# *Why Air Filters ???*

- Protection to Air Handler components like coil, fan etc.
- To get minimum required indoor air quality.
- To act as guard filters to high efficiency filters.
- To attain required cleanliness for process needs.
- Special filteration needs such as Gas, Odour, VOCs, Smoke, Bacterias etc.

nivia
utilities

# *Weight Arrestance Test*

- **A weight arrestance test measures how much dust has been removed by a filter at replacement, by weight.**
  - **The test is misleading, however, because it reveals how well a filter will remove only large and heavy particles, not the smaller particles found in common dust.**
  - **The results of this test are the ones most likely to be used in marketing claims that a given filter has 80% or greater efficiency.**
  - **Removing 80% of the large particles is relatively easy but does little to protect human health or equipment life.**
  - **To demonstrate how ineffective such a test is, try pouring table salt through a standard panel filter with a weight arrestance rating of 80% or greater. Be prepared to clean the floor, since the salt will pass freely through the filter.**

nivia
utilities

# *Atmospheric-Dust-Spot Test*

- **The Atmospheric Dust Spot test utilizes optical targets and atmospheric air to determine how many smudge causing particles pass through a filter. Two targets are compared for discoloration by particles. One target is up stream and one down stream of the filter. The ratio of the discoloration is rated in percent efficiency.**
  - This test is more accurate than arrestance because a 10-micron dust particle makes about the same size impact mark as a 1-micron particle.
  - An atmospheric-dust-spot test is more useful than a weight arrestance test because it measures a filter's ability to capture particles between 0.3 and 6 microns (μ) in size.
  - It has one flaw. The atmospheric dust in say New York City has different dust make up than atmospheric dust from Seattle Washington. Test air that has a lower percentage of small particles will allow a filter to have a higher rating.

# ***DOP Efficiency***

- **This test is very accurate. It is a test that counts the number of particles that are 0.3 microns up stream and down stream of the filter. If 1000 particles are on the upstream side and 1 particle is on the down stream side the filter has removed 99.9 percent of the particles and it is given a rating of 99.9 % efficient.**
- A material called dioctyl phthalate produces smoke with particles that average 0.27 microns in diameter.
- This is the test that is used to rate a High Efficiency Particulate Arrestance, HEPA, filter. For a filter to be called a HEPA it should removed 99% or more of 0.3 micron particles.
- In order to assure that factory tested HEPA filters do not have pin-hole "leaks" and that gasketing and frames are leak free, in-place testing with heterogeneous (cod) dioctyl phthalate (DOP) or suitable substitute is highly recommended. This process introduces cold DOP upstream at a concentration of 10-29 micrograms/liter of air and utilizes a forward light scattering photometer to scan downstream to detect leaks greater than 0.01% of upstream concentration.

nivia
utilities

# *Particle Size Efficiency*

- **This test will be used when ASHRAE 52.2 is adopted. It is very similar to the DOP test but measures several particle diameters not just 0.3 micron. It will be a very true comparison of how different filters perform.**

- Since there are many sized particles, the standard groups sizes together in ranges to make comparison easier. These ranges are then used to give Minimum Efficiency Ratings, MER. of 1 to 16.
- MER of 1 being the least efficient and MER of 16 the most efficient.

nivia
utilities

# Air Filter MERV Determination

- The MERV rating of an air filter or other air cleaning device is ascertained by using the ASHRAE Standard 52.2 Test Procedure.
- The process involves injection of an aerosol challenge (containing particles in 12 different known size ranges) into an air stream that passes through the air filter under test. Airborne particle counts are then recorded for each particle size, both upstream and downstream of the air filter in order to determine how efficiently the air filter filters out the particles.
- This test is repeated 6 times for each particle size, with the results stated as a filtration efficiency ratio of the downstream to upstream particle count. The lowest values over the six test cycles are then used to determine the Composite Minimum Efficiency Curve for that air filter.
- Once these values are compiled, the 12 size ranges are distributed into 3 larger groups called E-1, E-2 and E-3. Averaging the Composite Minimum Efficiency for each group will calculate the average Particle Size Efficiency (PSE) of the air filter, and the resulting percentages are used to determine the MERV rating.
- The MERV rating is a number from 1-16, stated along with air velocity at which the test was performed, to simplify the evaluation of an air filter using this test method. Higher MERV rating equates to higher air filtration efficiency.

nivia utilities

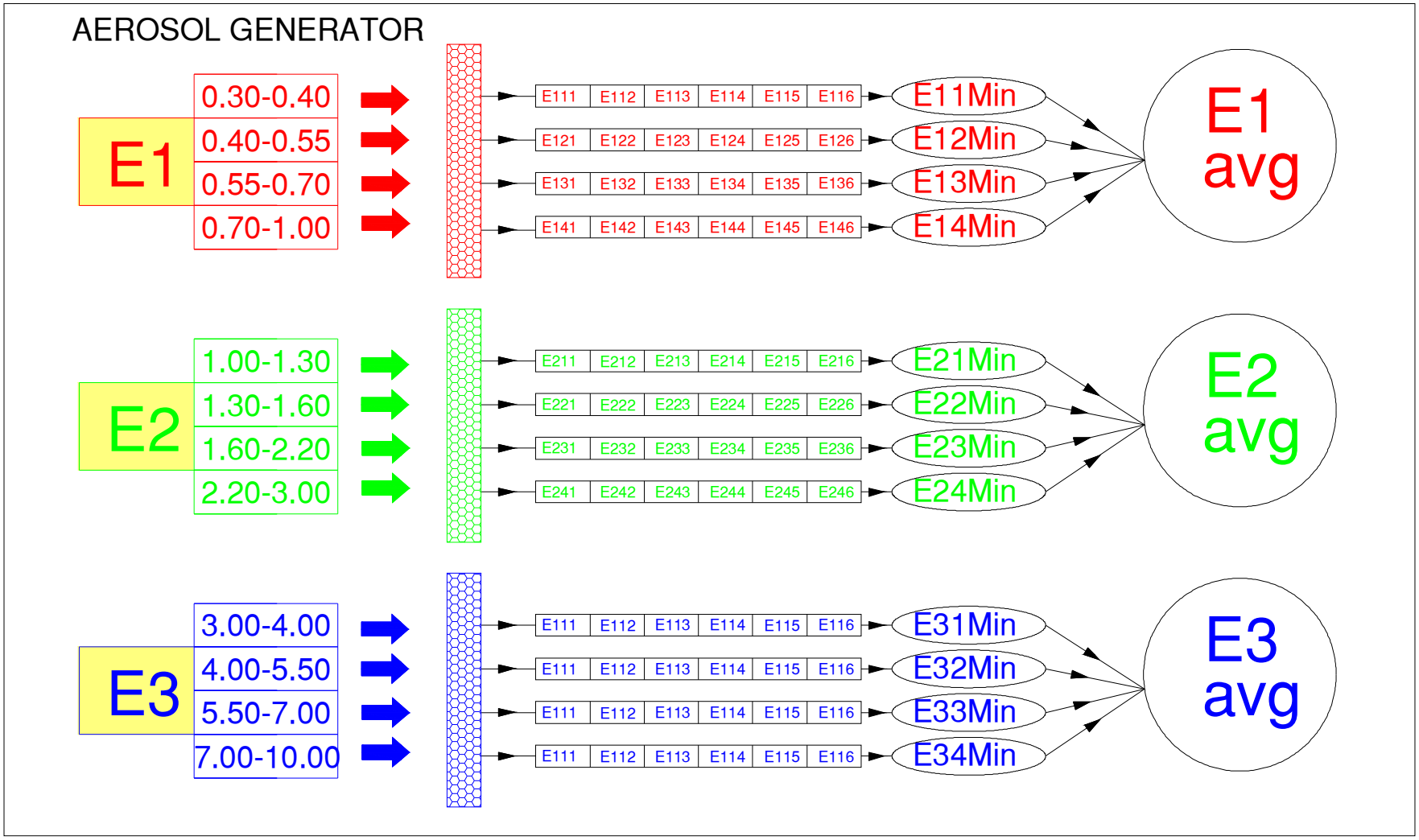
# MERV – Minimum Efficiency Reporting Value

**MERV -** Air Filter MERV or Minimum Efficiency Reporting Value is an expression of the filtering efficiency of an air filter that has been evaluated using the ASHRAE Standard 52.2 Test Procedure. An air filters performance is determined by comparing airborne particle counts upstream and downstream of the air filter (or other air cleaning device) under test

| Typical Air Filter | Disposable Panel Filters, Fiberglass & Synthetic Filters, Permanent Self Cleaning Filters, Electrostatic Filters, Washable Metal Foam | Pleated Filters,Extended Surface Filters,Media Panel Filters | Non-Supported Bag Filters,Rigid Box Filters,Rigid Cell / Cartridge Filters | Non-Supported Bag Filters,Rigid Box Filters,Rigid Cell / Cartridge Filters | HEPA Filters,ULPA Filters,SULPA Filters |
|---|---|---|---|---|---|
| MERV Std. 52.2 | 1-4 | 5-8 | 9-12 | 13-16 | 17-20 |
| Average Dust Spot Efficiency | <20 % | <20 to 35% | 40 to 75% | 80 to 95%+ | 99.97% 99.99% 100.00% |
| Average Arrestance ASHRAE Std. 52.1 | 60 to 80% | 80 to 95% | >95 to 98% | 98 to 99% | N/A |
| Particle Size Ranges | >10.0 microns | 3.0-10.0 microns | 1.0-3.0 microns | 0.30-1.0 microns | <0.30 microns |
| Typical Air Filter Applications | Residential, Light Commercial, Equipment Protection | Industrial Workplace, Commercial, Paint Booths | Industrial Workplace, High End Commercial Buildings | Smoke Removal, General Surgery, Hospitals and Health Care | Clean Rooms, High Risk Surgery, Hazardous Materials |

**nivia utilities**

# MERV Calculation



nivia
utilities

# *Air Filter MERV v/s. Efficiency*

| Rating | | E1 | E2 | E3 |
|---|---|---|---|---|
| | | 0.3 to1 mic | 1 to 3 mic | 3 to 10 mic |
| G2 | MERV 1 | | | < 20% |
| | MERV 2 | | | |
| | MERV 3 | | | |
| | MERV 4 | | | |
| G3 | MERV 5 | | | 20-35% |
| G4 | MERV 6 | | | 35-40% |
| | MERV 7 | | | 50-70% |
| F5 | MERV 8 | | | > 70% |
| | MERV 9 | | < 50% | > 85% |
| | MERV 10 | | 50-65% | > 85% |
| F5/F6 | MERV 11 | | 65-80% | > 85% |
| F6 | MERV 12 | | > 80% | > 90% |
| F7 | MERV 13 | < 75% | > 90% | > 90% |
| F7/F8 | MERV 14 | 75-85% | > 90% | > 90% |
| F8/F9 | MERV 15 | 85-95% | > 90% | > 90% |
| F9 | MERV 16 | > 95% | > 95% | > 95% |

nivia utilities

# Understanding Air Filters Rating

- Air filter manufactures rate their products according to standards established by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), which uses two different methods for describing filtration efficiency Test 52.2 and Test 52.1. A third test, referred to as a dust spot test is:

  - **Standard 52.2-1999:** This system quantifies air filtration efficiency against particle size ranges: 3 to 10 microns, 1 to 3 microns, and 0.3 to 1 micron. Particle size efficiency is further expressed based on a Minimum Efficiency Reporting Value (MERV) between 1 and 16. A higher MERV indicates greater filter efficiency and one that is more effective against smaller particles. The 52.2-1999 system is a newer approach which is more descriptive.
  - **Standard 52.1-1992:** This system quantifies air filter efficiency in terms of mass of particles removed or 'arrestance'. The 52-1 method is also called a weight-arrestance test. Weight-arrestance tests are misleading because they tell only how well a filter will remove relatively large particles but not the smaller particles typically found in dust.

  A third test, which is actually part of the 52.1 is called an 'atmospheric-dust-spot test'. A dust-spot test is more useful than weight arrestance because it measures a filter's ability to capture particles within a given range, usually between 0.3 and 6 micron.

nivia
utilities

# ***Average Arrestance by Standard 52.1***

Filters with an efficiency of less than 20% in E3 (MERV 1 through MERV 4) must be tested per the arrestance test of ASHRAE Standard 52.1

nivia
utilities

# Attempt to combine Testing Standrds

| Type | Eurovent Class | CEN EN779 Class | ASHRAE 52.1 | ASHRAE 52.2 |
|---|---|---|---|---|
| Coarse Dust Filters | EU1 | G1 | <65% Arrestance | MERV 1 |
| | EU2 | G2 | 65<70% Arrestance | MERV 2 |
| | | | 70<75% Arrestance | MERV 3 |
| | | | 75<80% Arrestance | MERV 4 |
| | EU3 | G3 | 80<85% Arrestance | MERV 5 |
| | | | 85<90% Arrestance | MERV 6 |
| | EU4 | G4 | >90% Arrestance | MERV 7<br>MERV 8 |
| Fine Dust Filters | EU5 | F5 | 40<45% ASHRAE | MERV 9 |
| | | | 50<55% ASHRAE | MERV 10 |
| | EU6 | F6 | 60<65% ASHRAE | MERV 11 |
| | | | 70<75% ASHRAE | MERV 12 |
| | EU7 | F7 | 80<90% ASHRAE | MERV 13 |
| | EU8 | F8 | 90<95% ASHRAE | MERV 14 |
| | EU9 | F9 | >95% ASHRAE | MERV 15 |
| High Efficiency Particulate Air Filter (HEPA) | EU10 | H10 | 85% DOP | MERV 16 |
| | EU11 | H11 | 95% DOP | |
| | EU12 | H12 | 99.5% DOP | ***** |
| | EU13 | H13 | 99.95% DOP | ***** |
| | EU14 | H14 | 99.995% DOP | ***** |
| Ultra Low Penetration Air Filter (ULPA) | EU15 | U15 | 99.9995% DOP | ***** |
| | EU16 | U16 | 99.99995% DOP | ***** |
| | EU17 | U17 | 99.999995% DOP | ***** |

nivia
utilities

# Standard Test Air Flow Rates

The Minimum Efficiency Reporting Value (MERV) must be stated with the air velocity at which the filter was tested. For example, if the filter was tested with an air velocity of 492 FPM and was found to be MERV 10, the filter's Minimum Efficiency Reporting Value would be MERV 10 @ 492 FPM. ASHRAE Standard 52.2 tests are to be conducted at one of seven airflow rates:

118 FPM (0.60 m/s)
246 FPM (1.25 m/s)
295 FPM (1.50 m/s)
374 FPM (1.90 m/s)
492 FPM (2.50 m/s)
630 FPM (3.20 m/s)
748 FPM (3.80 m/s)

nivia
utilities

# ASHRAE Standard 62-2001 Ventilation for acceptable IAQ

## Air Cleaning Specification

- Specify that filters with a MERV Rating of not less than 6 be installed upstream of all cooling coils.
- Specifies that gas phase adsorbers (typically activated carbon) be used to control gaseous contaminants when needed to provide an adequate level of indoor air quality.

nivia
utilities

# *Filters and Pressure Drop*

- Most forced-air systems have a filter located in the return ductwork to remove airborne contaminants before they reach the air handler. However, the filter restricts the flow of air, creating an additional pressure drop in the system that the air handler must then overcome.
- In general, the more efficient the filter is at removing particles, the greater its resistance to air flow, and the greater the pressure drop it creates (for filters of the same cross-sectional area). If the increase in pressure drop is too great, it can reduce energy efficiency, damage the equipment, and increase duct leakage at unsealed seams. Therefore, the filter's function of removing contaminants must be balanced against the additional pressure drop it creates. One way to get good filtration without a lot of pressure drop is to increase the filter area.
- The pressure drop that a filter or other type of air cleaner creates in a forced-air system changes over time. As particles accumulate, they reduce air flow, which increases the pressure drop. Following recommended maintenance schedules is critical to keeping the pressure drop at an acceptable level.
- For typical residential forced-air systems, the increase in pressure drop across the filter, from the time when it is first installed to the time when it should be cleaned or replaced, should be less than 0.5 inches of water gauge (about 125 Pascals). If a filter will create a greater change in pressure drop than this, then a stronger blower and special ductwork design may be required.

nivia
utilities

# *Fan Power Savings*

***An Illustration*** – For a 10,000 cfm system, If prefilter pressure drop increases by merely 0.25"wg. For a Fan eff of 60% and Motor eff of 80%. Also for 6000 hrs/yr and power cost Rs. 7/- per kwh.

- **Fan hp**
  $hp_f = Q \times (p_1 - p_2) / 6356 \times E_f = 10000 \times 0.25 / 6356 \times 0.6 = 0.66$
- **Motor hp**
  $hp_m = hp_f / Em = 0.66 / 0.8 = 0.82$
- **Annual Power Cost**
  $C = Q \times (p_1 - p_2) X hrs x rate / 8520 \times E_f' \times E_m'$
  $= 10000 \times 0.25 \times 6000 \times 7 / 8520 \times 0.5 \times 0.75$
  $= 32,864.00$
- Filter Cost = Rs. 3000.00
- Pay Back = Approx. 33 days

nivia
utilities

# Comparision between 52.2 and 51.1 Rating Systems

| | ASHRAE 52.2 | | | | ASHRAE 52.1 | |
|---|---|---|---|---|---|---|
| MERV | 3 - 10 micron | 1 - 3 micron | 0.3 - 1 micron | Arrestance | Dust Spot | Dust spot |
| 1 | <20% | - | - | <65% | <20% | |
| 2 | <20% | - | - | 65-70% | <20% | |
| 3 | <20% | - | - | 70-75% | <20% | >10 micron |
| 4 | <20% | - | - | >75% | <20% | |
| 5 | 20-35% | - | - | 80-85% | <20% | |
| 6 | 35-50% | - | - | >90% | <20% | |
| 7 | 50-70% | - | - | >90% | 20-25% | 3.0-10 mtcron |
| 8 | >70% | - | - | >95% | 25-30% | |
| 9 | >85% | <50% | - | >95% | 40-45% | |
| 10 | >85% | 50-65% | - | >95% | 50-55% | |
| 11 | >85% | 65-80% | - | >98% | 60-65% | 1.0-3.0 micron |
| 12 | >90% | >80% | - | >98% | 70-75% | |
| 13 | >90% | >90% | <75% | >98% | 80-90% | |
| 14 | >90% | >90% | 75-85% | >98% | 90-95% | |
| 15 | >90% | >90% | 85-95% | >98% | ~95% | 0.3-1.0 micron |
| 16 | >95% | >95% | >95% | >98% | >95% | |
| 17* | >99% | >99% | >99% | - | >99% | |
| 18* | >99% | >99% | >99% | - | >99% | |
| 19* | >99% | >99% | >99% | - | >99% | 0.3-1.0 micron |
| 20* | >99% | >99% | >99% | - | >99% | |

nivia
utilities

# Filter Application

| MERV | Application |
|---|---|
| 1-4 | minimum residential, minimum commercial, equipment protection |
| 5-8 | commercial, industrial, better residential, paint booth, finishing |
| 9-12 | better commercial, better industrial, superior residential |
| 13-16 | health care, general surgery, superior commercial, smoke removal |
| 17-20* | clean rooms, high risk surgery, hazardous materials |
| | |
| * = reserved for future classifications | |

nivia utilities

# Filter Application Guide

| MERV Std 52.2 | Average ASHRAE Dust Spot Efficiency Std 52.1 | Average ASHRAE Arrestance Std 52.1 | Particle Size Ranges | Typical Applications | Typical Filter Type |
|---|---|---|---|---|---|
| 1-4 | <20% | 60 to 80% | > 10.0 µm | Residential / Minimum Light / Commercial Minimum / Equipment Protection | Permanent / Self Charging (passive) Washable / Metal, Foam / Synthetics Disposable Panels Fiberglass / Synthetics |
| 5-8 | <20 to 35% | 80 to 95% | 3.0 - 10.0 µm | Industrial Workplaces Commercial Better / Residential Paint Booth / Finishing | Pleated Filters Extended Surface Filters Media Panel Filters |
| 9-12 | 40 to 75% | >95 to98% | 1.0 - 3.0 µm | Superior / Residential Better / Industrial Workplaces Better / Commercial Buildings | Non-Supported / Bag Rigid Box Rigid Cell / Cartridge |
| 13-16 | 80 to 95% + | >98 to 99% | 0.30 - 1.0 µm | Smoke Removal General Surgery Hospitals & Health Care Superior / Commercial Buildings | Rigid Cell / Cartridge Rigid Box Non-Supported / Bag |
| 17-20[1] | 99.97<br>99.99<br>99.999 | N/A | £ 0.30 µm | Clean Rooms High Risk Surgery Hazardous Materials | HEPA ULPA |

*Note: This table is intended to be a general guide to filter use and does not address specific*

*(1) Reserved for future classifications*

*(2) DOP Efficiency*

nivia
utilities

# MERV v/s. Efficiency v/s. Pr. Drop

| Standard 52.2 Minimum Efficiency Reporting Value (MERV) | Composite Average Particle Size Efficiency, % in Size Range, µm | | | Average ASHRAE Arrestance, %, by Standard 52.1 Method | Minimum Final Resistance | |
|---|---|---|---|---|---|---|
| | Range 1 (0.3 - 1.0) | Range 2 (1.0 - 3.0) | Range 3 (3.0 - 10.0) | | PA | Inches of Water |
| 1 | n/a | n/a | E3 < 20 | Aavg < 65 | 75 | .3 |
| 2 | n/a | n/a | E3 < 20 | 65 ≤ Aavg < 70 | 75 | .3 |
| 3 | n/a | n/a | E3 < 20 | 70 ≤ Aavg < 75 | 75 | .3 |
| 4 | n/a | n/a | E3 < 20 | 75 ≤ Aavg | 75 | .3 |
| 5 | n/a | n/a | 20 ≤ E3 < 35 | n/a | 150 | .6 |
| 6 | n/a | n/a | 35 ≤ E3 < 50 | n/a | 150 | .6 |
| 7 | n/a | n/a | 50 ≤ E3 < 70 | n/a | 150 | .6 |
| 8 | n/a | n/a | 70 ≤ E3 | n/a | 150 | .6 |
| 9 | n/a | E2 < 50 | 85 ≤ E3 | n/a | 250 | 1.0 |
| 10 | n/a | 50 ≤ E2 < 65 | 85 ≤ E3 | n/a | 250 | 1.0 |
| 11 | n/a | 65 ≤ E2 < 80 | 85 ≤ E3 | n/a | 250 | 1.0 |
| 12 | n/a | 80 ≤ E2 | 90 ≤ E3 | n/a | 250 | 1.0 |
| 13 | E1 < 75 | 90 ≤ E2 | 90 ≤ E3 | n/a | 350 | 1.4 |
| 14 | 75 ≤ E1 < 85 | 90 ≤ E2 | 90 ≤ E3 | n/a | 350 | 1.4 |
| 15 | 85 ≤ E1 < 95 | 90 ≤ E2 | 90 ≤ E3 | n/a | 350 | 1.4 |
| 16 | 95 ≤ E1 | 95 ≤ E2 | 95 ≤ E3 | n/a | 350 | 1.4 |

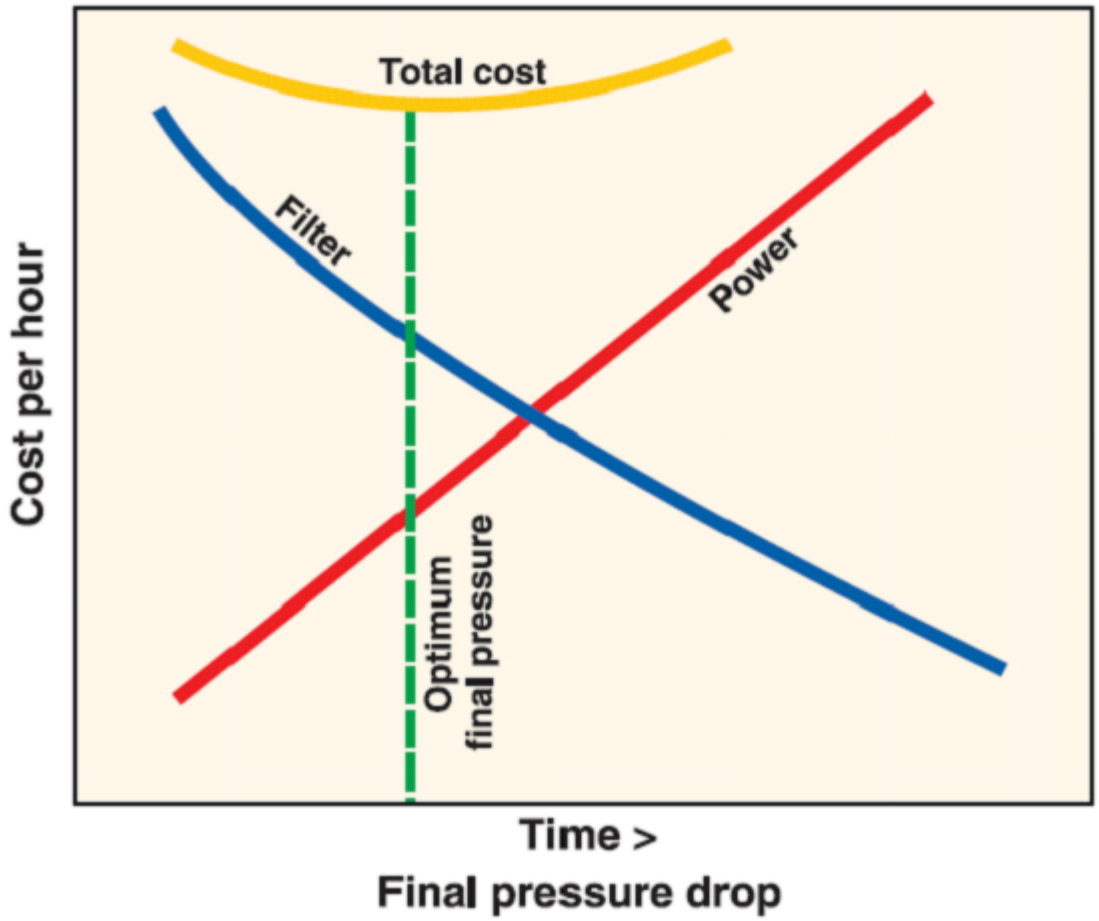
nivia
utilities

# Final Pressure Drop

Final resistance must be at least twice the initial resistance at the test airflow rate.

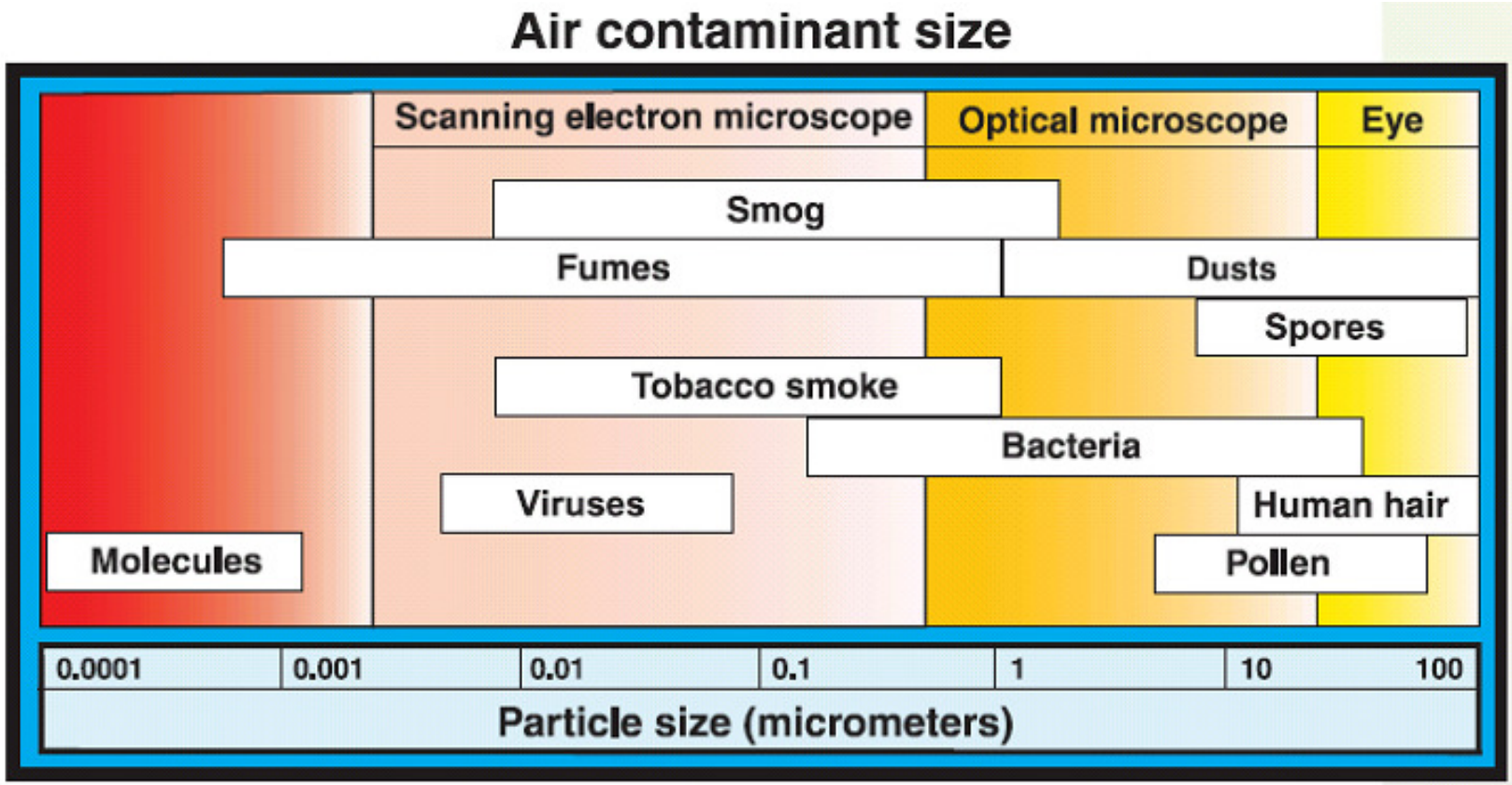
nivia
utilities

# Relationship between cost and life



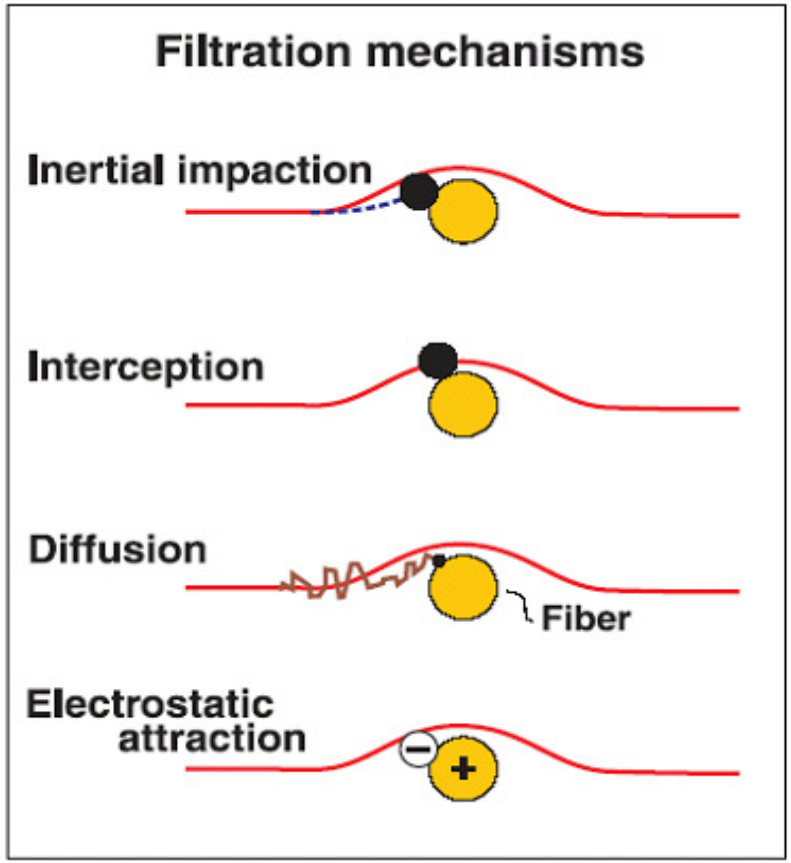
nivia
utilities

# Air Contaminant Size



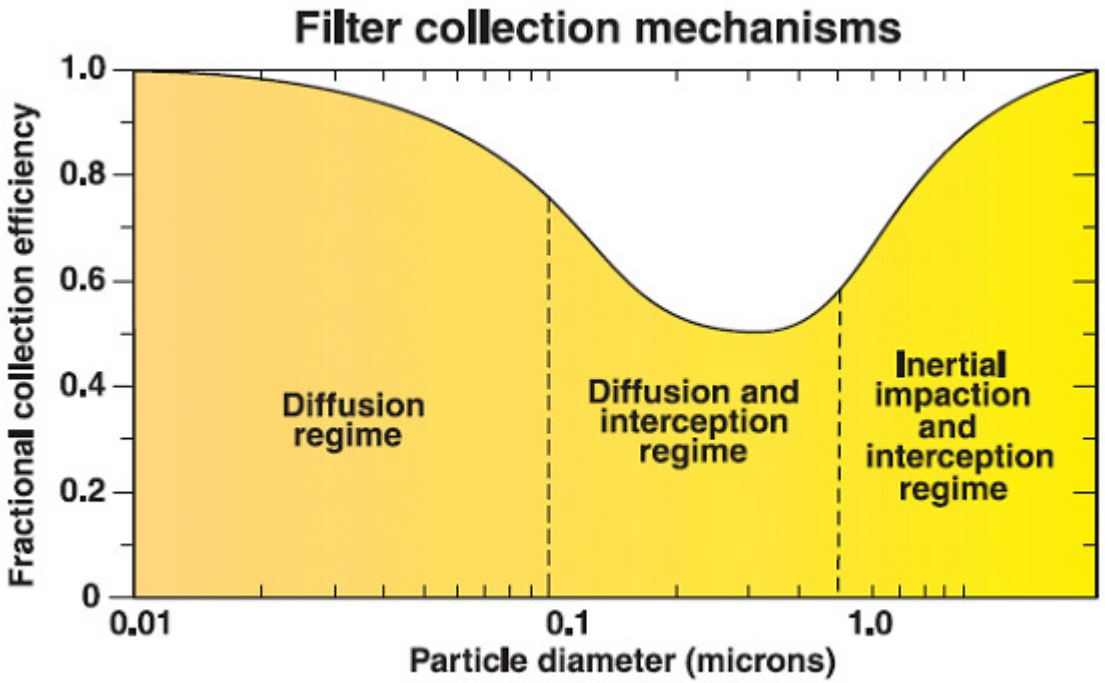
nivia
utilities

# Filtration Mechanism



nivia
utilities

# Fractional Collection Eff v/s. Particle dia



nivia
utilities

# Dust Holding Capacity

"The total weight in grams of ASHRAE dust caught by the filter before reaching a pre-determined pressure drop at a given rate of flow".

Components of ASHRAE Dust (by weight)

72% - Standardized Air Cleaner Test Dust, Fine

(Mean Particle Size – 7.7 microns)

23% - Powdered Carbon

5% - #7 Cotton Linters

nivia
utilities

# UL-900-Air Filter Flammability Standard

- ***Class 1 Air Filters***

➢ Those that, when clean, do not contribute fuel when attacked by flame and emit only negligible amounts of smoke.

- ***shall not produce flame or sparks when subjected to the UL Flame-Exposure Test. During the flame-exposure test, the Class 1 air filter shall not cause the development of an area of more than 16.1 $cm^2$ (approx. 2.5 sq.in.) as measured below the smoke-density time curve. Additionally, when subjected to the UL Spot Flame Test, the upstream face of a Class 1 air filter shall not continue to flame after removal of the test flame.***

- ***Class 2 Air Filters***

➢ Those that, when clean, burn moderately when attacked by flame or emit moderate amounts of smoke, or both

- **shall not produce flame or extensive (25 or more) sparks which are sustained beyond the end of the test duct when subjected to the flame-exposure test, and shall not cause the development of an area of more than 58$cm^2$ (approx. 9sq.in.) as measured below the smoke density time curve.**
- ***Adhesive Material- used for coating the filter media, or other part of the air filter, shall have a flash point of not less than 163 C (approx. 325 F) as determined by the Test Method for Flash and Fire Points by Cleveland Open Cup, ASTM D92-1990.***

❑ ***GENERAL - - shall not contain unbonded asbestos fiber materials.***

nivia
utilities

# Types of HEPA Filters

| Filter type | Penetration Test | | Scan Test (see note) | | Comments | Minimum efficiency rating |
|---|---|---|---|---|---|---|
| | Method | Aerosol | Method | Aerosol | | |
| A | MIL-STD 282 | Thermal DOP | None | None | | 99.97%* at 0.3 µm |
| B | MIL-STD 282 | Thermal DOP | None | None | Two flow leak test | 99.97% at 0.3 µm |
| C | MIL-STD 282 | Thermal DOP | Photometer | Polydisperse DOP | | 99.99% at 0.3 µm |
| D | MIL-STD 282 | Thermal DOP | Photometer | Polydisperse DOP | | 100.00% at 0.3 µm |
| E | MIL-STD 51477 or MIL-STD F51068 | Thermal DOP | Photometer | Polydisperse DOP | Two flow leak test | 99.97% at 0.3 µm |
| F | IES-RP CC007 | Open | Particle Counter | Open | | 100.00% at 0.1 to 0.2 µm |

nivia
utilities

# Standard s comparision