The Relationship of Sugar Moisture to Relative Humidity

J. E. MAUDRU[1] AND T. E. PAXSON[2]

The maintenance of proper relative humidity in sugar storage warehouses and bulk storage bins is of great importance not only from the standpoint of eliminating hard and lumpy sugar but also from a bag breakage standpoint.

The sugar crystal, possibly slightly hydroscopic in its pure form, contains minute amounts of ash and a thin coating of even more impurities on its surface which causes it to be even more hydroscopic.

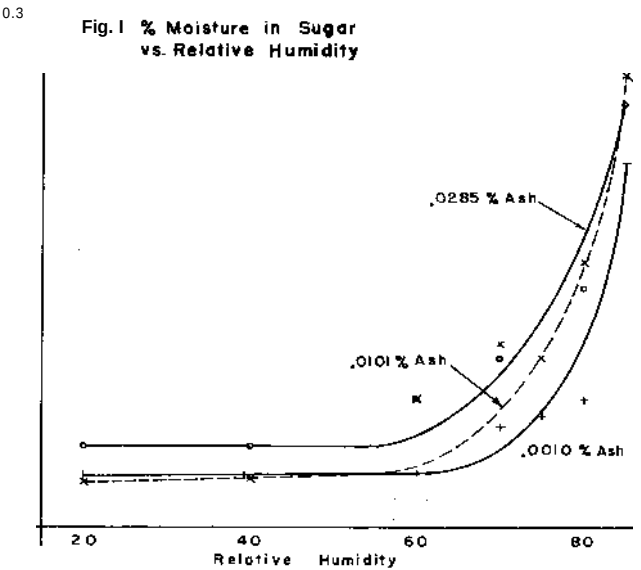
Changes in relative humidity cause sugar to absorb or release moisture to maintain equilibrium. An increase in relative humidity of the air surrounding the sugar releases moisture. This moisture dissolves a small amount of sugar from the crystal faces until a saturated solution of minute thickness occurs on the crystal face. This condition is not objectionable except at high humidities where the sugar becomes crawly.

Decreasing humidity causes hard sugar by reversing the above series of events. Water evaporates from the crystal faces and recrystallizes sugar on them. The point of contact of two touching crystals enlarges and fuses so that the crystals stick together. Each time the humidity is lowered the foregoing process is repeated so that finally the sugar becomes a hard mass.

Figure 1 shows the relationship of moisture in sugar to relative humidity of surrounding air. Conditions for sugar of low (.0010%) ash, medium (.0101%), and high (.0285%) ash are shown. The high ash sugar starts gaining moisture at something more than 40% humidity while the low ash sugar maintains a constant mositure content to more than 60%. All three sugars increase rapidly in moisture above 75% and at 85% humidity start to liquefy. This data was collected by determining moisture on small samples of sugar after they had been allowed to reach equilibrium in a dessicator in which air of controlled humidity was present. Humidity was controlled by the method of Stokes *8c* Robinson[3] in which sulfuric acid of various concentrations was placed in the bottom of the dessicator. Large quantities of the acid solution and small samples of sugar w[T]ere employed so that changes in moisture of the sugar would not change appreciably the concentration of acid. Samples remained in the dessicator 4 days to assure equilibrium.

Relative Humidity	% Anhydrous H^SO^ by weight
20	57.76
40	47-71
60	38.35
70	33.09
75	30.14
80	26.79
85	22.88

[1] General Chemist, Holly Sugar Corp., Colo. Springs, Colo.
[2] Chief Chemist, Holly Sugar Corp., Delta, Colo.
[3] Stokes, R. H., & Robinson, Ind. Eng. Chem. 41, 2013 (1949)

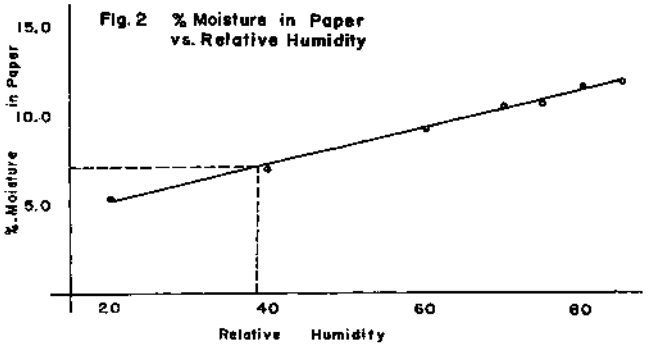


The straight line graph on Figure 2 shows moisture content of paper from a natural craft 5 ply, 250-lb. basis, 100-lb. paper bag again plotted against relative humidity. We have it on good authority that paper becomes dangerously brittle, causing excessive breakage below 7% moisture, which corresponds to about 40% relative humidity. We must then store sugar between 40 and 60% relative humidity to minimize breakage due to paper brittleness on the one hand and prevent hard sugar on the other, by drying out after the sugar leaves the warehouse.

The western climate is characterized by great changes in humidity. The humidity on a cold winter day may be as low as 10%. If the outside temperature is —20° F. and if the air is heated in the warehouse to +50° F. the relative humidity becomes almost 0. If later a warm thaw occurs, the outside temperature may become +40° F. with 60% humidity. Upon being heated to 50° F. the humidity is only reduced to 40%. Thus, the humidity varies from almost 0% to 40% without changing the warehouse temperature.

Warehouses, then, require controlled humidification and temperatures should be no higher than necessary.

Another source of hard sugar in connection with bin sugar occurs, during cold weather, by bringing the bulk sugar into a humid warehouse when the sugar is below the dew point of the warehouse air. The sugar absorbs moisture and later upon releasing the moisture to reach equilibrium it cakes and becomes hard.



In summary, warehouse air should be controlled both as to temperature and humidity. Relative humidities between 40 and 60% minimize breakage and prevent hard sugar. High ash sugars are more hydroscopic than sugars of lower ash content.

Additional investigation should be made on the factors which affect the strength of paper with the thought that a paper might be developed which is not so sensitive to low relative humidity.