Technology Update

Importance of the 3A Molecular Sieve Desiccant Coated Total Energy Recovery Wheel To The HVAC Indoor Air Quality (IAQ) Market

Revision 3

SEMCO® INCORPORATED

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SEMCO TECHNOLOGY UPDATE:
Importance of the 3A Molecular Sieve Desiccant Coated Total Energy Wheel to the HVAC Indoor Air Quality (IAQ) Market
(Revision 3)

Background on the development of the 3A molecular sieve "total energy" recovery wheel:

During the energy crisis of the 1970's, the interest in total energy recovery increased significantly. The manufacturers of total energy wheels grew in number, and by the end of the 1970's there were approximately 10 such companies. By the mid 1980's the number of US total energy wheel manufacturers was reduced to only 3. The reasons for this are many but include under capitalization and excessive warranty problems stemming from mechanical failures, lack of performance and cross-contamination. Such problems caused many users and specifiers to abandon the performance advantages promised by total recovery devices for less effective, sensible only technologies.

The SEMCO EXCLU-SIEVE® total energy wheel, which was introduced during 1987, was specifically designed to eliminate the problems associated with some of the past energy wheels. This product offered many enhancements; for example, increased performance, structural integrity, and the limitation of desiccant cross-contamination (accomplished through the use of the 3A molecular sieve desiccant).

Since the adoption of the ASHRAE 62-89 IAQ standard, which recommends increased quantities of outdoor air in order to maintain a healthy environment, the need for this technology is greater than ever and, as a result, the interest in total energy recovery is once again on the rise. This has caused numerous companies to enter the total energy wheel market, most of whom have little or no previous experience with this technology, and have products that have not been tested for performance or longevity. There is a significant difference between products. To avoid repeating the problems of the 1970's, a careful analysis of the options is critical.

This technology update has been prepared to discuss some of the more important technical differences between the SEMCO 3A wheel and these other products, and to help facilitate such an analysis.

What are molecular sieves and why is the 3A version the right choice for total energy wheels?

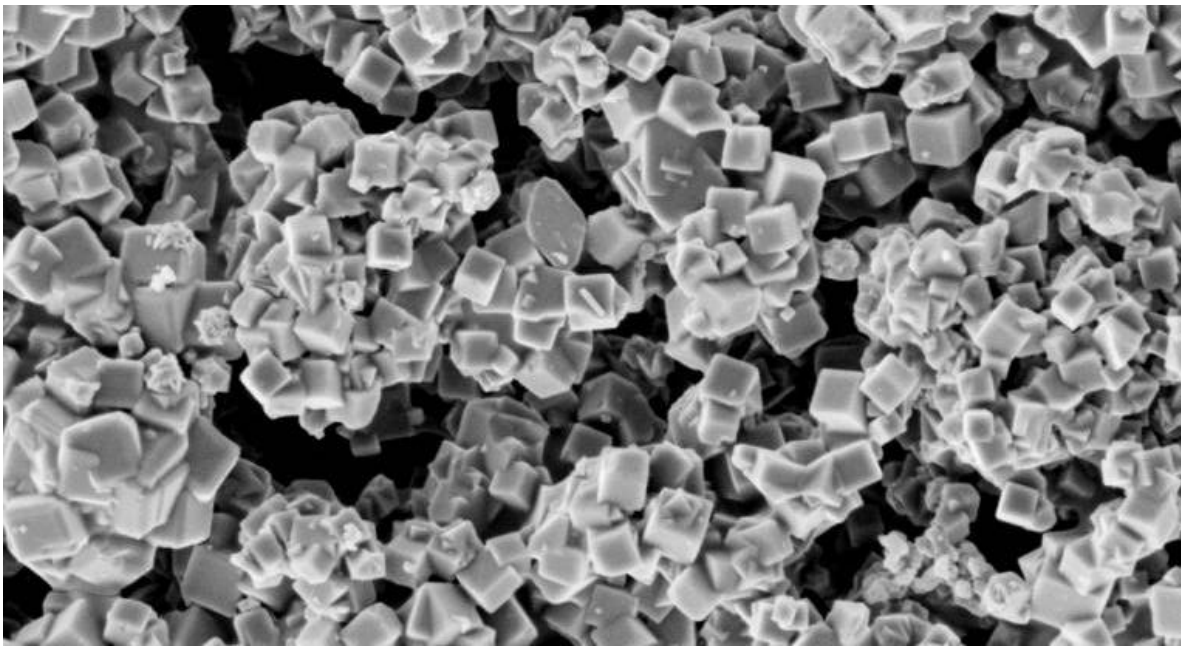

Figure 1

Molecular sieves are crystalline metal alumino-silicates (basically ceramic materials). When combined with oxygen atoms the resulting tetrahedra produce a three-dimensional interconnecting network, with a huge internal surface area into which various gases and liquids are adsorbed. By introducing cations such as sodium into the crystalline structure (similar to that used in the manufacturing of semi-conductors), the uniform pores of the molecular sieve through which the material that is to be adsorbed passes, can be controlled precisely to molecular dimensions (within 1 angstrom, which is one hundred millionth of a centimeter). This provides molecular sieves their unique advantage of being able to "selectively adsorb" materials based on their kinetic diameter, pulling in materials smaller than the size of their pore openings while excluding materials that are larger. This important capability is the primary reason for the existence of molecular sieves and gives this family of materials its name.

Far more common and less expensive desiccants such as silica gel, activated alumina, alumina oxide, deliquescent absorbents (i.e.: lithium chlorine, calcium chloride) and some of the new polymeric desiccants all adsorb and desorb water vapor as well as most other chemicals at different degrees of efficiency, since their adsorption surfaces are randomly formed and contain pores of varying dimensions. When such desiccants are applied to an energy recovery wheel serving an exhaust air stream containing contaminants, the desiccant surface has no way of differentiating water vapor from a pollutant, and will transfer some percentage of the pollutant back to the conditioned space.

Recognizing that avoiding such pollutant cross-contamination would provide a significant benefit, particularly with the growing awareness and importance of acceptable indoor air quality, SEMCO pioneered and was granted a patent for the use of a 3A molecular sieve as the desiccant for the EXCLU-SIEVE® total energy wheel. The 3A molecular sieve has the unique capability of limiting adsorption to materials that are smaller than approximately 3 angstroms. Given that water vapor has a kinetic diameter of 2.65 angstroms, it is preferentially and strongly adsorbed by a 3A

molecular sieve. Practically all materials that would be considered contaminants are larger than 3 angstroms. The net result in practical terms is an effective total energy wheel that can be applied to applications such as toilet exhaust, hospitals, painting areas and research laboratories, without experiencing detrimental effects to the indoor air environment due to cross-contamination.

This benefit has been clearly documented through an extensive independent testing program conducted by the Georgia Tech Research Institute over the past 7 years. A summary of some of the test results is provided in Table 1.

Common Indoor Pollutant Tested	Pollutant Challenge Concentration	Cross-contamination Measured for SEMCO 3A wheel	Cross-contamination Measured for Wheels Using Other Desiccants (See GTRI Final Rpt)
Isopropanol	20 PPM	None	up to 45%
Methanol	25 PPM	None	up to 50%
Acetaldehyde	50 PPM	None	up to 55%
Methyl Isobutyl Ketone	140 PPM	None	up to 40%
Xylene	100 PPM	None	up to 30%
Carbon Dioxide	1800 PPM	None	up to 1%
Propane	10 PPM	None	up to 3%
Sulfur Hexaflouride	5 PPM	None	up to 1%
Water	18,500 PPM	Up to 85%	Up to 80%

Table 1: This table summarizes independent testing conducted by the Georgia Tech Research Institute confirming the ability of the SEMCO 3A wheel to avoid cross-contamination as well as the range of contaminant carry-over measured for wheels, manufactured by SEMCO, using other desiccant materials such as silica gel and 4A molecular sieves. The concentrations and materials were selected by GTRI to be representative of a cross-section of pollutants typically encountered in indoor environments. For more detailed information, request the GTRI contaminant carry-over research summary report.

The importance of eliminating cross-contamination in projects such as research laboratories and hospital environments is obvious, however, it is also important for more conventional projects such as schools and conference rooms. Cross-contamination reduces the dilution ventilation effectiveness. As a result, a system employing a total energy recovery that allows for contaminant carry-over requires a significant increase in the amount of conditioned outdoor air that needs to be provided to the space to maintain the desired indoor air quality (see the SEMCO Ventilation Effectiveness Calculator). The cost of the larger “non-3A” system required to provide a comparable indoor air quality and the associated increase in the cost of operation will typically exceed any cost differential associated with the SEMCO 3A product.

In addition, for projects like schools and offices that have a significant amount of their exhaust from toilet areas or smoking applications, any significant cross-contamination is considered unacceptable and therefore cannot be offset by increasing outdoor air quantities. These types of projects require the benefits only offered by a 3A molecular sieve.

Are there other reasons for using the 3A molecular sieve in the SEMCO energy wheel?

Another very important reason for using the 3A molecular sieve is to obtain superior performance at high face velocities which results in a more compact wheel design for a given air flow quantity.

The 3A molecular sieve's higher rate of adsorption increased latent efficiencies

During the development phase of the EXCLU-SIEVE® wheel, SEMCO identified an additional benefit offered by the 3A molecular sieve. Since the pore size of the 3A sieve is very close to the critical diameter of a water molecule and because of the potassium cation incorporated into the 3A molecular sieve crystal, the 3A sieve has a very strong "affinity" for the polar water molecule. As a result, SEMCO determined that the rate of adsorption of water is very high relative to other more conventional desiccant materials. This performance advantage allows the latent efficiency of the SEMCO wheel to remain high at high face velocities. This is not the case for other energy wheels.

Unique desiccant coating process also enhances performance

The SEMCO manufacturing process that applies the dense layer of 3A molecular sieve to the aluminum is equally important in that it coats all surfaces of the aluminum prior to forming the honeycomb structure. This does two very important things.

(1) It assures that all surfaces are evenly coated with a thick desiccant layer (high loading capability) so that adequate capacity is available to allow for equal sensible and latent transfer efficiencies under high and low humidity conditions. (see fig. 1)

This is extremely important since reduced latent capacity causes premature freezing of the wheel in the heating mode, increases demand charges during the cooling mode and limits humidity control and reduces energy savings year round.

The SEMCO wheel is one of the few products that has been tested in accordance with the ASHRAE 84 standard and the only one to date to provide latent performance data at high humidity conditions.

(2) The pre-coating of the aluminum with the "ceramic" molecular sieve adds to the corrosion resistance and thereby life of the desiccant media core. It minimizes pressure loss and maximizes recovery efficiencies. Some total energy wheels corrode the surfaces of the aluminum to form a hygroscopic surface. Others attempt to dip or spray the desiccant coating onto the wheel surface after it is in the honeycomb shape, leaving surfaces unprotected, providing inconsistent desiccant loading and plugging flutes which increases pressure loss and reduces performance.

The important combination of the adsorption properties of the 3A molecular sieve, the high desiccant loading percentage and uniform coating thickness made possible by the SEMCO pre-coating process, and the unique media depth and flute size (which is 50% greater than the competition) results in a superior performing product. Other products have claimed to be the same as EXCLU-SIEVE®, however, none have produced the performance certification to support such claims. Such claims are not credible until certified testing in accordance with the ASHRAE 84 standard has been completed.

Some wheel manufacturers now offer a 4A molecular sieve wheel, which they claim is just as good as a 3A sieve. Is that true?

As mentioned previously the 3A molecular sieve has a pore opening, through which water vapor is adsorbed, of approximately 3 angstroms. A 4A molecular sieve, which utilizes a sodium cation in lieu of the potassium cation used by the 3A sieve, has a pore opening of approximately 4 angstroms. Given that the difference is only one angstrom, this cannot possibly make much difference in its ability to limit the transfer of pollutants; right? Wrong!

The primary reason for using a 4A sieve in lieu of a silica gel, for example, would be to eliminate the adsorption of pollutants larger than the kinetic diameter of a water molecule. Using a 4A molecular sieve wheel in lieu of the SEMCO 3A wheel is not advantageous because many common pollutants have a size that will allow them to fit through the 4 angstrom opening of the 4A sieve. What is equally important is that these materials will not only fit into the 4A sieve, but in some cases may be as strongly adsorbed as water vapor, resulting in very high cross-contamination percentages. In fact, 4A sieves are used primarily by the petrochemical industry to adsorb materials other than water vapor from liquid or gas streams.

As discussed previously, water is strongly attracted to the 3A molecular sieve due in part to the fact that the 3 angstrom pore opening is very close to the size of the water molecule. For the same reason, formaldehyde, a carcinogenic compound, commonly found in indoor environments is strongly adsorbed by a 4A sieve since it has a kinetic diameter of approximately 4 angstroms and is a polar molecule. In certain applications, the use of a 4A molecular sieve may result in more contaminant carry-over than the use of silica gel, for example, since it is specifically designed to strongly adsorb and transfer materials that have a molecular size between 3 and 4 angstroms. Since many undesirable pollutants are polar and have a size that would fit into this range, a total energy wheel made with a 4A sieve may, especially at low relative humidities, perform a very effective job of transferring such pollutants from the exhaust air stream to the supply air stream - precisely the opposite of the desired behavior.

A sampling of pollutants commonly found in indoor and exhaust environments that have kinetic diameters smaller than 4 angstroms but larger than 3 angstroms include:

Material	**Common Source**
Formaldehyde	Building materials, occupants, cleaning
Methanol	materials, etc.
Carbon Monoxide	“
Carbon Dioxide	“
Methane	“
Chlorine	“
Ethylene	“
Hydrochloric Acid	“
Nitric Oxide	Cigarette smoke
Nitrogen Dioxide	“
Methyl Chloride	“
Acetylene	School, laboratory environments
Hydrogen Sulfide	
Sulfur Dioxide	

Conclusion:

Now that the research is completed to clearly substantiate the difference between the ventilation effectiveness offered by the SEMCO 3A desiccant wheel and those utilizing other desiccants, the way that total energy recovery products must be compared has changed dramatically.

• When comparing the size of the non-3A wheel with a 3A wheel, the amount of carry-over needs to be factored into the comparison by increasing the outdoor air volume required by ASHRAE 62-89 guidelines for the non-3A wheels. The research completed by the Georgia Tech Research Institute has been integrated into the SEMCO "Ventilation Effectiveness Calculator" to simplify this process.

This Ventilation Effectiveness Calculator provides information for the SEMCO TE and TE-C products as well as guidance with regard to wheels made from either a 4A molecular sieve or a silica gel desiccant. This information is provided to the industry by SEMCO since the other US manufacturers of total energy wheels have not completed the necessary carry-over testing or have chosen not to make this available for their products. Information that is available from foreign manufacturers agrees well with the results of the Georgia Tech Research Institute.

In an attempt to make this information available for all total energy recovery products, SEMCO has recommended that carry-over testing with contaminants typically encountered in indoor environments be incorporated into the ARI performance certification program and the ARI 1060 standard that is currently being formalized by an ARI Air to Air Heat Exchanger Section made up of many of the US manufacturers. Incorporating this testing into the program will require the support of the majority of the heat exchanger members, and therefore, may or may not occur.

• Once the appropriate supply airflow rate is selected for the non-3A wheels, then the unit selection must be made to provide an equivalent performance (pressure loss, sensible and latent effectiveness, etc.).

• Once this selection is made, an energy analysis can be completed to compare the relative energy savings provided by the 3A and non-3A systems.

When this appropriate comparison is made, it will become clear that the SEMCO 3A wheel is both the highest performing and lowest life cycle cost alternative. In most cases, it will also prove to have the lowest first costs as well.

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