THE QUANTITY AND QUALITY ASSURANCE OF RAW SUGAR THROUGHPUT AT SOUTH AFRICAN SUGAR TERMINALS, DURBAN.

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Abstract

Raw sugar as handled at the Terminal is one of the most valuable substances to be handled in bulk. For this and other reasons, the quantity and quality assurance requires special precautions and care. Furthermore, the narrow limits of polarisation requirements of export sugar necessitate a very careful process control.

Introduction

The Sugar Terminal facilities include provisions for large-scale intake, storage of sugar (520 000 tons), a very accurate polarisation adjustment and also for rapid shiploading at a high rate. These operations can be carried out continuously and accurately. The intake and shiploading operations are largely independent of each other. Although there are similar storage plants around the the world, and some of them include concrete silos, as far as is known there are no other facilities which allow quality adjustment immediately prior to shiploading. Futhermore, the South African installation is unique in that it is the only one of its kind available in South Africa.

The main function of the Terminal is to accept raw sugar, to store it after a quality check, and to export it to overseas buyers with a polarisation adjustment if necessary. In order to be acceptable to overseas purchasers, the export sugar is required to have certain qualities, such as stipulated sucrose content, limited moisture content and its other qualities such as colour, starch content, ash and grain size, must also conform to the specified requirements. With a maximum of sixteen delivering mills, the quality of incoming raw sugar may vary for many reasons. In order to ensure that the received sugar is suitable in all respects for export purposes, it is necessary to check the quality of bulk sugar arriving at the Terminal, and this is carried out at the laboratory.

At the time ofacceptance of the incoming sugar, selection is made of the storage site in the silos and several considerations may be involved, viz:

(a) Assessment is made of the total quality of sugar stored for any purpose.
(b) Separation of particular consignments can be made, should they differ in quality in any way.
(c) Selection of any required sugars for any particular market can be made and the material batched for future disposal.

During its storage in the silos, the quality of sugar has to be checked to ensure that the storage conditions are at the optimum and that the quality does not deteriorate in any way[1]. Finally, when it is necessary to export sugar, quality adjustment may have to be made. This must be carried out at high rate, with a known degree of accuracy and with a dependable degree of confidence. It is therefore obvious that the handling of sugar at the bulk Terminal requires a great amount of quality assurance at all stages. The activities of the Terminal laboratory largely concentrate on this aspect of control.

Raw Sugar Intake

Rail Trucks

The bulk sugar is received in both road and rail consignments and it has been found that its handling and sometimes its quality is greatly affected by the mode of transport used. The previously used method of rail delivery utilised open 40 ton "C" rail trucks but becauseof inability to offload during inclement weather; lack of protection from pilferage; loss due to inadequate sealing; lack of accuracy in assessing mass due to dealing with two weights i.e. gross and tare; and finally, the necessity for labour-intensive tarpaulin-covering removal; these have been replaced by bottom-dumping 50 ton FCD rail trucks specially constructed for the purpose of raw sugar conveyance. The replacement by FCD closed trucks is almost complete at present, but some service snags have been encountered with the discharging of these trucks. Depending on the distance of the mill from Durban, the period in transit varies from 24 hours to 7 days. En route, particularly in winter (due to temperature differential between the freshly produced sugar and outside surroundings) caking occurs in the transported sugar and thereafter causes problems in unloading at the Terminal. Under optimum conditions, the normal 50 ton load of sugar can be discharged from an FCD truck in approximately 10 seconds, but badly caked consignments taking up to 2-3 hours to discharge, with the continuous use of two pneumatic vibrators, have been encountered.

It is interesting to note that some 450 FCD trucks in service at 50 tons each, contribute greatly towards the temporary storage facilities of bulk sugar available to the Industry.

Road Vehicles

Bulk road deliveries vary from 18-25 tons and generally take less time to reach the Terminal than rail consignments. This being so, the amount of caking in transit is reduced but, on the other hand, delivery temperatures are generally found to be higher. This is not a desirable factor since elevated raw sugar temperatures are not considered to be conducive to optimum storage conditions[1]. Generally, the discharge times and unloading problems are far shorter than those encountered with the rail system but mass differences between the mill and Terminal tend to be greater. Some weight disagreements have been traced to such factors as the use of different horse and trailer before and after weighing, loss of fuel during transport or various other associated weighing problems.

Preliminary Check of Incoming Raw Sugar

On arrival, each consignment is opened and examined for the following:

(a) Visual evidence of loss by pilferage;
(b) Moisture contamination;
(c) Unusual colour;
(d) Excessive lumping; and
(e) Any other undesirable characteristics which could make the sugar unacceptable and possibly lead to the subsequent contamination of the bulk stored in the silos.

If the sugar is judged to be suitable for the storage, it is discharged at the Servo Weigher and the following procedure takes place:

The delivery documents, issued by the manufacturing mill, are checked and the unloading continued, with the aid of pneumatic vibrators if necessary, until the stated mass (within ± 0,05%) agrees with weight indicated at the Terminal. Should there still be discrepancies, further action is taken to manually scrape and clear the vehicle, and, if this is still not satisfactory, an inspection of the delivered vehicle is made so as to ensure that every attempt has been made at the Terminal to unload the consignment completely, before the Terminal weight of consign-

ment vehicles is finally accepted. Any divergencies in mass are personally annotated by the intake personnel, for further action.

To ensure maximum accuracy, the Servo Weighers are equipped with an hydraulically operated assized set of weights which are used daily by the laboratory staff to load the devices, step wise, to their maximum capacity (60 tons rail and 30 tons road) and subsequently to record the weight displayed. Maximum weight divergency of ± 0,05% is accepted.

The sugar is weighed in the receiving hoppers in the Servo Weigher and is then discharged for conveyance to the silos. During this process the electronic printer automatically prints all the necessary details which are subsequently made available to all mills in copy form. This obviates any entry errors. The empty vehicles are then sealed and despatched back to the mills.

Quantity Control of Incoming Sugar

Weighing procedures and equipment at various mills are not identical and consequently certain mass differences may be expected when the despatched sugar is weighed at the Terminal. In order to include such items as the minimum scale readout additive error and the retention of small quantities of sugar in the delivery vehicles, variation of ±0,05% in weight is accepted at intake weighers. Thus a 50 ton and say 25 ton consignment weights agreeing to within 50 kg and 25 kg respectively at the Terminal would be ideally expected.

Many consigning mills reach and consistently maintain this agreement. The mill and Terminal weights are compiled daily and statistically examined to detect large disagreements and any consistent bias. The daily information is subsequently processed into weekly and monthly resuts. The weekly and monthly weight comparisons furnish several important items of information, such as:

(a) A list of mills with acceptable weighing procedures and equipment is compiled;
(b) Large positive and negative fluctuations which usually indicate operational error or equipment defect may be detected;
(c) Sporadic or consistent bias indicating a possibility of pilferage, or faulty equipment calibration, can be seen;
(d) Good weight agreement with many mills provides an assurance that the Terminal weighting equipment is functioning at the required level of accuracy.

A daily contact is maintained with mills showing weight differences and a monthly summary and recommendation is prepared for further action.

Sampling

Each incoming consignment of sugar is sampled immediately after weighing. The sampling devices consist of a motor-driven sampling spoon which removes approximately 50gm portions of sugar by cutting transversely across the sugar stream cascading from a conveyor belt into a chute. The sampling frequency is approximately once very 30 seconds and the total sample weighs 2-3kg. The sample is collected into a self-sealing plastic bag previously labelled by the intake clerk on duty (details: Mill Name, Vehicle Identification, Time and Sequence Number and Signature) and placed in position by the duty sampler. When the sample is complete, the bag is sealed and sent to store in the laboratory.

Sample processing

The accurate analytical assessment of the incoming sugar must commence with a fully representative sample. To this effect, the individual consignment samples have to be analytically combined and reduced in size. A predetermined mass of sample, of each consignment from a given mill, is combined so as to give a representative 24-hour sample. The composited sample is carefully mixed and reduced in size, using suitably sized rifflers, until a required mass of final sample is obtained. The mixing and reducing routines have been carefully prepared and the operators have been instructed to maintain care and repetitiveness in their procedures. The sample room is maintained at 65% Relative Humidity, which is close to the Relative Equilibrium Humidity of VHP sugar[2] to decrease any possibility of either uptake or loss of moisture by the sugar samples during handling. Samples of VHP sugar are stored in labelled and airtight containers for further usage.

Some analyses of VHP sugar are time-consuming and are therefore carried out at weekly or monthly intervals and here the samples are prepared from the daily samples, but in this case the mass of subsample for compositing is taken so as to give a final sample on a weighted average basis.

During the shiploading of bulk sugar, samples are continuously taken downstream of the Servo-Balans and at half-hourly intervals (representing approximately 400 tons of cargo) and are processed in the sample room prior to analysis.

Several refinements to sample handling during and after the shiploading have been instituted:

(1) Normal halfhourly duplicate samples are used for analysis.
(2) A continuously updated composite sample is made by the addition of subsamples to an airtight drum mixer, and mixed.
(3) The final composite sample often has a mass of ca 50kg and, to ensure thorough mixing, requires a large-capacity mixer. For this purpose a modified concrete-mixer is used and precautions are taken not to damage the sugar grains during the mixing stage.

High Test Molasses is drip-sampled during the intake and shiploading, and mixed and composited for subsequent analysis.

Quality control

The prepared samples are analysed at the laboratory to give accurate and reliable guide to quality assurance for entire South African sugar exports. To safeguard the maximum accuracy of the analytical information, all samples are duplicated and coded, the coded singlicates being analysed by separate analysts. In addition, coded standards are injected daily into the analytical stream to ensure that no variation in the analytical procedure occurs at any time. The large volume of routine analytical results produced is statistically examined for maximum accuracy to be expected, standard deviation, degree of confidence and operator error for each type of analysis[3].

The incentives to achieve and maintain high analytical accuracy and repetivity by the laboratory are very prominent:

(i) Payment for sucrose content, on Terminal analysis, to the manufacturing mills.
(ii) Large number of analytical crosschecks by the manufacturing mills and Sugar Milling Research Institute.
(iii) Target set by the Terminal laboratory to provide, on a routine basis, analytical results which, if necessary, will be confirmed by any referee analysis and thus provide a reliable quality assurance for the incoming and outgoing sugar.
(iv) The continual effort to achieve a tight analytical control of the incoming stock provides a valuable background of practice and experience which is essential for the quality control of export sugar.
(v) The necessity for reliable information for the application of penalties for the incoming raw sugar which is out of specification. These penalties, which the manufacturing mill pays into an internal fund, are designed to discourage the production of sugar of inferior quality. Items of quality such as the polarisation, colour, ash, grain size, and other

constituents, are tested for conformation with the set limits. When a penalty is awarded, the mill in question may request a referee analysis by the Sugar Milling Research Institute and under these circumstances it is highly necessary that the original analyses by the Terminal laboratory are confirmed as being correct.

(vi) Since the laboratory carries out a large number of routine analyses on sugar supplied by most of the mills in Natal, many queries and analytical agreement problems by these mills generate a background of an analytical clearing centre at the terminal laboratory.

(vii) The importance of a precise pol adjustment of the export sugar and the consequences of an incorrect preparation, with the resultant financial and goodwill implications.

The analytical methods and techniques used at the laboratory have been standardised throughout the industry[4] and need not therefore be reviewed here. However, a few points of interest may be noted:

(1) Because of the large number of samples handled daily, the flow of work and use of certain equipment has been optimised. In case of pol determination, use has been made of a large temperature and humidity conditioned room where all analytical procedures can be carried out at 20°C ± 0,5°C and 65 ± 10% RH.

(2) Routine use is made of multi-shakers, mixers, vibrators and other mechanical devices to speed up the work.

(3) The analytical data is processed by suitably programmed computer to calculate the final results[5].

(4) The results are uncoded, the duplicates paired and checked for conformation with the Standard Mean Deviation for the particular method. If the divergence is outside the limits, repeat analysis by different analysts is requested.

(5) For correspondence and record purposes, extensive use is made of the original computer print-outs which are attached to suitable pre-printed forms, and copied, so as to reduce the possibility of typing and copying errors.

Utilisation of analytical results

The daily analytical results are considered as a part of a general pattern and, in particular, any trends and quality drifts in sugars from any single mill are noted. The results are recorded and displayed on a transparent plastic board. The averages for each preceding week follow and, finally, the monthly averages complete the tabulation.

This method of displaying and its daily updating has proved very satisfactory and has made it possible to handle all the enquiries from the supplying mills at a moment's notice and also to provide information with regard to quality drifts and the possible penalties.

Processing and shiploading of export sugar

After a period of storage, the bulk sugar is shiploaded, but may require a prior polarisation adjustment. The latter has to be carried out in accordance with the excise requirements of the overseas buyers.

The Very High Pol (VHP) export sugar has good storage qualities and can be stored in the silos at the Terminal with very little deterioration[1]. The polarisation adjustment process commences with the exit of sugar from the silos through hoppers in the centrally situated tunnel and onto a conveyor belt where it is carefully "profiled" to maintain steady mass flow.

The process has been previously described[6] and therefore only a brief resumé is given. The sugar is now passed over mechanical belt-weighers which provide a mass readout within ± 0,5% and this information is fed into the invert syrup (High Test Molasses (HTM)) dosing devices. Other information such as the required polarisation of the export sugar (P_e), polarisation of sugar being processed (P_s), and polarisation of HTM (P_m), has to be supplied to the dosing device which then continuously solves the equation

$$W_m = \frac{W_s \ (P_s - P_e)}{(P_e - P_m)}$$

where W_m and W_s are the masses of HTM and VHP sugar respectively.

As can be seen, the dimensions used are pol (P) percentage polarisation of sugars and HTM and mass in tons (W).

In practice, the coating process is rather involved, with the following requirements and variables:

(a) Ability to handle ± 800 ton/hour throughput.

(b) Polarisation adjustment is set to vary only between narrow limits which are usually of the order of ± 0,05% polarisation. When the plant operates satisfactorily this usually narrows down to ± 0,02% polarisation.

(c) The incoming VHP polarisation (P) varies from 99,30 to 99,60% and because of the limits in (b) the process has to be carefully monitored. In practice, the treated sugar stream is sampled continuously and an aggregate sample, representing about 400 tons, is analysed every half hour. In addition, a continuously updated composite sample is prepared and analysed.

(d) The analogue dosing devices are adjusted when the arithmetical average and the updated composite results show an undesirable quality drift.

(e) The viscosity of HTM must be controlled to provide steady-state crystal coating conditions. The control is implemented by the production quality check of HTM and also by its temperature adjustment.

Quality control of syrup-coated sugar is complicated by atmospheric conditions when high relative humidity (often encountered in Durban and particularly after 15h00) may cause the hygroscopic invert sugar syrup on the crystal surface to absorb moisture and therefore depress the polarisation. Conversely, very dry weather conditions may result in overall moisture loss during the mixing and conveyance of the coated sugar to the ship's hold.

Quantity control of the outloaded sugar

An accurate intake quantity control requires an equally accurate weight check of the shiploaded sugar to ensure the correct shipment mass and also that the throughput can be balanced at the end of the production season. On its way to the outloading gantry, the sugar is passed through a Servo-Balans automatic batch weigher of 11 ton capacity. An average shipment of say 24 000 tons will involve over two thousand individual batch weighings which are totalised by the machine. It follows that 0,05% acceptable weight discrepancy is ± 12 tons, so that any additive error greater than 5,5 kg per weighed batch of 11 tons of sugar cannot be tolerated.

The Servo-Balans weigher is checked before and after each ship-loading with assized weights in a similar manner to that used for the intake weighers, but in this case at least ten consecutive weighings of 12 tons each are totalised to check for error.

A further cross-check on the Servo-Balans may be obtained from the readouts of belt weighers used to determine the mass of sugar prior to polarisation adjustment and from the HTM mass meters. The belt weighers in turn are calibrated against the intake weighers by re-circuiting sugar from the silos.

Conclusion

The stringent quality and quantity checks during the intake storage and shiploading of bulk sugar, coupled with the unique polarisation adjustment process, provide a firm quality basis for

the Natal Raw Sugar, as it is known around the world. It is necessary however, to ensure that the quality of the incoming sugar remains high and that in-plant precautions, procedures and calibrations are tightly controlled at all times.

Acknowledgments

The author wishes to thank the Board of the South African Sugar Terminals (Pty.) Limited for permission to publish this paper.

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