Not All 3A Recovery Wheels Limit Contaminant Transfer

A Comparison of Laboratory Test Data Shows Substantial Differences Between Products Claiming to Use a 3A Desiccant and the SEMCO 3 Angstrom Wheel

by John Fischer

Not All 3A Recovery Wheels Limit Contaminant Transfer

Several energy wheel manufacturers have begun to offer products claiming to use 3A molecular sieves. These manufacturers assume that their products will perform in the same manner as the SEMCO product since they employ the same type of desiccant used by SEMCO. This is a very poor assumption.

The 3 angstrom wheel is a SEMCO invention. SEMCO was the first to produce a 3 angstrom total energy recovery wheel globally. Producing a total energy wheel that exhibits "true" 3 angstrom behavior – effectively limiting the transfer of contaminants larger than 3 angstroms – is very complex. The cations within the molecular sieve desiccant, if not processed correctly, will move or be exchanged by other cations and will thereby allow contaminants larger than 3 angstroms to be transferred. In addition, there are numerous "grades" of 3A molecular sieves designed for various processes, some more costly than others and not all provide the desired 3 angstrom behavior. The binding mechanism used to secure the desiccant to the wheel matrix can also transfer contaminants if not carefully selected and evaluated. Likewise any exposed (uncoated) aluminum wheel surface will naturally oxidize and significant contaminant transfer can result from this unwanted oxide layer.

It is therefore very difficult to achieve the "true 3 angstrom" behavior exhibited by the SEMCO Total Energy (TE) wheel. SEMCO has invested 20 years of research and development to optimize its proprietary process. The performance of this product has been proven by years of successful operation, numerous independent field investigations as well as three independent laboratory evaluations. In contrast, the competition has been producing wheels claiming to use 3A molecular sieves for 1 to 4 years (depending on the competitor) so there is very limited operating experience for these products. Most importantly, to date, no independent test data has been provided to the market to support claims regarding the ability of these products to limit contaminant transfer. Therefore, either no effort has been made by these manufacturers to test the product or they have chosen to withhold this information from potential users.

The research data contained within this document highlights the risk of assuming that wheels reported to use a 3A molecular sieve desiccant will perform in the same manner as the SEMCO wheel. Upon reviewing the data, it becomes clear that no assumptions regarding wheel performance or carry-over claims should be made by wheel manufacturers until their products have been independently tested in accordance with the ASHRAE Standard 84 using "chemicals of concern" typically encountered in building environments.

Independent Carry-over Data Available to the Industry

From the beginning, SEMCO has led the market by providing independent carry-over testing of its products and making the resultant data available to the industry. Recently, a SEMCO competitor Seibu Giken has circulated a document that summarizes carry-over testing completed by researchers at Kanazawa University(1) in Japan. This investigation tested both the Seibu Giken HI-PANNEX-ion enthalpy wheel and a purchased "commercialized" 3A molecular sieve wheel, currently available to the Japanese market.

The Kanazawa University investigation concluded that while both wheels exhibited contaminant transfer for the chemicals tested, the HI-PANNEX-ion wheel exhibited significantly less transfer than that associated with the 3A molecular sieve wheel tested. These results are shown as a graphic included in the Kanazawa University summary and then again by Figure 1, contained within this document, but normalized to reflect the same face velocity used by the Georgia Tech Research Institute (GTRI)(2,3) to allow for a side by side comparison of data.

The Kanazawa document does not disclose the supplier of the 3A wheel tested. It does state that the wheel was a synthesized 3A wheel product, currently sold in Asia and having a wheel diameter of 32 centimeters (12.6 inches). Since the SEMCO TE product is not synthesized, marketed in Japan nor produced smaller than about 100 centimeters, it is clear that the wheel tested was not manufactured by SEMCO. Most importantly, the degree of contaminant carry-over observed is in sharp contrast to the data reported by GTRI for the SEMCO TE product – confirming that the 3A product tested at the Kanazawa University was from a manufacturer other than SEMCO.

Opportunity to Compare Research Findings

The research completed by Kanazawa University provides an opportunity to compare the results of their work with data collected previously by the Georgia Tech Research Institute for the SEMCO TE 3A molecular sieve wheel. In addition, Hygieia Sciences[4] has recently observed contaminant testing completed at the SEMCO test laboratory, of a second non-SEMCO 3A molecular sieve wheel product. This testing was conducted in accordance with ASHRAE 84 recommendations for tracer gas testing, using the same contaminants of concern selected by GTRI as part of their 1991 and 1999 research investigations. This data allows three different total energy recovery wheels employing 3A molecular sieve desiccants, all marketed as exhibiting three angstrom behavior, to be effectively benchmarked with regard to contaminant transfer.

Figure 1 combines the contaminant carry-over data reported by Kanazawa University for both the HI-PANNEX-ion wheel and the commercially available 3A wheel purchased in Japan, independent data for the SEMCO TE wheel collected by GTRI and data recently collected in the SEMCO laboratory and observed by Hygieia Sciences for another commercially available 3A wheel. As previously mentioned, the data from Kanazawa University was normalized to the 400 ft/min (2 m/sec) face velocity used by GTRI when testing the SEMCO wheel, allowing all wheels to be compared at the same operation conditions.

Figure 1. Normalized comparison of carry-over data for all wheels tested.

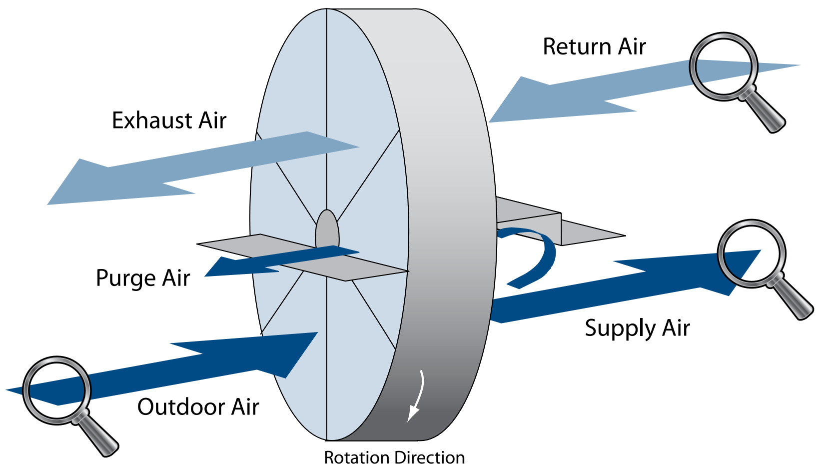
	Measured Contaminant Carryover Percentage Data – Normalized Data (400 ft/min face velocity)			
	Seibu-Giken ION (note 1)	Non-SEMCO 3A (note 1)	SEMCO 3A (note 2)	Non-SEMCO 3A (note 3)
Acetaldehyde/Formaldehyde	9.0	52.5	none detected	17.4
Acetic Acid	14.6	n/a	none detected	35.7
Carbon Dioxide	1.5	3.0	none detected	4.1
Isopropyl Alcohol	10.5	18.0	none detected	3.9
Methanol	n/a	n/a	none detected	11.3
MIBK	1.5	19.5	none detected	2.5
Propane	3.0	6.0	none detected	0.2
Xylene	3.0	28.5	none detected	13.1
Sulfur Hexafluoride	n/a	n/a	< .04%	0.3

Note 1 – wheels tested by Kanazawa University with data normalized to 400 ft/min for comparison.
Note 2 – SEMCO wheel tested by the Georgia Tech Research Institute at 400 ft/min, acetic acid data measured by SEMCO not GTRI.
Note 3 - wheel tested at SEMCO's laboratory.
Note: n/a means data not available.
Note: Contamination carry-over percentage is defined by ASHRAE as follows:
= (Supply Air Concentration – Outdoor Air Concentration)/(Return Air Concentration – Outdoor Air Concentration)

Review of Data Normalization and Test Procedures Used

The contaminant carry-over percentage is influenced by the supply air face velocity used for testing. As the supply air face velocity (and thereby airflow volume) is decreased, any contaminant carry-over is distributed into a lesser mass flow and therefore the carry-over percentage is increased. Normalization is simply done by taking the data measured by Kanazawa University and correcting it for the ratio of the difference between the 3 meters/second face velocity referenced within the report summary and the 2 meters/second used by GTRI. It is important to point out that GTRI chose the 2 meter/second (400 ft/min) face velocity to ensure the most conservative test protocol (trying to make the product "fail") with regard to contaminant carry-over.

Figure 2. Air sampling locations.



Reviewing the procedures used for these investigations, the data summarized within Figure 1 should provide a legitimate comparison since all research was completed in a controlled laboratory environment. The test contaminants were measured with either precision gas detection devices or mass spectrometers. The samples analyzed by GTRI and Hygieia Sciences (at the SEMCO laboratory) followed ASHRAE Standard 84 tracer gas sampling recommendations. Air samples were simultaneously collected via sampling grids located within the outside, supply, and return (challenge) air ducts using ten-liter Tedlar® sampling bags. Contaminant analysis was immediately conducted using a Bruel & Kjaer (B&K) photoacoustic multi-gas monitor and/or a Viking portable mass spectrometer.

Conclusions Based Upon Research Findings

This research shows that significant differences exist in the amount of contaminant transfer exhibited by total energy recovery wheels marketed as products employing a 3A desiccant. Three different 3A wheels were tested, in a similar manner. Only the SEMCO product exhibited "true" 3 angstrom behavior, showing no detectable contaminant transfer. The other two 3A wheels investigated resulted in unacceptably high levels of contaminant transfer for most of the chemicals investigated. The average carry-over for the two competitive 3A products was found to be 11% and 21% while the maximum carry-over levels observed were 35% and 52%.

The research also indicates that the contaminant transfer observed resulted from "adsorption" (i.e. desiccant, binder, oxidation) and not the recirculation of exhaust air. This is confirmed by the sulfur hexafluoride (SF6) data. Note that for both the SEMCO wheel and the competitor's 3A wheel tested in the SEMCO lab, the SF6 carry-over was documented to be below .3% of the challenge concentration. Therefore, any recirculated air volume would have to be no more than this percentage. For this reason, the contaminants transferred in excess of this amount must be attributed to transfer by adsorption.

Critical Duty Applications

Critical application like laboratories, hospitals and smoking facilities (i.e. casinos) must limit any contaminant carry-over as low as possible for health and safety reasons. Ideally, any carry-over associated with the energy recovery device should be below that associated with exhaust air re-entrainment between the fan outlet and fresh air intake of a well designed HVAC system. Field testing[5] has shown this re-entrainment to average approximately .2% of the exhaust air concentration for well designed laboratories. The AIHA/ANSI Standard Z9.5 – 2003 referenced by ASHRAE for proper laboratory design allows considerably more re-entrainment than this level. The SEMCO 3A product is routinely field tested and found to maintain any contaminant transfer well below this .2% level[5]. Based on the data shown within Figure 1, the contaminant transfer levels observed for the non-SEMCO 3A wheels are clearly unacceptable for critical duty applications.

In addition to health and safety reasons, there are code issues that need to be addressed. Both the NFPA 45 and the IMC code prohibit recirculation of exhaust air contaminants in laboratory applications. **As a result, independent carry-over testing involving contaminants of concern is often needed to confirm code compliance with local officials.** This testing is commonly provided by SEMCO to satisfy code requirements.

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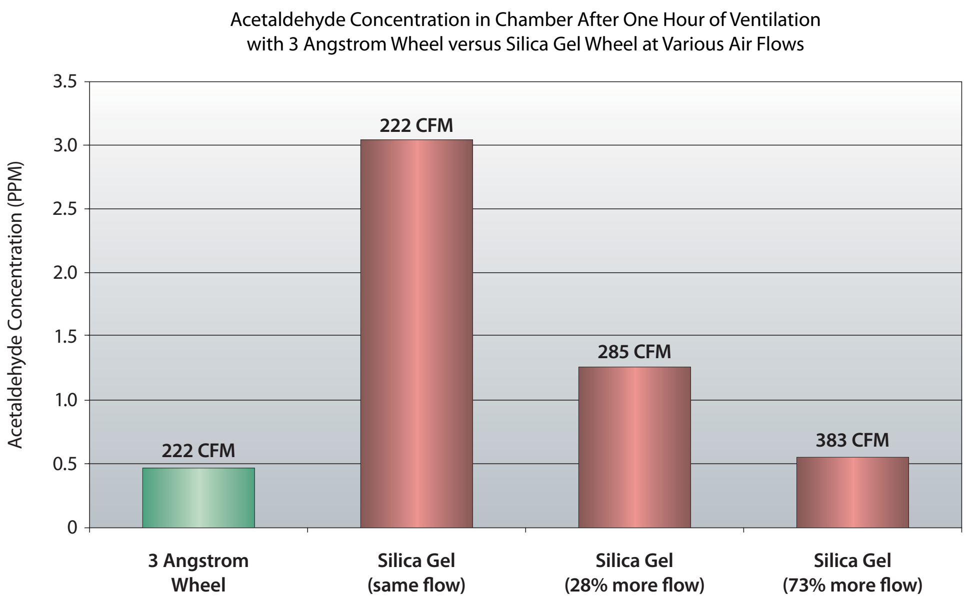
Non-Critical Duty Applications

Although the potential for impacting the health and safety of the building occupants is greatly reduced for non-critical applications, more conventional applications like schools are nevertheless negatively impacted by significant contaminant carry-over. When an energy recovery device recirculates or transfers contaminants from the exhaust into the supply airstream, the ventilation effectiveness is compromised and does not meet the intent of the ASHRAE ventilation standard. To compensate for this, significantly more outdoor air must be delivered by the ventilation system to achieve the same indoor air quality provide by a recovery device that does not recirculate contaminants.

A 2004 research report completed by the Georgia Tech Research Institute[6] concluded, for example, that the carry-over associated with a wheel tested that employed a silica gel desiccant required 73% more outdoor air to be introduced to the space to achieve the same level of indoor air quality provided by a recovery wheel that limited contaminant transfer (Figure 3).

Figure 3. Data from GTRI final report documenting significant impact on ventilation effectiveness as a function of desiccant wheel type used.



Similar findings were reported by a 2008 research project completed at Carnegie Mellon University[7] involving two major buildings on campus. The study involved the collection of air quality data from the same building, served by the same mechanical system but operated initially with a silica gel based total energy wheel then the next day using a 3A molecular sieve wheel that limited

Photo of SEMCO's Air Test Laboratory.

contaminant transfer. The report concluded that the level of indoor building pollutants was between 30% and 50% greater when the wheel that allowed contaminant transfer was used.

Put simply, a recovery device that transfers a significant amount of the exhaust air contaminants back to the occupied space is not a recovery device but a "recirculation damper". For more than 20 years SEMCO has been a strong advocate for independent contaminant carry-over testing by all manufacturers – but has met consistent industry resistance. The data contained within this document provides compelling evidence to support independent contamination testing for all products.

The facilities and services of Hygieia Sciences are now available to all manufacturers so independent contaminant carry-over testing can be easily obtained, even by manufacturers who have not invested in their own in-house air testing facility. Building owners and designers simply need to require this important testing for their projects.

Bibliography:

1) **Kodama, Akio**. "Cross Contamination Test of the Seibu-Giken Hi-PANEX-Ion Enthalpy Wheel", School of Mechanical Engineering, College of Science and Engineering, Kanazawa University. Ishikawa, Japan.

2) **Bayer, Charlene W and Downing, Chris**. "Results of Chemical Cross-contamination Testing of a Total Energy Recovery Wheel – Phase I", The Georgia Tech Research Institute, Atlanta Georgia, 1991.

3) **Bayer, Charlene W and Hendry, Robert.** "The Importance of the Desiccant in Total Energy Wheel Cross-contamination", The Georgia Tech Research Institute, Atlanta Georgia, 1999.

4) **Hygieia Sciences – Dr. Charlene Bayer, Chairman and Chief Science Officer**

Dr. Bayer Dr. Bayer founded HYGIEIA in 2008 building on her extensive research and management experience from years of experience at the Georgia Tech Research Institute (GTRI) of the Georgia Institute of Technology (GT). Her primary focus at HYGIEIA is to provide advanced technological solutions to commercial, governmental, and institutional clients' challenges for providing healthier and greener indoor environments.

5) **Downing, Chris**. "Summary Slide Showing SF6 Test Results Documenting Re-entrainment of Exhaust Air in Laboratory Buildings Tested vs. SEMCO Energy Wheel Carry-Over Results for the Same Facility", Various locations and dates.

6) **Bayer, Charlene W and Hendry, Robert**. "Total Recovery Desiccant Wheel Pollutant Contaminant Challenge: Ventilation Effectiveness Comparison - The Importance of the Desiccant in Total Energy Wheel Cross-contamination", The Georgia Tech Research Institute, Atlanta Georgia, 2004.

7) **Archer, David, Zhai, Chaoqin and Fischer, John**. "Improving IAQ at the Carnegie Mellon New House Dormitory - Field Research Supports Chamber Testing, Confirming that Avoiding Desiccant Cross-contamination within Total Energy Wheels is Essential to Optimizing Indoor Air Quality and Compliance with ASHRAE 62", Carnegie Mellon University, Pittsburgh, Pennsylvania, 2008.

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