A MODEL FOR HUMIDITY CONTROL USING GORE-TEX™ SILICA TILES

By Lowell Perkins

Abstract

GORE-TEX® membrane is a microporous film of polytetrafluoroethylene which is inert and contains no harmful additives. Because it allows water vapor transmission and has excellent particulate filtration efficiency it is used on the faces of a novel humidity buffering device for a sealed compartment. This product is the GORE-TEX™ Silica Tile, manufactured by W. L. Gore & Associates, Elkton, MD. A calculation method was developed to determine the number of tiles needed. Involved are such variables as the humidity differential between the inside and outside of the compartment; compartment volume; leak rate; days of desired humidity control; and the moisture buffering capacity of the tile. The impact of these variables on the number of tiles needed is discussed. A sample calculation shows that 15 tiles are required to maintain 50 + 5% at a leak rate of one-half air change per day for 60 days in a one-cubic meter compartent.

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This discussion concerns the use of the GORE-TEX™ silica tile as a humidity buffer in a sealed compartment. The tile is a six inch square polymethylmethacrylate grid of half-inch cells, one-half inch thick and filled with silica gel. GORE-TEX® membrane is laminated on both sides of the grid. This construction provides a support for easy handling and mounting. The GORE-TEX laminate serves two functions; (first), it provides effective transmission of water vapor for absorption by the silica gel thus allowing rapid correction of humidity changes and (second), the small pore size of the membrane retains the silica gel and prevents escape of abrasive silica gel fines.

The GORE-TEX™ Silica Tile
has GORE-TEX® Membrane
laminated to both sides of
polymethylmethacrylate grid.
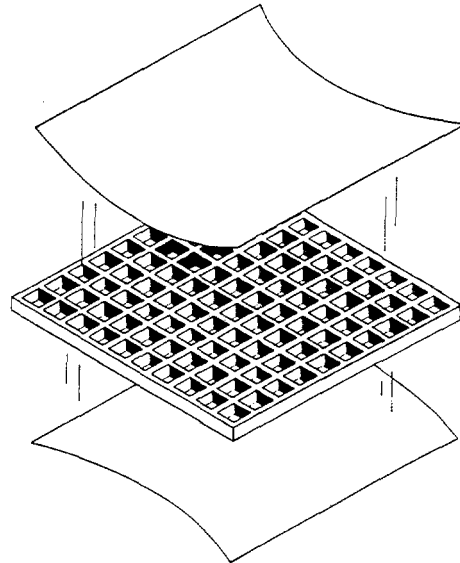
In a paper presented at the 1981 ICOM meeting[1], Steven Weintraub reported equilibrium moisture content values for various silica gels over a range of relative humidities. From these data we have calculated the corresponding moisture contents for the GORE-TEX silica tile over the relative humidity range.

SILICA TILE EQUILIBRIUM CAPACITY
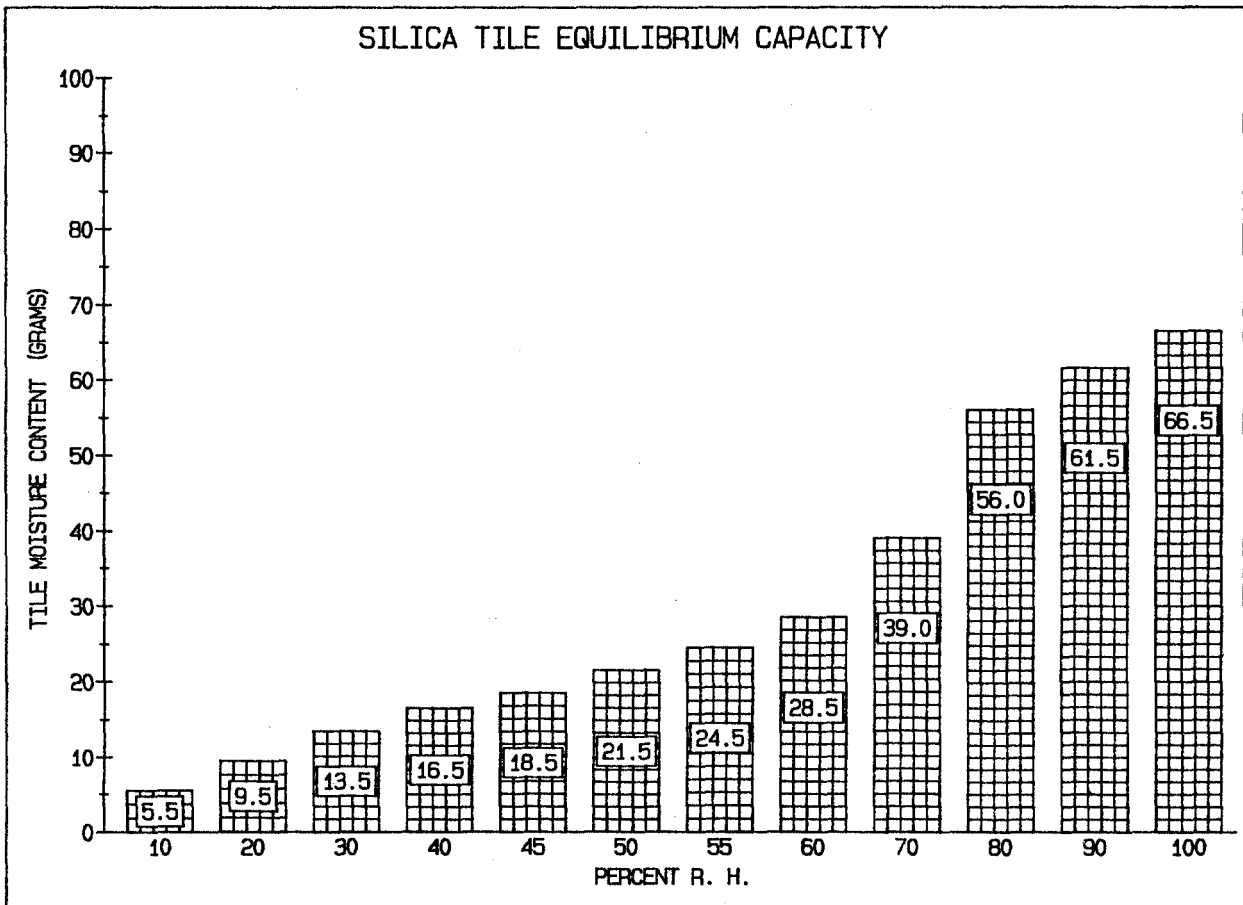
The silica gel chosen for the tile provides good surface availability for rapid absorption, as well as good absorptive capacity over the entire range of humidities. This is especially true in the 40-60% range which is the range most commonly used for display and storage items. The effective thickness of the silica gel layer in the tile is 1/4 inch, because moisture vapor transfer occurs through both faces of the tile and thus provides a large surface area of the silica gel for water absorption.

The buffering capacity of a tile is the difference between the weights of water absorbed at the ends of the desired humidity range. For example for the range of 45 to 55% the capacity is six grams of water. For the 40 to 60% RH range, the capacity is tweleve grams of water.

The moisture content of an exposed tile is determined by subtracting the dry weight of the tile (which is stamped on its side) from the tile weight after exposure. The percent relative humidity to which the tile was exposed can be determined from these data. One method for mounting the tiles in a compartment or display case is in slots cut into a polyethylene foam or nylon rod. This method makes both sides of the tile available for water vapor transfer to the silica gel.

In order to determine the number of tiles needed for humidity control in a compartment or display case this formula was developed:

$$T = \frac{C \times D \times V \times L \times N}{M}$$

T is the number of tiles needed to maintain the desired humidity range in a specific compartment for a specified period of time. The remaining variables are defined as follows:

Variable C is the mass of water vapor in saturated air at the display case temperature. The mass of water vapor in saturated air increases as the temperature increases. At 23°C (73°F) at saturation the water vapor content is 20 g/m^3. Thus for 50% RH the water vapor content at this temperature is 10 g/m^3.

The difference between the relative humidity inside the compartment and the average maximum relative humidity outside the compartment is important in determining moisture load resulting from compartment leakage. This difference is expressed in decimal form as Variable D. In a paper by Brimblecombe and Ramer[2], an average maximum relative humidity of 67% was reported in museums for Washington, D.C. and London, England. For a humidity range of 50% + 5%, a 70% average relative humidity is 15% higher than the upper humidity level of 55%. Thus the differential would be 0.15. For museums with controlled humidity environment this differential is reduced, which would lower the number of tiles needed, or lengthen the time between humidity adjustments for the same number of tiles.

Variable V is the compartment volume expressed in cubic meters.

Variable L is the leak rate in air changes per day. Control of the leak rate is extremely important. The literature indicates that a well-made case should have a leak rate of one air change per day. Improved gasketing through the use of pressure seals or GORE-TEX® joint sealant could reduce the leak rate to as little as one air change in 5 days or 0.2 air changes per day.

Variable N is the number of days of desired humidity control. The number of tiles needed can be reduced by more frequent adjustment of moisture content in the tiles. The control period may range from 30 to 150 days depending on requirements of the user. The most desirable period is 150 days because this length of time would provide humidity control through the high humidity summer conditions and during the dry winter conditions the case would return to the lower end of the desired range, thus minimizing the upkeep effort. It is apparent that it would take five times as many tiles to provide the 150 day protection as in the 30 day protection.

Variable M is the moisture buffering capacity of a tile. It is the difference between the equilibrium moisture content of the tile at the upper and the lower ends of the desired percent RH range.

As an example of a calculation using the formula
$T = \dfrac{C \times D \times V \times L \times N}{M}$, the following values were chosen:

Desired Humidity Range: 45-55%
Mass Water Vapor in Saturated Air at 23°C (g/m^3) C=20
Difference in % RH   D=0.15
Volume (m^3) V=1
Leak Rate (changes/day)   L=0.5
Number of Days of Humidity Control (days)   N=60
Moisture Absorption Capacity of GORE-TEX Tile,   M=6
   $(g\ H_2O/tile)$

Thus, $T = \dfrac{20 \times 0.15 \times 1 \times 0.5 \times 60}{6} = 15$ tiles

This table lists the number of tiles needed for various combinations of compartment size and number of days of humidity control with other variables held constant. The value for the sample calculation of 1 m^3 for 60 days of control is 15 tiles.

NUMBER OF TILES NEEDED
TO MAINTAIN 50 + 5% RH

Volume (V) in cubic meters	Number of Days of Control (N)				
	30	45	60	90	150
0.1	1	2	2	3	4
0.2	2	3	3	5	8
0.5	4	6	8	12	19
1.0	8	12	15	23	38

Summary

1. Air leakage rate is a very important factor. Efforts to minimize it in compartment design and construction will have a beneficial effect on the humidity control. If the leakage rate were reduced to 1/4 change per day from 1/2 change per day the number of tiles needed could be reduced to 1/2.

2. In the sample calculation, an average differential in percent RH of 15% between the atmosphere outside the case and that inside the case was assumed. If this differential were reduced by a building air conditioning system, the number of tiles needed could be reduced or the same number of tiles would result in a longer time between humidity adjustments.

3. Increasing the permissible range of percent RH change in the case to 50% ± 10% RH would require one-half of the number of tiles for the same number of days of protection or doubling the number of days of protection with the same number of tiles.

4. The presence of water absorbing materials in the case would provide additional humidity buffering capacity to the system. Their presence would result in an increase in the number of days of control in the desired humidity range. These materials include textiles (non-synthetic), paper, leather, fur, feathers and wood.

REFERENCES

1. Weintraub, S.A., "Studies on the Behavior of R.H. within an Exhibition Case, Part I: Measuring the Effectiveness of Sorbents for Use in an Enclosed Showcase", ICOM, Committee for Conservation 6th Triennial Meeting, Ottawa, 1981, 4/18/81.

2. Brimblecomb, Peter and Ramer, Brian, "Museum Display Cases and the Exchange of Water Vapor", Studies in Conservation, 28, 179-183 (1983).

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