Purpose: To determine the proper water pre-treatment for regular density silica gel (RDSG) desiccant for use in a cigar humidor.

Materials:
– Ultra Pet Crystal Clear Littler Pearls (Regular Density Silica Gel (RDSG))
– De-ionized water
– Various glassware and metalware
– 1 ml syringe
– Greased drying jar (2.5 quart volume)
– HygroSet Hygrometer
– Kitchen oven

Photo 1. HygroSet Hygrometer

Photo 2. 2.5 quart drying jar

Photo 3. Kitty litter packaging

Protocol:

Pre-Treatment

1. Dry a large quantity of silica gel in a THIN layer for 4 hours at 325F
2. Weigh out four 20 gram samples of dry silica gel.
3. Soak samples in 0% saline, 1% saline, 5% saline, and 10% saline respectively.
4. Drain samples, and dry in THIN layer for 5 hours at 325F.

Water Conditioning

5. Place sample in drying jar and allow to stabilize at room temperature. Record temp and %RH
6. Lower temperature of drying jar and allow to stabilize. Record temp and %RH.
7. Add 1 gram of deionized water to sample, stir, and repeat steps 5 and 6.
8. Add another gram of deionized water to sample (total 2 grams), stir, and repeat steps 5 and 6
9. Add another gram of deionized water to sample (total 3 grams), stir, and repeat steps 5 and 6
10. Add another gram of deionized water to sample (total 4 grams), stir, and repeat steps 5 and 6
11. Add another gram of deionized water to sample (total 5 grams), stir, and repeat steps 5 and 6
12. Continue adding water as above as needed to obtain data beyond 70%RH.

Hypothesis: The saline pre-treatment of silica gel will increase its holding capacity. This prediction is based on the salt/water slurry %RH equilibrium point of 75%. Even a watery slurry will equilibrate at 75% RH. This is evidence that salt binds tightly to water, and evidence that salt can store large quantities of water. These are precisely the characteristics we desire for maintenance free humidifcation. Unfortunately, salt/water slurry is messy and equilibrates at too high of a %RH value. It is hoped the combination of salt and silica gel will impart some of the characteristics of a salt/water slurry to the silica gel.

Results: **Hygrometer Characteristics**

Lower limit of detection

Actual %RH Control value for all samples was 21%. This fact suggests the hygrometer was driven to its lower limit. Since this level of %RH is not of interest, and since the true value is very likely close to zero, the Control %RH values were artificially pegged at zero. The second %RH values, 27 and 33 are also suspect. However, since we are not concerned with these %RH levels, they are not an issue.

Temperature stability

The raw %RH values at two temperatures (72F and 61F) were uniformly consistent. This shows the stability of the hygrometer, and allows us to ignore the effects of temperature on %RH.

Table 1. Sample	Weight (g)	Water (g)	Water / Gel ratio	Temp F	0% Saline %RH	1% Saline %RH	5% Saline %RH	10% Saline %RH
Control	20	0	0.00	72	0	0	0	0
1	20	1	0.05	72	27	33	33	27
2	20	2	0.10	72	61	57	52	50
3	20	3	0.15	72	69	66	61	56
4	20	4	0.20	72	74	71	66	59
5	20	5	0.25	72	75	74	69	61
6	20	6	0.30	72				63
7	20	7	0.35	72				65
8	20	8	0.40	72				66

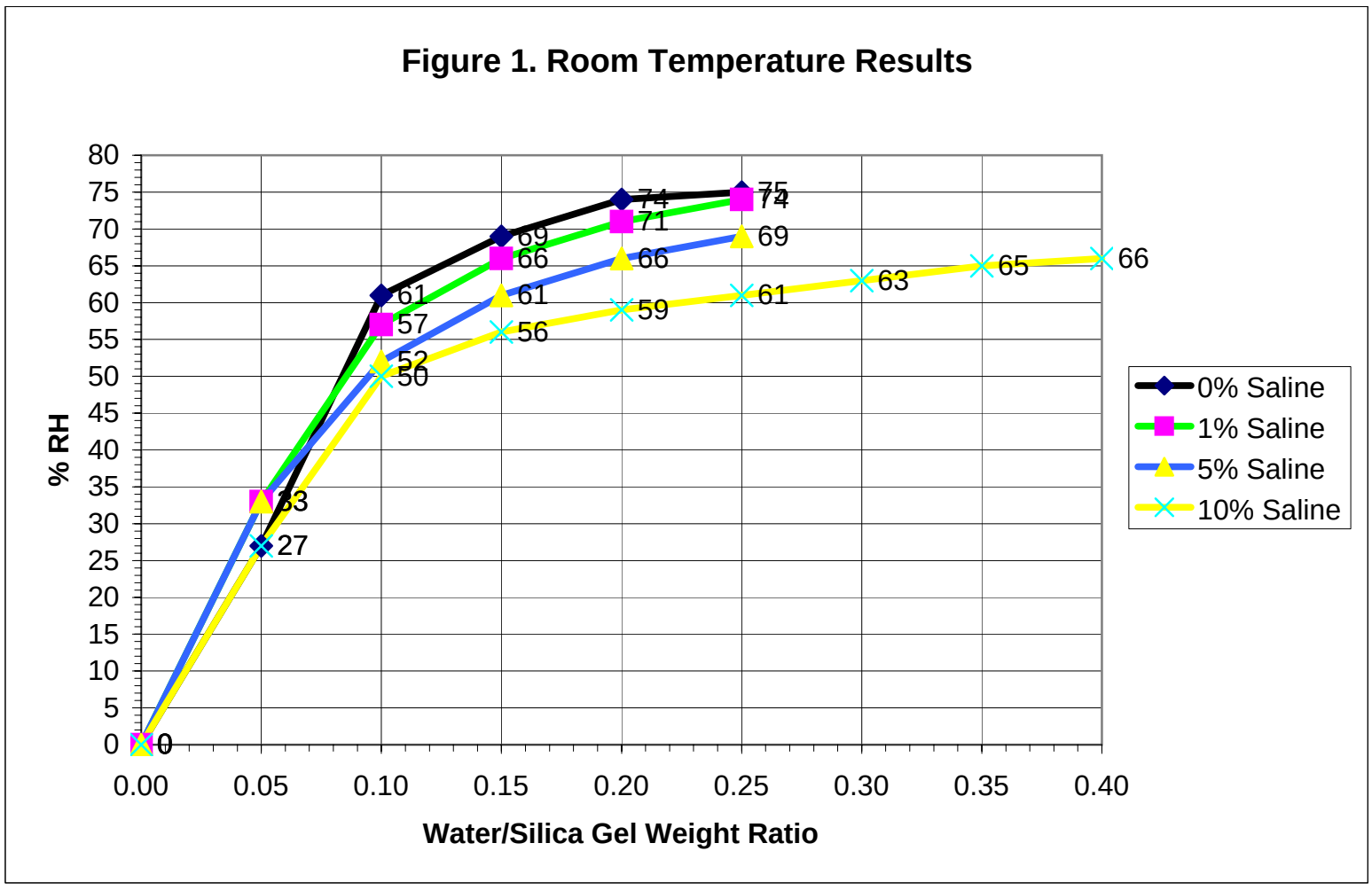

Figure 1. There are some interesting things to note in the plotted results.

1. The increasing saline pre-treatment has "pushed" %RH values farther out along the Water/Ge ratio axis.
2. The saline pre-treatments are reducing the equilibrium %RH response of the silica gel.
3. The pre-treatment allows the silica to hold more tightly to the adsorbed water and so lower the %RH equilibrium for a given Water/Gel ratio, and generally raising the M-value.
4. This effect was so pronounced it was difficult to drive up the equilibrium %RH in the 10% saline sample, and the experiment was terminated before 70% was attained.
5. The hypothesis is confirmed.

M-Values The moisture buffering capacity of a material is defined by its M value, which is the amount of water (in grams) that is gained or lost by 1 kilogram of silica gel for each 1% change in RH. M can be calculated for the %RH range of interest. For example, if 500 grams of silica gel adsorbs 25 grams of water between 40% and 50% relative humidity, then M = (1000/500) * (25/10) = 5 grams/%RH
The higher the M-value the higher the RH buffering potential of the material.
Here the M-values are calculated for various ranges of %RH response.

Table 2. Pre-treatment % Saline	Sample Weight (g)	Weight H_2O (g)	%RH Start	%RH Finish	M
0	20	3	61	75	**10.7**
1	20	3	57	74	**8.8**
5	20	3	52	69	**8.8**
10	20	3	59	65	**25.0**
0	20	2	61	74	**7.7**
1	20	2	57	71	**7.1**
5	20	2	52	66	**7.1**
10	20	2	61	65	**25.0**
0	20	1	61	69	**6.3**
1	20	1	57	66	**5.6**
5	20	1	61	66	**10.0**
10	20	1	63	65	**25.0**
0	20	1	61	69	**6.3** *
1	20	2	57	71	**7.1**
5	20	2	61	69	**12.5**
10	20	2	63	66	**33.3**

Table 2. M-values calculated over different ranges of %RH. The table shows that for similar %RH ranges the saline pre-treatment results in higher M-values.

Discussion Given the definition of the M-value, the fact we are interested in the 65% RH point, and the raw charted data. What we are looking for is the area of curve which contains the 65% RH point and has the lowes slope. If we are in interested in the %RH range of 60-70% then we should look for the curve with the flattest portion between 60% and 70%. This will also correspond to the curve with the highest M-value across this range.

In terms of usefulness for cigar humidification, we are looking for a number of characteristics:

1. Ease of pre-treatment, conditioning, and handling
2. High buffering potential in the 60-70% range (high M-value)

Clearly the easiest pre-treatment is none. Using untreated silica gel would simply be a matter of addin the appropriate amount of water.

The highest M-value over the %RH range of interest was for the 10% saline pre-treatment sample. These values were phenomenal at 25.

As the saline concentration increased the samples became more messy. That is, the pearls exhibited a greater tendency to fracture. The 10% saline pre-treatment sample was at least half powder. Even the 1% saline pre-treatment sample resulted in significant powder fraction. This would make the preparation, packaging, and airflow problematic. The control sample did not suffer from this effect. So while the pre-treatment of the silica gel with saline solutions did, as predicted, greatly increase the M-values, the practical concern of powder production precludes their use in real world application. It appears we are stuck with the much poorer performance of straight, non-pre-treated silica gel.

Photo 4. Non-pre-treated silica gel

Photo 5. 10% saline pre-treated silica gel

Usage

Based on the discussion above, it was decided to try the non-pre-treated silica gel in a real world application. 200 grams of silica gel was conditioned with 20 grams deionized water and split into 2 100 gram aliquots. According to the control plot, this should produce a 61% RH equilibrium leaving some room for error and adjustment. The conditioned silica gel was placed in two shallow plastic tubs and placed in a 64 quart cooler which at the time was at %64 RH at 62F with only 4 boxes of cigars. One of the aliquots was placed in a 1 gallon plastic bag and the equilibrium %RH measured. The value was 61% RH, precisely as predicted by the experimental results.

After 8 hours in the 64 quart cooler the %RH was unchanged at 64% and 64F.

Bottom Line

With the dried kitter litter above, use 0.053 grams per cubic inch, or 91 grams per cubic foot, or 3.05 grams per quart of humidor capacity conditioned with distilled water as follows:

%RH	Water
60	10% of dry weight of silica gel
65	12.5% of dry weight of silica gel
70	15% of dry weight of silica gel

One may wish to start a couple of % less water and add as needed in the actual application.
Use the silica gel in the humidor in as thin a layer as possible.
Dry silica gel kitter litter in a THIN layer for 4 hours at 325F.

The data plot shows 1 gram of water in 20 grams of silica gel moved the %RH equilibrium 8 points fron 61 to 69. That is, 0.00625 of the total weight of silica was used to move the %RH equilibrium point 1% within the range 61-69.

Example: I have 200 grams of conditioned silica gel in a 64 quart cooler. Let's say the cooler is holding 62% RH and I would like to get it to 66%, i.e., raise it 4%.

200 grams x 0.00625 x 4 = 5.0 grams of water.

1 gram of water equals 1 ml equals 1 cc. Use a syringe to "weigh" the water. Use distilled.