NATIONAL ENVIRONMENT AGENCY

# Practical Tips for Managing Particulate Matter Levels in Naturally Ventilated and Split-Unit Air-Conditioned Indoor Spaces During Haze

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# INTRODUCTION

## Preamble

Periodic trans-boundary haze due to forest fires in the region can affect the air quality in Singapore. Particulate matter (PM) has been identified as the main air pollutant in such haze episodes [1].

Singapore is not affected by such trans-boundary haze throughout the year. Any exposure is short-term in nature and such exposure may vary from year to year. As international studies are based on long term exposure to air pollution, there is little robust data on the longer-term effects of short-term exposure to haze like the pattern seen in Singapore. During a haze episode, please refer to MOH's "*Health Advisory for the General Public*".

In addition, some practical tips to reduce exposure to haze particles include:

- When the outdoor air quality becomes unacceptable, close doors and windows. This will help to reduce the rate of haze particles entering the home.
- Stay indoors and reduce physical activities.
- Re-open the windows and doors in the home when the outdoor air quality improves.
- Wet-cleaning methods (e.g. mopping or wiping) can be performed to remove settled dust.
- Fans or air-conditioners may be used for air circulation and cooling. If the air-conditioner draws unfiltered air from outside (e.g. window units), close the outdoor air intake openings.
- Portable air purifiers can be used to further reduce the indoor particle level.
- A fan-filter system that removes fine particulate matter can be installed if more ventilation is needed.

## Scope

This document provides practical tips to mitigate high indoor PM levels during haze episodes.

# PROTECTING THE INDOOR ENVIRONMENT FROM OUTDOOR PM

When the outdoor air quality appears to be worsening, the closing of doors and windows will help to reduce the rate of PM entering a naturally ventilated space. However, an enclosed indoor environment may lead to an accumulation of heat, carbon dioxide or other pollutants, especially in highly occupied spaces. Periodic re-opening of windows or doors, when outdoor air quality improves, will help to ventilate the enclosed room.

## Use of portable air purifiers

Portable air purifiers may be used to further reduce indoor PM pollutants [2-7]. The sizing and specification of air purifiers are typically calibrated or determined for rooms without continuous introduction of pollutants. Air purifiers may not work at the specified performance ratings if doors and windows of the room are not closed. The number and size of air purifiers thus depend on the effectiveness of the air purifiers used, as well as air flow obstructions and leakiness of room [5-7].

### *How to choose a portable air purifier*

#### *Efficient filter*

Indoor air purifiers usually consist of several layers of cleaning mechanisms to remove a variety of indoor pollutants, including fine particles [5, 6]. The air purifier should preferably consist of an effective filter, such as a High Efficiency Particulate Air (HEPA) filter to remove fine particles effectively..

#### *Appropriate size*

When choosing a suitable portable air purifier, users should consider the air flow of the system and the efficiency of the filters. A rating that users could refer to guide purchase is the Clean Air Delivery Rate (CADR)[1]. This allows users to estimate the appropriate air purifier size needed for the room its use is intended for [8]. Typically, three CADR numbers (in units of $ft^3$/min), one each for smoke, dust, and pollen are indicated on a CADR label. The smoke CADR is the most appropriate reference for haze pollutants. An appropriate air purifier should have a smoke CADR number that is at least 3 times the volume of the room in cubic metre, or 1/12 of the volume of room in cubic feet (see Annex A for example). A larger CADR number only means faster cleaning in an enclosed room. It should be noted that the placement of an air purifier in the room may also affect its effectiveness, for instance, the air flow of the air purifier should not be obstructed [9].

There are many effective air purifiers without CADR ratings in the market. Users should obtain from the manufacturer information that backs any claim on efficiency of removal of fine PM. Intact rubber seals and heavy-duty housing may also be suggestive of high quality manufacturing that maintains the air purifier's structural integrity.

[1] The CADR ratings were developed by the Association of Home Appliance Manufacturers (AHAM) in the United States.

For reference purposes, a list of portable air purifiers and suppliers can be found in the haze website (http://www.haze.gov.sg/haze-update/List-of-Portable-Air-Cleaners-and-Suppliers.aspx).

## Use of mechanical ventilators

Due to the restricted flow of air in an enclosed environment, heat, humidity, carbon dioxide, indoor-generated PM and other undesirable pollutants can build up over time, especially in spaces with high occupancy or high level of activities. In such settings, windows and doors should be opened periodically when air quality improves. An alternative can be to install a fan-filter system (mechanical ventilator) to replace stale indoor air with filtered outdoor air. In addition, a MERV 13 or F7[2] or higher filter may be considered for the fan-filter system to reduce PM particles at the air intake (Annex B). A schematic illustration of a fan-filter system is shown in figure 1.

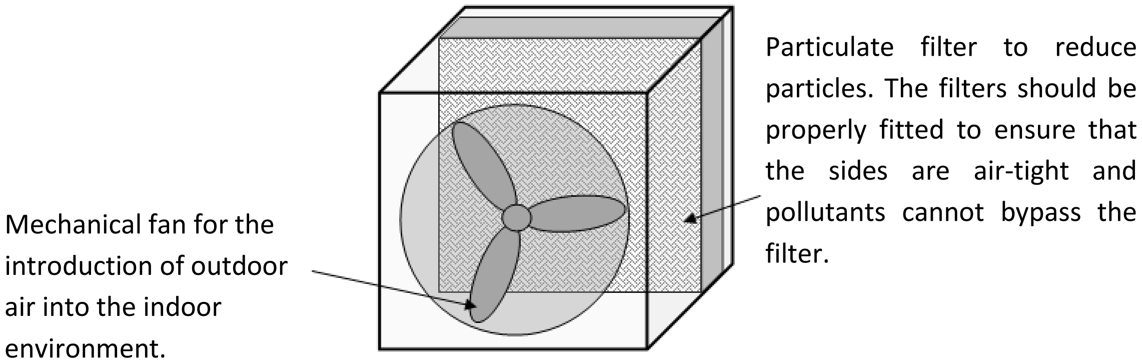


**Figure 1. Schematic illustration of a fan-filter system**

Such fan-filter systems may be custom-made, using fans and appropriate filters (Annex B) to filter outdoor air as it is drawn into indoor space, until commercial products are made available.

[2] MERV stands for the Minimum Efficiency Reporting Values, and is a measurement scale designed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) to rate the effectiveness of air filters. A MERV 13 filter must have particle removal efficiencies of <75% for particle size 0.3 – 1μm; ≥90% for particle size 1 – 3μm; and ≥90% for particle size 3 – 10μm.
The corresponding specification used by the European Union is the European Norm. A filter rated as F7 in the European Norm has approximately similar particle removal efficiency as a MERV13 filter.

# REFERENCES


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## Annex A. Selecting filtration-based air purifier using CADR

For room Volume in $ft^3$, **Required CADR (in $ft^3$/min) ≥** $\boldsymbol{Volume/12}$,

**or**

For room Volume in $m^3$, **Required CADR (in $ft^3$/min) ≥ 3 x** $\boldsymbol{Volume}$

For example, a room with an area of 40$m^2$ (or 430 $ft^2$) and a height of 3m (or 9.8 ft) has a room volume of 120 $m^3$ (or 4214 $ft^3$). In order to achieve the AHAM recommended cleaning efficiency, the required CADR value should at least be 360 $ft^3$/min.

This value can be found on CADR (smoke) on the AHAM label such as this:

**Rated value (usually in $ft^3$/min) should be larger than the calculated value for Required CADR (in $ft^3$/min)**

## Annex B. Efficient filters to remove fine particles.

The performances of some effective filters (based on two different classifications) are tabulated below for illustration purposes:

| EN779/ EN1822 | ASHRAE Standard 52.2 | | | |
|---|---|---|---|---|
| Filter class | MERV | **Removal Efficiency (E)** Percent (%) in diameter range | | |
| | | 0.3 – 1μm | 1 – 3μm | 3 – 10μm |
| H10* | 16 | 95% ≤ E | 95% ≤ E | 95% ≤ E |
| F9 | 15 | 85% ≤ E < 95% | 90% ≤ E | 90% ≤ E |
| F8 | 14 | 75% ≤ E < 85% | 90% ≤ E | 90% ≤ E |
| F7 | 13 | E < 75% | 90% ≤ E | 90% ≤ E |

The above table shows the approximate comparisons between Minimum Efficiency Reporting Value (MERV) and EN779/EN1822 filter classes[3], and aims at providing user-convenience in selecting the appropriate filter. User should note that there are differences in test procedures, aerosol types and sizes used in these standards.

*Filter classes of at least H10 (i.e H10, H11, H12, H13 and H14) may be considered generally as HEPA filters according to EN1822.

[3] Global standards for filter testing. P. Tronville, r. D. Rivers, *ASHRAE Journal* **48** (8), 2006, 58 – 62.