



Diesel particulate filter for the home

The State of California reported that diesel particulate is "responsible

for about 70% of California's estimated known cancer risk attributable to toxic air contaminants." By 2015 virtually all California diesel trucks were required to have filters that remove 90% of diesel particulate emissions. In the three-county Portland area, 3/4 of commercial trucks do not have a diesel particulate filter. So living near a truck route in Portland can be dangerous to human health and may require installing an indoor air filter.

For more information and citations on diesel particulate and human health, go to:
<http://portlandcleanair.org/files/reports/new%20PCA%20diesel%2012.pdf>

For a map of Portland-area neighborhood diesel particulate exposure go to:
<http://portlandcleanair.org/files/reports/Portland%20Diesel%20Particulate%20Concentrations.pdf>

Choosing an indoor air filter to remove airborne diesel particulate

Diesel particulate is comprised of unusually small particles .1 microns in diameter. HEPA filters are rated for particles .3 microns and larger. However, a study by NASA found that HEPA removes up to 100% of .1 micron particles due to the unusual physics of nanoparticles. See:
<https://ntrs.nasa.gov/api/citations/20170005166/downloads/20170005166.pdf>

Woodsmoke from fireplaces and wildfires is also dangerous to human health. Multnomah ranks in the worst 1% of counties for woodsmoke exposure according to the EPA. Like diesel particulate, woodsmoke is also comprised of .1 micron particles

which can entirely removed with HEPA. For more information on woodsmoke go to:
<http://www.portlandcleanair.org/files/Woodsmoke%20factsheet%20PCA.pdf>

HEPA filters are rated to capture up to 99.7 percent of all contaminants 0.3 microns or greater while a filter with a MERV rating of 13 to 16 is rated to remove up to 75 percent of all airborne particles 0.3 microns or greater from the air. NASA cites only HEPA as effective for .1 micron particle removal.

Build your own home HEPA filter for lowest cost

Four HEPA panels made by 3M can be purchased on Amazon for \$68 here:

www.amazon.com/Filtrete-FAPF-F2-2P-AMZ-Premium-Filter-White/dp/B07XCY8NT3/ref=sr_1_5?dchild=1&keywords=filtrete+true+hepa&qid=1607986920&sr=8-5



DIY HEPA filter for diesel particulate and woodsmoke

This is enough panels for a do-it-yourself box fan home air purifier, so that you do not damage the fan with backpressure, explained here:
<https://tombuildsstuff.blogspot.com/2013/06/better-box-fan-air-purifier.html>

The HEPA panels should go on the front of the fan and some distance away from the blades, explained here:
www.quora.com/Where-should-an-air-filter-be-placed-relative-to-the-fan-for-best-efficiency/answer/Thomas-Talhelm

A box fan can cost as little as \$20 but for \$51 you can buy the Air King fan, the best box fan I could find. This is a more durable fan with a better motor and is more quiet and powerful. Its noise, measured in decibels on high, medium, low speed is 65, 48, and 43. It is available here:
<https://www.amazon.com/gp/product/B0007Q3RM?tag=htwtbal1010-20>

The directions to make this air purifier are here:
<https://tombuildsstuff.blogspot.com/2013/06/better-box-fan-air-purifier.html>

However this design needs to be modified, using the four 13 x 8.2 HEPA panels instead of the much less effective 20 x 20 MERV panels.

This design above has 3-4x the HEPA surface area for \$68 as the Blue Air replacement filter below for \$80. The advantage of spending an extra \$3-400 on ready-made filter, and up to 3x as much on HEPA panel replacements, is they are much more quiet and smaller units with a sensor to work harder when particulate levels rise.

The best ready-made home HEPA filter

Any HEPA air filter will work if powerful enough for your room size.

The Rabbit Air SPA-700A (\$550 on Rabbit Air website) was our choice for the best HEPA air filter. It appears to be by far the quietest choice at 20.8 - 45.6 db. It achieves this by using a brushless Panasonic motor. This motor is also unusually long lasting. The unit is only seven inches thick and can be placed right against the wall or even wall mounted. Other air purifiers require the unit to be located well away from a wall. The filter medium costs \$85 and lasts one year. The Rabbit Air includes an ionizer which can be shut off with a switch. Ionizers are controversial; we recommend never turning it on.

The Blue Air 480i (\$417 on Amazon), our second choice, is 32 - 52 db. Consumer Reports charged us \$8 so I could view their air purifier ratings; Blue Air models had the top two spots in 2018. Blue Air makes four models based on room size. I called Blue Air and they told me a unit can only effectively filter one room. The filter medium lasts 6 months to one year and costs \$80 for a normal filter and \$120 for the addition of carbon which removes some VOCs. Ironically, diesel particulate is made of

carbon and is doing the same thing as the carbon in the filter, capturing harmful VOCs. However diesel particulate delivers these poisons to our lungs where it can cross the blood barrier due to its microscopic particle size and enter the bloodstream. The Blue Air uses HEPA as well as electrostatic charge generation but NASA advises this is not necessary.

Both the Rabbit Air and the Blue Air have a particulate sensor, on auto mode it increases its motor speed when you cook or whenever it senses an increase in particulate. We reviewed the CA Air Resources Board (CARB) website which reported both Rabbit Air and Blue Air are safe in regard to how much ozone it produces. Both companies have been in business for decades so getting a replacement filter many years from now should be no problem. Replacement of the filter medium could be dangerous, releasing particles in the process. Doing this outside would be ideal.



Rabbit Air SPA-700A

Diesel particulate filtration for HVAC systems

An HVAC filter capable of removing diesel particulate can be installed by homeowners using tin snips, duct tape, and sheet metal screws. HVAC air filter media such as HEPA can create back pressure which can harm a furnace and may require an expert to install. Diesel particulate can be removed using electrostatic systems which do not create back pressure. Such a filter can be installed on the supply or return side. While supply side is preferred, due to space constraint and other factors, HVAC filters can sometimes only be set up on the return side. The unit requires a grounded outlet. If you do not have this near the installation spot, you would need an electrician to install one. We contacted two Portland HVAC installers listed online. They both recommended the Trane CleanEffects which is apparently only sold through HVAC companies. One charged a total of \$1,126 for the unit and installation, the other charged a

total of \$2,580. One charged \$139 to make a home visit and provide a quote. Portland Clean Air recommends the Honeywell 300, which is available on Amazon for between \$530 – 600 depending on the air duct size you need.

We decided the

Honeywell 300 is more effective than the Trane CleanEffects, and other electrostatic HVAC filters available based on this research paper: www.aprilaire.com/docs/default-source/default-document-library/eac_lab_comparison.pdf

This device removes up to 99.98% of airborne particles - including those as small as .1 micron. This makes it up to 100 times more effective than a standard 1-inch filter. Standard air cleaners have filters that are dense, they stop the dust by trapping it in a slightly porous filter. The fewer the pores, the more dust it can trap. However, this not only stops particles, it also stops the air from moving as well. So, you may not be as comfortable, and less air is cleaned efficiently. This is called pressure drop. Electrostatic filters become less effective if not cleaned as recommended, but do not cause pressure even when clogged.

The HVAC technician we talked with said they were installing a lot of the Trane CleanEffects in new buildings and have not seen many problems. The few problems are with the electronics; power surges have fried the electronics and once replaced the filter works fine again. Therefore an additional surge protector may be required. When asked about the lifespan they remarked the filter itself should never really have any problems, except for the electronics as mentioned above and felt it should probably last about 20 years.

The two ways to measure the effectiveness of an air filtration system are Minimum Efficiency Reporting

Value (MERV) and Clean Air Delivery Rate (CADR). MERV is designed for systems with media-based filters, and involves loading the filter with varying size micron particles until the percent of efficiency fails to meet minimum air filtration

standards. CADR does the same as well as measures the rate at which clean air is delivered to your living space.

Often there is concern about ozone with some air filtration. Electrostatic systems produce very low ozone output falls far below EPA standards, much lower than appliances such as toasters, and heaters.

How do I know if my neighborhood has high diesel particulate levels?

Our model for airborne

Portland diesel particulate

concentrations in neighborhoods

based on EPA NATA's model and ODOT 24-hour truck counts:

<http://portlandcleanair.org/files/reports/Portland%20Diesel%20Particulate%20Concentrations.pdf>

A free and easy way to check for diesel particulate is run a finger up and down your door or porch hand rail. If your finger turns black or dark grey, this is most likely an unusually high amount of diesel particulate because you live near a truck route. We have found having so much exposure that the particulate is this visible is unusual, and only found in the most extremely affected areas such as adjacent to the in-city highways and heavily trafficked surface roads.

Even if your home is near a busy unfiltered diesel truck route, it is currently unknown how much airborne diesel particulate migrates into the house from outside.

For more information on Portland particulate monitoring go to:

<http://portlandcleanair.org/files/reports/Diesel%20particulate%20monitoring.pdf>



**Honeywell 300
HVAC filter for diesel
particulate and woodsmoke**

How can I be sure exactly how much airborne diesel particulate is in my house?

Because directly measuring diesel particulate is so expensive, we are left guessing how much of a problem indoor diesel particulate exposure is. We have found no literature that answers this either.

There is not an ideal device to measure airborne diesel particulate. A Pocketlab Air or Purple Air monitor can measure PM1 which is particles smaller than one micron. However, they cannot see particles smaller than .3 microns. These devices cost approximately \$300. Portland Clean Air owns 15 Pocketlab Air monitors and we are working to analyze years of data from over 50 Purple Air and similar DIY devices build by Chris Eykamp. However it is not known at this time how PM1 measurements from this device correspond to .1 micron particle counts.

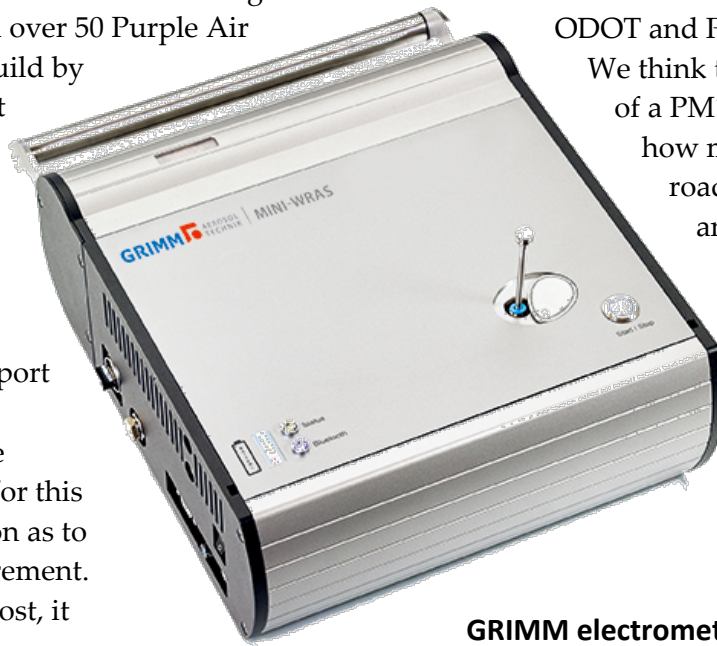
One source cited in this report used a Dylos DC1100 to measure PM1 however the website and user manual for this device gives no information as to how it obtains this measurement. Considering its low \$200 cost, it appears to have the same limitations as the PocketLab Air and Purple Air:
<http://www.dylosproducts.com/dc1100aqmc.html>

The gold standard to measure .1 micron particles is a Grimm electrometer, a \$43 K device that counts particles and measures their individual sizes, from .01 to 35 microns. Diesel particulate leaves the tailpipe at .01 microns and quickly aggregates to .1 microns. Particles sizes and amounts are reported by the Grimm on 41 evenly spaced channels including .01 and .1 micron channels. See more about the Grimm here:
<https://www.grimm-aerosol.com/products-en/indoor-air-quality/the-wide-range-hybrid/1371/>

Another option is a \$35 K aetholometer which precisely measures color change of filter paper. DEQ owns many aetholometers. An aetholometer cannot tell the difference between woodsmoke and diesel particulate, both registering as the same color on the filter paper.

Portland Clean Air cannot currently afford to purchase the Grimm electrometer so we are working on a statistical analysis option to answer this question. We are using data from Purple Air, Pocktlab Air, and home built Plantower sensor monitors to calculate how readings change in relation to distance to truck routes based on ODOT and PBOT 24-hour truck counts. We think this will explain how much of a PM1 reading is woodsmoke and how much is coming from the road. We welcome statistical analysis volunteers to work with our team on this task.

We are writing grants and requesting money from individuals to purchase a Grimm electrometer. Another approach is to find people anywhere in the world who own this device or journal articles reviewing data from this instrument to partially answer this question for us.



**GRIMM electrometer
monitor for precise
measurement of airborne diesel
particulate and woodsmoke**

If you have questions, comments, or would like to volunteer or donate please contact Greg at:
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