# A DESCRIPTION OF THE SUGAR BEET TARE LABORATORY AT TABER, ALBERTA

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## ABSTRACT

Until 1989, sugarbeet growers in southern Alberta were paid on the basis of tonnage only. Declining beet quality, especially in the early 1980's, finally led to payment based on sugar content. A new tare laboratory was constructed in 1989 using state-of-the-art equipment from Italy and Germany. At the same time, operations of the six beet receiving stations were computerized, using bar-coded grower ID cards and tare sample cards. The new laboratory consists of two independent PLC-controlled lines, each capable of processing up to 120 samples per hour. Computers interfaced to each line record the gross and net weights of each sample, together with other pertinent information (presence of rocks, mud, trash or poor topping). A second computer controls the operation of the analytical instruments. Sucrose content, amino-nitrogen, sodium and potassium levels are determined on each sample. In addition, the alkalinity coefficient, extraction and sugar loss to molasses are calculated and provided to growers on a daily basis. Construction of the facility began in early 1989 and was completed in time for the 1989 harvest. The equipment has performed as expected, processing between 2500 and 3000 samples daily during the peak harvest period. After only two years of operation, the new payment method has resulted in noticeable improvements in beet quality.

## INTRODUCTION

Sugar beets have been grown continuously in southern Alberta since 1925. Until 1989, growers were paid on a tonnage basis only. Beet quality varied considerably, often dependent on uncontrollable factors such as plant stand and weather conditions. However, with the advent of improved agronomic practices, increased fertilizer usage, better varieties, and reduced labour usage, beet quality and extraction began a continuous decline as growers strived to increase yields. Increasing productivity, both in the field and in the factory, was essential if the industry was to continue in the future.

During contract negotiations with the growers in 1986, the Company agreed to begin preparations for payment on the basis of sugar content. Payment for beets based on sugar content was hardly a new concept - most sugar beet-producing countries had been paying for beets based on sugar content or quality for many years, with well-documented results. To prepare growers for the introduction of the system, selected fields were sampled and tested for sugar content and purity in 1986, 1987 and 1988. Results were presented to the individual growers involved and at grower meetings each year. A change in the method of payment was viewed by most (but not all)

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growers as a positive step. In 1989, a new three year contract was signed with the growers which included payment based on individual sugar content, beginning with the 1989 crop.

Prior to 1989, approximately 25% of the loads were sampled for dirt and top tare. All samples collected at the six receiving stations were processed through a central lab at the factory. The old lab was small and lacked space for expansion. It was obvious that a completely new building would be required in order to handle the sample preparation and analysis from an increased volume of samples. In selecting the equipment, the following requirements had to be met:

1. A "turnkey" installation with a high degree of automation and reliability was desired. Since the lab had to be in operation by the 1989 harvest, equipment delivery and installation was critical.

2. Up to 1500 samples had to be processed during each 8 hour shift during the peak harvest period. The equipment should have the capacity to handle large research plots up to 100 kg in size.

3. In addition to sugar content, other quality information (amino-nitrogen, sodium and potassium levels) was also desired.

4. All manual entry of tare data into the mainframe computer system was to be eliminated. The beet receiving scale houses were to be computerized at the same time using bar-coded grower ID and tare cards. The tare lab equipment (both for dirt and top tare and the analysis) would have to be compatible with this system.

5. Parts and service should be readily available.

6. Cost.

After visiting several tare labs in the U.S. and various European countries in 1988, it became apparent that a complete "turnkey" job, including a data collection system, from one supplier was not practical. A decision was made to purchase Italian tare lab equipment from RE.LO.BO Engineering of Parma, Italy. RE.LO.BO. was able to supply all equipment with the exception of the analytical instruments, data collection system, high pressure pumps and screens. The gross and net weight scales supplied with the equipment could be interfaced to a computer, with sample numbers input through a bar-coded scanner, or the weight data could be printed on tickets in the event of computer failure. The firm has manufactured and installed more than 50 automated tare laboratories in Europe as well as two research units in the U.S. RE.LO.BO. offered a complete tare lab installation (including motors and drives) that met Alberta Sugar's requirements at a reasonable cost. The new facility consists of two identical but independent lines, controlled by programmable logic controllers, each with a capacity of up to 120 samples per hour.

For the analysis, the German Betalyzer system, manufactured by Dr. Wolfgang Kernchen of Seelze, Germany, was selected. All the required analyses (polarization, amino-nitrogen, sodium and potassium) were available in a relatively compact, computer-controlled system. Once again, sample ID numbers could be input using a bar-code reader. In addition, the capacity of the Betalyzers matched that of the RE.LO.BO. equipment well. Finally, several factories in Europe were using the Betalyzer with RE.LO.BO. equipment with excellent results. The analytical lab is located in a separate area at one end of the building. A chemical preparation room, washrooms and lockers are located on a mezzanine floor above the lab.

The data collection system, both for the scale houses and the tare lab, was designed by Superior Weighing Systems of Winnipeg, Manitoba, a company specializing in the design of computerized industrial weighing applications. Each line in the lab has a separate computer for data collection located in the analytical area of the building. In addition, computers were installed in all scale houses. All computers are industrial construction, IBM-compatible PC computers. The decision to use PC's rather than direct connections to the mainframe has proved to be very practical, allowing greater flexibility at a reasonable cost.

Orders for all equipment were placed early in 1989 and construction of the building began in April. Both lines were fully assembled and tested by RE.LO.BO. in their shop in Italy prior to shipment. A mechanic and an electrician from Alberta Sugar were present during the testing and subsequent disassembly and crating. This later proved to be invaluable during installation. The four containers arrived in Taber on schedule at the end of July. Installation proceeded very well: two RE.LO.BO. technicians plus Alberta Sugar personnel installed the equipment within three weeks after the equipment had been delivered. A third technician from RE.LO.BO. was present during the testing of the lines to make any necessary changes to the PLC program. Approval by the Canadian Electrical Standards Branch was also received at this time. Test samples of sugar beets were run through the lab in mid-September, just prior to the start of harvest.

## OPERATION

The collection of the tare samples begins at any one of the six scale houses. Prior to the start of harvest, the desired sampling frequency (anywhere from 0 to 100%) is input to the scale house computer systems. Every load is sampled for all contracts less than 30 acres (this can be changed). In addition, the first load delivered on any contract held by a grower each day is sampled. When a grower's bar-coded ID card is read by the scanner, the computer system determines whether a sample is to be taken from that particular load. Selection of the loads to be sampled is entirely at random (with the above exceptions) and there is no way to determine beforehand whether a given load will be sampled. If a sample is to be collected, the scale operator is prompted to read a tare sample card into the system. The number on the card is then "attached" to that load, along with other information (date in, time in, truck number, gross weight etc). Both cards are returned to the driver. The tare card is given to the tare person at the pilers and inserted into a pouch on the sample bag. The samples are transported to the lab for processing in large tote bags, eliminating much of the manual labour involved in handling the samples several times. The tote bags are picked up by a truck equipped with a "cherry picker". To improve the reliability of the system, all tare takers were converted to hydraulic operation prior to the 1989 harvest. The growers ID card is read a second time as the truck weighs out and a scale ticket is printed, completing the transaction. If for any reason the tare sample is not taken, the sample number is deleted from the transaction and replaced with asterisks (to indicate sample required but not taken). This system has worked very well and the possibility exists for fully automated, driver operated scale houses.

## GROSS WEIGHT SCALE

At the central tare lab, the bags are transported to the Gross Weight Scale by means of an inclined slat conveyor. A pneumatically operated arm lifts the bag over the scale hopper. The operator removes the sample card from the bag and passes it across the scanner. The sample ID number is transmitted to the data collection computer located in the analytical area of the lab. After emptying the bag, the scale unlocks, and after a preset but variable settling time, transmits the gross weight to the computer via an RS 422 interface. A keyed selector switch alternately allows for printing the weight on a ticket in the event of computer problems. The presence of excess mud, trash, rocks or poor topping can also be noted using a small keypad located near the scanner. Provided the scale has transmitted the weight, the hopper opens, dropping the sample into a skip hoist. If the scale fails to transmit the weight, an alarm sounds and the hopper remains closed until the problem has been corrected. Once the scale hopper has discharged the beets, the scale automatically re-zeros and blocks, ready for another cycle. The operator inserts the ID card into a plastic carrier and places it on a small card conveyor which travels above, but in synchronism with the main conveying equipment. Once an electric eye detects the presence of a card on the conveyor, the skip advances, carrying the sample to the washer.

## SAMPLE WASHING

Each line has two washers. The PLC ensures that beets are dumped to an empty washer only by controlling the action of a divider gate located in the feed hopper to the washers. If both washers are full, the skip will not advance. If the divider gate fails to return to the next position after a sample is dumped, an alarm sounds and the line halts until the problem has been corrected. A similar divider located on the card conveyor controls the movement of the cards to ensure that the proper card travels with each sample.

The washers have rotating undulated plate bottoms and are equipped with three sets of 1 mm nylon brushes - one on the side body of the washer, one on the washer door and one positioned in the center of the rotating plate. Eight, 3 mm nozzles are located in the upper part of the washer. Three high pressure pumps (one per line plus a common spare) were installed to deliver water at the required 16-20 bar (232-290 psig) pressure. Factory clarified water, screened over a wedge wire screen to remove suspended solids, is used for washing the beets. The washers normally do an excellent job of cleaning the beets. Some plugging of the nozzles can occur at times, and for this reason all nozzles are cleaned each week. The washing time can be varied if necessary. At present it is set at 30 seconds. Water consumption is 250 to 300 liters (65-80 USG) per sample.

## TOPPING AND SORTING

After washing, the washer door opens, discharging the beets to a multi-compartmented, double race sorting and topping conveyor. This conveyor and the card conveyor then advance one position. Any necessary topping is done at one of three topping machines located along the conveyor. The beets are then transferred to the opposite side of the conveyor, leaving any debris and rocks to be discarded. This step is necessary in order to prevent rocks from entering the brei saw. As the line advances, the beets are discharged into a second skip which conveys the sample to the Net Weight Scale. The clean weight is transmitted to the computer and matched with the corresponding gross weight on a first in, first out basis. Provided the data transmission has been completed, the scale hopper opens, discharging the beets onto a short belt conveyor feeding the brei saw.

## BREI SAW

The brei saw consists of 8 blades rotating at 2200 RPM. If the saw stops for any reason, the line will halt until the problem has been corrected. After the beets pass through the saw, the chips are carried on two belt conveyors to the factory for processing. If the factory is not operating, the beets are automatically diverted onto a storage pad outside the building. After the sample has passed through the saw, the card arrives in the analytical lab.

## BREI RECOVERY

Two pneumatically operated scrapers discharge brei into a waiting stainless steel cup located on a homogenizer track. This track is used to convey the brei samples to the analytical area in the lab as well as mix the brei. If the homogenizer fails to move after brei has been expelled, the brei scrapers will not operate to expel the next sample, shutting down the line until the problem has been corrected. After the brei sample has been taken for analysis, the cups on the track are automatically washed and dried prior to being used again. All excess brei and water are removed by a pump. The homogenizer can operate in either an automatic or manual mode. In automatic, the line continues to advance as new samples are fed into the line, whereas in manual, the operator must press a button to advance the line. The overall effect of operating in manual, however, is a reduction in the number of samples processed each hour. For this reason, the homogenizer usually operates in the automatic mode. The operator can still stop the line if necessary by pressing an emergency stop button. The entire line will then halt temporarily until the button is released.

## SAMPLE PREPARATION

Approximately 26 grams of brei are removed from each sample and placed on a Bosch proportional balance, which dispenses the correct volume of clarifying solution. At the present time, a 3 brix lead subacetate solution is used for clarification. The solution is prepared in 600 liter batches in a tank located in the chemical preparation room. It is gravity fed to a 200 liter stainless steel tank located in the lab and then circulated continuously from this tank to small head tanks above the proportional balances. Heating/cooling elements in the tank maintain the solution at a constant temperature of $20^0$ C.

## MIXING/FILTERING TRACK

The brei, weighing paper and solution are placed in the first available cup on the mixing track. The sample card is placed in a special tray on top of the cup. A small steel magnet in each cup mixes the solution as the track advances. At the end of the mixing line, the tray carrying the sample card is lifted off the cup and placed on the stand supporting the filter funnel and beaker on the filtering track while the contents from the cup are poured into the filter. The first drops of filtrate are collected and discarded. Although the speed of the mixing line can be varied, it is largely dependent on the person reading the samples through the Betalyzer. Normally, 25 to 30 seconds are required to read each sample.

## BETALYZER

Operation of the Betalyzer is controlled from an IBM PS/2 Model 30 computer using software supplied by the manufacturer. All phases of operation including start-up, calibration, data editing etc. are included in the menu-driven software. The Betalyzer consists of a Sucromat Digital Automatic Polarimeter, Testamin Digital Photometer and a FP-2 Flame Photometer. A standard test solution, prepared daily, is used for calibration of all three instruments on an hourly basis.

When the filtrate arrives at the Betalyzer, it is poured into the polarimeter feed funnel. A conductivity probe detects the presence of solution, activating a peristaltic pump which sends a portion of the solution to the photometers, along with the other required reagents (copper solution, lithium standard solution and distilled water). The computer then prompts the operator to enter the sample number. Once the bar-coded card is scanned, the pump operates for a fixed length of time, after which a solenoid valve opens allowing the remaining solution to enter the polarimeter tube. The values for sucrose, sodium, potassium and alpha-amino nitrogen are then transmitted to the computer and written to the hard disk. The results for each sample are also printed. Values for sugar loss to molasses, extractable sugar and alkalinity coefficient are also calculated and printed. By this time, the computer is already prompting the operator to feed the next sample. The Betalyzers have proven to be reliable and relatively trouble-free, provided regular cleaning is done. The tubing supplying the flame photometer is very small (0.01" ID) and can easily plug if the sample is not absolutely clear.

## DATA COLLECTION

At the end of each day, data from the scale house computers and tare lab is exported to floppy disks and transferred to a PC in the main office where the tare lab data is matched with the load data from the scale houses. Daily delivery reports are usually available at the scale houses within three days of delivering the beets.

## SYSTEM CONTROL

All phases of the tare lab lines, including the mixing and filtering tracks, are controlled and managed by Klöckner-Moeller SUCOS PS 22 programmable logic controllers (PLC). The program resides in non-volatile EPROM memory. Pushing the "Line Start" button on the control panel initiates the automatic cycle at the start of each day. As long as samples continue to be fed into the system, the line will keep advancing. Emergency stop buttons are located at the Gross Weight Scale, the brei saw, the homogenizer and the mixing/filtering track. There are also more than 25 conditions which will stop the line and sound an acoustic alarm. These include:

- brei saw stopped
- rasped beet conveyor stopped
- low air pressure
- line overload trip
- emergency stop button pressed (any one)
- washer shut down
- data transmission failure (either scale)
- failure of scale hoppers to open or close
- failure of either skip to ascend/descend completely
- washer divider blocked
- failure of either washer door to open or close
- topping conveyor stopped or blocked
- topping conveyor position incorrect
- bag lifting arm blocked
- homogenizer overload trip
- mixing/filtering track trip

The alarm condition is also displayed on a screen located in the control panel for each line. Once the condition causing the alarm has been corrected, simply pushing "Line Start" will re-start the line. The PLC "remembers" where each sample was in the system and no samples or data is lost. If necessary, all steps in the process can be performed manually.

OTHER REQUIREMENTS

High quality water must be used to prepare the required reagents. An ion exchange system was installed to provide water with a minimum quality of 1,000,000 ohms. The system includes, in sequence, carbon filters, an organic scavenger filter, cation exchange, anion exchange and finally a mixed bed polishing filter. Capacity of the system is 12 liters/minute. Water from the system is also used in the main factory lab, eliminating the need for water stills.

Since the tare lab may have to operate before the factory begins slicing, it was decided to provide power from the local utility company rather than use factory power. Total power requirement for the tare equipment, including the high pressure pumps is about 210 KW/hour.

Air quality for both the RE.LO.BO. equipment and the Betalyzers must also be high. Factory instrument air at 6 bar (87 psig) is supplied to all tare lab equipment.

Technical data for the RE.LO.BO. equipment is shown below:

| | |
|---|---|
| Capacity: | 100 - 120 samples/hour/line |
| Sample weight: | up to 100 kg |
| Air pressure: | 6 Bar (87 psig) |
| Air consumption: | 400 Liters/minute/line (14 cfm) |
| Water pressure: | 16 - 20 Bar (232 - 290 psig) |
| Water consumption: | 250 - 300 Liters/sample (65 - 80 usg) |
| Power supply: | 440 Volts, 60 Hz |
| Power consumption: | 210 Kw/h (total both lines) |
| PLC power supply: | 24 Volt DC transformer |
| Control power supply: | 24 Volt AC transformer |

LABOUR REQUIREMENTS

The labour requirements for each line are shown below:

| | |
|---|---|
| - Bag handling | 1 |
| - Scale operator | 1 |
| - Topping/Sorting | 2/3 |
| - Analysis | 3 |
| Total | 7/8 |

A total of 7 or 8 persons per shift are required to operate one line, depending on the number required for topping and sorting. On normal tare samples (15 - 25 kg), two persons are usually sufficient.

SUMMARY

The new tare lab installed at Alberta Sugar in 1989 has performed as expected. Some routine maintenance is required during intercampaign and regular lubrication is essential during operations. As with any new installation, some problems were encountered during the first few days, but they were generally of a minor mechanical nature. Problems caused by people were more frequent, primarily due to lack of experience. It took some time for the personnel to feel comfortable with their jobs. However, most employees returned for the 1990 harvest and problems caused by personnel were minimal. In 1990, the lab operated two shifts daily and ran at capacity on most days, processing a total of more than 26,000 samples. Average sample size was 18.26 kg.

The response by growers has been most encouraging, with an improvement in quality already evident. Much further work remains to be done, but the long overdue first step has been taken.