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Using Silica Gel In Microenvironments

Regulating the relative humidity (RH) in your exhibit space and collection storage areas is an essential part of preventive conservation. Silica gel (silicon dioxide) is a material that can be used to control RH within microclimates in exhibit cabinetry and storage units. This man-made material can create and maintain both high and low humidity levels within well-sealed enclosures. If used properly, silica gel will reduce daily, weekly, and seasonal fluctuations in humidity.

Silica gel is particularly useful in museum microenvironments because it is non-toxic, and does not give off gaseous pollutants. You can use it as a desiccant at moderate or high RH levels to prevent damage to metal objects that may rust or corrode. Because silica gel acts as both a moisture absorber and desorber it can be used as a humidity buffer, providing a stable environment for moisture-sensitive objects, such as glass, ivory, wood, leather, bone, and textiles. These objects often require moderate levels of RH and restricted fluctuation (e.g., 40% to 60% RH) .

Types of Silica Gel

Silica gel is a hard, inert, crystalline material that can absorb up to 40% of its weight in moisture through millions of tiny pores. Traditional silica gel (commonly referred to as standard gel) acts efficiently as a desiccant to create drier microenvironments (e.g., below 40% RH). Newer hybrid gels are more effective as buffers in a museum environment than traditional silica gel. They are considered high-performance gels and are most effective between 40-60% RH. Standard silica gel is also available in a self-indicating form, which will change from blue to pink when it reaches its absorption capacity near 40% RH. Therefore, indicating gel is not useful at very low RH levels. Although self-indicating gel is more expensive than standard silica gel, small amounts of it can be mixed in with regular gel and still give effective readings. Hybrid gels are not available in a self-indicating form.

Several commercial products are available in which materials such as paper or expanded foam have been impregnated with silica gel. Pre-packaged silica gel is also available in heat-resistant polyester or nylon bags of different sizes. Many museum staff, however, prefer to fabricate their own silica gel containers, custom-sizing them to fit their individual exhibit or storage cabinetry. Custom-made containers are also less costly than commercially-manufactured products. Instructions for constructing silica gel containers appear later in this leaflet.

Requirements for Using Silica Gel

Silica gel can only maintain a microenvironment in a well-sealed enclosure. To ensure that cabinetry has limited air exchange with the room, seal all leaks and use conservation-appropriate caulk sealant or gaskets where necessary.

- To remove or replenish the gel provide easy access to the areas where the gel containers will be located. When silica gel no longer maintains the required RH it can be reconditioned back to the desired RH. (See reconditioning instructions below.)

- Never let silica gel come in direct contact with museum objects.
- When working with silica gel use an approved dust mask and latex or nitrile gloves; the dust can cause lung damage.

Calculating the Amount of Gel Required

Numerous factors affect the quantity of gel required for a specific application:

- humidity vulnerability of the objects
- degree of RH restriction required
- RH differences between the enclosure and room
- volume of the enclosure
- permeability and air leakage of the enclosure
- stability of overall room temperature
- desired maintenance cycle

When using hybrid gels, museums commonly use the ratio 1/4 lb. to 1/2 lb. gel per cubic foot of space. Determine the size of your storage or exhibit enclosure in cubic feet by multiplying length times height times width. It is recommended, however, that you consult the gel manufacturer for exact requirements.

Monitoring the Microenvironment

In order for any microenvironment to be successful, it is necessary to monitor it regularly. Use humidity-monitoring strips or a hygrometer to evaluate your microenvironment's climate. Self-indicating gel will alert you when standard gel is nearing its saturation point, but it won't reveal the exact RH. Check the RH level frequently.

How to Make Silica Gel Containers

In traditional applications silica gel has been spread loosely on trays or pans that are placed in cases or storage units. This approach will work, but is less desirable due to the risks from handling and the potential for spilling and airborne dust. The use of closed containers is recommended for convenience and to reduce the risks to adjacent objects.

The thickness of any silica gel container should be less than two inches because gel is most effective when maximum surface area is exposed. Rigid, compartmentalized containers (called cassettes or tiles) are a good choice because they can fit into narrow spaces. Small fabric bags allow for effective surface exposure and are easier to handle than large ones. Tubular, snake-like bags can be fed through small doors and can bend around corners. Choose the type, size, and shape of container that best fits your application and cabinetry. Instructions for fabricating standardized containers follow.

Bag Fabrication: Use non-woven, polyester-bonded fabric (e.g., Tyvek®), nylon screening, or polypropylene screening to construct the bag:

- Sew together three sides of each bag with cotton thread, leaving one side open for filling and emptying.
- Fill the bag with silica gel, using a funnel under an exhaust hood or outdoors.
- Close the top with a hook and loop type fastener, or by sewing the open edge of material closed.
- Use compressed air in a hood or outdoors to remove dust from open screen bags.

Large sized enclosures or cabinetry require larger quantities of gel. Oversized bags can be fabricated but need compartments to prevent the gel from settling along one edge or corner of a huge pocket. To create smaller compartments, begin by stitching through the two layers of fabric at several intervals. Leave the top outside edge of each section open for filling; after introducing the gel close the open edges as described above.

Making rigid tiles: Custom, thin-profile containers can be fabricated to hold standard amounts of gel (e.g., 1/2 to several pound units). These shallow containers provide a large amount of surface area, increasing the silica gel's responsiveness.

To fabricate use 1/2-inch square, acrylic light-diffuser panels. These grid-patterned panels (referred to as "egg-crate") are conventionally placed over fluorescent lights and can be purchased at hardware or lighting supply stores. The most commonly available panel size is 2 x 4 feet.

- Cut the panel to size with a handsaw or electric saw. Size them to fit the cabinet. Grind or file off any remaining rough edges.
- Cover one side of the panel with fabric or screening.
- Glue the material into place with an acrylic adhesive (using a paint roller) or low melting-point hot glue gun stick.
- Fill the squares of the diffuser panel with silica gel.
- Attach a top covering of fabric using the same adhesive or glue system as above.

Rigid cassettes or tiles can fit vertically or horizontally into a storage container; in exhibit cases they can be installed in an environmental control maintenance chamber or can simply be hidden with a decorative fabric and left in the display area.

Conditioning Silica Gel

Silica gel must be conditioned to the desired RH before placement inside an exhibit case or storage unit. If you intend to use silica gel as a desiccant, a humidifier, or as a buffer the gel must be conditioned or "adjusted." Conditioning silica gel involves either removing or adding water to adjust the gel's moisture content.

Most silica gel is shipped in a desiccated condition. Some manufacturers pre-condition silica gel making it ready for use. In some instances, the gel can be sent back to the manufacturer for reconditioning. This service is convenient, but more expensive than purchasing unconditioned silica gel.

To condition silica gel you will need to monitor the gel's moisture content, at the beginning and throughout the process. Do this either by weighing the gel or by monitoring the RH of the air that surrounds the gel.

Weighing Silica Gel: Choose one of two methods: Weigh a known quantity of gel, and check it against a calibration chart that gives standard weights in relation to humidity level. Request a chart from the manufacturer if one does not accompany the silica gel products.

As an alternative, the gel can be exposed to an environment that has the desired RH, such as a climate-controlled room or chamber. Weigh the gel repeatedly until its weight stabilizes, indicating that it has reached equilibrium with the RH of the room or chamber.

Monitoring the Air Around Gel: Put a small amount of gel (about 1/2 cup) in a well-sealed jar or self-seal bag with a calibrated hygrometer. Do not let the hygrometer touch the gel. After two hours the hygrometer should give an accurate reading of the humidity level the gel is able to maintain.

Conditioning and Re-conditioning Techniques

Four different methods to condition silica gel:

1) Direct Heat Application. This technique is used when silica gel needs to be adjusted down and as much moisture removed as possible.

Conventional oven:

- Spread loose gel to a depth no more than 1/2 inch in a shallow, heat-resistant pan.
- Set oven to 150°F, and heat gel for four hours. Temperature and time may vary depending on the gel's moisture content, the RH required and the type of gel used.

If you choose to heat silica gel in its bag or cassette, check with the manufacturer of the container to determine an appropriate temperature to avoid accidental melting or burning.

Microwave oven:

- Spread loose gel in a shallow glass pan to a depth of no more than 1/2 inch.
- Heat in microwave for two minutes on high.
- Cool gel for one minute outside of the oven.
- Repeat 10 times or until dry.

2) Room or Chamber Exposure. This method can be used to adjust gel up or down. It may take several weeks, depending on how much change in RH is required. Use this technique when you want to buffer your silica gel to a specific level.

- Place silica gel in a room or chamber that is at the desired RH level.
- Position a fan near the silica gel, blowing air over it to decrease the conditioning time.
- Check RH daily; continue until desired level is reached.

3) Exposure to Water Vapor. This method is used for adjusting up. It will increase the gel's RH level.

- Spread the gel evenly in a shallow pan.
- Put the pan in a chamber or plastic bag.
- Place a container of water or wet sponge in the chamber or bag (the larger the surface area of the water, the faster the gel will absorb the moisture). Do not wet the gel.

Note: If this method is used to recondition gel directly in storage or exhibit cabinetry, great care must be exercised to avoid a water spill or over-humidification.

4) Gradual exposure to new gel. This technique can be used to adjust gel up or down. It is especially useful because it ensures slow and gradual change of the RH within a storage container or exhibit case.

- Put a small amount of pre-conditioned gel (15-20% of the volume of gel you want to condition) into the cabinet or container. It should be fully saturated if you want to raise the RH, or fully desiccated if you want to lower the RH.
- Place the new gel near the original gel, but in a separate container.
- Closely monitor the interior RH until desired RH level is achieved.

Sources

Standard Silica Gel and Self-Indicating Gel
Fisher Scientific
7722 Fenton Street
Silver Spring, MD 20910
(800) 766-7000

Specialized Silica Gel Products and Equipment
Art Preservation Services
539 East 81 Street
New York, NY 10028
(212) 427-6726

Conservation Support Services
924 West Pedregosa Street
Santa Barbara, CA 93101-4622
(805) 682-9843

Bibliography

LaFontaine, Raymond H. "Silica Gel," *Technical Bulletin No. 10.* Ottawa, Ontario: Canadian Conservation Institute, 1984

Thomson, Garry. *The Museum Environment*, 2d ed. Woburn, Mass.: Butterworth-Heinemann, 1986.

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