Filtration Standards and Applications

Arkansas Chapter of ASHRAE

December 6 & 7, 2006

Outline

- Important Aspects of Particulate Filters
- Particulate Filter Test Standards
- Local Codes & Requirements
- Application Summary

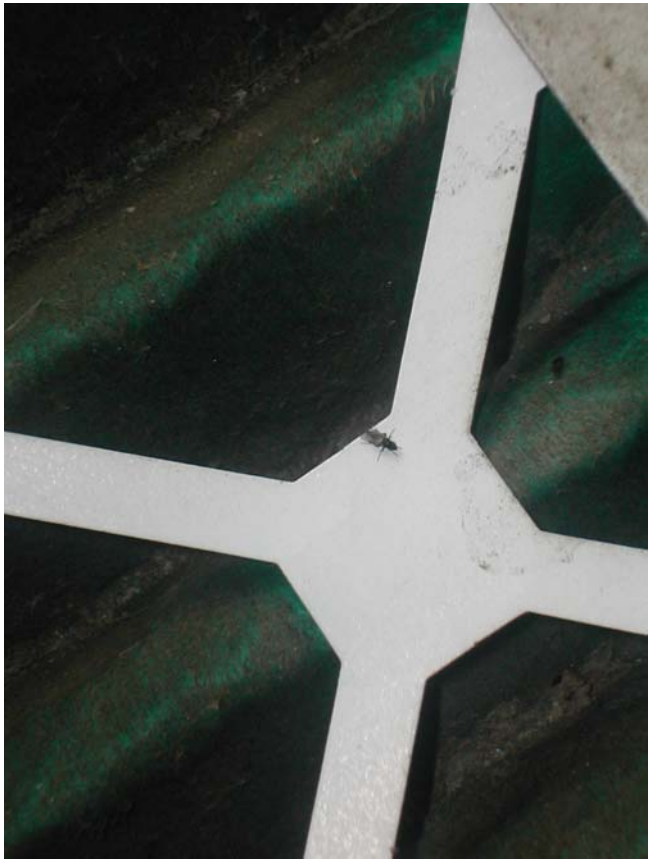
Discussion on Gaseous Contaminants and Gas Phase Filter Test Standards and Applications Are Saved For Another Time

Why Filter?

- Remove Dust, Dirt, & Microbials
  - Keep Equipment & Systems Clean
    - Reduce Maintenance Cost
    - Reduce Energy Cost
  - Keep the Indoor Environment Clean
    - Improve Health
    - Improve Cleanliness

What is This?

What is That?



What To Filter?

Particle	Particle Size (μm)
Respirable Particles	*<5*
Viruses	0.003 – 0.06
Individual Bacteria	0.4 – 5
Fungal & Bacteria Spores	2 - 10
Pollen Grain	10 - 100
Dust	<100
Human Hair (Diameter)	*100 - 150*

Excerpted from 2005 ASHRAE Handbook – Fundamentals, Chapter 12

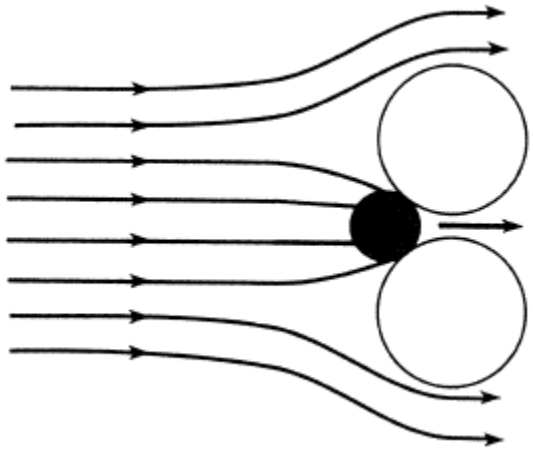
Filtration Methods

- Straining
- Inertial Impingement
- Interception
- Diffusion
- Electrostatic

All Methods Are Used in Capturing Particles in Most Filters; However, Filters are Typically Designed with a Dominant Method

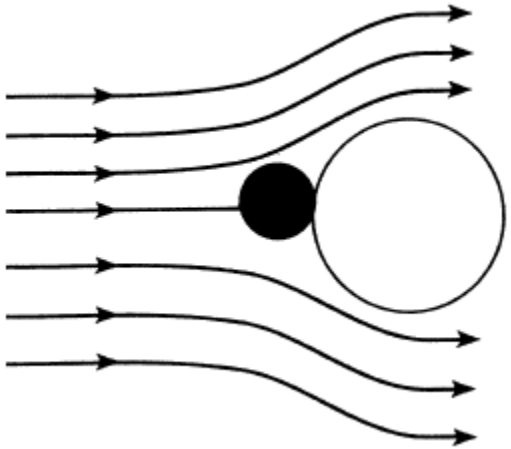
Straining

- The Particle is Larger Than the Opening Between Media Fibers
- A Dominant Method of Particulate Removal in Low Efficiency Air Filters (Pleated Prefilters)



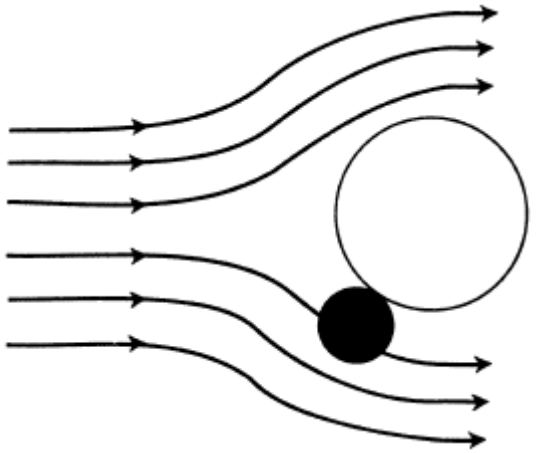
Inertial Impingement

- A Large, Dense Particle Collides with the Fibers and Attaches to the Media
- Adhesives or Tackifiers Can Be Used to Enhance Capture Efficiency
- A Dominant Method of Particulate Removal in Low Efficiency Air Filters (Flat Panel Prefilters)



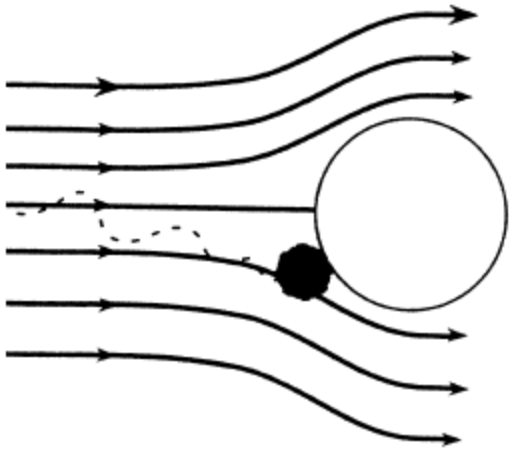
Interception

- Particle Follows Airstream at Lower Velocities and Contacts Fiber Through Weak Intermolecular attractions (Van Der Waals Forces)
- The Dominant Method of Particulate Removal in Medium Efficiency Air Filters (Bags and Extended Surface Final Filters)



Diffusion

- Small Particles Collide with the Air Molecules and Move in An Erratic Path (Brownian Movement) and Attaches to the Media Fibers
- The Dominant Method of Particulate Removal in High Efficiency Air Filters (HEPA Filters)



Electrostatic Effects

- An Electrostatic Charge Is applied to the Fiber that Can Produce an Attracting Force if the Particle is of Opposite Charge
- Passive (One-Time, Initial) and Regenerative Charges
- The Dominant Method of Particulate Removal in Metal Panel Prefilters and Some Room Purifiers

Effects of Filtering

- Restricts Airflow
  - Added Pressure Drop Requires Energy
- Requires Space and Cost
  - Requires Additional Equipment / Frames
  - Replacement Additional Maintenance

Is It Worth It?

- “60% of the Service Calls on Air Conditioning Units Could Be Reduced if the Dirt Was Removed From the Airstream Before The Components.”

How to Value Differences

- Dust Removal Efficiency
  - The Percentage of Airborne Particulate the Filter Will Remove (ASHRAE Standards 52.1 and 52.2 Handle this Differently and Both are Applicable)
- Dust Holding Capacity
  - The Amount of Dust the Filter Will Hold To a Maximum Resistance Value (ASHRAE Standard 52.1 Only)
- Filter Resistance
  - As a Function of Airflow & Dust Load

Test Standards

- Particulate Filter Test Standards
  - **ASHRAE Standard 52.1 - 1992**
  - **ASHRAE Standard 52.2 – 1999**
  - UL Standard 900 (Flammability)
  - US Military Standard MIL-STD-282 DOP Method for HEPA Filters
  - International (CEN EN 779:1993, Others)

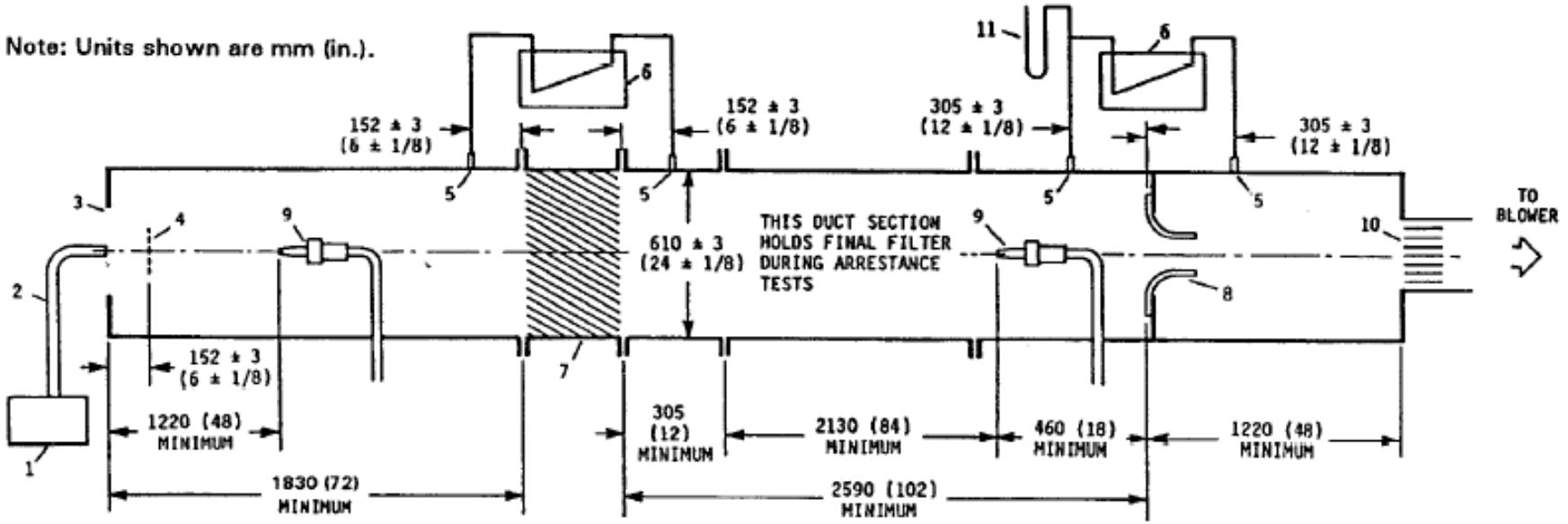
ASHRAE Standard 52.1 - 1992

- Atmospheric Dust Spot Efficiency Test
- ASHRAE Dust Weight Arrestance Test
- ASHRAE Dust Holding Capacity Test

Atmospheric Dust Spot Efficiency Test

- The Dust Spot Test Measures the Ability of a Filter to Reduce Soiling of Fabrics and Building Interior Surfaces using Unconditioned Outside Air
- Variety and Variability of Atmospheric Dust May Cause the Same Filter to Test at Different Dust Spot Efficiencies at Different Locations

ASHRAE Standard 52.1 – 1992 Test Apparatus



LEGEND

1. DUST FEEDER
2. DUST FEED PIPE
3. MIXING ORIFICE
4. PERFORATED DIFFUSION PLATE
5. STATIC TAP
6. MANOMETER
7. FILTER DEVICE AND TRANSITIONS (IF ANY)
8. MAIN FLOW MEASUREMENT NOZZLE
9. DUST-SPOT SAMPLER
10. FLOW STRAIGHTENER
11. VERTICAL MANOMETER FOR MEASUREMENT OF NOZZLE INLET PRESSURE
12. PERFORATED PLATE FOR FLOW DISTRIBUTION

ASHRAE Dust Weight Arrestance Test

- The ASHRAE Dust Weight Arrestance Test Measures The Amount of Dust (By Weight Fraction) The Filter Will Capture
- Requires High Degree of Standardization of Testing Apparatus
- More Suited for Low to Medium Efficiency Air Filters

ASHRAE Dust Holding Capacity Test

- Measured Amounts of ASHRAE Dust are Used to Artificially Load the Filters in Hours and Not Months
- ASHRAE Dust is Not Atmospheric Dust; So, Results May Vary Greatly in Actual Installations

ASHRAE Standard 52.1 Actual Test Report Excerpt

Test Results	
Test Air Flow Rate(CFM)/Velocity (FPM)	**2000 cfm/ 500 fpm**
Initial Resistance (in. WG)	**0.224**
Final Resistance (in. WG)	**1.0**
Initial Atmospheric Dust Spot Efficiency	**37.1**
Average Atmospheric Dust Spot Efficiency	**40.6**
Average Synthetic Dust Weight Arrestance	**91.6**
Ashrae Dust Holding Capacity	**146.6 grams**
Dust Feed Rate	**2 grams/ 1000cfm**

Why a 52.2?

- Needed a Means to Measure Removal Efficiency by Particle Size
- Needed more Mandatory (Code) Language
- Needed More Reliable and Verifiable Results

ASHRAE Standard 52.2 – 1999 Test Apparatus

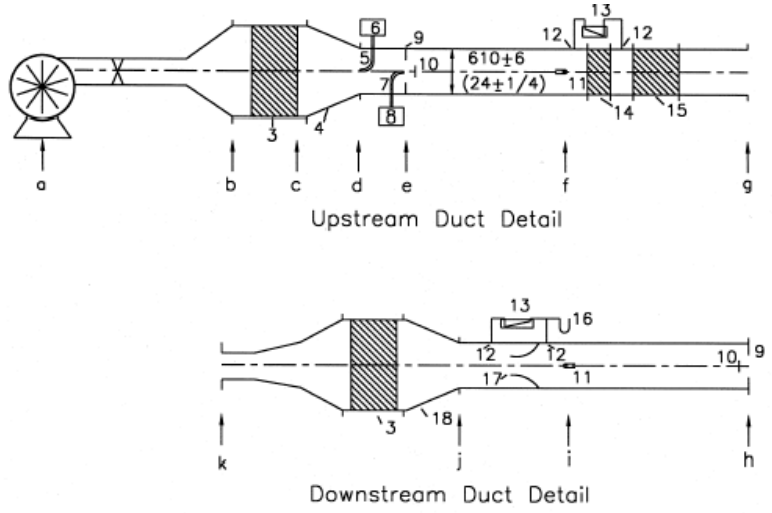


Figure 4-1 Schematic diagram of the test duct (notes and legend are below). Dimensions are in mm (in.).

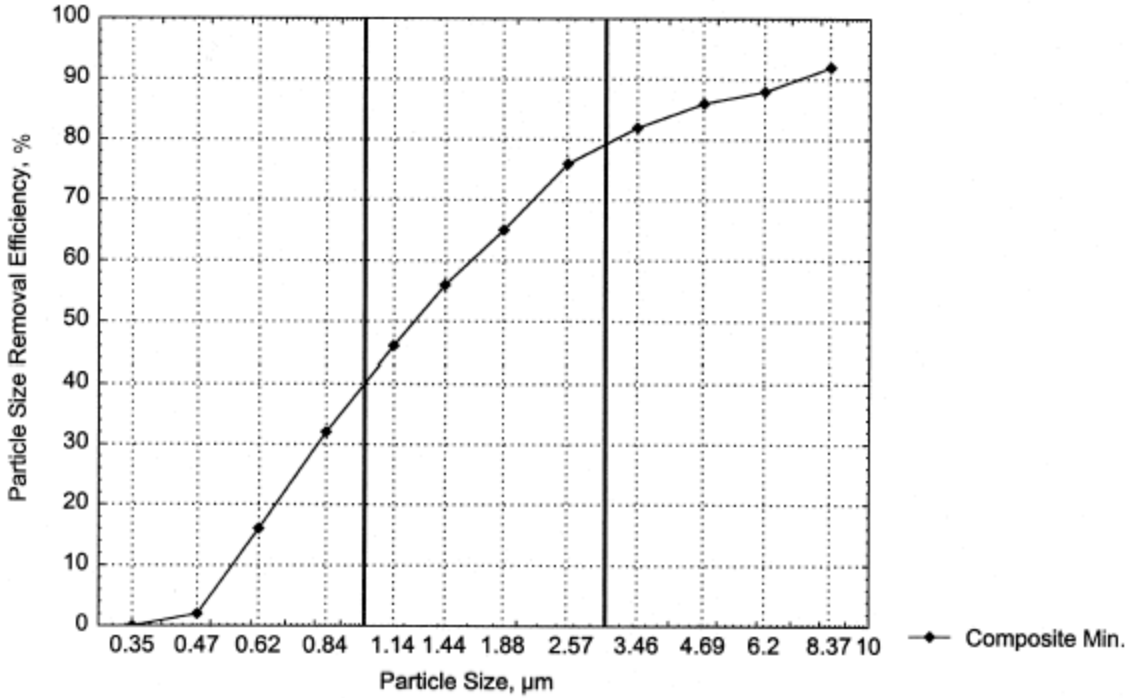
LEGEND FOR FIGURES 4-1 and 4-2d	
1. Blower	10. Perforated diffusion plate
2. Flow control valve	11. Location of sample probe
3. HEPA filter bank	12. Static tap
4. Transition, if any, from filter bank to 610 mm × 610 mm (24 in. × 24 in.) ducting. Maximum transition half angle = 45°.	13. Manometer 14. Air cleaner device and transitions (if any)
5. Aerosol injection tube	15. Final filter (installed only during dust loading)
6. Aerosol generator	16. Vertical manometer
7. Dust feed pipe	17. Main flow measurement nozzle
8. Dust feeder	18. Transition, if needed
9. Mixing orifice	19. Bend, optional

ASHRAE Standard 52.2 - 1999

- Twelve (12) Ranges of Particle Counts are Taken Over a Range of Particles Six (6) Times for a Total of Seventy Two (72) Data Points
- For Each Measurement, the Filtration Efficiency is Stated as a Ratio of Downstream-to-Upstream Particle Count

Result? MERV

- The Lowest Values then Determine the Composite Minimum Efficiency Curve



Composite minimum efficiency curve. (15)

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

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency,% in Size Range, µm			Average Arrestance,%, by Standard 52.1 Method	Minimum Final Resistance	
	Range 1 0.30 - 1.0	Range 2 1.0 - 3.0	Range 3 3.0 - 10.0		Pa	in. of water
1	n/a	n/a	$E_3 < 20$	$A_{avg} < 65$	75	0.3
2	n/a	n/a	$E_3 < 20$	$65 \le A_{avg} < 70$	75	0.3
3	n/a	n/a	$E_3 < 20$	$70 \le A_{avg} < 75$	75	0.3
4	n/a	n/a	$E_3 < 20$	$75 \le A_{avg}$	75	0.3
5	n/a	n/a	$20 \le E_3 < 35$	n/a	150	0.6
6	n/a	n/a	$35 \le E_3 < 50$	n/a	150	0.6
7	n/a	n/a	$50 \le E_3 < 70$	n/a	150	0.6
8	n/a	n/a	$70 \le E_3$	n/a	150	0.6
9	n/a	$E_2 < 50$	$85 \le E_3$	n/a	250	1.0
10	n/a	$50 \le E_2 < 65$	$85 \le E_3$	n/a	250	1.0
11	n/a	$65 \le E_2 < 80$	$85 \le E_3$	n/a	250	1.0
12	n/a	$80 \le E_2$	$90 \le E_3$	n/a	250	1.0
13	$E_1 < 75$	$90 \le E_2$	$90 \le E_3$	n/a	350	1.4
14	$75 \le E_1 < 85$	$90 \le E_2$	$90 \le E_3$	n/a	350	1.4
15	$85 \le E_1 < 95$	$90 \le E_2$	$90 \le E_3$	n/a	350	1.4
16	$95 \le E_1$	$95 \le E_2$	$95 \le E_3$	n/a	350	1.4

NOTE: The minimum final resistance shall be at least twice the initial resistance, or as specified above, whichever is greater. Refer to 10.7.1.1.[45]

[45] The minimum final resistance specified is for test purposes to determine minimum efficiency, not as a recommendation for actual use. For example, air cleaners used in residences may be changed or cleaned at a lower final resistance than that required by this standard. Also see Appendix A3.1.

This Table Excerpted from ASHRAE Standard 52.2 - 1999

TABLE E-1
Application Guidelines

Std. 52.2 Minimum Efficiency Reporting Value (MERV)	Approx. Std. 52.1 Results		Application Guidelines		
	Duct Spot Efficiency	Arrestance	Typical Controlled Contaminant	Typical Applications and Limitations	Typical Air Filter/Cleaner Type
20	n/a	n/a	**≤0.30 µm Particle Size** Virus (unattached)	Cleanrooms Radioactive materials	**HEPA/ULPA Filters** ≥99.999% efficiency on 0.10–0.20 µm particles, IEST Type F ≥99.999% efficiency on 0.30 µm particles, IEST Type D ≥99.99% efficiency on 0.30 µm particles, IEST Type C ≥99.97% efficiency on 0.30 µm particles, IEST Type A
19	n/a	n/a	Carbon dust Sea salt	Pharmaceutical manufacturing	
18	n/a	n/a	All combustion smoke Radon progeny	Carcinogenic materials	
17	n/a	n/a		Orthopedic surgery	
16	n/a	n/a	**0.30–1.0 µm Particle Size** All bacteria	Hospital inpatient care General surgery	**Bag Filters** Nonsupported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets. **Box Filters** Rigid style cartridge filters 150 to 300 mm (6 to 12 in.) deep may use lofted (air laid) or paper (wet laid) media.
15	>95%	n/a	Most tobacco smoke Droplet nuclei (sneeze)	Smoking lounges Superior commercial buildings	
14	90–95%	>98%	Cooking oil Most smoke		
13	80–90%	>98%	Insecticide dust Copier toner Most face powder Most paint pigments		
12	70–75%	>95%	**1.0–3.0 µm Particle Size** Legionella	Superior residential Better commercial buildings Hospital laboratories	**Bag Filters** Nonsupported (flexible) microfine fiberglass or synthetic media. 300 to 900 mm (12 to 36 in.) deep, 6 to 12 pockets. **Box Filters** Rigid style cartridge filters 150 to 300 mm (6 to 12 in.) deep may use lofted (air laid) or paper (wet laid) media.
11	60–65%	>95%	Humidifier dust Lead dust		
10	50–55%	>95%	Milled flour Coal dust		
9	40–45%	>90%	Auto emissions Nebulizer drops Welding fumes		
8	30-35%	>90%	**3.0–10.0 µm Particle Size** Mold	Commercial buildings Better residential	**Pleated Filters** Disposable, extended surface, 25 to 125 mm (1 to 5 in.) thick with cotton-polyester blend media, cardboard frame. **Cartridge Filters** Graded density viscous coated cube or pocket filters, synthetic media **Throwaway** Disposable synthetic media panel filters
7	25-30%	>90%	Spores Hair spray	Industrial workplaces Paint booth inlet air	
6	<20%	85–90%	Fabric protector Dusting aids		
5	<20%	80–85%	Cement dust Pudding mix Snuff Powdered milk		

This Table Excerpted from ASHRAE Standard 52.2 - 1999

52.1 and 52.2 Coexist

- 52.1
  - Used for MERV 1-4 filters
  - Many Local Standards Reference 52.1 and Dust Spot Efficiency Tests
  - Dust Holding Capacity Has Merit
- 52.2
  - Gaining Popularity
  - Some Manufacturers Test New Products Only Using 52.2
  - Table E-1 is a Good Crossover Reference Chart
  - Now You Have Met MERV

Next Steps for Filter Testing

- ASHRAE Standard 52.2
  - Addendum A: Reference Filter Check; (Approved and Included)
  - Addendum B: Incorporating Elements of 52.1 Into 52.2 (Waiting for More Data...)
  - Addendum C: Conditioning Step (Waiting for More Data...)
- Global Standards for Filter Testing (ISO)?
  - ASHRAE Journal Article, August, 2006, Page 58

UL Standard 900

- The UL 900 Standard is Designed to Determine Combustibility and the Amount of Smoke Generated for Air Filter Units Under Test
- A Methane Flame is Ignited on the Upwind Side of the Filter, Resulting in a Direct Flame Against the Filter, Which is Maintained For Three (3) Minutes

UL Standard 900 (Cont.)

- Class 1 Air Filters
  - No Flames or Sparks May Pass Through the Filter and Only a Small Amount of Smoke Can Be Generated
- Class 2 Air Filters
  - Limited Flaming and Sparking are Acceptable and a Larger Amount of Smoke May be Generated

US Military Standard MIL-STD-282 For HEPA Filters

- Reserved For a Later Date

Codes and Requirements

- 2003 Arkansas Mechanical Code
- 2005 Arkansas Hospital Rules & Regulations
- American Institute of Architects (AIA) Guidelines for Design and Construction of Health Care Facilities
- Joint Commission: A Guide To Managing Indoor Air Quality in Health Care Organization
- ASHRAE Standard 62.1 - 2004
- Proposed ASHRAE Standards 170P & 180P

2003 Arkansas Mechanical Code

- Section 605 Air Filters Requires:
  - Heating and Air Conditioning Equipment to be Provided with Approved Air Filters
  - Filters to Be Installed in the Return Air System, Upstream of Any Heat Exchanger or Coil
  - Filters to be Listed and Labeled

2005 Arkansas Hospital Rules and Regulations

- References ASHRAE Standard 52.1 Values & AIA Guidelines for Design and Construction of Health Care Facilities

Rules and Regulations for Hospitals and Related Institutions in Arkansas

TABLE 1

Filter Efficiencies for Central Ventilation and Air Conditioning Systems in Health Care Facilities			
Area Designation	No. Filter Beds	Filter Bed No.1 (%)	Filter Bed No.2[1] (%)
All areas for patient care, treatment, and diagnosis, and those areas providing direct service or clean supplies such as sterile and clean processing.	2	30	90
Protective Environment Room	2	30	99.97
Laboratories	1	80	-
Administrative, Bulk Storage, Soiled Holding Areas, Food Preparation Areas, and Laundries	1	30	-

[1]These requirements do not apply to small outpatient clinics or outpatient clinics that do not perform invasive applications or procedures.

Notes: The filtration efficiency ratings are based on average dust spot efficiency per ASHRAE 52.1 – 1992.

Additional roughing or prefilters should be considered to reduce maintenance required for filters with efficiencies higher than 75 percent.

This Table Excerpted from Section 74, 2005 Rules and Regulations for Hospitals and Related Institutions in Arkansas

AIA Guidelines for Design and Construction of Health Care Facilities

- References ASHRAE Standard 52.1
- Requires a Manometer across each filter Bed Having a Required Efficiency of 75% or more
- For Individual Room Units, a Minimum of 68% Weight Arrestance Filters Are to Be Used (ASHRAE 52.1)

This Table Excerpted from Section 7.31 of the 2001 Edition of AIA Guidelines for Design and Construction of Health Care Facilities

NFPA Standard 90A

- Requires Filters To be Renewed or Cleaned when the Resistance to Airflow has Increased to Two Times the Original Resistance or When the Resistance Has Reached a Value of Recommended Replacement by the Manufacturer.
- ...Avoid Gaps Between Filter Sections,

This Information Excerpted from Annex B: Maintenance of the 2002 Edition of NFPA Standard 90A

Joint Commission: A Guide To Managing Indoor Air Quality in Health Care Organization

- Composite Filter Banks with a Final Filter Efficiency of at Least 95% Removal of Particles of 1 Micron Size is the Critical Quality Target
- Does This Contradict Current 2005 Arkansas Hospital Rules and Regulations?

This Information Excerpted from A Guide To Managing Indoor Air Quality in Health Care Organization, 1997

ASHRAE Standard 62.1-2004

- Section 5.9 States That the Minimum of a MERV 6 Filter Must Be Used and It Should Be Located Upstream of Cooling Coils and Wetted Surfaces
- Section 7.1 States That During Construction Measures Should be Taken to Prevent Construction-Generated Contaminants From Spreading to Occupied Spaces

Proposed ASHRAE Standards 170P and 180P

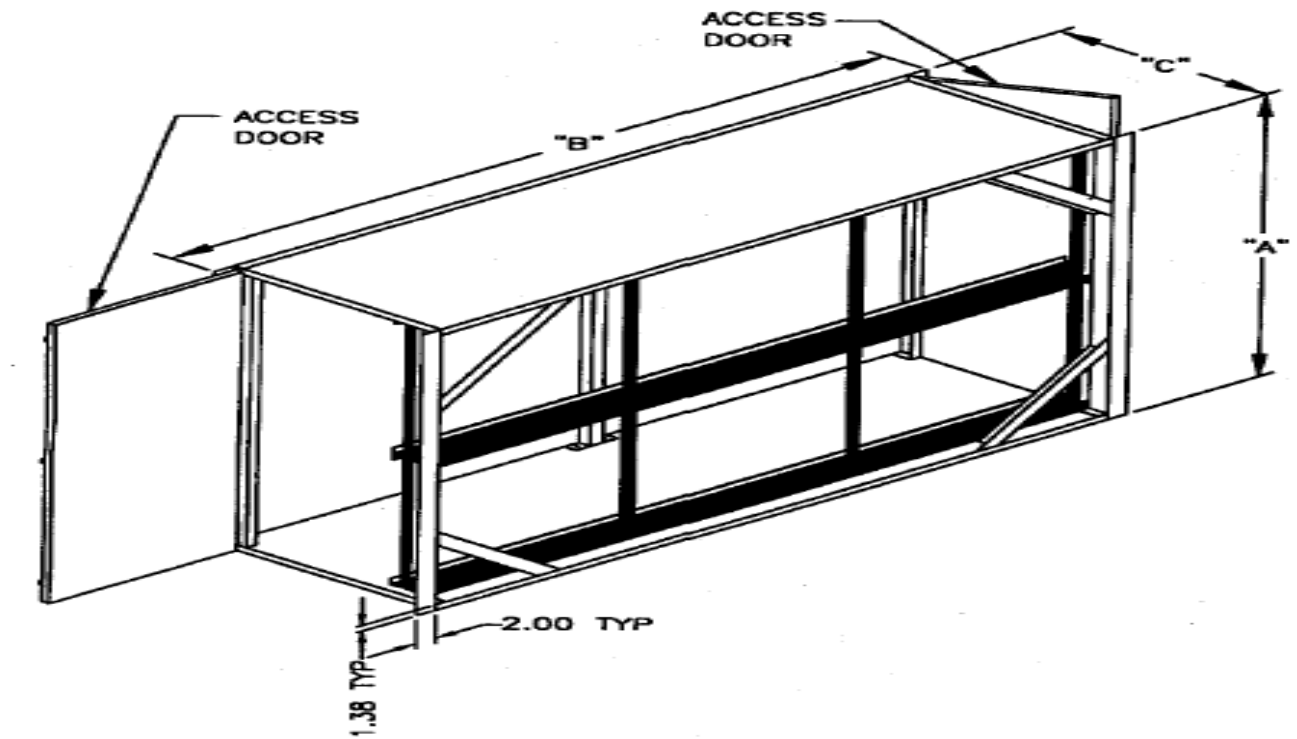
- 170P: Ventilation of Health Care Facilities
- 180P: Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems

Application – Apply Right Filter

- Minimum MERV 6 Prefilter Rating In Non-Health Care Settings
- Minimum MERV 8 Prefilter Rating In Health Care Settings

Application - System Efficiency

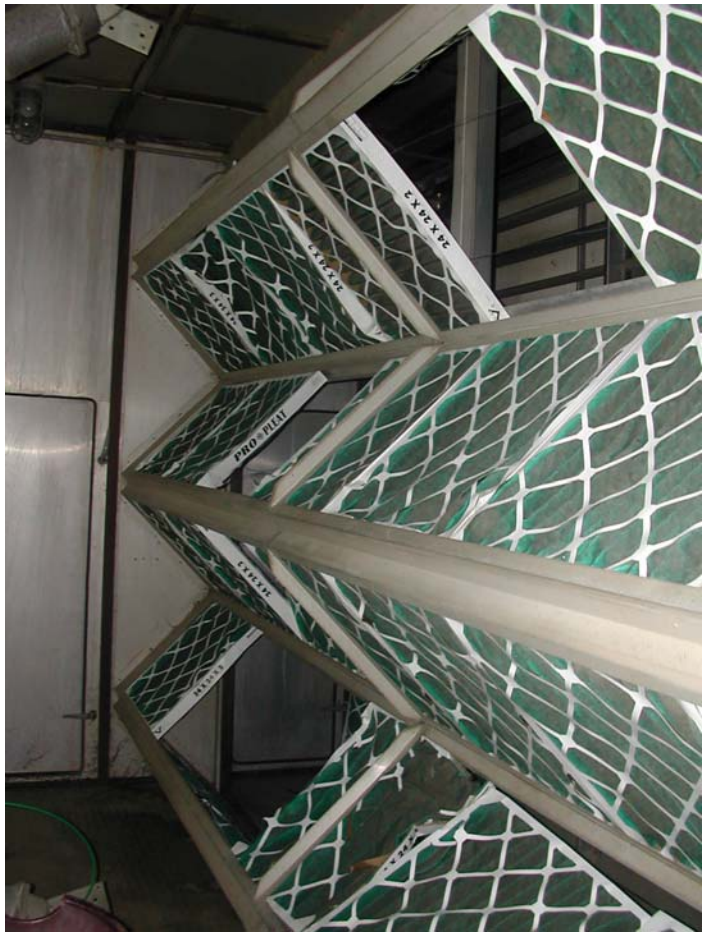
System Efficiency Starts With the Frame / Housing



Application – System Efficiency (Cont.)

System Efficiency Continues With Eliminating Bypass

Application – System Efficiency (Cont.)



Application – Consider New Technology

Durable media pack resists damage

Questions?

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