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Air Purifier Comparison: Performance & Efficiency

How to Truly Measure an Air Purifier's Ability to Clean Your Air

CELIOS G200 | WHITE PAPER

Evaluating the performance of a portable home air purifier is a detailed process.

Evaluating the performance of a portable home air purifier is a detailed process. Many of the accepted testing methods used for evaluating air purifiers came from the Association of Home Appliance Manufacturers (AHAM) an organization founded in 1967 by manufacturers in the electrical appliance industries. The organization has developed voluntary standard test methods for measuring the performance characteristics of various electrical appliances. AHAM's test standard for evaluating the performance of air purifiers is called the "CADR" test. Clean Air Delivery Rate (CADR) testing was developed by the AHAM as a way for the general public to evaluate the effectiveness of air purifiers on the market. Although the idea of creating an easy to understand method for "scoring" air purifiers on the market seems well intentioned, the test they have developed is severely limited. CADR is a test of how well an air purifier can remove airborne particulates down to 0.3 microns in size from a controlled room environment within a 20 minute testing duration. The rated performance or CADR is computed by multiplying the airflow output of the device by the particulate removal efficiency within the 20 minute duration which provides the air purifier with a numeric score that is computed using the equation CADR = ε X Q where, ε is the air purifier's particle removal efficiency percentage (%) and Q is the volumetric air flowrate in cubic feet per minute (CFM) from the air purifier.

CADR test limitations include:

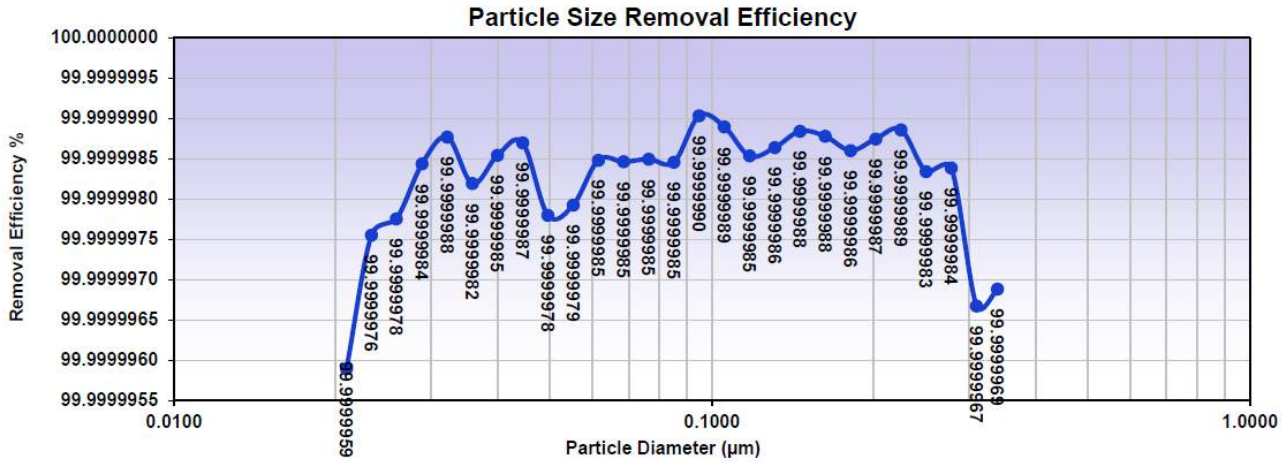
1. The CADR test weights a devices fan over filtration performance.
2. "Ultrafine particles" (particles smaller than 0.3 microns in size) are not tested.
3. The test duration is only 20 minutes long.
4. CADR does not test for volatile organic compounds (VOCs) and gases.

Despite the significant limitations of the CADR test method, it is still considered by much of the industry as an acceptable method for evaluating air purifier performance and claims. However, due to these limitations Celios along with other premium brands do not use CADR to evaluate performance. If achieving a high CADR score was all an air purifier company was concerned with then it would be as simple as picking a powerful fan and a filter technology good enough to remove "larger" particle sizes at an efficiency a little over 50%. The end result of designing a product this way would lead to an air purifier that recirculates dirty air in your environment around at a fast rate. A design like this is good for a CADR score but not good for use in a home.

What follows is a description of the test methods with explanations used for validating the performance claims of the Celios G200.

Particulate Filtration Performance Testing

To evaluate our filtration performance, unlike many of our competitors, we do not simply quote the filtration performance of the filter media that we are using. We use the rigorous EN1822-5 test standard to demonstrate that our filters have no air "by-pass" and maintain seal integrity so that the air coming out of the filter cartridges is completely filtered and maintains (in our case surpasses) the specification of the filter media. The EN1822-5 test standard, evaluates a filters' particle removal efficiency in a size range between (20 nm – 300 nm). This particulate size range includes the most dangerous and most abundant types of particles known as "ultrafine particles" that are less than 100 nm in diameter. The reported efficiency from the EN1822-5 is given at the lowest measured efficiency value recorded during the challenge. The EN1822-5 test is also performed on fully constructed filter assemblies/cartridges and thus represents what the filtration performance would actually be when connected into the device (as opposed to the efficiency of the filter material by itself which can have many leaks when assembled). Filter cartridges from the G200 were sent to a reputable 3rd party vendor (Blue Heaven Technologies) to carry out



Test Results

Initial / Final Resistance ("WG): **0.74 / 0.75**
MPPS Determination (µm): **0.0209**
Efficiency at MPPS (%): **99.99999589**
Projected Rating (Min.Integrel for E10=85%): U17

Viral Filtration Efficiency (VFE) at an Increased Challenge Level GLP Report Results:

Test Article	Total PFU Recovered	Filtration Efficiency (%)
01VFE123	30	99.99976
02VFE121	<1[a]	>99.9999919
03VFE073	<1[a]	>99.9999919

[a] There were no detected plaques on any of the assay plates for this test article.

Bacterial Filtration Efficiency (BFE) at an Increased Challenge Level GLP Report Results:

Test Article	Total PFU Recovered	Filtration Efficiency (%)
01BFE164	18	99.99975
02BFE035	3	99.999958
03BFE029	<1[a]	>99.999986

[a] There were no detected colonies on any of the assay plates for this test article.

the EN1822-5 test. The test results showed that our filters can achieve seven 9's (99.99999%) of efficiency at the lowest performing particle size region (MPPS) of the filter in the ultrafine particle size range. This result far exceeds (3000 times better) the standard HEPA filtration performance of three 9's (99.97% @ 300 nm).

At the same 3rd party test facility we performed a modified CADR test where we compared the level of ultrafine particles in the 3rd party test chamber room before and after cleaning with the standard procedure of the test facility vs. cleaning with the G200. The standard cleaning procedure of the 3rd party test facility consisted of a large HEPA filter combined with a high powered fan that when powered on had a much higher CADR than the G200. The results showed that after 90 minutes of runtime the G200 removed ultrafine particles at an efficiency greater than 99% over the entire range of particles challenged in the room. In contrast, the standard cleaning procedure used by the third-party test procedure only removed up to 85% and for many particle sizes fell well below this value (less than 65%). This test demonstrated that a higher CADR air purifier does not necessarily translate to a cleaner environment.

Virus and Bacteria Removal Efficiency

Beyond the typical particle and VOC removal efficiency tests it is also important to know how well an air purifier can perform when challenged against airborne bacteria and viruses. Bacteria and Virus Efficiency (BFE/VFE) removal tests are not a standard part of the CADR testing protocol. It is typical for manufacturers to claim their removal performance of bacteria and virus based solely on their particulate removal performance. At Celios we have taken this approach a step forward by not only demonstrating the ability to remove particles that are within the size range of bacteria and viruses, we also had our filter cartridges sent to a reputable 3rd party (Nelson Labs) to perform VFE and BFE tests on our filter cartridges at an airflow rate level that is within the range of the G200's operating airflows when in use. When testing for virus efficiency performance our filter cartridges were challenged with PhiX174 bacteriophage which is one off the smallest known viruses (25 nm - 27 nm) in size. The virus was aerosolized into airborne droplets and delivered to our filter cartridges as a challenge. The result was that our filters can filter out over 99.99999% of the aerosolized viral load. The test for the bacteria filtration efficiency (BFE) was conducted in a similar fashion as the VFE test except, the aerosolized challenge was Staphylococcus aureus. As with the VFE test, our results from the BFE test showed that the G200 can remove over 99.99999% of the challenged aerosol.

VOC Removal Testing

As mentioned previously, another downside of judging the performance of an air purifier based on the CADR method is the fact that there is no evaluation of the VOC removal performance of an air purifier. Many air purifiers will claim they can help with removing

odors and VOCs from the air; however, they provide little to no evidence of how effective their device actually is at removing these pollutants. Like most of the industry we use activated carbon to adsorb the VOCs and odor pollutants from the air. This is one of the oldest and most effective ways known to remove these types of pollutants which is why it is trusted by so many. However, as with all "collecting" (catching, trapping, adsorbing, etc.) techniques for filtration there are important design considerations that must be considered for the implementation to be effective in real use situations. The two most important design considerations for activated carbon to be effective in a consumer environment are, surface area and residence time. Surface area is related to how much activated carbon you have available for VOCs to adsorb onto, meaning the more activated carbon you have, the better adsorbing performance you get. Residence time relates to the amount of time the polluted air is in contact with the activated carbon. The longer the time that the air is moving in the activated carbon, the better the activated carbon is at adsorbing the VOC pollutants. Celios has implemented these key design requirements by using bulk granular coconut shell activated carbon as opposed to the thin single layer sheets that are used by many other brands. Using an adequate amount and thickness of granular style coconut shell activated carbon we were able to maximize surface area and residence time without drastically limiting air movement. This "balancing act" in design has allowed us to show through third party testing how effective our device is at removing common chemical airborne contaminates.

After 8 hours of testing the G200 removed 99% of toluene, 99% of D-limonene, 71% of formaldehyde.

We submitted our device to a reputable independent 3rd party test facility (Intertek), where they performed VOC reduction testing (ISO 16000-3, ISO 16000-6 Referencing NRCC-54013). In the test the G200 was challenged with three VOCs representative of what are found in homes: formaldehyde, toluene, and D-limonene. They found that after 8 hours of testing the G200 removed 99% of Toulene, 99% of D-Limonene, 71% of Formaldehyde.

Conclusion

At Celios we understand that if the air coming out of an air purifier is not properly filtered, then there is little benefit to circulating the air quickly around a room. For this reason, we used the independent testing methods described above to assure that the air coming out of the G200 is of the highest possible quality. This commitment to quality is why we go above and beyond typical air purifier test requirements to demonstrate that what we say is actually what the device can do. We use the best technology for removing not only the large particulates, but also the smallest most dangerous and most abundant particulate pollutants in the air, ultrafine particles. We also believe that it is important to demonstrate through test results a purifiers' ability to remove any claimed pollutant including: viruses, bacteria, and VOCs so that a user has a better understanding of the air being delivered from their device.

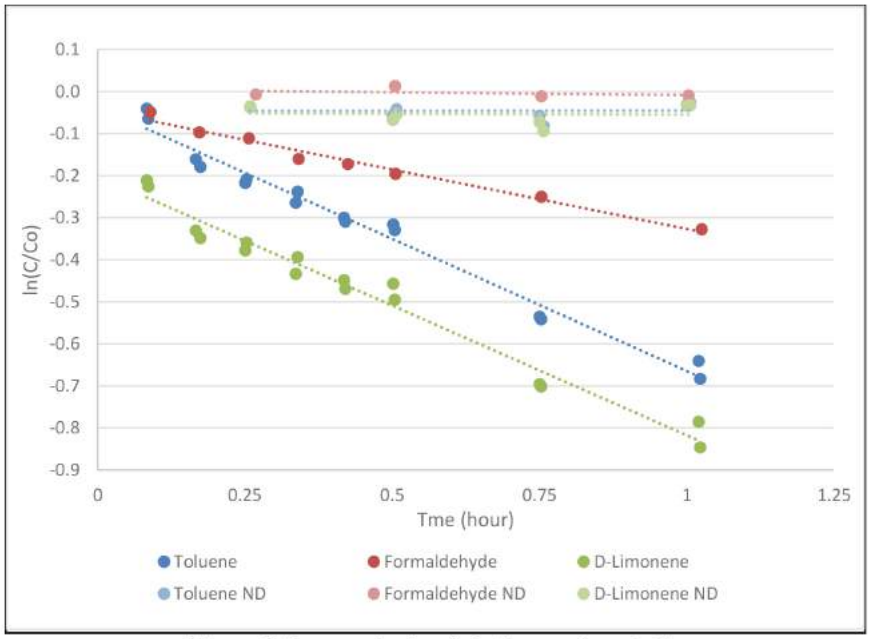


Figure 2: Removal rate of challenge chemicals.