendees:

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Name</th>
<th>Company</th>
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<tr>
<td>Joel Davis</td>
<td>AAF Flanders</td>
<td>Thomas Arnold</td>
<td>Puget Sound Navel Shipyard</td>
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<td>Jonathan Rajala</td>
<td>AAF Flanders</td>
<td>Chris Stewart</td>
<td>Puget Sound Navel Shipyard</td>
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<td>Satish Dinakaran</td>
<td>AAF Flanders</td>
<td>Robert Kellogg, Engineer</td>
<td>Puget Sound Navel Shipyard</td>
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<td>Vijay Kumar</td>
<td>Aerfil</td>
<td>Brandon Boor</td>
<td>Purdue University</td>
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<tr>
<td>Andrew Goodby</td>
<td>Ahlstrom</td>
<td>Randy Bramen</td>
<td>Quality Filters, Inc.</td>
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<td>Chris Stone</td>
<td>AHRI</td>
<td>Jim Hanley</td>
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<tr>
<td>Marisa Jimenez de Segovia</td>
<td>Air-Care de Mexico</td>
<td>Bruce McDonald</td>
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<td>Thad Ptak</td>
<td>AO Smith</td>
<td>Mark Tucker</td>
<td>SWM Intl</td>
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<td>Bob McAfee</td>
<td>Berry Global</td>
<td>Stevan Brown</td>
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<td>Bob Burkhead</td>
<td>Blue Heaven Technologies</td>
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<td>Bobby Singer</td>
<td>Blue Heaven Technologies</td>
<td>Phil Maybee</td>
<td>The Filterman</td>
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<td>Connie Burkhead</td>
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<td>Ray Rite</td>
<td>Trane</td>
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<td>HE Barney Burroughs</td>
<td>BWCI</td>
<td>Tim Johnson</td>
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<td>Zied Driss</td>
<td>Camfil</td>
<td>Oludami Adesanya</td>
<td>United Technologies</td>
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<td>Don Thornburg</td>
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<td>Kevin Kwong</td>
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<td>Daniel Vangilder</td>
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<td>Alex Wells</td>
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<td>Rahul Bharadwaj</td>
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<tr>
<td>Randi Huckaby</td>
<td>Camfil APC</td>
<td>Geoff Crosby</td>
<td>Lydall</td>
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DRAFT Meeting Minutes
ASHRAE SSPC 52.2
MOT - General Ventilation Air-Cleaning Devices for Removal Eff. by Particle Size
Saturday, 12 Jan. 2019, 8:00 am – 12:00 pm
Atlanta, GA

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Contact</th>
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<tbody>
<tr>
<td>Jim Benson</td>
<td>Camfil Power Systems</td>
<td>Trey Fly</td>
<td>NAFA</td>
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<tr>
<td>Gemma Kerr</td>
<td>Canada</td>
<td>Michelle Czosek</td>
<td>NAFA</td>
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<tr>
<td>Kyung-Ju Choi</td>
<td>Clean &amp; Science</td>
<td>Kathleen Owen, Chair</td>
<td>Owen Consulting</td>
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<td>Tim Ahn</td>
<td>Clean &amp; Science</td>
<td>Dan Haas</td>
<td>Parker Hannifin HVAC</td>
</tr>
<tr>
<td>Yeo</td>
<td>Clean &amp; Science</td>
<td>Keith Chesson, Research Chair</td>
<td>Parker Hannifin HVAC</td>
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<tr>
<td>Jeong Hwan Shin</td>
<td>Clean &amp; Science</td>
<td>Christine Sun</td>
<td>FTI</td>
</tr>
<tr>
<td>Vivek Gaur</td>
<td>Columbus Industries</td>
<td>Todd McGrath, ViceChair</td>
<td>Glasfloss</td>
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<tr>
<td>Chrystal Jolliffe</td>
<td>Columbus Industries</td>
<td>Monroe Britt</td>
<td>Green Leaf</td>
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<td>Chris Fischer</td>
<td>Donaldson</td>
<td>Dara Feddersen</td>
<td>H &amp; V</td>
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<td>Jayesh Doshi</td>
<td>eSpin Technologies</td>
<td>Donna Kasper</td>
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<td>Marguita Beard</td>
<td>eSpin Technologies</td>
<td>Jay Reese</td>
<td>JBR Associates, LLC</td>
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<tr>
<td>Mustafa Ozturk</td>
<td>Fibrix</td>
<td>John Simenson</td>
<td>Johns Manville</td>
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<tr>
<td>Matt Middlebrooks</td>
<td>Filtration Group</td>
<td>Jeni Wong</td>
<td>Johns Manville</td>
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<tr>
<td>Phil Winters</td>
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<td>Sanjeev Hingorami</td>
<td>Lennox Industries</td>
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<td>Jenny Berens</td>
<td>Freudenberg</td>
<td>Henry Greist</td>
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<td>Thomas Caesar</td>
<td>Freudenberg</td>
<td>Leslye Sandberg, Secretary</td>
<td>Permatron</td>
</tr>
<tr>
<td>Kia Kiantaj</td>
<td>LMS Technologies</td>
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Attachments:
- Changes in fibers during IPA conditioning - Chrystal Jolliffe
- Improving Charge Neutralization – Bruce McDonald – presentation on neutralization and support documents.
- PM efficiency Change Proposal – Mike Corbat
• **Background:** Work undertaken to develop a pre-screening method for selecting filter media in product development cycle

• **Conditioning setup per ISO 16890**
  • Overall cabinet size 30x48x41, approximately 34ft³
  • Surface area liquid IPA 10.8ft²
  • 0.31ft² IPA liquid surface area / chamber volume ft³
  • Condition for 24 hours
IPA Vapor Conditioning Flat Sheet Media

- Experimental test setup
  - Chamber 32x18x13.5
  - 4.5ft³ Chamber Volume
  - IPA tray 11.5x19.5
  - 1.55ft² liquid surface
  - 0.34ft² IPA liquid surface / ft³ chamber volume
  - Media/Filter holding rack placed directly above IPA liquid with 2” between filter and liquid
Experimental test procedure
- Media placed in chamber
- Chamber is sealed
- Chamber is in an air conditioned lab
- Test media before and after conditioning
  - Efficiency
  - Pressure drop
  - 2 test methods
    - Flat sheet efficiency test setup on 12x12 samples
    - Also used TSI 8130 for higher efficiency media
## IPA Vapor Conditioning Flat Sheet Media

Results various materials and suppliers media for wire backed products all different grades of material. Raised question: **What is happening to pressure drop?**

<table>
<thead>
<tr>
<th>Test Velocity 125 FPM</th>
<th>INITIAL EFFICIENCY</th>
<th>POST 24 HOURS IPA VAPOR EXPOSURE</th>
<th>DP CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dP (in. wc)</td>
<td>E1 (%)</td>
<td>E2 (%)</td>
</tr>
<tr>
<td><strong>Electrostatic Type 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>0.083</td>
<td>62.16</td>
<td>90.18</td>
</tr>
<tr>
<td>B</td>
<td>0.210</td>
<td>54.12</td>
<td>87.75</td>
</tr>
<tr>
<td>C</td>
<td>0.152</td>
<td>56.71</td>
<td>87.89</td>
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<td><strong>Electrostatic Type 2</strong></td>
<td></td>
<td></td>
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<tr>
<td>A</td>
<td>0.213</td>
<td>43.0</td>
<td>83.9</td>
</tr>
<tr>
<td>B</td>
<td>0.106</td>
<td>25.9</td>
<td>65.1</td>
</tr>
<tr>
<td>C</td>
<td>0.071</td>
<td>17.2</td>
<td>48.6</td>
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<td><strong>Nanofiber Materials</strong></td>
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<td></td>
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</tr>
<tr>
<td>A</td>
<td>0.329</td>
<td>57.4</td>
<td>92.0</td>
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<tr>
<td>B</td>
<td>0.118</td>
<td>25.68</td>
<td>57.66</td>
</tr>
<tr>
<td>C</td>
<td>0.130</td>
<td>30.95</td>
<td>66.13</td>
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### IPA Vapor Conditioning Flat Sheet Media

**Melblown-Single grade 3 flat sheets each mini-pleat media**

**TSI 8130 data at 32 lpm**

<table>
<thead>
<tr>
<th></th>
<th>Unconditioned</th>
<th>Conditioned</th>
<th>dP difference</th>
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<tbody>
<tr>
<td></td>
<td>DP (mm H2O)</td>
<td>Efficiency</td>
<td>DP (mm H2O)</td>
</tr>
<tr>
<td>#1</td>
<td>1.0</td>
<td>95%</td>
<td>0.8</td>
</tr>
<tr>
<td>#2</td>
<td>1.0</td>
<td>97%</td>
<td>0.8</td>
</tr>
<tr>
<td>#3</td>
<td>0.9</td>
<td>98%</td>
<td>0.7</td>
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<tr>
<td><strong>Average</strong></td>
<td><strong>0.967</strong></td>
<td></td>
<td><strong>0.767</strong></td>
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IPA Vapor Conditioning Flat Sheet Media

SEM Analysis fiber diameter 10,000+ data points

Type A Electrostatic Control

![Frequency vs. Fiber Diameter Micron](chart.png)
IPA Vapor Conditioning Flat Sheet Media

SEM Analysis fiber diameter 10,000+ data points

Type A Electrostatic Conditioned

Fiber Diameter Micron

Frequency
IPA Vapor Conditioning Flat Sheet Media

SEM Analysis fiber diameter 10,000+ data points

Type A Electrostatic Comparison

5% shift on each end towards center
IPA Vapor Conditioning Flat Sheet Media

SEM Analysis fiber diameter 10,000+ data points

Melblown Control

![Histogram of Average Fiber Diameter (Micron) with Frequency on the y-axis and Average Fiber Diameter on the x-axis. The histogram shows a distribution with two peaks, one around 2.5 microns and another around 10.5 microns.](image-url)
SEM Analysis fiber diameter 10,000+ data points

Meltblown 24 hrs IPA Vapor Histogram
SEM Analysis fiber diameter 10,000+ data points

Control & Conditioned Overlay

29% of fiber diameter measurements < 4 micron in control
12% of fiber diameter measurements < 4 micron after conditioning
IPA Vapor Conditioning Flat Sheet Media

Questions for further research and study:
• What studies were done to show how isopropyl alcohol changes the media?
• What media attributes could be studied besides efficiency?
  • Fiber size
  • Density
  • Thickness
  • Stiffness
  • Basis weight
  • Charge
• Can the differences here be explained by
  • variation in testing?
  • variations in the media?
Aerosol Neutralization and Air Filter Testing

Bruce McDonald
For ASHRAE SSPC 52.2
January 2018
Outline

• Back ground and Terminology
• The need for neutralization.
• How do we neutralize an aerosol?
• How do we know that the aerosol is neutralized?
  – Methods in current standards.
  – Other possibilities.
• Conclusion
Background and Terminology

• Why aerosol are charged.
  – Background ions in the air
    • Boltzmann equilibrium charge distribution
  – Triboelectric charging
  – Generated ions
  – Evaporation
  – Heat
• Neutral aerosol
• Neutralized aerosol
Need

• Charge on aerosol affects measurement of filter efficiency.
  – Electret filter media
  – But also “mechanical” filters.

• What is the state of charge on the efficiency test aerosol in your test duct?
Severity of problem

• Oil aerosol: neutral with good repeatability and reproducibility. (atomizer, no solvent)

• Salt aerosol from water solution: Some charge.

• Solid aerosol from powder: likely highly charged.
Figure 1. This is Figure 3 from reference ISO TC 22/SC 7/WG 3 N414 Bittermann, H., “Round Robin Test ISO/TS 11 155-1 Status Report and Summary of First Results” 2.
Round Robin Test Campaign ISO TS 11 155-1

Figure 3: Results Phase B: Initial Fractional Collection Efficiencies

Efficiencies A2-Dust-not neutralized Filter Type 1

- Efficiency [%]
- Optical Particle Size [μm]

Graph showing efficiency as a function of optical particle size for different filters labeled A2 to I.
Efficiency Test Aerosol

• Efficiency test aerosol charge needs to be:
  – Known!
  – Repeatable!
  – Reproducible!
  – Realistic!

• What about loading?
  – Dispersion of solid particles into air generally results in highly charged aerosol.
How to Neutralize

• Use ambient aerosol not close to any ion sources (other than background)
• Radioactive sources
  – Inherently balanced source
• Powered corona discharge
  – DC
  – AC
• Is a balanced source the proper approach?
Is the Neutralizer working?

- **Current Standards:**
  - ASHRAE 52.2
  - ISO 16890
  - ISO TS 11155-1
  - ISO 19713-1

- Are those adequate?
- What else can be done?
- A balanced ion source may not neutralize an aerosol in some circumstances.
Range of Possibilities 1

• Install a neutralizer and hope for the best
• Install a neutralizer and require maintenance
• Require specific neutralizer capability, require maintenance.
  – ASHRAE 52.2
  – ISO 16890
• Determine that the neutralizer is working properly
Range of Possibilities 2

• Determine that the aerosol approaching the filter has X percent neutral fraction
• Adjust neutralizer to maximize the percent neutral particles
• Adjust neutralizer to minimize efficiency with electret media.
  — 19713-1 Annex G
Range of Possibilities  3

• Determine that the aerosol approaching the filter is neutral overall.

• Determine that the aerosol approaching the filter is at Boltzman equilibrium charge distribution.

• Determine that the proper filtration efficiency is measured.
Conclusion

• Control of aerosol charge distribution is required.
• Boltzmann equilibrium charge distribution is a realistic, known, repeatable, reproducible goal
• Are the methods in current standards adequate?
• Goal of presentation: Make you think about improvements to 52.2.
Additional Information

• Informal papers/presentations by Bruce McDonald
  – Prepared for ISO TC 22/SC 7*/WG3
    • A brief discussion concerning the need to neutralize...
    • List of alternatives:
  – Background: Current Standards
    • ASHRAE 52.2, ISO 16890, ISO 19713-1

* Now SC 34
A brief discussion concerning the need to neutralize the aerosols used for measuring the fractional efficiency of air filters to obtain repeatable and reproducible results.

Contents:
1. Need for repeatability and reproducibility
2. Effect of neutralizing the efficiency aerosol on repeatability
3. Effect of neutralizing the efficiency aerosol on reproducibility
4. Effect of neutralizing the efficiency aerosol on non electret filters
5. Concerns:
   a. Variability and high efficiency
   b. Particle charging is variable and depends on test system configuration
6. Recommendation

1. Need for repeatability and reproducibility
Quoting from the “Why Standards Matter” page of the ISO web site:

   “… Agreement on test methods allows meaningful comparisons of products, …” ¹
(References are listed at the end of the document.)

A filter efficiency test method that yields results such as those shown in Figure 3 of N414² do not allow meaningful comparison of products. A copy of that figure is shown as Figure 1 of this document.

The requirements for any standard test method is that the results are repeatable within any test lab and reproducible between all laboratories that use the method. The standard must include sufficient information such that any one skilled in the art can obtain repeatable and reproducible results.

The filter efficiency results shown in Figure 1 do not demonstrate reproducibility.

2. Effect of neutralizing the efficiency aerosol on repeatability
During the SAE Round Robin³, ⁴, 2 laboratories measured initial efficiency with and without neutralizing the ISO dust aerosol. See Figure 2 below. When the efficiency test aerosol is not properly neutralized it is not possible to get consistent results within labs. The results are not repeatable even when the tests are run at about the same time as in this example. Experience would suggest that even greater variability will be found when making comparison between tests that are several months apart.

3. Effect of neutralizing the efficiency aerosol on reproducibility
The results from the current ISO round robin of TS11155-1 show large variability between lab, i.e. poor reproducibility. See Figure 1. Results containing that much variability do not allow for meaningful comparison of products.
A graph of the results from the SAE round robin test from laboratories that properly neutralized the efficiency test aerosol and had sufficiently low concentration to avoid serious coincidence errors is shown in Figure 3\textsuperscript{5, 4}. While the results are far from perfect, it represents the best results obtained in any of the SAE, DIN, and ISO round robins.

In the first ISO round robin, it was found that attempts to neutralize the efficiency test aerosol could increase the differences between laboratories. While neutralizing the aerosol reduces the measured efficiency, some attempts at neutralizing the aerosol actually charged it and raised the measured efficiency. It appears that a similar problem may be affecting the results of the current ISO round robin. Some laboratories successfully neutralized the aerosol, causing their measured efficiency to decrease while other laboratories were less successful so their measured efficiency did not change. This might explain why the reproducibility appears worse for the neutralized case.

Results from a recently completed round robin of ASHRAE Standard 52.2 \textsuperscript{6} will be published before the next ISO meeting\textsuperscript{7}. Those results will show good repeatability and reproducibility using a neutralized KCl aerosol. Examples of those results will be included in this document when they become publicly available.

4. Effect of neutralizing the efficiency aerosol on non electret filters

It is clear that the state of charge of the aerosol will affect the measured efficiency for electret filters. However, as Figure 4\textsuperscript{8} shows, neutralization of the efficiency test aerosol affects the efficiency measured on filters that depend on mechanical filtration. It is also apparent in Figure 2 that the repeatability of the measurement of the efficiency of mechanical filters is improved by neutralizing the test aerosol.

When measuring the efficiency of mechanical filters, neutralizing the test aerosol affects both the level of efficiency that is measured and the repeatability of the measurement.

5. a. Concerns: Variability and high efficiency

One needs to be cautious interpreting the variability of efficiency measurements. While it may appear that the variability is lowest for the non neutralized case, it must be remembered that the value being measuring is bounded. Efficiency can not exceed 100\%, and the test systems have a finite resolution. Hence it will appear that lower variability is obtained for higher efficiency cases. The effect is also evident if one considers the differences of penetration, i.e. dust passed, it is clear that the variability is in fact quite high. For a crude illustration of the effect, consider the efficiency in the smallest size range in Figure 1. The results for type 2 filters tested with dust – not neutralized look less variable than the similar test for type 1 filters. However the range of dust passed in the various test of type 1 filters is on the order of 4 to 1, while the range for type 2 is greater than 10 to 1. The soon to be published results of the ASHRAE round robin\textsuperscript{7} very clearly demonstrate that the apparent variability is maximum for measured efficiencies around 50\% and are less when the measured efficiency approaches either 0\% or 100\%.

The results in Figure 1 make it look like neutralization can increase variability. When the aerosol is neutralized, the lowest measured efficiency decreases, while the highest
measured efficiency does not change. The only explanation is that there is a large variation in the ability to properly neutralize the aerosol. Evidently some of the laboratories neutralize the aerosol while some of the laboratories do not neutralize the aerosol at all.

5. b. **Concerns: Particle charging is variable and depends on test system configuration.**

In his presentation \(^9\) at the WG 3 meeting in October 2004, Dr. Trautmann clearly portrayed the difficulties of properly neutralizing the efficiency test aerosol and the difficulty of knowing that the neutralization is done properly. Certainly, the particle charging will be different for each test systems and even depends on the exact configuration of a test system.

It is precisely because the particle charging is unknown and varies with every filter test system that it is important that all laboratories strive to obtain the same state of charge. The best choice for that state is the Boltzman equilibrium charge distribution as it represents the state of charge of naturally aged atmospheric aerosols.

6. **Recommendation**

At the 1999 meeting, ISO TC 22/SC 7/WG 3 agreed that the most likely cause of the poor repeatability and reproducibility in the round robin was caused by inadequate charge neutralization. At that meeting WG 3 established an international task group to study the problem and propose a solution. The task group consider several methods for determining if the test aerosol is properly neutralized. The results of that group’s work is Annex G which was accepted by WG 3 for inclusion in TS 11155-1. That Technical Specification was adopted and published in 2001. That same Annex G is in the current WD for “Inlet air cleaning equipment for internal combustion engines and compressors — Fractional efficiency testing”.

Annex G includes two methods; one for radioactive type neutralizers and one for the powered corona type neutralizers. It was anticipated that varying the concentration for testing radioactive type neutralizers could be more difficult than adjusting the corona output of the electrically power type. The figure on page 10 of N416 \(^9\) is an excellent demonstration of Method 1 for testing radioactive type neutralizers. It is included as Figure 5 in this document. That figure should be included in any future versions of Annex G.

Members of the task group realized that the methods in Annex G were an imperfect but thought that the methods were a workable solution. No one expected that it would be easy. The current round robin was undertaken to test if the addition of Annex G would improve the repeatability and reproducibility of tests conducted according to ISO TS 11155-1. The results presented in N 414 show that either Annex G is not adequate or compliance with Annex G was not achieved.
However, a neutralized efficiency test aerosol can and must be done to obtain repeatable and reproducible results. If repeatability and reproducibility can not be obtained, then the test method can not qualify as a test specification or a standard.

Bruce McDonald
For the SAE Air Cleaner Test Code Standards Committee
29 March 2005
Figure 1. This is Figure 3 from reference ISO TC 22/SC 7/WG 3 N414
of First Results” \(^2\).
Figure 2. Effect of neutralizing dust aerosol on the repeatability of measurements within each laboratory $^{3,4}$. 

**Comparison of neutralized and unneutralized dust aerosol**

Repeatability within labs

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Normalized standard deviation of penetration for 0.5 to 1 micrometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level D</td>
<td></td>
</tr>
<tr>
<td>Level F</td>
<td></td>
</tr>
</tbody>
</table>

Level D is a mechanical filter
Level F is an electret filter

Laboratory, using neutralized dust except as noted.
Figure 3. Results from laboratories that neutralized the efficiency aerosol and had low aerosol concentrations to avoid coincidence errors.
Figure 4. Effect of neutralizing the efficiency test aerosol on measured efficiency of cellulose filter media. 8
Fractional separation efficiency, flat sheet measurement, neutralization with Krypton ion source with constant discharge.


Figure 5. Illustration of method 1 from Annex G of TS 11155-1 From Trautmann, 2004\textsuperscript{9}
References:
The complete title for the source of the “N” documents listed below is: ISO Technical Committee TC 22, Road vehicles, Subcommittee SC 7, Injection equipment and filters used on road vehicles, WG 3 Air and oil filters.

1 http://www.iso.org/iso/en/aboutiso/introduction/index.html#one
2 ISO TC 22/SC 7/WG 3 N414, Bittermann, H., “Round Robin Test ISO/TS 11 155-1 Status Report and Summary of First Results”, October 2004, Figure 3
7 ASHRAE final report on: 1088-RP: “Coordinate and Analyze Inter-Laboratory Testing of Filters Under ASHRAE Standard 52.2 to Determine the Adequacy of the Apparatus Qualification Tests”, to be published summer 2005 Authors: Hanley, J., and Elion, J.
9 ISO TC 22/SC 7/WG 3 N416, Trautmann, P., “Fractional separation efficiency measurement according to ISO 5001”, October 2004,
List of alternatives:
Our charter is to create an annex to the existing document, to fix the test method as it stands. What other options are there? For instance, it is possible to reduce the need for neutralizing the efficiency aerosol if the aerosol is KCl or an oil. Assuming that it is not acceptable to change the efficiency test aerosol, what are the options for ensuring its neutrality?

Following is a list of alternative possible methods of dealing with the need to properly neutralize the efficiency test aerosol. The alternatives are arranged from the least direct to the most direct; from the action taken to the desired end result with increasing levels of verification that the action taken is working properly. Generally that means that they are arranged from the easiest to do to the most difficult to do. That also means that they are arranged from the least assurance that the system is working properly to the most assurance that the system is working properly.

These alternatives are not complete. Some of them are more like questions because I am not sure how to implement the method or I don't have enough information to fill in all of the necessary specifications. Obviously there are different methods for the radioactive neutralizers and the powered, corona types of neutralizers.

1) Install a neutralizer and hope for the best.
   a) Radioactive neutralizers:
      Can we specify size (dwell time and level of radioactivity (depends on type)),
      flow rate and maximum aerosol concentration?
   b) Powered, corona type neutralizers:
      Can we specify the current flow, air flow, continuous direct current (not pulsed or
      AC), dwell time, and maximum aerosol concentration? Are there other
      characteristics that need to be specified? Should there be any concern about the
      generation of particles?

2) Install a neutralizer and require maintenance.
   a) Radioactive neutralizers:
      Can we specify a cleaning schedule? Measure external radioactivity when new
      and periodically (Only detects presence of source for Kr type. Does not detect if
      there is dust coating the source). Require replacement at one half life after the
      manufacture date.
   b) Powered, corona type neutralizers:
      Clean and replace electrodes periodically. Include a balancing method?

3) Determine that the neutralizer is working properly. (It is possible that the neutralizer
   is functioning properly but the aerosol not be completely neutralized if the aerosol
   concentration in the neutralizer is too high. This may also be a problem if the aerosol
   enters the neutralizer highly charged. Because the aerosol concentration must be low
enough for the optical particle counters helps keep aerosol concentration in neutralizer low. This is not true for all counters. (Information from the Fraunhofer Institute states that having balanced ion output does not result in maximum neutral particles. See attachment. Paolo has data that shows that the positive and negative voltages need to be different. Bruce has some old data supporting this too.)

a) Radioactive neutralizers:
How? Can we measure the + and - ion output at a specified air flow? There is an air ion meter available for less than $600 or instructions to build one in Scientific American September 1999. It is probably too sensitive as delivered to measure the ion output of a neutralizer directly.

b) Powered, corona type neutralizers:
Is it adequate to balance per manufacturer's instructions? Are methods using a charged plate or an electrostatic voltmeter adequate? If we know that having a balanced ion output is not necessarily the best situation, can we specify how much unbalance and use an air ion meter to adjust the neutralizer?
At least one system is available that allows measurement of current to the corona. Is it adequate to insure that the positive and negative currents are equal? (Note: NOT equal voltage!)

4) Determine that the aerosol approaching the filter has X percent neutral fraction.
   a) Radioactive neutralizers:
      This requires a high voltage electrostatic trap. Presently there is not a commercial unit available. Can we provide the design for one or will one become available? A very large unit is required to remove all charged particles for particles larger than about 1 μm. It is relatively easy for submicron aerosols. Is it adequate to measure the neutral fraction for just the submicron particles? The required neutral fraction is a function of particle size. An electrostatic trap with an integral photometer has been suggested. Will a photometer be sensitive enough to work at the low concentrations required by many optical particle counters? Why not use the particle detection and sizing equipment already in the test system?
   b) Powered, corona type neutralizers:
      Same as in radioactive case.

5) Adjust neutralizer to maximize the percent neutral particles.
   a) Radioactive neutralizers:
      Not applicable for the radioactive type, there are no adjustments.
   b) Powered, corona type neutralizers:
      See 4a.

6) Adjust neutralizer to minimize efficiency with electret media.
   a) Radioactive neutralizers:
      Not directly applicable. However, testing the efficiency of a strong electret with and without the neutralizer installed provides some information. But it can only tell you that the neutralizer is working or is not working assuming that the efficiency aerosol is charged as it enters the neutralizer¹. With this test it is not possible to tell if neutralizer is not working or if the efficiency aerosol is not charged before the neutralizer. This test can not measure how well the neutralizer

¹ KCl aerosols from a water solution and atomizer are not highly charged. The change in efficiency with and without a neutralizer is likely to small or perhaps undetectable.
is working. Measuring the efficiency of a strong electret at a series of different flow rates through the neutralizer provides information about whether or not the concentration is too high or dwell time is too short.

b) Powered, corona type neutralizers:
Specify the use of large fiber electret medium that gets most of its efficiency from electrostatic effects. For example: use mixed fiber, tribo electrically charged medium or charged film, split fiber medium. The medium should have a minimum efficiency between 20 and 40% for 0.3 to 0.4 μm particles when tested with a neutral aerosol. Adjust corona voltage to minimize efficiency. Turn neutralizer on and off. Note change in efficiency of electret

7) Determine that the aerosol approaching the filter is neutral overall (regardless of charge distribution).
   a) Both types:
      This can be done with an aerosol electrometer however, the commercially available units don't meet the criteria of being inexpensive. We can probably design a home made, inexpensive one based on air ion meter in Scientific American.
      Can we do it with enough resolution and accuracy by collecting aerosol on a filter and measuring the electric field around the filter with an inexpensive static voltmeter? Remember that this is the efficiency test aerosol, the concentration is relatively low, so charge will not accumulate very fast. Moreover, the filter needs to be non conductive to retain the charge. Does this have to be done in place, or can the test duct be opened after loading the filter? If it has to be done in place, the probe will need to be kept clean, and not interfere with loading the filter. Some expensive electrostatic voltmeters come with air purged sensors that are not built into the body of the voltmeter. At least one inexpensive unit is available with a remote probe. It might be possible to modify the probe to include air purge.

8) Determine that the aerosol approaching the filter is at Boltzman equilibrium charge distribution.
   a) Both types:
      Requires high voltage EST (electrostatic trap) and considerable work. Difficult to do for particles larger than about 1 μm. or a tandem DMA set up.

9) Determine that the proper filtration efficiency is measured.
   a) Both types:
      How? We would need an efficiency standard. The standard would need to be an electret. Could this be done with an EST of standard design and operated at a standard voltage and standard flow rate? (This is effectively the same as measuring the neutral fraction.)

---

2 KCl aerosols from a water solution and atomizer are not highly charged. The change in efficiency with and without a properly operating corona type neutralizer is likely to small or perhaps undetectable. An corona type neutralizer that is not working correctly may cause a large increase in the measured efficiency of an electret media.
Estimated PMs Based on Flat Distribution for 52.2
Data From Actual Tests

• MERV 5
  • E1: 4
  • E2: 20
  • E3: 33

• MERV 11
  • E1: 31
  • E2: 73
  • E3: 97

• MERV 15
  • E1: 88
  • E2: 98
  • E3: 99
Applied Multiple Evaluations

- Applied ISO ePM Calculations – Urban
- Applied ISO ePM Calculations – Rural
- Applied ISO ePM Calculations – Combined
- Applied Flat Distribution Curve
- Applied Curve from RP-1734 – Lower
- Applied Curve from RP-1734 – Upper
- Applied Traditional 52.2 E Numbers
Merv 11
MERV 15

- ePM1: 87%, 88%, 87%
- ePM2.5: 90%, 90%, 93%
- ePM10: 98%, 97%, 95%

Legend:
- Urban
- Rural
- ISO Combo
- Flat
- E Value
New MERV Calculations – Eliminate E’s

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<th>PM10Est</th>
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</table>
Summary

• Estimate PM values based on average of efficiencies
  • PM 1 Est = Average 1st 4 Channels
  • PM 2.5 Est = Average 1st 8 Channels
  • PM 10 Est = Average all 12 Channels

• Eliminate E1, E2 and E3 and calculate MERV on above estimates
  • Apply flat distribution to MERV table

• Applies to existing composite curve
  • Does not include any discharge/conditioning method
MEMORANDUM

DATE: November 12, 2018
TO: SSPC 52.2
FROM: Mark Weber, Manager of American Standards
SUBJECT: Proposed Changes to ANSI/ASHRAE Standard 52.2-2017

The enclosed revised change proposal (52.2-18-12-0001/001REV) will replace the one distributed to the committee on October 19, 2018, which should be discarded. Also, enclosed is a copy of the Continuous Maintenance Procedures from PC's Guide to PASA and a Response to Change Proposal form.

Make sure to copy your liaison and me on all correspondence between the project committee and the proposer.

Thank you.

MJW/dl

Enclosures

cc: Adrienne Thomle, SPLS Liaison
CONTINUOUS MAINTENANCE (CM)

In some instances a PC determines that updates to the SCD will be needed more frequently than every five years. This could be because the industry changes very quickly, there may be multiple documents the PC is responsible for, the SCD is referenced in code, or errors were found in the published version. A PC usually asks to be placed on CM in these instances, usually when the first version of the SCD is ready to publish.

If approved, the PC becomes a Standing Standard Project Committee (SSPC) or Standing Guideline Project Committee (SGPC). When this occurs the Chair must create a rotating roster with term limits for the members. The same rules for balance will apply. A committee on continuous maintenance that does not publish an addendum within 4 years will automatically be placed back on periodic maintenance.

For SSPCs that are high profile standards or referenced in the codes 18 month supplements are issued and then at 36 months the entire standard or guideline is republished. Deviations from this schedule should be discussed with the MOS.

The task of the SSPC or SGPC is to create changes via addenda, issued at least once every four years, to the standard or guideline. These changes can be generated internally by members of the PC or from materially interested parties through a continuous maintenance change proposal form. (CMP Form Standards/ CMP Form Guideline)

When a formal CMP is submitted the SSPC or SGPC needs to review and respond to it within 13 months of receipt. The SSPC or SGPC can respond to the author of the CMP as follows:

a) proposed change accepted for public review without modification;
b) proposed change accepted for public review with modification;
c) proposed change accepted for further study; and
d) proposed change rejected

If the SSPC or SGPC choses option a no additional information is needed. If the PC choses option b or d then the PC will need to provide technical reasons for that decision. A reason that states “the PC doesn’t like it” does not satisfy the requirement. If the SSPC or SGPC decides that option c is appropriate the additional study needs to be completed within 7 months otherwise the committee should reject the proposal and ask that it be resubmitted at a later time. If option c is chosen than after 7 months the committee will need to respond with options a, b, or d.
FORM FOR RESPONSE TO CHANGE PROPOSAL

DATE: ______________

PROPOSER: ____________________________________________________________________________________

SSPC NO. : ____________  PROPOSAL NUMBER(S): ______________________________________________

RESPONDER'S NAME: _______________________________________________________________________

ADDRESS: _________________________________________________________________________________

_______________________________________________________________________

_______________________________________________________________________

TELEPHONE: ________________________________ FAX:  _________________________________

EMAIL: _________________________________

| Project Committee Action: | ___ Proposed change accepted for public review without modification |
|                          | ___ Proposed change accepted for public review with modification (See below) |
|                          | ___ Proposed change accepted for further study (See below) |
|                          | ___ Proposed changed rejected (See below) |

Project Committee Response:

cc:  Senior Manager of Standards, ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305
Revised July 2017
<table>
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<td>Michael Corbat</td>
<td>52.2-18-12-0001</td>
<td>001-001</td>
<td>10/18/2018</td>
<td>Email; Proposal 001 was revised and resubmitted on 11/12/18. Original proposal is to be discarded.</td>
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<tr>
<td>Rensa Filtration</td>
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<tr>
<td>37900 Mound Rd</td>
<td></td>
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<td>Sterling Heights, MI</td>
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<tr>
<td><a href="mailto:mcorbat@rensafiltration.com">mcorbat@rensafiltration.com</a></td>
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<td>(586) 872-0705</td>
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* Bad Adress. No forwarding address available.*
FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

NOTE: Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), or submitted in paper by mail or fax to ASHRAE, Senior Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

1. Submitter: Michael Corbat

   Affiliation: Rensa Filtration
   Address: 37900 Mound Rd City: Sterling Heights State: MI Zip: 48310 Country: USA
   Telephone: 5868720705 Fax: E-Mail: mcorbat@rensafiltration.com

I hereby grant ASHRAE the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

Submitter’s signature: _____________________________________________ Date: __11/12/2018__ Revised

All electronic submittals must have the following statement completed:

I, Michael Corbat, through this electronic signature, hereby grant ASHRAE the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

2. Number and year of standard: 52.2-2017

3. Page number and clause (section), subclause, or paragraph number:

4. I propose to: 
   [ X] Change to read as follows
   [ ] Delete and substitute as follows
   [ ] Add new text as follows
   [ ] Delete without substitution

   Use underscores to show material to be added (added) and strike through material to be deleted (deleted). Use additional pages if needed.

   10.8.1 The four data points from the Section 10.8.2 composite curve in each of the three size range groups from Table 10-2 shall be averaged and the resultant three average minimum PSEs \( PM1_{EST} \), \( PM2.5_{EST} \), and \( PM10_{EST} \) shall be reported.

   10.8.2 For air-cleaning devices with efficiencies less than 20% in the size range of 0.30 to 10.0 \( \mu m \), calculate the average arrestance \( A_{avg} \) as follows:

   Table 10-2 Size Range Groups

<table>
<thead>
<tr>
<th>Average Minimum PSE Designator</th>
<th>Corresponding Size Range Group, ( \mu m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( PM1_{EST} )</td>
<td>0.30 to 1.0</td>
</tr>
<tr>
<td>( PM2.5_{EST} )</td>
<td>0.30 to 3.0</td>
</tr>
<tr>
<td>( PM10_{EST} )</td>
<td>0.30 to 10</td>
</tr>
</tbody>
</table>

11.2.k Performance Curves

   4. Resistance vs. synthetic loading dust fed (for air-cleaning devices with efficiencies less than 7% in the size range of 0.30 to 10.0 \( \mu m \))
11.2.1 Minimum efficiency reporting value (MERV)

1. The average of the minimum PSE of the four size ranges from 0.30 to 1.0 μm ($PM_{1_{EST}}$)
2. The average of the minimum PSE of the eight size ranges from 0.30 to 3.0 μm ($PM_{2.5_{EST}}$)
3. The average of the minimum PSE of the twelve size ranges from 0.30 to 10.0 μm ($PM_{10_{EST}}$)
4. MERV for the device

Table 12-1 Minimum Efficiency Reporting Value (MERV) Parameters

<table>
<thead>
<tr>
<th>Standard 52.2 Minimum Efficiency</th>
<th>Composite Average Particle Size Efficiency, % in Size Range, μm</th>
</tr>
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</table>


<table>
<thead>
<tr>
<th>Reporting Value (MERV)</th>
<th>Range 1 0.30 to 1.0</th>
<th>Range 2 0.30 to 3.0</th>
<th>Range 3 0.30 to 10.0</th>
<th>Average Arrestance, %</th>
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<tbody>
<tr>
<td>1</td>
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<td>$E_3 &lt; 20$</td>
<td>$A_{avg} &lt; 65$</td>
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<td>$65 \leq A_{avg}$</td>
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<td>4</td>
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<td>N/A</td>
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<td>$75 \leq A_{avg}$</td>
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<td>10</td>
<td>N/A</td>
<td>$25 \leq PM2.5_{EST}$</td>
<td>$44 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
<tr>
<td>11</td>
<td>$20 \leq PM1_{EST}$</td>
<td>$43 \leq PM2.5_{EST}$</td>
<td>$57 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
<tr>
<td>12</td>
<td>$35 \leq PM1_{EST}$</td>
<td>$58 \leq PM2.5_{EST}$</td>
<td>$69 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>$50 \leq PM1_{EST}$</td>
<td>$68 \leq PM2.5_{EST}$</td>
<td>$75 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
<tr>
<td>14</td>
<td>$75 \leq PM1_{EST}$</td>
<td>$83 \leq PM2.5_{EST}$</td>
<td>$87 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
<tr>
<td>15</td>
<td>$85 \leq PM1_{EST}$</td>
<td>$88 \leq PM2.5_{EST}$</td>
<td>$90 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
<tr>
<td>16</td>
<td>$95 \leq PM1_{EST}$</td>
<td>$95 \leq PM2.5_{EST}$</td>
<td>$95 \leq PM10_{EST}$</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**J11.2 Minimum Efficiency Reporting Value (MERV-A)**

According to Appendix J

a. The average of the minimum PSE of the four size ranges from 0.30 to 1.0 μm ($PM1_{EST}$ -A)

b. The average of the minimum PSE of the four size ranges
   from 0.30 to 3.0 μm ($PM2.5_{EST}$ -A)

c. The average of the minimum PSE of the four size ranges from 0.30 to 10.0 μm ($PM10_{EST}$ -A)

d. MERV-A for the device

**J11.3 Minimum Efficiency Reporting Value (MERV-A) According to Appendix J for Air Cleaners**

J11.3.1 The minimum efficiency reporting value (MERV-A) for an air cleaner shall be based on three composite average PSE points developed from a test at a manufacturer’s specified airflow rate selected in accordance with Section 8.1. Dust loading shall follow the procedure outlined in Section 10.7 except substituting Section J10 of this appendix for Section 10.7.1.2(b) of the standard. The results of the tests shall be reported in accordance with Sections 10.8.1 and 10.8.2. The four data points from the Section 10.8.2 composite curve in each of the three size range groups from Table J-1 shall be averaged and the resultant three average minimum PSEs ($PM1_{EST}$ -A, $PM2.5_{EST}$ -A, and $PM10_{EST}$ -A) shall be reported.

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Table J-2 KCl Conditioned Per Appendix J Minimum Efficiency Reporting Value (MERV-A) Parameters
5. Proposed change:

Apply a flat volume distribution calculation to the composite curve produced by standard 52.2-2017 to form an approximation for PM1, PM2.5 and PM10. The calculations would average all channels less than their size to form the calculations. For estimated PM1 would be the 4 smallest channels, estimated PM2.5 would be the 8 smallest channels, and estimated PM10 would be the average of all 12 channels.

PM1 (estimated) =

All results must be published and would replace the E values within the report. Table 12-1 would need to be rewritten to account for averages and would look as follows for MERV 5-16

<table>
<thead>
<tr>
<th>Existing</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
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</tr>
<tr>
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</tr>
<tr>
<td>0</td>
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<td>20</td>
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<tr>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>20</td>
<td>65</td>
</tr>
</tbody>
</table>
6. Reason and substantiation:

After discussing with Chair’s of SSPC 62.1 and 62.2 there is a definite need that an estimate of PM2.5 and PM10 performance is given for a filter. They prefer SSPC 52.2 supply this information rather than having estimates. The reason is due to the overall health effects related to PM 2.5 airborne contaminants.

7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified. No

Notes about following charts, the numbers following the MERV are E1, E2 and E3 respectively for that filter tested. ISO-16890 calculations applied to the 52.2 composite curve data and has not experienced any IPA. All data is pulled from the same test report.