# Virtual Tour of Plant Engineering-HVAC

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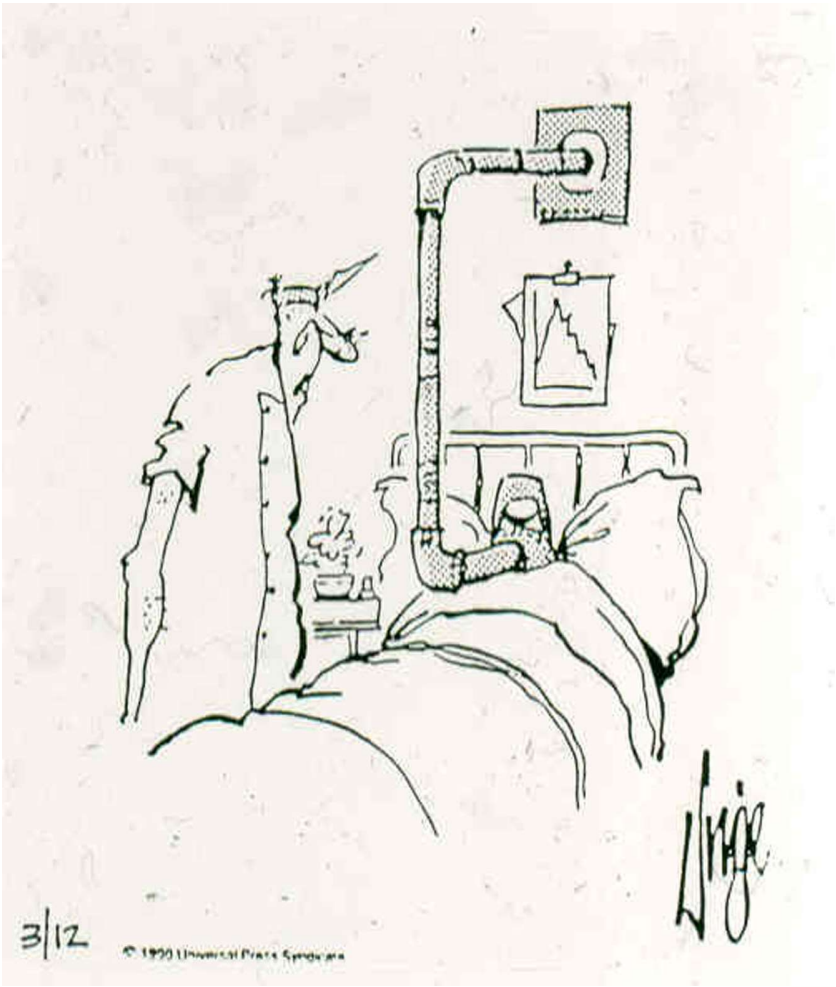
# HVAC

## Heating, Ventilation and Air Conditioning

- Air handling units are the core elements of HVAC systems
- HVAC systems condition and circulate the air throughout the hospital
- Central air handling units connect ducts that run through the building
- Air filters are built into the heating and cooling systems
- The air filters reduce airborne contaminants
- Humidity, temperature and pressure (through ducts) sensors

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# SPECIAL HEALTHCARE SETTINGS

## (Airborne Infection Isolation-AII)

- Planning new or renovating AII units
  - **Directed airflow:** exhaust air to the outside, away from air-intake and populated areas (IC)
  - **Well-sealed room** (IB)
  - **Room-air pressure:** Maintain continuous negative room with respect to corridor; monitor air pressure periodically (IB).; install self-closing doors (IC)
  - **Room-air changes:** Maintain at ≥12 per hour (IB)

# Calculate Air Changes Per Hour

- Air changes per hour is a calculation of how many times per hour the entire volume of air in a room is replaced with supply air.
- ACH = CFM x 60m / volume (l x w x h of space) of room $ft^3$
- To **calculate** room **air changes**, measure the supply airflow into a room, multiply the CFM times 60 minutes **per hour**. Then divide by the volume of the room in cubic feet (just changing CFM into Cubic Feet **per Hour** (CFH).
- For example, 200 CFM x 60 m/h =12,000 CFH
- If room is 12 ft x 10 ft x 10 ft =1200 cubic feet
- 12,000 CFH/1200 CF = 10 AC/hour

## Air Quality System Mgmt

| Area Designation | Air movement relationship to adjacent area | Minimum total air changes per hour UNC Hospitals* | All air directly exhausted to outdoors | Filtering System | Monitoring | Plant Engineering schedule for verification and documentation** |
|---|---|---|---|---|---|---|
| **Hospitals Ventilation Systems** | NA | NA | Variable depending upon area | Filter bed #1 – MERV 7<br>Filter bed # 2 – MERV 14 | Operation of fans continuously monitored (alarmed). PM program for HVAC. | Filter bed #1 are visually inspected every 12 weeks and replaced as needed. Filter bed #2 are visually inspected annually and changed as needed. HEPA filters are inspected every 5 years and changed as needed. |
| **Protective Environment Rooms**<br>(see Listing of Protective Environment Rooms) | Continuous positive pressure | 9 air changes per hour (ACH) | NO | HEPA filtration MERV 17 | PM program for HVAC. | ACH verified and documented annually by PE |
| **Airborne Isolation Rooms** (i.e., TB)<br>(see Listing of Airborne Isolation Rooms) | Continuous negative pressure | 6 ACH* | YES | | Monitored daily (when used for isolation) by nursing staff using tissue test and documented in the patient's medical record.<br>PM program for HVAC. | ACH verified and documented annually |
| **Negative Pressure Rooms (i.e., other airborne diseases such as chickenpox)** | Continuous negative pressure | 6 ACH | NO | | Monitored daily (when used for isolation) by nursing staff using tissue test and documented in the patient's medical record,<br>PM program for HVAC. | ACH verified and documented annually |
| **Operating Rooms, Main Campus**, Chapel Hill | Continuous positive pressure | 15 ACH | NO | MERV 17 | PM program for HVAC.<br>Temperature and humidity history recorded in HVAC control system.<br>Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented annually |
| **Operating Rooms,** Hillsborough Hospital | Continuous positive pressure | 20 ACH | NO | MERV 17 | PM program for HVAC.<br>Temperature and humidity history recorded in HVAC control system.<br>Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented annually |
| **Operating Rooms,** Ambulatory Surgery Center (ASC) at ACC | Continuous positive pressure | 20 ACH | NO | MERV 17 | PM program for HVAC by UNC Facilities Services.<br>Temperature and humidity history recorded in HVAC control system by UNC Facilities Services.<br>Temperature, humidity, pressure monitored by clinical department. | ACH verified and documented annually |

# Air Quality System Mgmt

| Area Designation | Air movement relationship to adjacent area | Minimum total air changes per hour UNC Hospitals* | All air directly exhausted to outdoors | Filtering System | Monitoring | Plant Engineering schedule for verification and documentation** |
|---|---|---|---|---|---|---|
| **Bronchoscopy Rooms:** 6th Floor Main Hospital and 2nd Floor Children's Hospital | Continuous negative pressure | 12 ACH* | YES | | PM program for HVAC. | ACH verified and documented annually |
| **Central Sterile Processing Sterilizer Equipment Room, Chapel Hill** | Continuous negative pressure | 10 ACH* | YES | | PM program for HVAC.<br>Temperature and humidity history recorded in HVAC control system. Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented annually. |
| **Central Sterile Processing Sterilizer Equipment Room, Hillsborough** | Continuous negative pressure | 10 ACH* | YES | | Temperature and humidity history recorded in HVAC control system.<br>Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented annually. |
| **Central Sterile Processing Sterilizer Equipment Room, ASC** | Continuous negative pressure | 10 ACH* | YES | | PM program for HVAC by UNC Facilities Services.<br>Temperature and humidity history recorded in HVAC control system by UNC<br>Facilities Services. Temperature, humidity, pressure monitored by clinical department. | ACH verified and documented annually. |
| **Central Processing**<br>**Sterile Storage Room, Chapel Hill** | Continuous positive pressure | 4 ACH* | NO | | PM program for HVAC.<br>Temperature and humidity history recorded in HVAC control system.<br>Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented within 3 years. |
| **Central Processing**<br>**Sterile Storage Room, Hillsborough** | Continuous positive pressure | 4 ACH* | NO | | Temperature and humidity history recorded in HVAC control system. Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented within 3 years. |
| **Central Processing**<br>**Sterile Storage Room, Sterile Processing Room and Clean Cart Holding Room, ASC** | Continuous positive pressure | 4 ACH* | NO | | PM program for HVAC by UNC Facilities Services.<br>Temperature and humidity history recorded in HVAC control system by UNC Facilities Services.<br>Temperature, humidity, pressure monitored by clinical department. | ACH verified and documented within 3 years. |
| **Central Processing**<br>**Decontamination Room, Chapel Hill** | Continuous negative pressure | 6 ACH* | YES | | PM program for HVAC.<br>Temperature and humidity history recorded in HVAC control system.<br>Temperature, humidity, and pressure monitored by clinical department. | ACH verified and documented annually. |
| **Central Processing**<br>**Decontamination Room, Hillsborough** | Continuous negative pressure | 6 ACH* | YES | | Temperature and humidity history recorded in HVAC control system. | ACH verified and documented annually. |

# Hospitals

| | Air Movement Relationship to Adjacent Area | Minimum Air Changes Of Outdoor Air Per Hour | Minimum Total Air Changes Per Hour |
|---|---|---|---|
| Surgery and Critical Care | | | |
| Intermediate Care | — | 2 | 6 |
| Gastrointestinal Endoscopy Room | Out | 2 | 6 |
| Endoscopic Instrument Processing Room | In | — | 10 |
| Laser Eye Room | Out | 3 | 15 |
| X-ray (Surgical/ Critical Care and Catheterization) | Out | 3 | 15 |
| Ancillary | | | |
| Lab Biochemistry | In | — | 6 |
| Lab Serology | In | — | 6 |

# Residential Buildings

| Location Type | Suggested Outdoor Air Ventilation Rate (air changes per hour) |
|---|---|
|  Homes | 0.35–1 |
|  Hotel Rooms | 1–2 |
|  Offices | 2–3 |
|  Retail Shops | 2–3 |
|  Schools (except lecture halls) | 5–6 |
|  Sports Facilities | 4–8 |
|  Restaurants | 6–8 |

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## Recommendations for Cleaning and Disinfecting of Noncritical Surfaces and Medical Devices in COVID-19 Patient Care

Kanamori, Weber, Rutala, Clin Infect Dis, https://doi.org/10.1093/cid/ciaa1467, 28 September 2020

- Standardize cleaning/disinfection of environmental surfaces and medical devices in rooms occupied by COVID-19 patients.
- Follow CDC recommendation for letting room remain empty after discharge for the specified time period.
- Provide education and training for cleaning/disinfecting staff on proper donning and doffing of PPE as recommended by CDC.

# Air changes/hour (ACH) and time required for airborne-contaminant removal by efficiency *

| ACH § ¶ | Time (mins.) required for removal 99% efficiency | Time (mins.) required for removal 99.9% efficiency |
|---|---|---|
| 2 | 138 | 207 |
| 4 | 69 | 104 |
| 6+ | 46 | 69 |
| 8 | 35 | 52 |
| 10+ | 28 | 41 |
| 12+ | 23 | 35 |
| 15+ | 18 | 28 |
| 20 | 14 | 21 |
| 50 | 6 | 8 |

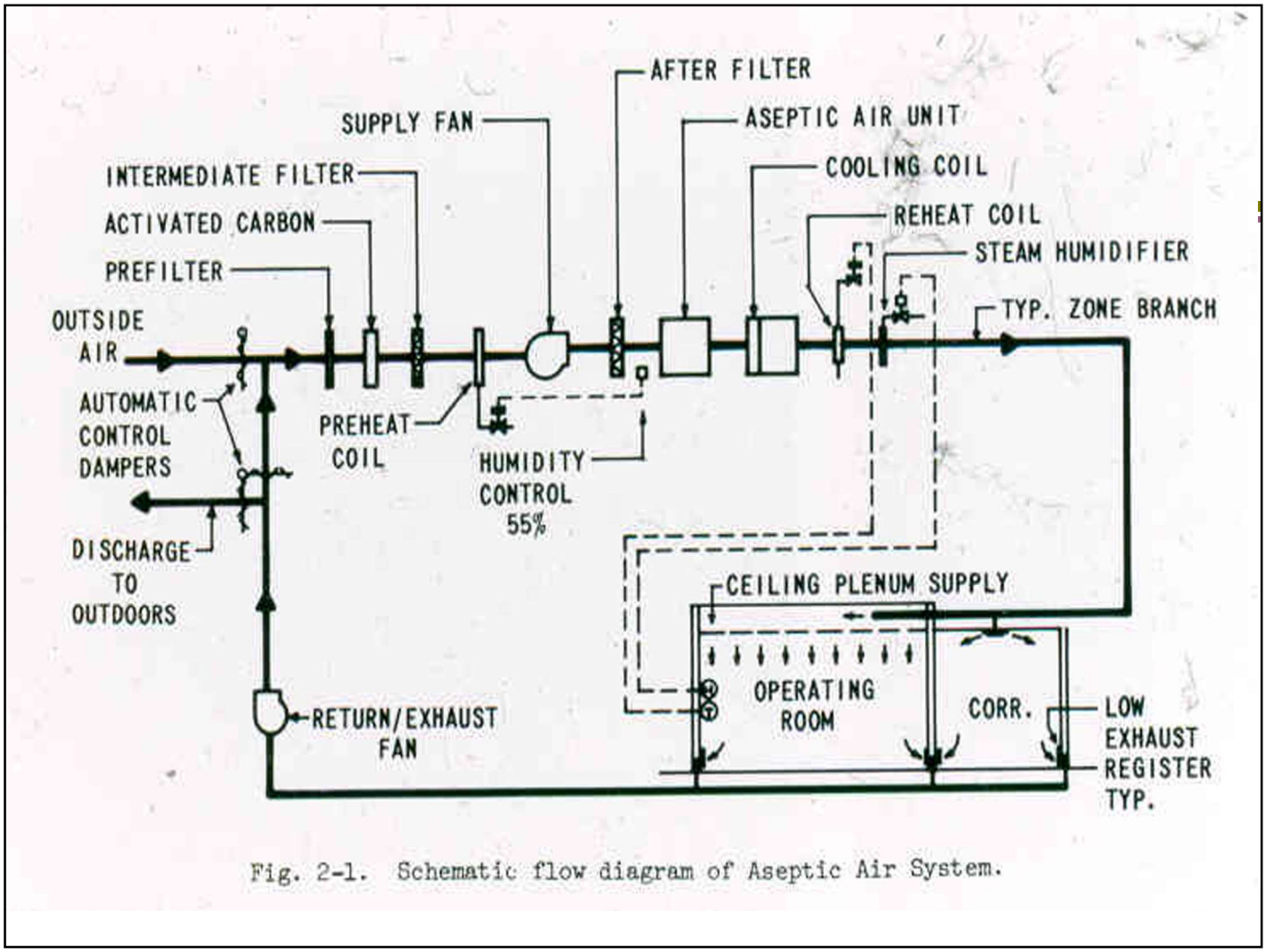


Fig. 2-1. Schematic flow diagram of Aseptic Air System.

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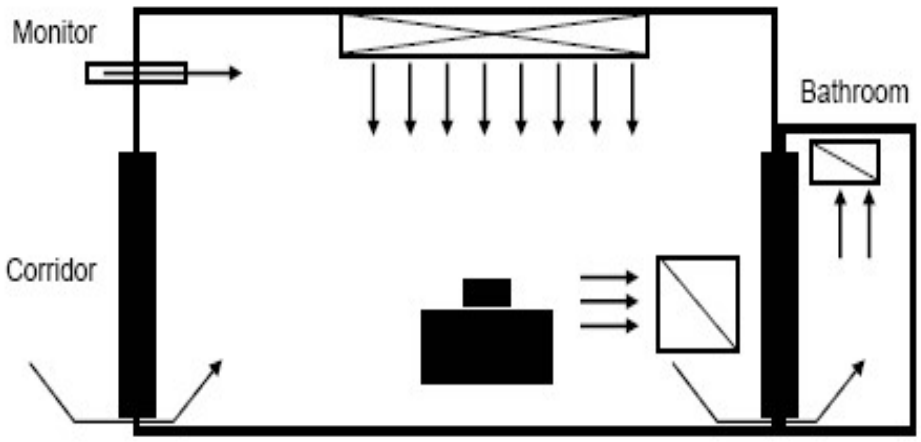
# Environmental Infection Control for Special Health Care Settings

**Figure 3. Example of negative-pressure room control for airborne infection isolation (AII)* + §¶**




* Stacked black boxes represent patient's bed. Long open box with cross-hatch represents supply air. Open boxes with single, diagonal slashes represent air exhaust registers. Arrows indicate direction of air flow.

\+ Possible uses include treatment or procedure rooms, bronchoscopy rooms, and autopsy.

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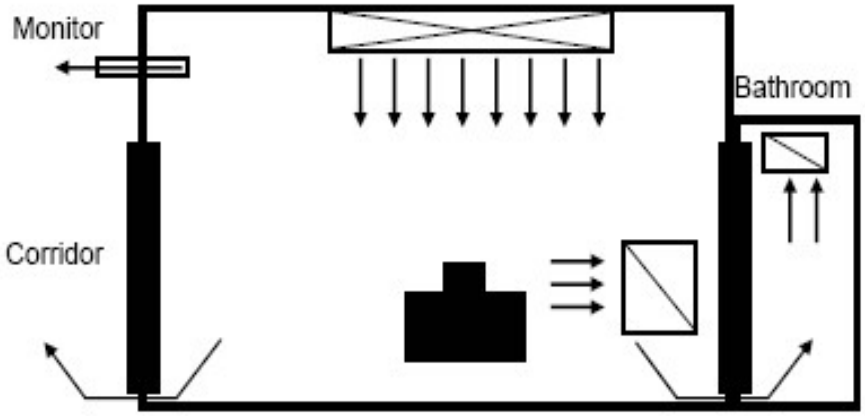
# Environmental Infection Control for Special Health Care Settings

**Figure 2. Example of positive-pressure room control for protection from airborne environmental microbes (PE)* + §**




* Stacked black boxes represent patient's bed. Long open box with cross-hatch represents supply air. Open boxes with single, diagonal slashes represent air exhaust registers. Arrows indicate directions of air flow.

\+ Possible uses include immunocompromised patient rooms (e.g., hematopoietic stem cell transplant or solid organ transplant procedure rooms) and orthopedic operating rooms.

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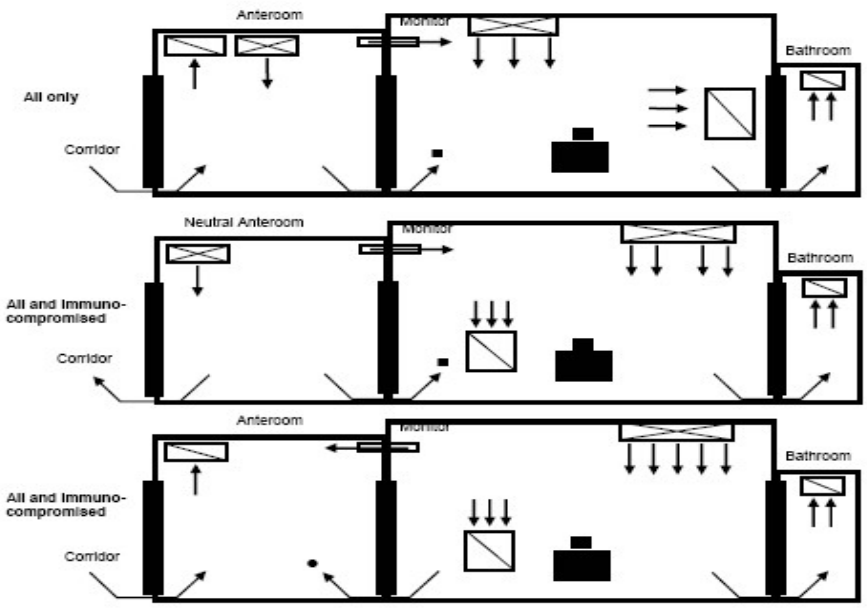
# Environmental Infection Control for Special Health Care Settings

**Figure 4. Example of airborne infection isolation (AII) room with anteroom and neutral anteroom* + §**




* The top diagram indicates air flow patterns when patient with only airborne infectious disease occupies room. Middle and bottom diagrams indicate recommended air flow patterns when room is occupied by immunocompromised patient with airborne infectious disease. Stacked black boxes represent patient beds. Long open boxes with cross-hatches represent supply air. Open boxes with single, diagonal slashes represent air exhaust registers. Arrows indicate directions of air flow.

# Minimum Efficiency Reporting Value

## What does a MERV Rating mean to me?

The acronym MERV stands for "Minimum Efficiency Reporting Value." MERV ratings are used to rate the ability of an air cleaner filter to remove dust from the air as it passes through the filter. MERV is a standard used to measure the overall efficiency of a filter. The MERV scale ranges from 1 to 16, and measures a filter's ability to remove particles from .30 to 10 microns in size. To give you an idea of the scale of a micron, 100 microns is about the thickness of a piece of paper or a human hair. Filters with higher ratings not only remove more particles from the air, they also remove smaller particles.

MERV ratings are determined by adding particles of varying sizes into a controlled testing environment. The particles are added upstream of the test filter and a laser particle counter samples the air before it enters the filter and after it leaves the filter. The two particle counts are compared to calculate the Particle Size Efficiency of the tested filter. Once this is determined, a MERV Parameters chart is used to determine the MERV rating.



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# Minimum Efficiency Reporting Value

## MERV Rating Chart

| MERV Rating | Dust Spot Efficiency* | Typical Controlled Contaminant | Applications | Air Filter Type |
|---|---|---|---|---|
| 1 | <20% | *>10.0 micron Particle Size*<br>Pollen, Dust Mites, Sanding Dust, Spray Paint Dust, Textile Fibers, Carpet Fibers | Minimal Filtration<br>Residential<br>Window A/C Units | **Throwaway** - Disposable fiberglass or synthetic panel filter<br>**Washable** - Aluminum mesh<br>**Electrostatic** - Self charging woven panel filter |
| 2 | <20% | | | |
| 3 | <20% | | | |
| 4 | <20% | | | |
| 5 | <20% | *3.0-10.0 micron Particle Size*<br>Mold Spores, Hair Spray, Fabric Protector, Dusting Aids, Cement Dust, Pudding Mix | Commercial Buildings<br>Better Residential<br>Industrial Workplace<br>Paint Booth Inlet | **Pleated Filters** - Disposable, extended surface area, thick with cotton-polyester blend media, cardboard frame<br>**Cartridge Filters** - Graded density viscous coated cube or pocket filters, synthetic media<br>**Throwaway** - Disposable synthetic panel filter |
| 6 | <20% | | | |
| 7 | 25-30% | | | |
| 8 | 30-35% | | | |
| 9 | 40-45% | *1.0-3.0 micron Particle Size*<br>Legionella, Humidifier Dust, Lead Dust, Milled Flour, Auto Emissions, Welding Fumes | Better Commercial<br>Superior Residential<br>Hospital Laboratories<br>Welding Booth Inlet | **Bag Filter** - Nonsupported microfine fiberglass or synthetic media, typically 6" - 36" deep, 6 - 12 pockets<br>**Box Filter** - Rigid style cartridge filters typically 4" - 12" deep may use lofted or paper media |
| 10 | 50-55% | | | |
| 11 | 60-65% | | | |
| 12 | 70-75% | | | |
| 13 | 89-90% | *.30-1.0 micron Particle Size*<br>All Bacteria, Most Tobacco Smoke, Droplet Nuceli (Sneeze) | Superior Commercial<br>General Surgery<br>Hospital Rooms<br>Smoking Lounge | **Bag Filter** - Nonsupported microfine fiberglass or synthetic media, typically 6" - 36" deep, 6 - 12 pockets<br>**Box Filter** - Rigid style cartridge filters typically 4" - 12" deep may use lofted or paper media |
| 14 | 90-95% | | | |
| 15 | >95% | | | |
| 16 | >95% | | | |

* *Dust spot efficiency* measures a filter's ability to remove large particles, those that tend to soil building interiors.



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# Heating, Ventilation and Air Conditioning
# MERV 8 (30-35% in 3-10µ)


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# Heating, Ventilation and Air Conditioning
# MERV 8 (30-35% in 3-10µ)

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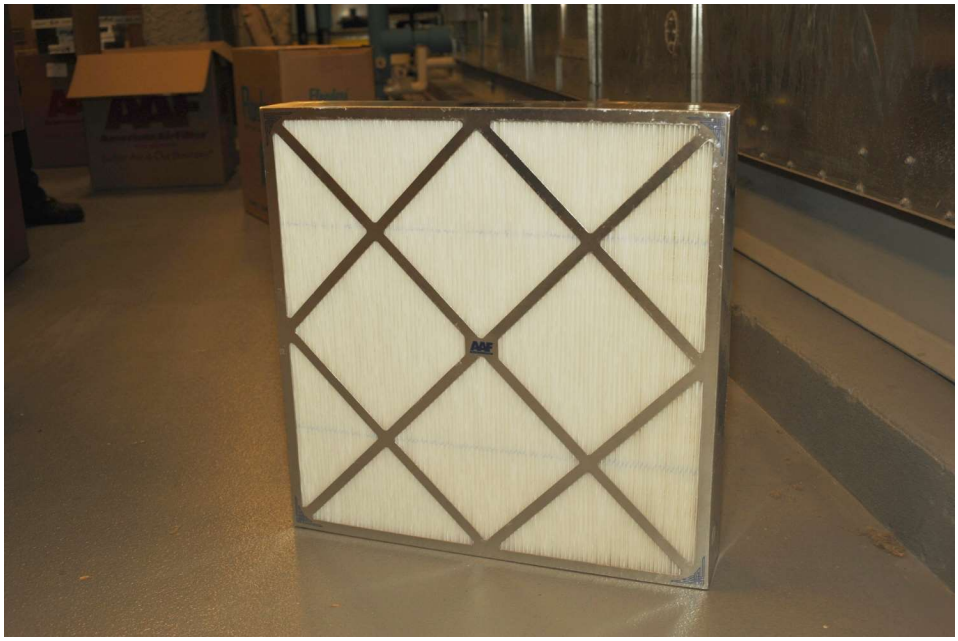
# Heating, Ventilation and Air Conditioning
# MERV 11 (60-65% in 1-3µ)



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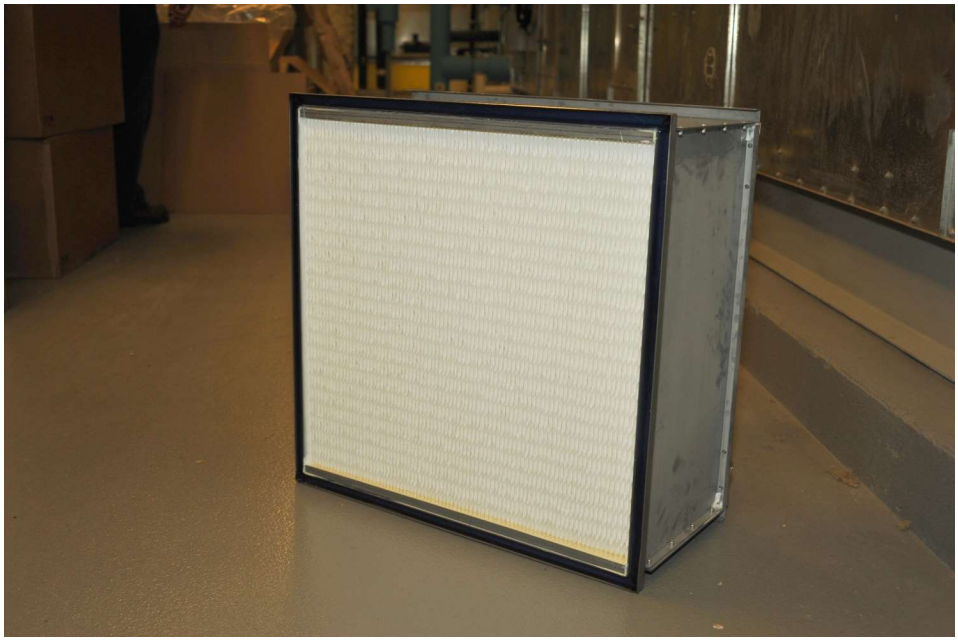
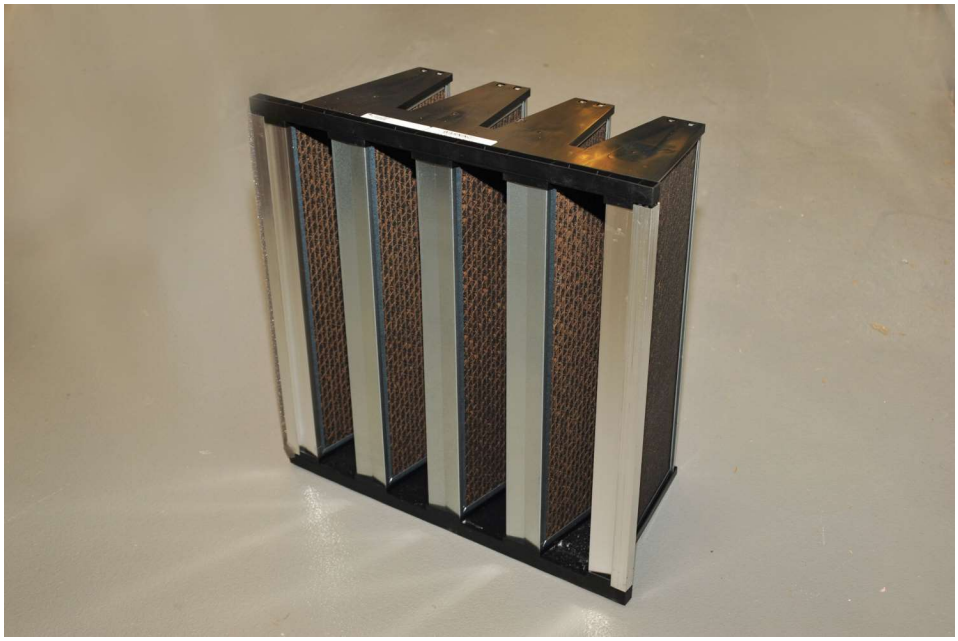
# Heating, Ventilation and Air Conditioning

## HEPA (High Efficiency Particulate Air)

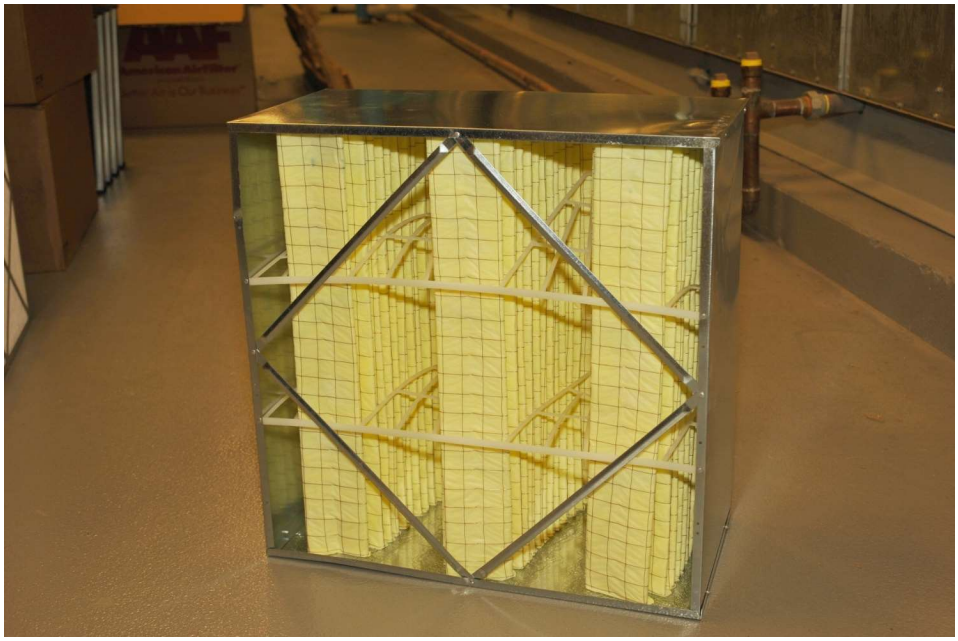


# Heating, Ventilation and Air Conditioning

## Activated Carbon Filter-removes organic compounds and odors



# Heating, Ventilation and Air Conditioning
# MERV 14 (90-95% in 0.3-1µ)



# Heating, Ventilation and Air Conditioning

## Four HVAC Systems In Cancer Hospital

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# Heating, Ventilation and Air Conditioning

## Supply Air from Outside

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# Heating, Ventilation and Air Conditioning

## Filter Bank of MERV 8

# Heating, Ventilation and Air Conditioning

## Removal of MERV 8 from Filter Bank

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# Heating, Ventilation and Air Conditioning

## Air from Patient Rooms Recirculated

# Heating, Ventilation and Air Conditioning

## Return Air Hits Wall and Directed to Filters

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# Heating, Ventilation and Air Conditioning

## Return Air with Diffusion Screen and MERV 11

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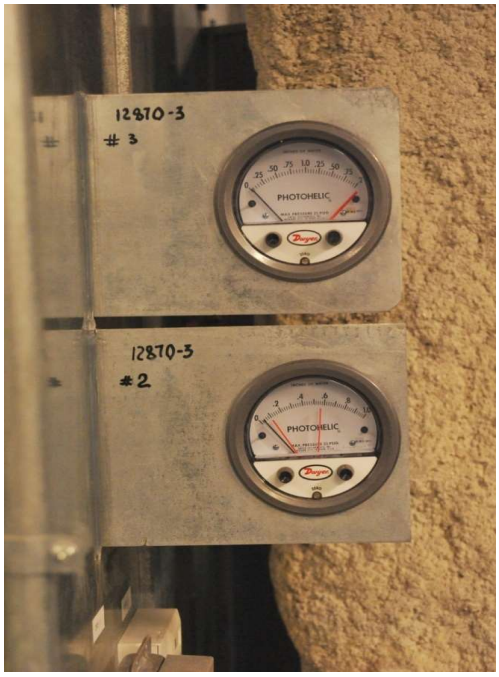
# Heating, Ventilation and Air Conditioning

## MERV 11 with Activated Carbon Filter

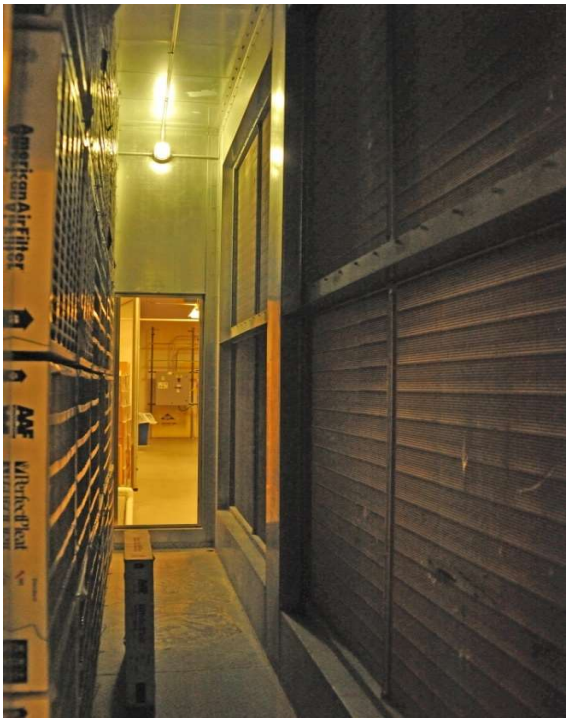
# Heating, Ventilation and Air Conditioning

## Magnehelic Gauge Used to Measure Pressure Differential



# Heating, Ventilation and Air Conditioning

## Filtered Air is Conditioned

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# Heating, Ventilation and Air Conditioning

## Filtered Air is Conditioned

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# Heating, Ventilation and Air Conditioning

## Filtered Air is Conditioned (Cooled) Causing Condensate with Antimicrobial Tablets

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# Heating, Ventilation and Air Conditioning

## Filtered Air is Conditioned (Cooled) Causing Condensate with Antimicrobial Tablets

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# Heating, Ventilation and Air Conditioning

## Supply Fan

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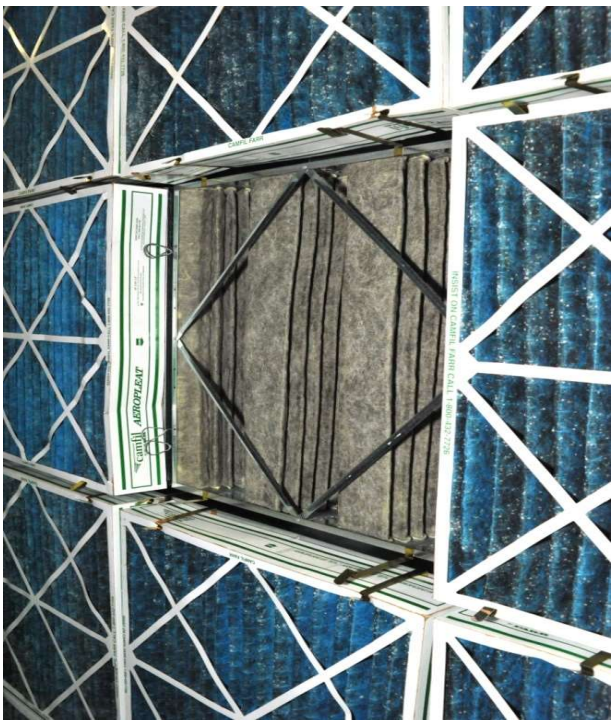
# Heating, Ventilation and Air Conditioning

## Roughing Filter with MERV 14

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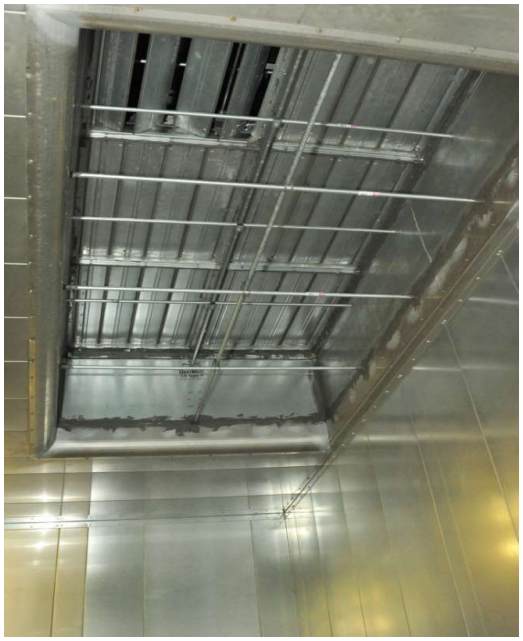
# Heating, Ventilation and Air Conditioning

## Back Side of MERV 14 with Humidification Rods

# Heating, Ventilation and Air Conditioning

## Filtered and Conditioned Air Supplied to Patient Rooms



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# Heating, Ventilation and Air Conditioning

## Supply Air to Hospital Patient Rooms


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# Heating, Ventilation and Air Conditioning

## Exhaust Fans on Roof

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# Thank you