CHAPTER 2
FUNDAMENTALS

Operating Principles

Desiccant components are mechanically quite simple, durable and reliable.

DESICCANTS

Desiccants are materials which can attract and hold moisture. Nearly any material is a desiccant—even glass can collect a small amount of moisture. But desiccants used in commercial equipment are selected for their ability to hold large amounts of moisture. For example, the silica gel packets often sealed into vitamin bottles can hold moisture equal to about 20% of their dry weight. Liquid desiccant materials can hold even more moisture. But all desiccants used in commercial systems work the same way.

HOW DESICCANTS WORK

Desiccants remove water vapor by chemical attraction caused by differences in vapor pressure. When air is humid, it has a high water vapor pressure. In contrast, there are very few water molecules on a dry desiccant surface, so the water vapor pressure at the desiccant surface is very low. Water molecules move from the humid air to the dry desiccant in order to equalize this pressure differential.

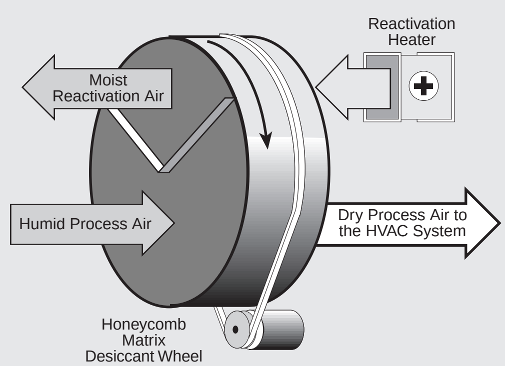
With desiccants, moisture removal occurs in the vapor phase. There is no liquid condensate. Consequently, desiccant dehumidification can continue even when the dew point of the air is below freezing. This is different from cooling-based dehumidification, in which the moisture freezes and halts the process if part of the coil surface is below 32°F.

Desiccants can be either liquids or solids, and there are many different materials of both types. The principles described here apply to both liquid and solid systems. However, the great majority of systems built for commercial buildings use solid desiccants.

DESICCANT WHEELS

Figure 1 shows the basic desiccant component—the wheel. The desiccant material, usually a silica gel or some type of zeolite, is impregnated into a support structure. This looks like an honeycomb which is open on both ends. Air passes through the honeycomb passages, giving up moisture to the desiccant contained in the walls of the honeycomb cells. The desiccant structure is formed into the shape of a wheel. The wheel constantly rotates through two separate air streams. The first air stream, called the process air, is dried by the desiccant. The second air stream, called reactivation or regeneration air, is heated. It dries the desiccant.

Desiccant Wheel Operation



Moist "process" air is passed through a rotating wheel, which looks like a ceramic honeycomb. The desiccant in the wheel absorbs moisture. Then the wheel slowly rotates into a second, heated air stream.

The hot "reactivation" air removes moisture from the desiccant so it can absorb more humidity when the wheel rotates back into the process air stream.

Figure 1. Desiccant wheel operating principles

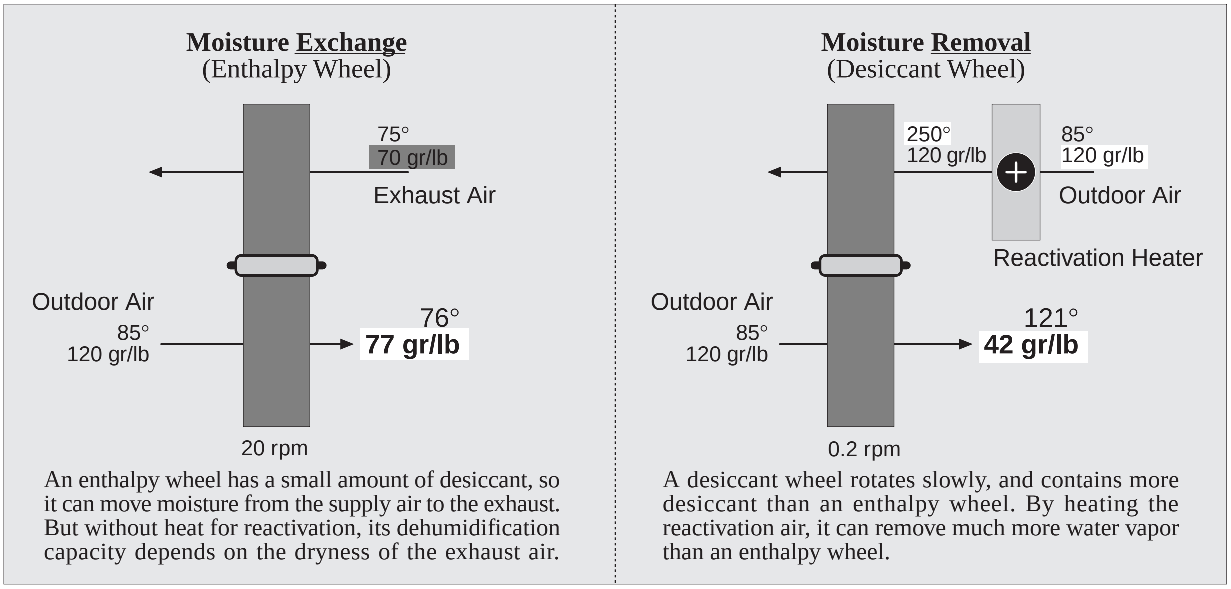


Figure 2. Desiccant wheels compared to energy recovery wheels

DESICCANTS CHANGE VAPOR TO HEAT

One aspect of desiccant wheel behavior can be confusing to the first-time user of the technology; air leaves a desiccant wheel dry, but warmer than when it entered the wheel. For example, if air enters a desiccant wheel at 70°F and 50% rh, it will leave the wheel at about 100°F and 4% rh.

This non-intuitive behavior becomes easier to understand as the reverse of evaporative cooling. When water is sprayed into air, it evaporates by using part of the sensible heat in the air—so the dry bulb temperature falls as water vapor is added to the air. That process is intuitive to children running through sprinklers in summertime.

Desiccants produce the opposite phenomenon. As water vapor is removed from air, the dry bulb temperature of the air rises. The amount of temperature rise depends on the amount of water removed. More water removal produces a greater temperature rise. The initial user naturally asks: how can desiccant systems save cooling energy if dehumidification adds sensible heat to the air? Part of the answer is that some heat is moved to reactivation by a heat exchanger. (Chapter 3, figure 4) The rest of the answer depends on the application.

For example, if air is dry, it may not be necessary to cool it if the space is already overcooled—as in a supermarket, where display cases cool the aisles as well as the product. Alternatively, dry air can be cooled using low-cost indirect evaporative cooling such as cooling towers, or with highly efficient vapor compression systems operating at high evaporator temperatures. In such cases, desiccants can save energy and energy cost.

ENERGY RECOVERY VS. DESICCANT WHEELS

Desiccant wheels are often confused with energy recovery wheels. The confusion is understandable. Both devices look nearly the same, because energy recovery wheels and desiccant wheels are constructed with honeycomb media. Also, total heat or "enthalpy" wheels contain desiccant. Also, sensible-only heat wheels are sometimes used as post-coolers in desiccant systems. But there are important functional differences between these devices which appear so similar.

Heat wheels are optimized to transfer sensible heat between two air streams, while desiccant wheels are optimized to remove moisture. These different purposes lead to differences in materials and in wheel rotation speed. An energy recovery wheel rotates at a comparatively high speed (20 rpm), to maximize the heat transfer between air streams. A desiccant wheel rotates 60 times more slowly (10 to 20 rph). The slow rotation speed allows the desiccant to adsorb more moisture, and it *minimizes* the amount of heat carried over from the hot reactivation air into the cooler process air.

If the exhaust air is dry, an energy recovery wheel can transfer some moisture out of the incoming air. But energy recovery wheels contain less desiccant than desiccant wheels. Also, the honeycomb material, air seals and support structure of an enthalpy wheel cannot endure the temperature and moisture differences typical of desiccant wheel operation. Consequently, the wheels perform quite differently.

As seen in figure 2, thermal energy used for reactivation allows desiccant wheels to remove much more moisture than energy recovery wheels. Desiccant wheels can deliver air below the moisture condition of the exhaust air. That level of dryness cannot be reached with energy recovery wheels.