MODULE 142

HVAC&R SKILLS WORKSHOP

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AIR CLEANERS

Skills summary

What?

This Skills Workshop provides an introduction to different types of air cleaners and how they are used.

Who?

Aimed at practitioners who design, construct, operate or maintain buildings and HVAC systems.

This Skills Workshop provides an introduction to different types of air cleaners, their operation, components, benefits and applications, as well as how they should be placed.

The workshop also looks at using air cleaners for HEPA retrofit applications, creating positive and negative pressure rooms, and after decontamination.

PULLOUT

What are air cleaners?

Air cleaners are designed to purify localised air by extracting the air through a filtration system, then re-supplying the filtered clean air back into the room or zoned space.

Depending on the application and requirements, this filtration system may include the following:

- Multi-staged particulate filtration (pre-filter and HEPA filter)
- Multi-staged particulate filtration (pre-filter and HEPA filter) and single-stage gaseous/molecular filtration (activated carbon filter)
- Multi-staged particulate filtration (pre-filter and HEPA filter) and single-stage custom gaseous/molecular filtration (custom blend of activated carbon and/or chemical media filtration designed to capture specific toxic, hazardous or corrosive gases).

Depending on the application, unit size, airflow capacity and manufacturer, filtration options may include:

Particulate pre-filter (typically rated G4 - F9 to EN779)

- Flat panel filter
- V-pleat style filter
- Multi-pocket bag filter
- Cartridge-style filter.

High efficiency filter (typically rated E11-E12, H13, H14 to EN1822)

- Mini-pleat panel filter
- Mini-pleat cartridge style filter.

Typically, the better the filter rating, the tighter the filter should fit and seal inside the housing to ensure no contaminant bypass.

Gaseous/molecular filter (typically activated carbon only or a custom blend of activated carbon and/or chemical media filtration designed to capture specific toxic, hazardous or corrosive gases such as formaldehyde, hydrogen sulphide, sulphur dioxide, ozone)

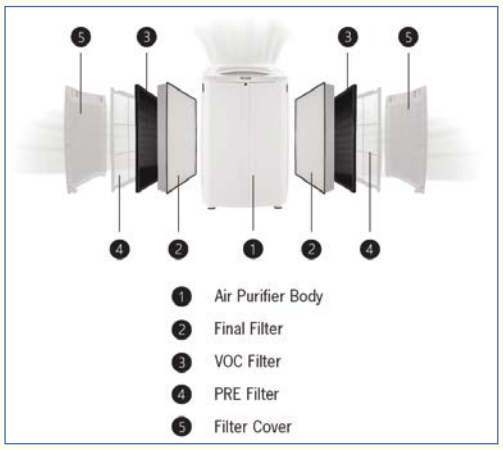
- Flat panel filter
- V-pleat style filter
- Multi-pocket bag filter
- Cartridge-style filter

- Housing or cannister filled with pelletised media.

Generally, the greater the mass of the molecular filter, the better, and longer it will work.

Additional system components typically include fans, air inlet and outlet louvres, system controls (including airflow volume/speed modes, timers, child lock, LED brightness, filter replacement indicators), status indicators, air quality sensors and indicators.

Optional accessories may include atmospheric sensor monitors, silencers, extractor arms and wi-fi connectivity.



Example of small in-room air cleaner configuration showing particulate pre-filter, molecular VOC filter and particulate final filter.

Example of free-standing large-scale air cleaner configuration showing options for all particulate filters, combined particulate and molecular filters, or all molecular filters with fan system and final safety filter.

Example of large-scale modular air cleaner configuration showing particulate bag-style pre-filter, molecular cannister-style housing filled with pelletised media, final safety particulate panel filters, and fan system.

Why use air cleaners?

The direct link between air quality and health is well documented by the World Health Organization.

The Australian government has noted:

> *"Air quality affects our health, the liveability of our cities and towns, and our environment. Air pollution, particularly from human activity, can cause health problems that affect the heart and lungs, and can cause cancer.*
>
> *"Even short-term exposure to air pollution can cause health problems. Children, the elderly and people with existing heart and lung conditions are especially affected by air pollution."*
>
> *Source: https://www.environment.gov.au/protection/air-quality*

When building/facility HVAC filtration systems are absent or insufficient for the air quality requirements of a designated indoor space, air cleaners may be used to improve indoor air quality by removing pollutants from the localised air.

Similarly, when it is not deemed viable to upgrade existing HVAC filtration due to existing infrastructure or cost (upgrades often include changes to the fan and power consumption and duct or frame modifications), the use of air cleaners to supplement existing HVAC systems may be a cost-effective solution to reduce airborne particle loads.

Benefits

The general benefits of using air cleaners equipped with HEPA air filters include:

- Reduced particle loads through the removal of dust, allergens, viruses, and airborne contaminants from the localised airstream
- Cleaner indoor air quality for a healthier indoor environment
- Improved health for people due to the removal of fine particulates from the localised airstream
- Cleaner indoor air quality for a cleaner indoor environment
- Extend the product life of foods for consumption, stocked products in storage areas, and equipment
- Reduced need for surface cleaning through the efficient removal of dust and airborne contaminants
- Reduced energy costs through efficient air purification
- Recirculated indoor air reduces the need to draw in and heat as much cold air from outside, resulting in more efficient heating and reduced energy costs. Significant energy savings are offered in rooms with high ceilings during colder months, since heat rises and the temperature is higher at the ceiling than the floor. Air cleaners remix the air to equalise the difference in temperature, resulting in warmer air by the floor and reduced fan operation for the heating system.
- More efficient production through zone cleaning within larger premises. Extremely pure air is delivered to areas that are particularly sensitive, while other areas of the room can maintain a lower requirement level. This minimises the number of operational disturbances caused by dirt and dust and saves money.
- Flexibility to move units around to suit occupancy and cleanliness requirements.

Similarly, general benefits for air cleaners equipped with HEPA air filters and custom gaseous/molecular filtration designed to capture specific toxic, hazardous or corrosive gases include:

- Removal of nuisance odours, harmful vapours or chemical problems within a specified area
- Removal of corrosive gases to protect electronic and production equipment
- Reduced maintenance and repair time on plant and machinery
- Helping facilities comply with industry guidelines and regulations.

Air cleaners can be used to improve localised room conditions such as:

- Positioned in an airlock to reduce the residual particle load
- Positioned near workstations to reduce the particle load from staff
- Positioned near equipment or processes that generate large number of particles (such as process lines and conveyors).

Applications

Air cleaners may be used for a wide range of applications, including:

- *Residential* – bedroom, study, living areas
- *Commercial* – offices, meeting rooms, hotel rooms, classrooms, communal shared spaces and waiting areas, canteens and food prep areas, indoor recreation facilities, gymnasiums, sporting facilities, locker rooms
- *Building and construction* – offices, meeting rooms, communal shared spaces
- *Healthcare* – communal shared spaces and waiting areas, canteens and food prep areas, offices, hospital suites and consulting rooms, dental surgeries, cleanrooms and research laboratories, negative pressure or positive pressure applications, IVF clinics, patient immune suppressed areas (chemotherapy treatment and waiting areas)
- *Food and beverage* – cleanrooms and test laboratories, production line clean air zones, raw material or finished production storage areas, bakeries, internal eating areas
- *Life science* – communal shared spaces and waiting areas, canteens and food prep areas, offices, cleanrooms and research laboratories, cannabis grow houses, negative pressure or positive pressure applications
- *Warehousing and logistics* – product storage areas, localised pollution control near workstations (meat works/coolrooms)
- *Microelectronics, data centres and switch rooms*
- *Industrial* – control rooms of petrochemical facilities, metal refining and pulp and paper mills, timber facilities, welding/oil mist applications, printing facilities, packaging production
- *Mining and oil rigs* – staff accommodation areas.

Similarly, air cleaners may be useful for specific applications, including:

- Reducing indoor pollen counts
- Reducing vehicle exhaust emissions within indoor spaces near heavy traffic zones
- Reducing bushfire smoke emissions within indoor spaces
- Reducing mould spores and odour within indoor spaces in the aftermath of flooding.

Air change rates/air changes per hour

Air change rates or air changes per hour (ACH) is a measure of how many times the air within a defined space is replaced each hour, and minimum recommendations are often specified within ventilation design standards.

With regards to air cleaners, ACH determines how many times the air cleaner can clean a room or designated clean space in one hour. For example, four air changes per hour means that four times the air volume of the room is filtered through the air cleaner per hour (a full room volume every 15 minutes).

Generally, the recommended ACH per hour depends on the level of contaminant generation with a space. Contaminants refer to levels of fine particulates and of odorous, toxic, hazardous or corrosive gases.

* Refer to the relevant ventilation design standards and industry guidelines for specific applications.

ACH	Contaminant generation level
2–6	Light (residential rooms, minimal shared spaces)
8–10	Average (communal shared spaces, healthcare)
12–14	Heavy (cleanrooms general and after decontamination, negative or positive pressure applications, industrial)

Common types of air cleaners

Common air cleaner styles include:

Small portable in-room style on wheels

Freestanding in-room style on wheels

Floor or wall-mounted (via mounting stand/bracket)

Ceiling-mounted (via hanging nuts/wire, suspension arms)

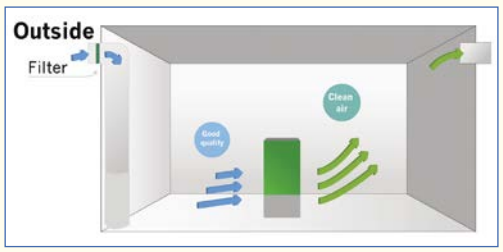
In-duct concealed.

Air cleaner unit placement

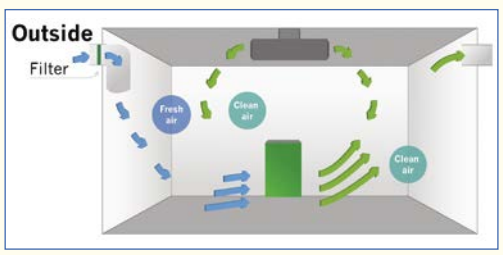
Placement of a single, or multiple units is important to ensure adequate and optimal airflow around these systems and throughout the room, and to deliver filtered clean air throughout the designated space to meet the desired air quality requirements for that space.

Common configurations include:

- Central floor freestanding unit in rooms with displacement ventilation

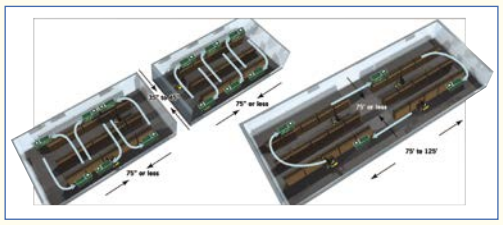


- The inflow of supply air travels along the floor and maintains a lower temperature than the air in the room. Therefore, you should aim the purifier's outlet in the same direction as the flow so that it works with the airflows and not against them.
- Combined ceiling suspended and floor standing units in rooms with high ceilings



Because larger particles fall to the ground considerably faster than nanoparticles, this configuration captures particles at the point where they are most commonly found.

- Ceiling-mounted cross-bay airflow configuration for large areas
- Ceiling-mounted circular airflow configuration for large areas



Single or dual direction air intakes

Not all air cleaners are designed in the same way. Some include single-direction air intakes, others include dual or two-way air intakes, allowing the air cleaner to filter air from two separate directions. *Please check system specification data with your air cleaner manufacturer or supplier.*

Air cleaners with inbuilt two-way air intakes can be cost effective in some situations. For example, in a hospital room, a wall-mounted air cleaner with inbuilt two-way air intakes could have one side ducted to the outside so that 50 per cent fresh air is taken from the outside, filtered, then supplied to the room. The remaining 50 per cent of air would be taken from inside the room, filtered, and redistributed around the room (creating a positive pressure). Alternatively, two separate air cleaners with single-direction air intakes could be used to recreate this same scenario.

Air cleaners for HEPA retrofit applications

For applications where a HVAC system upgrade to HEPA filtration is required to create clean spaces, the supplemental use of air cleaners equipped with HEPA air filters may be a cost-effective way to help reduce the particle load.

Typically, high-efficiency HEPA filters require large amounts of air to pass through the ventilation system. An increase in efficiency and thus pressure drop in a HVAC system can mean possible changes in the fan, power consumption, and a requirement for duct or framework modifications. Accommodating these changes without an upgrade to an existing HVAC system is not always possible.

An effective and swift alternative to a HEPA filter upgrade in the HVAC system is the use of portable air cleaners equipped with HEPA air filters to help reduce the particle load.

Air cleaners for positive pressure rooms

The concept of creating positively pressurised rooms is to ensure that the air introduced to the room is clean and any air that escapes will not affect other patients or staff. Typically, positive pressurised rooms are created by introducing ultra-clean fresh air from outside sources into a room to create positive pressure within the room. Ensuring that both the external air introduced to the room and the air within the room are cleaned to the highest standard, is key to creating optimal positively pressurised environments.

Within healthcare, positive pressure rooms can assist with improved patient room conditions, as an HVAC upgrade in low immune patient environments, or during mould/fungus prevention works.

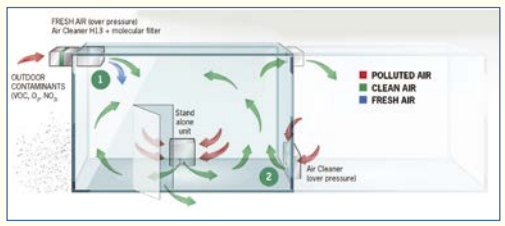
To generate positive pressurised rooms using air cleaners:

Option 1

Ducting the air intake from the external environment can allow for clean air to be introduced into the target room. This can be wall- or ceiling-mounted. The air cleaners use HEPA filtration to ensure no unwanted contaminants can enter the room, and dual-air intakes allow additional room-side air cleaning.

Option 2

Ducting the clean air outlet into the target area from an external room can ensure that the target area becomes positively pressurised with HEPA-filtered clean air.



Next issue:
Measuring water flow

Air cleaners for negative pressure rooms

The concept of creating negatively pressurised rooms is to utilise the exhaust air system to contain any infectious contamination within the isolated room and prevent transmission to corridors and attached rooms. Because the air in negatively pressurised rooms is often hazardous to other patients, the idea is to take the contaminated air from the room, clean it, and distribute the cleaned air externally.

Within healthcare, negative pressure rooms can assist with waiting rooms, triage, isolation/quarantine rooms, nuclear medicine, serialisation rooms, laboratories, autopsy rooms, soiled workrooms, holding rooms, or decontamination rooms.

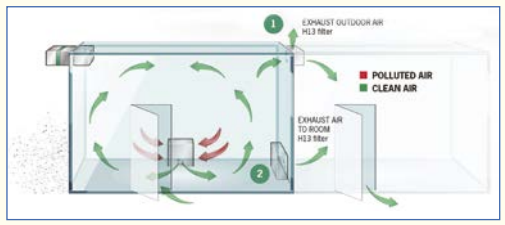
To generate negative pressurised rooms using air cleaners:

Option 1

With the air cleaner positioned outside the area and with slip-collar-mounted ducts on both intake and exhaust, excess air can be drawn through the exhaust duct to outside, generating negative pressure.

Option 2

With the air cleaner positioned inside the room, the outlet should be ducted to a new environment to help create a negative pressure room.



To recirculate HEPA-filtered air:

1. Positioned where needed and draws in air through the bottom, exhausting filtered air through a vented top. Note: some models draw in air through the top, exhausting filtered air through a vented bottom.
2. Positioned outside the area and with slip-collar-mounted ducts on both intake and exhaust, air is drawn through the duct, filtered, and exhausted through a duct back into the originating area.

Air cleaners following decontamination

For life science and healthcare applications where cleanroom processes have been compromised and have been exposed to contamination, it becomes necessary to decontaminate the cleanroom and equipment before restarting work. This involves sanitisation of the cleanroom and equipment with a cleaning agent in gaseous form such as hydrogen peroxide (H_2O_2). Due to the toxicity, gaseous concentration levels need to be reduced before the room can be used safely again by personnel. This process can take several hours. Portable air cleaners equipped with custom gaseous/molecular filtration can fast-track the process of removing the hydrogen peroxide in gaseous form to reduce downtime. ■

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