Humidity in Relation to Packing and Storage of Sugar.

(Paper by Mr. W. V. BLEWETT, General Manager, Kynochs, Ltd.)

By the humidity of the atmosphere is meant, of course, the moisture or water-vapour present in the air. The atmosphere is never free from moisture, and the quantity present is always varying. During the worst months of our summer we rightly blame the humidity for the feeling of heaviness and discomfort, which is so common. The warm air from the Mozambique current contains often up to eight or nine grains of water in a cubic foot. At the prevailing temperature in Durban during the daytime in the summer, the air could hold up to 13 grains (at 85 deg. F. about), but, fortunately for us, the air rarely, if ever, contains the full amount of moisture possible. It has been shown of recent years that if the air is saturated at 85 deg. F. the temperature of the human body rises and fever sets in, but conditions approaching these can exist only under abnormal conditions, e.g., in mines. If the air is saturated it cannot take up any more moisture, and nature's method of maintaining the normal temperature of the body, by perspiration, is interfered with. It is not the amount of moisture in the air which matters, but rather the ratio between the moisture present at a certain temperature, and what the air could contain at that temperature when saturated. In Durban we do not have many days with the relative humidity over 80. If the temperature is 85 degrees, the atmosphere can hold 13 grains of water in a cubic foot. A relative humidity of 80 means that 80 per cent. of the 13 grains of moisture is present, i.e., 10½ grains. On a cold, wet day, in London, wrapped in mist or fog, the air could not hold more than say 2½ grains, i.e., not half as much as we should have in the air during the driest hot wind we are likely to get at the coast. The warmer the air, the more moisture it can hold before it becomes saturated, and, conversely, as the air is cooled, it can no longer hold so much moisture as when warm, and a point will be reached on continued cooling when the air will have to deposit some of the moisture in the form of mist, dew or rain.

Conditions in Natal, from the point of view of the sugar industry, are by no means as bad as in other sugar-growing areas, e.g., Mauritius and Java. Over a number of years, taking the monthly averages, the relative humidity in Durban is 75 in February—this reduces to 70 by May, and averages 65 for June, July and August, after which it increases steadily to 75 in February. The period from September to May shows a humidity above 70.

In Johannesburg, for comparison, for three months of the year the humidity is over 70, from which it ranges down to 42 in August.

The figures vary considerably from day to day, and averages are, therefore, to some extent misleading. The rainfall, of course, affects the figures.

The relative humidity at Mauritius, taking again monthly averages, shows at Pamplemousses for seven months over 75, with no month below 68—conditions much worse than at Durban.

At Java, again, the figures are during six months of the year, over 80 and for the other six months about 75.

Before discussing how the humidity of the atmosphere affects stored sugar, it will perhaps be of interest to mention how the relative humidity is estimated, as no doubt in future far more records of humidity will be kept than before. The most accurate method of finding what moisture there is in the air, is to pass a known volume of air slowly through tubes packed with a material such as phosphorus pentoxide, or strong sulphuric acid, which absorbs the water in the air. The increase in weight of the tubes gives the amount of water present in the volume of air drawn through. This method, although very accurate in reliable hands, is cumbersome, and takes some hours and a trained man to do one estimation, hence simple instruments, called hygrometers, have been devised, which give the required information with little trouble. The simplest type of instrument is that in which a bundle of hairs is connected to a spring which operates a needle. The hairs shorten when damp, and lengthen in a dry atmosphere, and the needle is thus moved over a scale showing directly the relative humidity. Such an instrument is very handy, but it needs to be checked occasionally. The more generally adopted type is the Wet and Dry Bulb Thermometer. Two similar thermometers are fixed side by side, the bulb of one being covered with muslin, one end of which hangs in a small vessel of water. The water is sucked up by the muslin, and evaporates off the bulb, thus lowering the temperature of the bulb—the wet bulb, i.e., it shows a temperature lower than that shown by the dry bulb thermometer. On a dry day the evaporation is rapid and the difference in temperature is greater than on a wet day. Obviously, if the air were saturated with moisture there could be no evaporation, and both bulbs would be at the same temperature. The difference in temperature is, therefore, a guide to the humidity, and a reference

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to the tables which are supplied with the instrument enables the observer to calculate the relative humidity. (Prices of various hygrometers vary from 10s. to 40s. in England.)

The effect of humidity on stored sugar must be looked at from two points of view:—

(1) To what extent is the weight likely to be affected.

(2) To what extent is the deterioration in the sugar due to humidity.

(1) **Effect on Weight.**

Under the new Weights and Measures Act it is laid down that materials generally must, when sold, be the nett weight shown on the container. Obviously, if the moist sugar is sent up to the Transvaal during the dry season, there will be a tendency to lose weight. It would be difficult to state exactly what weight would be lost—it will depend on so many factors, e.g., the conditions of storage, but with good mill white sugars the loss in weight would be negligible.

Since the subject of this paper was first suggested, there has not been sufficient time for experiments to be carried out to show the loss in weight of pockets of sugar in an atmosphere artificially maintained for months at a low humidity. Several samples of sugar exposed in open dishes were tested to see what loss or gain in weight occurred. The sugars were mill whites and treacles. The results showed that those sugars which had a low moisture content absorbed moisture more slowly than those with a larger amount of moisture.

Sugars with moistures of 0.2 per cent. and less, when exposed at humidities from 72—76, i.e., about the average humidity in Durban during the summer, did not gain in weight (with one exception). White sugars with moisture over .2 per cent. increased steadily in weight at humidities from 72—76, but at a humidity of 60—65 there was, with these sugars, no longer any increase in weight; below 60 there was a definite loss in weight. These figures are of interest as showing that in high grade white sugars, the increase in weight on storage is slight, and if kept below 70 per cent. humidity would be practically nil. By far the most rapid increase of weight was with a treacle sugar containing 3.8 per cent. moisture when received.

These results should be compared with those obtained by Geerligs and others. Geerligs in his text book states:—

"We thus find that although pure sugar does not absorb moisture, raw sugar is hygroscopic, and however well dried will absorb moisture as soon as it finds an opportunity to do so."

"This opportunity arrives as soon as the sugar comes in contact with air containing over 70—75 relative humidity."

This statement of Geerligs agrees well with the experiments mentioned above.

On the other hand, the authors (Tempany and de Charmoy) of a recent Mauritius Bulletin on the Deterioration of White Sugar during Storage, state definitely that "White sugar has appreciably greater hygroscopic power than lower grade sugars."

At Umbogintwini, 15 samples of sugar were taken and dried till free from moisture, and then exposed to air which could be kept at a required humidity. In a few hours' exposure at 74 humidity nearly all the sugars had regained their original moisture as if there were a definite quantity of moisture which each sugar could rapidly absorb at that humidity. The drying, therefore, had no effect on the tendency of the sugars to absorb moisture when exposed to a damp atmosphere.

Again, it was shown that the best mill whites, i.e., those with 0.2 per cent. of water, or less, did not gain in weight beyond their original moisture, and that treacle sugars rapidly absorbed moisture up to 2 or 3 per cent. below 75 humidity. (See Note A.)

It will be seen, therefore, that the loss in weight on storing high-class white sugars in a climate which is drier than that of the Natal coast, will not be a serious matter, and can be avoided provided correct conditions of storage in Natal are maintained before sending to dry parts of the country. On the other hand, treacle sugars, on being sent to a drier climate, will certainly lose weight to an appreciable extent, especially if bags are exposed in small numbers in places where air is frequently changed. (See Note B.)

(2) **Deterioration of Sugar.**

A good deal has been written recently by workers in various parts of the world on the deterioration of sugar during storage. In Natal, Professor van der Byl has already published bulletins on the subject, but this paper does not deal (except in passing) with the micro-organisms, which he and other workers have studied. It is, however, difficult to separate the consideration of humidity in its effect on sucrose, from that of the micro-organisms concerned. Geerligs, in his well-known book on Cane Sugar Manufacture, states that it has been agreed in Java that deterioration is due chiefly to moisture. Sugars that had been manufactured under various conditions were tested by being exposed during the wet season, and it was shown that the presence of impurities, the size of the grain and the difference in methods of clarification had no effect. The disinfection of bags was tried, but was not altogether satisfactory. (Further work on the effect of disinfectants will be found in Prof. van der Byl's bulletins on South African sugars.)

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As already stated, Geerligs concluded that pure sugar is not hygroscopic, whereas sugar coated with molasses can absorb a considerable amount of moisture, and therefore deteriorate. As sucrose must re-act with water before it can form reducing sugars, only when moisture is present can the micro-organims have any effect.

The recent bulletin on storage conditions in Mauritius deals somewhat fully with the effect of humidity as distinct from that of micro-organisms. The authors sum up their conclusions as follows:—

"The cause of deterioration of white sugars in Mauritius is primarily the absorption of moisture from the atmosphere. If such sugar can be protected from absorbing moisture from the air, it will not deteriorate, but will keep indefinitely. The fact that organisms capable of causing destruction of sucrose invariably exist in such sugars, is a matter of smaller importance, since it is impossible to produce commercially absolute sterile sugars under existing conditions, and if the moisture content does not exceed the danger point, they cannot develop.

"The question, therefore, of minimising loss of this description consists essentially in protecting sugars, as far as possible, from conditions likely to lead to moisture absorption. In this connection, the construction of warehouses where sugar is intended to be stored is a matter of the greatest importance."

It should be borne in mind that nearly all Mauritius sugar is treated with steam in the centrifugal, and may be regarded as nearly sterile as is possible in practice when it leaves the centrifugals.

In trying to account for the deterioration of various sugars, the authors suggest the difference in the size of the grain, or in the mineral content of the sugar, herein differing from Geerligs. Their description of the deterioration which takes place agrees with their explanation as to the cause of the deterioration, viz., humidity. It is noticeable first by the sweating of the bags of sugar, the sugar itself becoming more and more sticky. This action is invariably from the outside; generally it is confined to the lowest layer of bags, especially to the side of the bag in contact with the floor, or with the dunnage. In localities with a high rainfall, bags which were exposed to air blowing direct from doors or windows showed deterioration on the exposed ends or sides. They follow up this statement by a description of a store where no deterioration took place in six months.

The question of the construction of stores for maintaining the best conditions for the storage of sugar has been raised by various authors, e.g., Prof. van der Byl, in his Bulletin on the Deterioration of South African Sugars, who suggests storehouses with double walls with an air space between the walls, should be used. He adds: "At the same time, the admittance of air should be prevented during unfavourable weather conditions." To take the latter point first, relative humidities are taken daily at Umbogintwini, and the figures for the first three months of this year may be taken as typical. It will be found that during January there were eight days when the humidity was 80 per cent. and over. On most of these days it was raining, but one often gets a high humidity when there is no rain. It would seem obvious that on these moist days the store should be kept tightly closed against the outside atmosphere. There were 19 days when the humidity was 70 and over, and only four days on which the humidity was 60 or less. For February/March there were:—

Humidity	80 and over ..	5 and	6 days.
	70 and over ..	11 „	17 „
	60 and less ..	8 „	6 „

If we may assume that high grade white sugars do not appreciably absorb water below 65 per cent. humidity, there would be on an average about two days a week during these three wettest months of the year when the store could be safely opened. Whether or not this is practicable is a matter for the storekeeper to settle. It should be pointed out that the humidity at Umbogintwini is less than in Durban (being higher and further from the sea).

From our knowledge of humidity and atmospheric conditions it should be easy to lay down principles that should be observed during storage:—

(1) The store should be built of such materials and in such a way that it is not liable to sudden changes of temperature. With solid walls and roof, or with an insulating air space round walls and roof, the store is not liable to sudden cooling. It will be obvious that if a store and the air inside it cool quickly at night-time after a warm day, a point may be reached when the air can no longer hold its moisture, and the latter will be deposited, and then later absorbed by the sugar.

(2) The floor should be of non-conducting material, built over an air space, and thus insulated. This tends to prevent moisture being deposited on the floor. Obviously, flooring likely to cool rapidly will cool the air next to it and cause moisture to be deposited. Tempany and de Charmoy, in Mauritius, stated that in a store where a floor had been built over two large pits there was no deterioration whatever in six months, although the amount of humidity in that district is much higher than at Durban. In this case there was a dead space under the floor of five or six feet. They showed that when a layer of insulating material was placed between the sugar bags and the floor (the material used was volcanic ashes in half-inch pieces), the sweating of the sugar

was greatly reduced; and that in a case where sugar was placed on boiler tubes it deteriorated rapidly where in contact with the metal.

These facts are all in accordance with the statement that humidity is the prime factor in causing the deterioration of sugar.

(3) Doors and windows are only to be opened on dry days. On days when it is raining, or when the humidity is high, all openings should be tightly closed.

By placing hygrometers in the vicinity of the store it is a simple matter to avoid unnecessarily exposing the sugar to atmospheric moisture.

Further, by means of a fan, the air in the store could be rapidly changed when the atmosphere outside was dry. Merely opening a store to the dry air is not sufficient without thorough ventilation.

(4) It is probable that if the above suggestions were given effect to, it would not be necessary to go further, and artificially dry the air in the store. On the other hand, where stores, badly constructed, are already in use, it would be an expensive matter to re-build; in such cases the advisability of drying the air should be considered. Air can be dried in various ways:—

(a) By cooling it so that it can no longer hold the moisture originally present, which is then deposited. On re-warming the air it can then take up more moisture, and so dry the material with which it is in contact. One method of doing this is to pass air through a tower down which very cold water runs. This method of drying the air requires a refrigerator plant.

(b) A more common method is to heat up the air, by which means its capacity for holding moisture is increased, and here, again, it can remove moisture from materials containing water.

(c) A third method, which is applicable to stores in which the air is only occasionally changed, is to use a drying agent. One that is used in various industries is calcium chloride. Air can be drawn over trays of calcium chloride into a store, and when it has taken up as much moisture as is practicable, the moisture is driven off the calcium chloride by heat and the latter can be again used. Without any alterations to a store, trays of calcium chloride can be placed in it. In a few days the lumps of chloride will have disappeared and the trays will become full of liquid—the chloride having absorbed a large portion of the moisture in the store, especially if the air is circulated. Provided a store can be kept tight, and the air but occasionally changed, this method has many points in its favour. It has already been tried recently in a sugar store in Durban, and those in charge seem very pleased with the results.

Note A.—To test the statement that pure sugars are more hygroscopic than raw sugars, three sugars, a No. 1 refined, a good mill white, and a treacle sugar, were taken and exposed in dishes to an atmosphere at 90 relative humidity for 48 hours. All three increased in weight, but where the white sugars increased from 0.1 per cent. to 0.8 per cent., the treacle sugar absorbed twice as much (from 0.5 to 2.1). After a further 48 hours, the two white sugars contained 2.2 per cent. water, and the treacle sugar 4.2 per cent.

The same sugars (this time in sugar pockets) were exposed to a dry atmosphere for 10 days, the relative humidity being 57. The three sugars lost in weight, the white sugars losing .04 per cent. moisture, while the treacle sugar lost .3 per cent., i.e., from .5 per cent. down to .2 per cent. by the end of 10 days. (It should be mentioned that this treacle sugar had been previously dried down to .5 per cent.)

Note B.—With regard to the effect of the material used in packing: Geerligs took sugar already containing 0.7 per cent. water and stored in ordinary bags alongside of bags lined with waxed paper. He states that moisture was absorbed in both cases at the same rate—and also when the bags were lined with paper dipped in rubber solution. He concludes that it is impossbile to modify the packing so that the absorption of moisture could be prevented. This conclusion is so unexpected that it would seem to need confirmation. Natal sugars were, therefore, stored at a humidity of 70 (average), in various coverings: the normal bagging material, paper bags, waxed paper bags, and in rubber linings, but the results were not sufficiently concordant to enable one to say whether they confirmed Geerligs' statement or not, and the experiments will have to be repeated.

DISCUSSION.

The Chairman, in thanking Mr. Blewitt for his paper, referred to Mr. Blewitt's remarks concerning the warm air from the Mozambique Channel, and stated that the practical experience of everyone connected with the storage of sugar in Durban was that at all costs the easterly winds should be avoided, and it was therefore obvious that it was the east winds we have to fear more, so far as the storage of sugar was concerned. The westerly wind did not appear to affect sugar adversely. The question of the storage of sugar will have to be faced in the near future; the present methods were haphazard. During the last season sugar had been stored in approximately twenty stores in Durban, not half of which were in any way suited for the purpose.

Mr. J. L Malcom expressed his pleasure at having heard Mr. Blewitt's paper, and stated that some years ago, when the Government taxed sugar they were desirous of arriving at the amount of loss in the storage of sugar, and the losses as represented to the Government were not correct.

Mr. Malcolmn stated that his company took half a ton of sugar from four mills; the moisture contents were taken of that sugar and also the sucrose. The test lasted six months, and during that period some of the sugar lost very little sucrose and did not gain very much weight. Some of it gained in weight and lost in sucrose, the reason being that the moisture in sugar was high and above what is considered a safe point. That point, of course, is disputed even to-day. There are people who think that sugar with a moisture content of .2 is safe, but he did not think it was safe; it has to be a bit drier if it is for consumption. He had had refinery sugar in the store for over a year which had not increased to any appreciable extent in moisture. Not many months ago complaints were received that treacle sugar was arriving in Johannesburg with a loss in weight. Sugars that had been in the store for some months were then tested, and were something like ten to fifteen pounds over weight.

Mr. Alfred Townsend also spoke on the question of the storage of sugar, stating that some time ago at the mill he was connected with, they had occasion to store sugar in large quantities, and they therefore built a store and ventilated it well. The result was disastrous. On the second occasion, at Sea Cow Lake, he and his brother had to store sugar, and they adopted the opposite way and had a sealed store with the result that they had dry sugar. By keeping the atmosphere away from the store no trouble was experienced so far as sweating was concerned. The sugars in both instances were identical.

Fungi and Bacteria in Sugar and Sugar Cane.

(Paper by P. A. VAN DER BIJL, D.Sc., Professor of Plant Pathology, Stellenbosch University, late Government Mycologist, Durban.)

The sugar industry has during its development passed through various phases. In its early history man's taste was deemed sufficiently delicate to decide the degree of ripeness or the nature of the cane, but with the application of science to industries it soon appeared that chemical tests provided a far more delicate and certain means for ascertaining the qualities of cane and for controlling milling operations so as to minimise loss.

The cane grower and miller have also benefited from the application of botanical science to the sugar industry; on the one side, through the efforts made at increasing the yield of sugar by studying methods of cultivation and by selecting and breeding for high sugar content and other desirable properties, and on the other by investigations seeking to control losses occasioned to cane and cane products by those miscroscopic plants known as fungi and bacteria.

Like the majority of cultivated plants, sugar cane is also subject to a number of diseases of which some are caused by fungi, others by bacteria, and others again by constitutional derangements in the normal activities of the plant, and unfavourable conditions of growth.

We will first briefly refer to some of the diseases of cane caused by fungi and known to occur in Natal and Zululand. (No bacterial disease has thus far been recorded in cane from Natal and Zululand.)

The root disease of cane caused by the fungus himantia stellifera—the stellate crystal fungus—is prevalent in Natal and Zululand and may be responsible for a poor stand of cane and a consequent less yield per acre.

This disease is recognisable to the naked eye by the basal leaves of the cane being matted together, and if the stool is uprooted, white fungoid threads are seen on and between the roots and on old cane material decaying in the soil. Many of the roots of the stool will also be dead.

The fungus responsible for this disease is of the nature of a weak parasite, and the amount of damage caused by it is largely dependent on weather conditions and the nature of cultivation the cane is receiving.

Given good cultivation and moderately favourable weather conditions, the cane outgrows the fungus, but under dry conditions and poor cultivation the cane is handicapped, on the one hand by the poor cultivation—young buds find it difficult to force their way through the hard soil, and in their struggle may be killed by the fungus or other agencies; and on the other hand, by the scanty amount of moisture at its disposal. The fungus has also partly killed the roots of the cane, which is hence not in a position to get the full benefit from such moisture as may be still present in the soil.