

Use of Type A Silica Gel in Airxchange Energy Recovery Ventilation Wheels

Introduction

Energy recovery ventilation when properly applied to an HVAC system adds substantial heating and cooling capacity, provides ongoing operating savings, and improves overall system energy efficiency. In order to maximize these benefits, many systems employ a total energy wheel, also known as an enthalpy wheel, which transfers heat and moisture between the exhaust and incoming fresh air streams.

Moisture transfer in a total energy wheel is made possible by using a desiccant. There are numerous types of desiccants available in the market. This paper outlines the benefits of using Type A silica gel desiccant and address the risk of pollutant cross contamination in comfort HVAC applications.

What is Silica Gel

Silica Gel is an inert, amorphous form of silica, synthetically manufactured from the chemical reaction between sulfuric acid and sodium silicate. The internal structure of silica gel is composed of a vast network of inter-connected microscopic pores. Standard silica gels can adsorb more than 40% of their own weight of water. There are over 25 different types of silica gels each with their own unique moisture adsorption/desorption characteristics.

Silica gel is the highest capacity desiccant available today, an obvious benefit in enthalpy wheel applications. Its adsorption characteristics are a result of its highly porous nature creating a huge surface area. These pores vary in size: Type A silica gel used by Airxchange has pore sizes averaging 22 angstroms in diameter, whereas other silica gels have pore sizes up to 100 angstroms or

more. 1 gram of Type A silica gel exhibits an internal surface area of approximately 800 square meters, or stated another way; a teaspoonful has an internal area equivalent to a football field including the two end zones.

Adsorption and Desorption Characteristics of Type A Silica Gel

Type A silica gel adsorbs and desorbs gas molecules, i.e. components, through a process of molecular attraction. Molecules form a single layer on the surface and remain in gas phase. Adsorption of component molecules is driven primarily by three factors: relative vapor pressure of the component, 'competition' with other components, and the molecule's polarity.

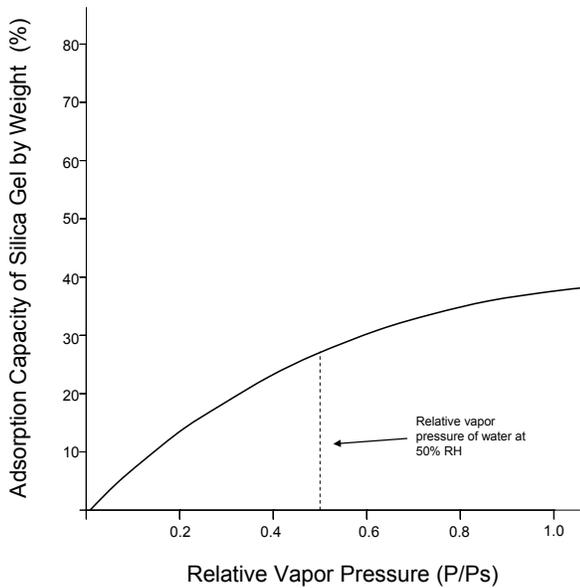
Impact of relative vapor pressure on silica gel adsorption capacity

In a typical building environment, there are many different components in air. Silica gel's adsorbent capacity is directly correlated to the component's relative vapor pressure, which is defined as the ratio of partial pressure to vapor pressure (P/P_s).

Figure 1 demonstrates the adsorption capacity for water of Type A silica gel versus relative vapor pressure. This curve is similar for other components. As relative vapor pressure of a component approaches zero, silica gel's adsorption capacity also approaches zero. Table 1 illustrates the relative vapor pressure of various components using concentration limits set by OSHA.

As illustrated in Table 1, relative vapor pressures (P/P_s) for components other than water are extremely low. For example, the relative vapor pressure of

Figure 1: Representation of Adsorption Curve for Water of Airxchange Silica Gel at Constant Temperature



water is 5,646 times that of carbon dioxide at typical indoor conditions. Given the low relative vapor pressure of contaminants other than water, Type A silica gel's effective adsorption capacity is very low and, therefore, is less likely to adsorb contaminants.

'Competition' with other molecules

An additional factor adversely impacting silica gel's adsorption capacity for any one component is the number of different types of components in the air. There is limited space on the silica gel surface, so molecules must compete with one another to occupy the available adsorption sites.

Since water exhibits a relative vapor pressure that is between 72 and 3.5 million times the components listed in Table 1, water molecules are the first to occupy available locations on the silica gel surface. Components with lower relative vapor pressures are then left to compete with each other for the few remaining locations further reducing silica gel's adsorption of any one component.

Polarity and molecular attraction

In addition to its overwhelming presence and subsequent relative vapor pressure, water's high polarity gives it an additional advantage. Molecules attach to silica gel through molecular attraction, accordingly, the higher the polarity of the component, the stronger attraction it will have to silica gel. Water has among the highest polarity of all molecules.

The combination of these factors limits the adsorption capacity, and hence cross contamination, believed to be on the order of 1-2% for components other than water.

At this low level, cross contamination is essentially a non-issue when one considers ASHRAE standards. ASHRAE standard 62.1-2004 currently categorizes air into different classes. The standard permits re-designation of Class 2 and 3 air to Class 1 as long as carry over is less than 10% and 5% respectively. For more information on ASHRAE classes of air see Airxchange's tech note on the subject.

Table 1: Calculation of Relative Vapor Pressures for Various Components

Component	Concentration ¹ (ppm)	Relative Vapor Pressure (P/Ps)	Multiple of Water Pressure Versus Component ²
Water	14,900	0.5	1
Isopropyl Alcohol	400	0.0069	72
Ammonia	50	0.000006	87,639
Carbon Dioxide	5,000	0.00009	5,646
Formaldehyde	.75	0.0000001	3,406,109

¹ Concentrations are OSHA limits for 8 hour exposure. Typical buildings should be well below these levels. Water concentration is 75°F, 50% rh

² Ratio of water to component relative vapor pressure

Other Silica Gel Types and Cross Contamination

It's important to note that there are studies demonstrating silica gel adsorbing contaminants at higher rates than discussed in this paper. These studies generally are performed with higher component concentrations than those found in comfort HVAC applications, and many use different types of silica gel than Type A, or don't disclose the type used.

As discussed above, silica gel will more readily adsorb a component with higher concentration and the resulting higher relative vapor pressure. Extending conclusions from these studies to a comfort HVAC application is misleading.

The type of silica gel can also have a significant impact. Silica gels with pore sizes larger than approximately 30 angstroms have an additional adsorption process. With larger pores, a phenomenon known as capillary condensation develops where water molecules begin to condense within the pores of the silica gel. The condensation process provides a mechanism for higher contaminant adsorption rates than monolayer attraction, because contaminants can dissolve in the water. For example, a study performed with 30 ppm toluene demonstrated Type B silica gel, with pore sizes in the 100 angstrom range, transferred 18% of

toluene's concentration as compared to Type A's transfer of only 0.8%.

Therefore, when selecting a desiccant for energy recovery ventilation, it is important to use one that has high adsorbent capacity for water, low capacity for adsorbing contaminants at low concentration, and does not exhibit appreciable capillary condensation. Type A silica gel satisfies all of these requirements.

The Importance of AHRI Certification and ASHRAE Standards

Given the inability of Type A silica gel to effectively transfer contaminants in comfort HVAC applications, the greater risk for cross contamination lies in the enthalpy wheels ability to limit seal leakage and carryover of air within the wheel. Third party measurement and certification of Exhaust Air Transfer Ratio (EATR) is provided by AHRI Standard 1060 which quantifies this leakage and provides appropriate Outdoor Air Correction Factors (OACF's) for designers. See www.ahri.org for listings of certified air-to-air energy recovery products.

Most manufacturers of energy recovery ventilation devices publish their performance under AHRI 1060. One should question critically those manufacturers not certified and should be concerned with the risk an unknown EATR may present in the context of cross contamination.