

An Odor Test was performed to compare the Genesis Air catalyst panels with a 50/50 blend of activated carbon and potassium permanganate using the criteria set forth by ASTM E-679-04. After injecting both the carbon testing rig and the Genesis testing rig with 10 ppm of nitric oxide gas, the resulting Odor Detection Threshold was determined to be 1 for each technology. After injecting both the carbon testing rig and the Genesis testing rig with 50 ppm of nitric oxide gas, the resulting Odor Detection Threshold was determined to be 51 for the carbon blend and 71 for the Genesis Air panels. This demonstrates that for NO reduction at typical concentrations, Genesis was tested to be comparable to the carbon design.

In November of 2016, Genesis Air decided to perform an Odor Test using ASTM E 679-04: Standard Practice for Determination of Odor and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits protocol. In this way, Genesis Air could be considered an alternative to the PENNFirst carbon blend basis of design. After examining the results of an Odor Test using Nitric Oxide gas (NO) and observing the results, Genesis Air PCP panels achieved “comparable” to the carbon blend design.

Two testing rigs were constructed, side by side, one for the Genesis catalyst and the other for the carbon design. In this manner, simultaneous samples could be taken with identical atmospheric conditions. The other conditions that must be equivalent in both rigs were the average air speed, height and width dimensions at the catalyst/carbon location and the concentration of the NO gas injected.

The average airspeed thru the test rig units must be equivalent to the AHUs being designed for the PENNFirst project. According to design engineers, the air handler cross-section is 122” W x 140” H with airflow of 52000 CFM. This equates to @ 440 FPM.

Sampling Design:

The PENNFirst carbon blend design calls for:

- 50/50 blend of activated coconut shell carbon and potassium permanganate in a V-bank configuration.
- 6” across the “V”, 24” along the “V” and 18” in direction of airflow.
- A 4” prefilter and a 2” dusting filter.

Air Filters USA provided Genesis with three of these modules at 6” x 24” x 18” and 33 lbs per module. The carbon test rig holds three of these modules with minimal blank off for a total of 100 lbs of carbon blend, along with the required 20” x 24” x 4” MERV 13 prefilter and the 20” x 24” x 2” MERV 8 dusting filter. The carbon blend module is rated at 0.45” WC at 500 fpm. By contrast, the catalyst rig requires one 20” x 24” x 6” catalyst panel at 15 lbs with a 20” x 24” x 4” MERV 13 prefilter. The catalyst panel is rated @ 0.05” WC at 500 fpm.

To perform an odor test, two test rigs were used. Both rigs were set up for 440 FPM across the face of the filtration device. They both allowed for a measured NO introduction at the intake and a measured NO at the discharge. In this manner, the inlet and outlet concentrations were determined for both devices. This also allowed a correlation of measured concentration to the Odor Units determined by ASTM E 679-04.

The “left” rig was set up using a Genesis 2008B1 unit. In direction of airflow, this rig consists of one 20” x 24” x 4” MERV 13 filter, one 2021 2HO UV shield, one 2021PCP compound and one 2300 CFM backwards inclined impeller, dialed back to @ 1500 CFM to provide 440 FPM average face velocity. The 2021PCP compound houses three 20” UV lamp and ballast assemblies with 35 ft<sup>2</sup> of TiO<sub>2</sub> catalyst material.

The “right” rig was set up using a Genesis 2008B shell. This will have an identical cross-section to the left rig. In direction of airflow, this rig consists of one 20” x 24” x 4” MERV 13 filter, three 6” x 24” x 18” carbon blend modules, one 20” x 24” x 2” MERV 8 dusting filter and one 2300 CFM backwards inclined impeller, dialed back to @ 1500 CFM to provide 440 FPM average face velocity.

A cylinder of NO with a stainless steel regulator was obtained for the test. The injection lines were plumbed with ¼” stainless tubing. The injection line tee’d before the intakes. The resulting two lines each had stainless steel needle valve to help regulate the amount of gas injection. After the needle valve, the lines ran to either intake, split once more for even mixing, and then entered the intake.

**Sampling Procedure:**

The gas was allowed to flow into one of the test rigs. A NO meter in the intake recorded the concentration in parts per million (ppm) every second and allowed the operator to dial in the desired amount of NO. After the gas was injected, it traveled through the ductwork to the device and then to the discharge. Another identical NO meter located in the discharge provided the resulting NO concentration. Once the desired inlet concentration was achieved and maintained for 30 seconds, a sample of the resulting discharge mixture was collected. The bag was allowed to fill in the airstream for 10 seconds and then evacuated. This was done three times. On the fourth fill, it was collected, sealed and tagged. The samples were then sent to the lab to begin the Odor Test.

Initially, the NO was to be injected at the OSHA Odor Threshold Level of 1 ppm. However, a steady state condition at that concentration proved impossible to achieve. At an intake concentration of 10 ppm (10x the OSHA Detection Threshold), steady state conditions were achieved. Discharge samples were collected and the Odor Test was performed on these resulting concentrations. The results show that no odors were detected by any panelist at this concentration using either technology, indicating Genesis is a comparable technology. Afterwards, another test was performed at a highly elevated injection concentration of 50 ppm to determine at what level the discharge became detectable. This concentration was 50x the OSHA Detection Threshold and half the value of the OSHA Immediately Dangerous to Life or Health level. The results are below:

	Guess	Detection	Recognition
Carbon Blend Odor Units, 10 ppm	<b>6</b>	<b>1</b>	<b>1</b>
Genesis Air Odor Units, 10 ppm	<b>6</b>	<b>1</b>	<b>1</b>

	Guess	Detection	Recognition
Carbon Blend Odor Units, 50 ppm	<b>155</b>	<b>51</b>	<b>17</b>
Genesis Air Odor Units, 50 ppm	<b>178</b>	<b>71</b>	<b>25</b>

With typical values of NO found around diesel exhaust, both technologies virtually eliminated any trace of odor. Once the concentrations were increased to dangerous levels, the odor units were found to be very comparable. After evaluating the two technologies by the Odor Test for NO, the Carbon Blend has

a slightly less Odor Units than the Genesis. This demonstrates that for NO reduction at typical concentrations, Genesis was tested to be comparable to the carbon design.

### Maintenance

Carbon blend:

- The Carbon Blend has to be replaced when it is loaded, which could be quarterly depending on RH levels and loading.
- The whole array must be replaced, so the initial cost is very similar to the maintenance cost.
- For this air handler, maintenance must remove and replace roughly 120 modules, some of which require 2 people on a 12' ladder removing a 33 lb minimum module.
- The air handler must be shut off to remove and replace the modules in case the carbon blends are considered a HAZMAT, and must be bagged.
- Disposal practices and fees vary, but many times the Carbon Blends must be incinerated.

Genesis:

- The Genesis Air lamps must be replaced after 15-16 months of continuous use. The lamps can be disposed of in the same manner as the regular fluorescent lamps.
- The Genesis Air PCP media can last up to 15 years with proper maintenance.

### Weights

Carbon blend:

- The carbon blend module weighs 33 lbs/ft<sup>2</sup>, or 3900 lbs.

Genesis:

- The Genesis Air PCP weighs 4.2 lbs/ft<sup>2</sup>, or 500 lbs. The total weight for the replacement lamps in this air handler design is 35 lbs.

### Power

Carbon blend:

- The brake horsepower required to run an airhandler with a large carbon bed varies, but generally must be able to handle an extra 1.5" of static for the adsorption beds.

Genesis:

- The power required to operate the Genesis lamps is roughly 0.05 kW/ft<sup>2</sup>, or 6 kW.

## Moisture

Carbon blend:

- It is widely known that even a low level of moisture in the entering air can greatly inhibit the adsorption of activated carbon.

Genesis:

- The catalytic reaction is not inhibited by higher levels of moisture in the air.

## For One 52,000 CFM Air Handler:

	Carbon Blend	Genesis
<b>Replacement Frequency:</b>	Monthly to annually, depending on moisture loading	Lamps every 15 months, catalyst media last 15 years with proper maintenance
<b>Replacement Count:</b>	120 modules	69 lamps
<b>Replacement Cost:</b>	Wholesale cost of \$300 per module, or \$36000 per changeout	Lamps cost roughly \$0.08 to \$0.10 per CFM, or \$5200 per changeout
<b>Replacement Weights:</b>	3900 lbs	35 lbs of lamps
<b>Labor Considerations:</b>	Does the changeout need to happen after hours? Overtime?	Lamp changeout will take one person about 5.75 hours.
	Shutting down AHU to perform changeout?	Not necessary.
	How to move roughly 2 tons of carbon to and from AHU?	Not difficult.
	Number of personnel needed to perform the changeout?	2-3 is ideal.
	Do you need a scaffold crew?	A 12' ladder is needed.
<b>Disposal Considerations:</b>	Landfill charges, bagging and HAZMAT, Incineration	Same manner as fluorescent
<b>Power Required:</b>	The AHU must be able to handle an extra 1.5" static	Lamps require 0.05 kW/ft <sup>2</sup> , or 6 kW.
<b>Additional Filtration:</b>	Requires a 4" MERV 13 prefilter and a 2" MERV 8 post filter.	Requires a 4" MERV 13 prefilter
<b>Performance:</b>	Will help remove VOCs and odors. Requires a dusting filter to prevent carbon dust from entering the supply. Does nothing for surfaces. Can collect and spawn bioaerosols. Will offgas once loaded. Performance degrades with moisture.	Will help remove VOCs and odors. Prevents biologic growth on irradiated surfaces. Can reduce bioaerosols. Does not broadcast "cleaning agents". Not affected by higher levels of moisture.