How does silica gel control the relative humidity within an exhibition case?

All silica gels are hygroscopic, and respond to the relative humidity (RH) of the surrounding air in the same way as most organic materials such as paper, textiles and wood. Like organic materials, the amount of moisture in silica gel will increase as the RH rises, and will decrease when the RH falls. Unlike organic materials that expand and contract with changes in moisture content, silica gel remains stable. Also, unlike organic materials, silica gel adsorbs and desorbs much larger amounts of moisture when the RH changes under normal conditions.

All exhibition cases have some degree of leakage. If the RH in the air surrounding the case is not the same as the RH in the case, moisture will be transferred between the case and the surrounding air. As the RH in the case increases or decreases, the moisture within the hygroscopic materials of the case will gain or lose moisture in order to remain in equilibrium with the RH of the surrounding air. Since the objective is to prevent a change in the moisture content of museum objects, we add silica gel as a supplement to the case. Since silica gel, if used properly, gains or loses a much greater quantity of moisture than the organic materials on exhibition, the presence of silica gel slows down the rate at which the hygroscopic museum objects gain or lose moisture. This is referred to as the silica gel's buffering capacity.

How do we determine the buffering capacity of silica gel and why is it important?

Buffering capacity is determined by measuring the amount of moisture that is gained or lost by silica gel as the RH changes in the surrounding air, described by its M value. M is equal to the amount of water (in grams) that is gained or lost by 1 kilogram of silica gel for each 1% change in RH. For museum applications, where the case will cycle within a controlled RH range, the buffering capacity of silica gel is measured by its MH value, which takes into account changes in buffering capacity based on whether the RH increases or decreases. The M value or MH value of silica gel is important because it is used as the basis for determining how much silica gel must be added to the exhibition case.

What are the differences between the various types of silica gels used in museums?

For museum applications, the most important difference is buffering capacity, defined by the gel's MH value.

- The most commonly available silica gel, referred to in the industry as regular density or RD silica gel is universally available. Its primary function in industrial use is as a desiccant. Because of its poor hygroscopic properties around 45-50% RH and above, it is not recommended for museum applications requiring control in the mid to upper RH range. Within the range of 40-55% RH, it has an MH value of 2.
- Arten Gel and Rhapid Gel were developed for museum applications because of their high moisture buffering capacities throughout the entire RH range of interest for museums. Within the range of 40-55% RH, they have an MH value of 9.
- Art-Sorb has a high buffering capacity above 60% RH, but has a lower capacity than RD gel or Arten and Rhapid Gel in the lower RH region. Within the range of 40-55% RH, it has an MH value of 4.5. In sum, for an exhibition case maintained within the 40-55% RH range, for each pound of Arten or Rhapid Gel used, twice as much Art-Sorb or more than four times as much RD silica gel would be required for comparable buffering capacity.

How much silica gel is required in an exhibition case?

Recommended quantity of silica gel for temporary exhibition cases in rooms with moderate to good climate control are as follows: **RD gel** 9 kg/m³ or 0.55 lb/ft³ **Art-Sorb** 4 kg/m³ or 0.25 lb/ft³ **Rhapid Gel** 2 kg/m³ or 0.125 lb/ft³ Recommended quantity of silica gel for maintenance-free exhibit cases are as follows: **RD gel** 18 kg/m³ or 1.1 lb/ft³ **Art-Sorb** 8 kg/m³ or 0.5 lb/ft³ **Rhapid Gel** 4 kg/m³ or 0.25 lb/ft³

These recommendations are based on average exhibition conditions using standard assumptions about leakage rates and RH conditions within and outside the exhibit case. These recommendations were determined with the following equation, described in detail in the Objects Specialty Group article entitled Demystifying Silica Gel [Steven Weintraub, OSG Postprints (Vol. 9), 2002. Washington, D.C.: American Institute for Conservation].

$$Q = (Ceq\ D)V(Nt)/(\ MH\ F)$$

Through the application of this equation, it is possible to adjust the amount of silica gel required for a specific application. For example, if a case is measured and is known to be extremely airtight, it is possible to use less silica gel.

Why do some publications recommend 20 kilograms of silica gel per cubic meter, while others recommend only 0.5 to 1.0 kilograms per cubic meter of case volume? What is the correct amount?

The correct amount is determined by the equation, described above, and summarized by the above recommendations, based on common assumptions about typical museum conditions. Garry Thomson's book, *The Museum Environment, 2nd ed.,* recommends 20 kilograms of regular density silica gel per cubic meter of case volume (he actually calculated 18.75 kg!) for maintenance-free cases, which is in excellent agreement with the above recommendation. If Thomson's calculation were modified to take the MH value of Art-Sorb, Arten or Rhapid Gel into account, Thomson's results would remain in agreement with the above recommendations.

Art-Sorb recommends 0.5 to 1.0 kilograms per cubic meter, based on short-term changes in RH due to a change in temperature. It does not take long-term leakage into account. Since the primary purpose of using silica gel is protection against leakage, Art-Sorb's recommendation is incorrect. The proper amount of Art-Sorb should be determined on the basis of its MH value, as previously described.

How long does silica gel last?

Silica gel lasts indefinitely in terms of its ability to adsorb and expel moisture and never has to be replaced. It is the moisture within the silica gel that gets used up when it is buffering against changes in RH within an exhibit case. There are a number of methods for reconditioning silica gel. Some methods require the removal of some or all of the silica gel, and other methods allow for reconditioning silica gel within the case through the addition of a controlled amount of water or additional dry silica gel. Please refer to our PDF sheet on Reconditioning Silica Gel.

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