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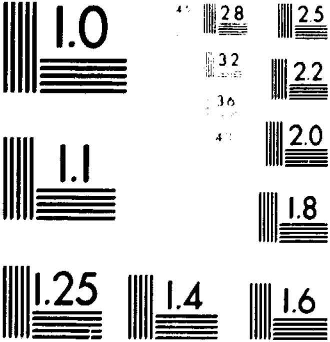
This report covers a United Nations Industrial Development Organization Project in the People's Republic of China completed between January 28th and February 23rd, 1985. It was assigned number DP/CPR/82/005/11-06/31.7.C.

The stated purpose was "To strengthen the capabilities of the Cane Sugar Industry Research Institute in the field of sugar processing, utilization of by-products, and the abatement of pollution so as to prepare a better foundation for the establishment of a National Cane Sugar Industry Research Center."

The service request called for lectures on the latest sugar boiling techniques, including instrumentation available for operator assistance and for automatic regulation of the boiling process. Suggestions for improvement in sugar quality and reduction of present energy consumption were desired as well as means to improve the quality of alcohol made from the by-product molasses.

Lectures were given to members of the Cane Sugar Industry Research Institute and to members of the Guangzhou Factory staff as well as a day-long symposium for delegates from other Guangdong Province factories at the Science Hall in Guangzhou. At a later meeting written questions from the delegates were answered at the Guangzhou factory where they were able to observe some of the experimental work in progress. While waiting on pans at the Guangzhou Factory a great deal of information was imparted to the assisting Institute staff on the subject of sugar boiling in general, pan problems that had been encountered over the years and even a short course on practical automatic control application in all industries.

Copies of articles regarding sugar crystallization, boiling techniques and related subjects were left with the people at the Research Institute for reproduction in their publications as they see fit. Also copies of instruction forms and operating instructions for the various special measuring instruments made for the sugar industry of our manufacture. Charts giving saturation data on syrups from many sources and solubility data will be found useful in disseminating information to the sugar industry in China. Also furnished to the institute were reprints of technical articles on automatic control theory that should prove to be of much guidance to those adding new controls to the various stations in sugar factories in China.



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NATIONAL CANE SUGAR INDUSTRY RESEARCH CENTRE

DP/CPR/82/005

THE PEOPLE'S REPUBLIC OF CHINA

Technical report: Introduction of Current Sugar Boiling Technology to the Cane Sugar Industry*

Prepared for the Government of China
by the United Nations Industrial Development Organization
acting as Executing Agency for the United Nations Development Programme

Based on the work of J.G. Ziegler
Expert in Sugar Boiling

United Nations Industrial Development Organization
Vienna

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The request for assistance also called for advice on ways to improve the quality of alcohol being produced from by-product molasses but apparently the urgency of this project had abated. However, we did supply information on the subject in the form of sketches of improved still systems for making aldehyde, ester and quality spirits free of heavier components so they would approach cologne spirits in quality without excessive steam consumption. The people at the Sugar Institute will be free to contact us if the improvement of alcohol quality again becomes urgent.

A. Guangzhou Factory

All the investigative and experimental work conducted with the staff members of the Cane Sugar Industry Research Institute was done at the Guangzhou Sugar Factory which is located on the Pearl River Delta a short distance from the center of Guangzhou. It is rated to grind a nominal 2600 tons cane per day which is reputed to be the capacity of most factories in China. Its juice purification system is somewhat unique since it uses first and second carbonation and sulfitation very similar to a normal beet sugar factory and thus somewhat different from most of the factories producing plantation white sugar in China. But this interfered not at all with our investigation of sugar boiling methods.

At Guangzhou Factory, final "A" sugar is boiled from a magma footing of "B" sugar in syrup. "C" sugar is all remelted into syrup from the evaporator. Typical "A" massecuite 92 purity; "B" massecuite, 80 purity and "C" massecuite 55 purity with about 32 purity final molasses. These figures show quite good crystal yields on total solids of 60%, 55% and 34% respectively for the three boilings.

Centrifugal operation and washing leave room for improvement. Washing is done haphazardly with a heavy stream from a hand-held hose, generally before the machine has attained maximum speed and syrup adequately purged from the crystals. Separation of green and wash syrups is done on the whim of the particular operator so it is doubtful that good separation is achieved. Wash syrups are used to top off their respective pans and generally contain fine crystals as no means are provided to heat most pan storage tanks.

Pans are dropped to receiving tanks and generally held for a while before delivery to the centrifugal feed trough which is good as it gives time for the highly oversaturated mother liquor in the massecuite to drop toward saturation from the high level at pan drop and deposit sugar on the existing crystals.

Sugar discharged from the "A" centrifugals is carried via a grasshopper conveyor to the boot of a bucket elevator conveying it up to a single grasshopper screen. The only conditioning the damp sugar receives is the cooling on the conveyor and screen as there is no hot air granulator and there are no plows for the centrifugal baskets so many chunks of adhering crystals remain on the screen and are removed as oversize.

The production sugar lies between 0.8 and 1.6 mm with a mean aperature about 1.13 mm. It was not possible to determine what authority specified this large grain size. Microscope examination of the undersize from the screen showed it to be of better structure than the production material as it contained fewer conglomerate crystals and undoubtedly had lower ash and color. But the small fraction along with the oversize, mostly conglomerates and poorly purged chunks from the centrifugals were sent to a nearby rock candy and gur factory as its raw material.

The evaporator at Guangzhou was a straight quintuple effect operating on turbine exhaust at about 1.5 atmospheres gage pressure. First vapor was used for vacuum pans and some secondary juice heaters. Second vapor went to some primary heaters and, although it was piped to the pans, was useless as it was generally at or below atmospheric pressure. Exhaust steam was also piped to the pans but only with 6 inch valves.

The vacuum pans were of Czechoslovakian design with the name "Rozpiscu" given on the drawings. The original five were apparently supplied around 1958 and the sixth built locally to the same design but somewhat larger, 55 M^3 instead of 45 M^3. The originals had 225 M^2 of heating surface. They were of the floating calendria design with a central downtake 1000 mm diameter and a 120 mm downtake space around the 3700 mm O.D. of the calendria. The shell over this was increased to 4300 mm diameter. The tube sheets were inclined toward the center at approximately 15° to follow roughly the contour of the pan bottom. Feed was introduced in a ring under the lower tube sheet but it was only

380 mm in diameter so feed was not dispersed under the calendria but toward the center of the 1000 mm central downtake.

It would not have been easy to find pans less adapted to teach operators the clear principles of precision sugar boiling. In the first place, the so-called "low head" pans with enlarged diameter above the calendria are not able to boil the uniform grain (low cV) that can be produced in the straight sided ones because of the massecuite circulation pattern they induce. In the second place, floating calendria pans are notorious for their poor circulation pattern since they do not know whether to circulate "outside-in" or "inside-out" and generally do little of either. The absence of proper feed distribtion under the calendria heating surface and the lack of facilities to heat incoming syrup so it would flash on entering the pan and induce some circulation made it very difficult to maintain reasonably uniform massecuite throughout the pans. First vapor supplied to the pans varied between 0 and 0.8 atmospheres gage pressure at the calendria, averaging around 0.2 atmospheres. The large grain was not well held in suspension.

On the plus side was the availability of good wet ground fondant for seeding the B and C strikes. Apparently Mr. Chen Shi-Zhi had initiated many of the factories to its use prior to 1966 with good results. The people familiar with its use and the seeding techniques he developed were lost from the sugar industry during the following 10 years and now only a few including Guangzhou still use it. The practise should be encouraged because it is the only method now known to establish the correct amount of grain in a pan reliably.

The wet grinding of fondant was first used by Ditmar Jansse in Java before the war; Gene Gillette of the C&H refinery in Crockett California introduced it to Hawaiian mills in the 50's and it was adopted by the U.S. beet sugar industry in the 1960's for use with the Taylor pan control systems as seeding was the last important variable to pin down. Nearly all factories in the United States now use wet ground fondant exclusively.

B. Sugar Boiling Tests at Guangzhou.

In 1984, the Cane Sugar Industry Research Institute obtained two sets of Ziegler and Associates Oversaturation and Consistency Monitors which were installed on the #1 and #2 pans at Guangzhou factory for use in the experiments.

The Oversaturation Monitor measures the boiling point elevation of the mother liquor in the massecuite; the difference between the temperature at the top level of the boiling material in the pan and the temperature of hot water flashing down to equilibrium at the vacuum of the vapor space above the massecuite. The Monitor converts this temperature difference into a direct meter reading of Syrup "Oversaturation" which requires definition.

A sugar crystal suspended in a syrup that is just saturated will neither grow or dissolve. If some water is removed from the syrup or its temperature lowered, it is said to be supersaturated and the suspended crystal will grow. The degree of supersaturation as defined by Claassen as the grams of sugar per gram water in the syrup divided by the grams sugar per gram water that would be present in a syrup that was just saturated at the same temperature. For example, a pure sugar solution at 63.5°C is just saturated at 75 brix, or 3 g sucrose per 1 g water. If it were concentrated until it contained 4.5 g sugar per 1 g water it would be at 1.5 supersaturation or 50% "Oversaturated". Since syrups below saturation are of little interest in sugar boiling, the 970-M Oversaturation Monitor is calibrated in "% Oversaturation".

Impure sugar solutions have more solids at saturation than pure ones and, of course a higher boiling point elevation, so dials on the Monitor are provided so that they can be set for the syrup purity to make it still read in terms of Oversaturation, as it is the most important variable in sugar boiling.

Crystal growth rate increases with oversaturation but there is a limit that must not be exceeded in pan operation. If syrups are allowed to get above 65% oversaturation, myriad fine crystal nuclei appear spontaneously in the syrup and grow as "False Grain" making another crystal crop. So, in precision sugar boiling once grain is established, one wants to keep a high oversaturation for rapid crystal growth but never over 65%.

The second constraint in precision sugar boiling is massecuite consistency. As grain grows in the early stages of a strike, the crystal/liquor ratio increases and the overall viscosity gets higher due to the smaller liquor film between crystals. At some point, when the crystal yield is around 15% of total solids in the massecuite, syrup feed must be adjusted to prevent further rise or pan circulation will deteriorate and this viscosity maintained until the pan is full and final tightening initiated. There is not much change in the viscosity of concentrated syrup and an optimum massecuite consistency but a large percentage change from there on up to dropping consistency. So constant speed devices for measuring consistency give little readability at the low and most important end of the scale and too much at the high end. The 970-C Monitors are designed to cover over two decades of viscosity on almost a perfect logarithmic scale with adequate readability for a decade above and below, providing good resolution over more than the usual consistency range encountered in pan operation.

Pans at Guangzhou factory were normally operated at the minimum absolute pressure attainable by the water jet condensers which often fell below 3" hg. Abs. giving massecuite temperatures in the low 50°C range. This is too cool for successful sugar boiling as crystal growth rate increases with temperature at the same degree of oversaturation. Fortunately Mr. Wang of the Research Institute, acting on an earlier suggestion, had constructed two weight loaded vacuum relief valves for bleeding air to load the condenser jets and maintain fairly close regulation of pan vacuum and had installed them on the #1 and #2 pans being used for test. These were set to hold about 4.5" Hg. Abs. over the massecuite bringing its temperature into the low 60°C range. This made the two oversaturation Monitors operable as they are calibrated for use on pans operating in the normal range of pressures between 4"and 10" Hg. Abs.

Pan operators had been in the habit of periodically venting non-condensable gases from the pan calandrias when the spirit moved them. It was pointed out that continuous bleeding was preferable especially in view of the low first vapor pressure available. No drawings were available showing the steam side calandria baffling if any, but suitable designs were discussed in the event that additional pans were built locally.

Water Jet Condensers are quite inefficient regarding air removal so considerable time was required to raise vacuum on a pan full of air. If the air has been partially purged out by recent steaming between strikes, the interval is greatly reduced and this was pointed out to the operators as a means of increasing pan floor capacity and as an incentive for better pan scheduling in the future.

Sugar boiling at Guangzhou was sort of a hand to mouth operation. When syrup supply was plentiful, all pans would be operating, competing for the meager amount of first vapor available. At other times, pans had to be uneconomically held on water to prevent an excessive pressure increase. This situation could be easily corrected by the addition of simple pressure controls on the evaporator as will be discussed later in this report.

The course of several A and B strikes as normally boiled were observed with the help of the monitors on #2 pan and recorders supplied by the Cane Sugar Research Institute. It was not possible to determine where their boiling technique originated; presumably it had simply evolved over the years.

For an "A" strike, a charge of about 15 M^3 of syrup was drawn in and steam turned on to concentrate it. At around 50% Oversaturation, 4 M^3 of magma was introduced consisting of about 0.5 mm MA "B" sugar in syrup. Boiling was continued until the mother liquor was well into the labile zone and a copious quantity of fine grain was formed. They took several minutes to grow to a size visible to the operator on a proof slide with nothing but his unaided eye. He then poured in a large amount of water through the overhead wash-out line. This dropped the syrup concentration to an unsaturated level, at least in the upper part of the boiling and poorly circulating massecuite, but not in the lower part of the calandria and below it. As the oversaturation rose and some mixing took place, the growing fine grain again appeared on the proof slide and more water spray was administered. After two or three such additions, he would judge that the charge was reasonably free of fines and would let the oversaturation increase until, estimating the concentration only by mother liquor viscosity, that it was time to start syrup feed. But instead of a slow feed to match the rate of evaporation, he would pour in a large drink, again dropping the oversaturation to a low level. As it slowly rose, grain growth increased until the next copious drink of feed went in. This was continued until massecuite approached the 34 M^3 final level. The strike was usually topped off with "A" Wash syrup which generally contained fine grain that had gone through the centrifugal screens and were not melted out before reaching the pan as there were no facilities for heating the pan storage tanks.

Final tightening of the massecuite before dropping the strike was done blindly and usually as quickly as possible with the steam available at the time. The oversaturation exceeded the safe limit so that more fine grain was formed which, of course, added to the overall viscosity but added little to the yield of production sugar due to their small size unless they adhered to the surface of clean crystals and created dust and packaging difficulties.

It was not difficult to see that the low average oversaturation of mother liquor created by periodic syrup additions was the major cause of the very long pan cycles of 7 to 8 hours so continuous syrup feeding was instituted.

The time required to boil a strike of sugar is either that needed to evaporate the required amount of water between syrup and final massecuite or the time needed to grow grain of the desired size. A typical white beet sugar strike making 0.4 mm MA sugar from fondant seed can be completed in about 1.7 hours if the standard liquor feed is near 70 brix and a 50°C temperature difference exists between boiling steam and massecuite; this in a typical pan with 1.5 square feet of heating surface per cubic foot of pan volume. With a lower liquor concentration or less temperature driving force, the time increases because of the reduced evaporating rate available. Larger grain requirements or higher feed concentration necessarily increase the required time to form clean sugar crystals since the maximum rate of growth is near 300 g/hr/M^2 of crystal surface area which is something less than 0.66 mm/hr. on each crystal face. These values are for relatively high purity syrups and the rate drops considerably with syrup purity.

At Guangzhou, the syrup feed to "A" pans was around 92P and at varying but relatively low concentrations. The steam supply was very erratic and the grain size required was large by most standards. These factors indicated that pan cycles could be reduced to about 4 hours by regulating feed to keep syrup oversaturation high during the early stages of each strike to increase crystal area as fast as possible and then hold massecuite consistency at a reasonable level to promote its circulation until final level was reached. This method seems to make the best use of pan capacity.

There is an almost universal desire for some one measurement that will indicate the best condition for sugar boiling throughout each strike but it now appears to be a futile quest. There are two separate constraints on the boiling process. At no time should the oversaturation of the mother liquor exceed the limit of the metastable zone or a new crop of grain will form and, during the growing period, the overall massecuite consistency or viscosity must be held within limits determined by the pan design to maintain optimum circulation and mixing of the material being boiled. These limits are close to 65% oversaturation and a crystal yield near 15% of total solids in the massecuite. During the final tightening, the crystal yield is increased to 50 to 60% of total solids, but during this phase, oversaturation must not be allowed to exceed the safe limit or wasteful fine grain will form.

These simple rules are easy to follow if the two important variables are displayed for the operator's guidance. He first watches Oversaturation, putting in the required fondant seed or magma when it is in the 40 to 50% range and starts syrup feed as it approaches 60%, regulating the feed rate so the reading never exceeds 65%; When the massecuite "pulls together" and the Consistency rises to a good value (found to be around 64% at Guangzhou for both A and B strikes) he regulates syrup feed to hold it in this area. Oversaturation will then slowly fall to a safe 45 or 50% as crystal surface area increases. When maximum level is reached and syrup feed is shut off, he again turns his attention to the Oversaturation reading which will slowly increase because all the water evaporated must come from the mother liquor. If it reaches 65% he should start a little water feed to prevent fine grain formation. With increasing crystal yield, the mother liquor purity falls as shown on drawing ZA-116 but rather than set the monitor purity dials for the estimated purity, it has been found better to leave them set for the massecuite purity and let the reading increase until a microscope examination finds the point at which fine grain begins to appear. On the syrups being boiled at Guangzhou, "A" strikes could be allowed to reach a 72% oversaturation reading during the final tightening process without the need for water addition. The "B" strikes could go a little higher because of their greater purity drop. Usually, just before dropping, the oversaturation will begin to fall naturally, due to the lower evaporating rate with increasing consistency and the increase in crystal surface being available for sucrose deposition.

People yearn for a model pattern of oversaturation and consistency with time but this is not possible due to normal factory variations in steam pressure and feed concentration. However, the simple rules for observing the indicated constraints during the course of the sugar boiling cycle have made it easy to train operators in many sugar producing areas of the world.

At Guangzhou factory, "A" and "B" strikes of excellent sugar crystals were boiled in about half the time formerly required and with almost theoretical steam use; occasionally a little water feed was required at the end to keep oversaturation to acceptable levels because of the limited crystal surface presented by the large grain desired for production sugar. A decrease in both boiling time and steam use were the major objectives of this project and it was demonstrated that both could be accomplished with a minimum amount of suitable additional instrumentation coupled with adequate operator training in their use.

This project only entailed work at the Guangzhou Factory so did not give an overall view of the problems in other factories of China's Cane Sugar Industry although discussions with Mr. Chen Shi-Zhi of the Research Institute indicate that most could benefit from the observations and accomplishments at Guangzhou. A day spent touring the newer factory at Mei Shan with members of the Institute staff under the guidance of Mr. Fang, general manager and Mr Ho, factory superintendent, gave a broader view of present trends in the industry. But suggestions for changes that could be made to improve factory operation are based on observations made in Guangzhou factory.

C. Suggested Changes at Guangzhou Factory.

1) These recommendations are based on the recent pan tests and years of experience in many beet and cane sugar factories over the years. Much can be done to improve day to day operation with minor capital outlay. All six pans should have the simple vacuum regulators such as were installed on #1 and #2 during the test work to maintain a steady absolute pressure around 115 cm. Hg. Abs at all times. If all pans are held and operated at the same pressure, the useful strategy of cutting over massecuites from one to another is greatly simplified and bad manipulation avoided in the operation. Once the boiling time per strike is reduced, even higher pan temperatures can be used to speed crystal growth and boil cleaner grain. Eventually pans can be boiled around 125 to 150 cm. Hg. Abs. as higher steam temperatures become available to keep massecuites in the more favorable 65° to 70°C temperature range.

2) Effort should be directed toward improving the massecuite circulation in the pans by constructing proper feed distributors. The present small diameter feed ring under the center downtake should be replaced by at least eight 3 cm. inlets in the bottoms on about a 2900 mm. diameter circle so that feed enters near the wall side of the calandria area and contributes to the desired outside-in circulation.

3) Syrup feeds at Guangzhou are allowed to cool in the pan storage tanks and no provision is made to keep them hot except for one tank which has an open

exhaust steam line. This was used to heat the syrup for one "B" strike and improved pan circulation in spite of the poor feed ring location. American sugar factories maintain pan storage tanks in the 90° to 100°C range at all times so that syrup will flash on entering the pan under the calendrias and provide good mixing with the massecuite as well as improved heat transfer from the bubbles rising through the calendria tubes. Heat in the pan supply tanks also serves to melt out any crystals remaining in the syrups before they enter the massecuite and introduce unwanted grain. Flashing syrup introduced near the bottom of a pan and properly distributed can work wonders in improving massecuite circulation not only in pans but in evaporator bodies. Some years ago an evaporator of European design was installed in a Canadian beet sugar factory and, for years never reached design capacity. Between each effect the liquor was flashed and the vapor piped to the downstream body. The purpose of this folly was to produce a simple level control for each body using weir overflows. Eventually, the lines carrying flashed vapor were blanked off so that the so-useful vapor and juice both entered the downstream bodies to increase the agitation and heat transfer. From then on, the system readily exceeded the design capacity.

For the time being, all pan storage tanks at Guangzhou can be provided with perforated live or exhaust steam lines near the bottom so that syrups can be held near their atmospheric boiling point. The dilution from live steam injection is to be deplored but will be repaid by the improved heat transfer and better massecuite circulation. Eventually, the tanks should be equipped with indirect steam heated surface made of about 2.5 cm. tubing or pipe. The surface should be located toward one side of the tank bottoms to allow for a downflow area at the other side to promote thermal circulation. A simple "self-acting" vapor pressure temperature controller with its bulb located just over the heating tubes is adequate for automatic control of tank temperature. The water used for holding strikes or limiting syrup oversaturation during final tightening should also be maintained at high temperature for the flash it can provide on entering the pans.

4) Consideration should be given to the installation of Oversaturation and Consistency Monitors on all pans, at least on those used for boiling "A" and "B" strikes and all operators trained to follow their guidance at all times. This will do much toward eliminating the present waste of time and steam on the pan floor.

Later, the electrical output of the Consistency Monitors can be converted by current-to-air transducers to actuate proportional response indicating or recording controllers connected to pan feed valves as described in the paper titled "Some Useful Strategies". This will simplify pan operation still more.

5) Evaporator Control Systems were first installed in American sugar factories in the early 1940's primarily to reduce operating labor cost but this turned out to be only a minor benefit compared to the increased capacity and economy they provided. Their use quickly spread in a few years, so that now practically every plant is so equipped. By maintaining the juice level in each effect at the value giving the best heat transfer, evaporating capacity was markedly increased. The syrup leaving was held at a constant high brix for factory heat economy because a multiple effect evaporator removes water far more economically than a pan which operates at single effect. The systems automatically adjusted the evaporating rate to just meet the demand and did it gradually to eliminate sudden load changes on the boiler house, making steam generation more efficient. But most important, the systems maintained constant pressure of exhaust steam and the vapors withdrawn from the evaporator to operate pans and other heat users. No longer was there competition for a share of vapors as at Guangzhou. Suddenly there was enough for all stations in the factory; pans could be scheduled to equalize their need for first and second vapors. The plants began to run smoothly and more economically because lower pressure vapor could be relied upon for the less critical uses.

Evaporator control systems were not in the least complex since each variable was controlled in the most straightforward way possible; the juice level in each body regulated juice inflow, the concentration of syrup leaving the last effect regulated the outflow. An increase in syrup brix speeded its withdrawal rate and the resulting drop in body level increased the inflow of lower density juice from the previous body. The need for more or less evaporation was sensed by a level controller on the evaporator supply tank; a rising level gradually increased the steam flow until it balanced out at a higher level.

Due to the demand for vapors by the rest of the factory, evaporating rate was reduced by throttling the flow of vapors from 2nd effect (usually the lowest vapor used) into the 3rd effect calendria. This effectively lowered the overall evaporation since it reduced the flow to #3, #4 and #5 as well as the flow from #1 and #2. At low evaporating rate, first and second vapor pressures tend to rise rather than fall as they would have done if the exhaust steam flow to first body had been throttled. To prevent any pressure variations in these useful vapors, controllers measuring them throttled inlet steam and vapor valves to the respective bodies.

The total evaporation from a quintuple effect evaporator from which 1st and 2nd vapor are withdrawn for process use is equal to 1st vapor + 2 x 2nd vapor + 5 x 5th vapor or very nearly so. At very low evaporating rates, after fifth vapor flow is reduced to a minimum, the evaporator must still supply vapors and the evaporation is 1st vapor + 2 x 2nd vapor; if there is less water than this available in the juice, water must be added to the juice tank to supplement the low flow. In the evaporator control systems, this was done automatically by means of a trip valve that maintained minimum level in the tank after it had fallen below the point that closed the second vapor valve to third body. It would thus maintain first and second vapor supply when there was no juice and pick up evaporation again when flow was restored.

Such systems have run reliably for many years with only the attention needed to clean heating surfaces when consistently rising juice tank level indicated that bodies were getting dirty. Otherwise they take the juice available and deliver syrup at the required brix continuously. Guangzhou factory would benefit from the addition of an evaporator control system as so many others have. But until a decision is made to add such control, something should be done to insure a more reliable first vapor supply to the pan floor.

6) First Vapor supplied to the vacuum pans varies in pressure over quite a range making it difficult at times to provide adequate massecuite agitation and requiring a great deal of attention to maintain pan conditions by adjusting syrup feed rate. At present, when clarified juice supply falls, the steam to first body is throttled and first vapor pressure falls, starving the pan floor. This can be easily corrected manually by installing a butterfly valve in the approximately 16" vapor line between #2 and #3 and partially closing it to reduce total evaporation when needed. It need not be an expensive commercial valve but can be easily fabricated in the pipe shop. Mr. Chen Shi-Zhi has a copy of a drawing showing typical construction which has been used many times in constructing hundreds of valves for evaporator controls. He also has curves giving capacity and unbalanced torque of such valves. They can be

positioned manually or automatically by using commercially available lever motors. If first vapor pressure rises too much when the valve is throttled for low evaporating rates, the exhaust steam valve to 1st body should be closed somewhat to maintain the same 1st vapor pressure.

7) The Exhaust Steam Pressure system at Guangzhou factory was not investigated fully so these notes are added to guide interested parties contemplating better regulation of this process facility. Reasonably precise control of turbine exhaust pressure can pay dividends in terms of steam saving and steady factory operation.

The quantity of steam to a turbine varies with the electrical power load on the generator and the exhaust steam is used primarily to satisfy the heat load of the factory, evaporator, etc. When the heat load is greater than the power load, live steam is used to make up the deficiency and maintain the pressure. When the opposite condition prevails with power load greater than heat load, the turbine governor increases steam flow and the excess exhaust must be vented to the roof. One hates to see this loss of steam so the venting is often delayed until the exhaust pressure has risen as much as is allowable. This is a bad mistake. At higher back pressure, the water rate of the turbine increases and makes that much more exhaust to eventually be relieved. It is good economy to maintain a constant exhaust pressure whether make-up or relief is required.

This was one of the first controls almost universally adopted by the sugar industry in the U.S. and Canada. A Proportional plus Automatic Reset controller is used to operate staggered make-up and relief valves set so that at mid-controller output both valves are just closed; increasing output opens the make-up valve and falling output opens the relief to the roof. There should be no dead spot between valve actions so valve positioners are used on both for precise staggering.

8) Centrifugal operation on production "A" sugar could benefit from adoption of some practises generally observed in other factories. The present haphazard washing with a heavy stream from a hand directed hose would be better done through two or three spray heads from fixed positions inside each basket and carefully directed to distribute wash water uniformly over the face of the sugar cake. Using water maintained at a very high temperature, reduces the

viscosity of wash syrups leaving thinner films on the crystal surfaces, aiding drying and increasing sugar purity.

Another good-practise rule, often ignored in the centrifugal operation at Guangzhou, is that all possible molasses be removed from the crystals before wash water is applied; certainly not before the basket has reached maximum speed as was often observed. Simple sequence timers and solenoid valves could well be employed on these machines to insure that purging was complete before the admission of wash water on a timed interval. The same timer could also be used to switch the curb valve for better separation of molasses and wash.

9) One small possibility for increasing the quantity of production sugar produced per day was noted at Guangzhou factory. With no hot air granulator and a minimum of agitation of sugar on the grasshopper conveyor as the sugar was dried and cooled, there were many clumps of adhering crystals delivered to the final screen. Microscope examination of the sugar in these clumps showed that the crystals were just as good as those shaken apart on the conveyor and in the bucket elevator. These clumps were easily crushed by mild hand pressure so it might be desirable to add a soft roller near the elevator end of the conveyor to provide the small extra energy needed to separate the clumps into distinct crystals and make them amenable to screening for production sugar.

10) As noted earlier, it was not possible to determine the origin of the specification calling for the large sized production sugar. Equally good sugar is routinely produced from no purer syrups with grain less than half as large. It would be worth investigating the possibility of reducing grain size to around 0.5 mm MA. With precision sugar boiling methods, it is easily possible to produce sugar almost free of conglomerate grain and the clean crystals purge freely and wash to sugar with low color and ash content.

Production of smaller grain also increases pan capacity because strikes can be boiled to almost the same crystal yield in less time since the available crystal area is higher throughout strike period, making for easier regulation of syrup oversaturation and massecuite consistency. Final brixing to dropping consistency is faster with the increased crystal area and less or no water feed is required during this phase.

Studies on this possibility can best be undertaken by the Cane Sugar Industry Research Institute. It must also be depended upon to spread the word of the advances made during these tests on newer sugar boiling techniques. Advances that were only made possible by the excellent cooperation of the Institute staff and the personnel at Guangzhou Sugar. Mr. Chen Shi-Zhi and his wife, Ms. Bao Guo-yu, organized the activity superbly well. Staff members of the Institute, Mr. Wang, Mr Liang, Ms. Chou, Mr Wu, Ms. Qi not only supervised instrument installation but kept the experimental facilities operating during the test period. Without their help it would not have been possible to accomplish as much in so short a time.

Equal thanks are due to the people at Guangzhou factory for their whole-hearted cooperation in this investigation; Mr. Chun, Technical Manager, Mr. Huang, Chief Engineer and Ms. Ho, Production Superintendent furnished much assistance and encouragement as the recurring problems were being solved. Special thanks also to Mr. Wang Rong-Liang, head sugar boiler, for his help and patience as we upset his normal boiling methods in our efforts to find better and faster ways to accomplish the same result.

11) One other experiment was conducted, not related to sugar boiling, but one that could be of assistance in juice purification. The pH of solutions were being determined by the use of indicators such as bromthymol blue by periodic checks which was laborious and not adapted to continuous or automatic control. For many years, Hawaiian mills have used antimony electrodes to provide the measurement of juice pH quite successfully. Compared to the more modern glass electrodes, the antimony ones are very rugged, last indefinitely, and, in not requiring exotic, high impedance amplifiers have proved to be much more practical for every day plant use. Most Hawaiian mills and many beet sugar factories now use them exclusively. Reputedly, they are not capable of the same degree of accuracy as glass electrodes but then, scale or scum on either one destroys its accuracy and the antimony ones are easier to clean and keep clean by directing the sample flow across the antimony metal face.

In order to see if these useful units might provide a practical solution to juice pH measurements to the Chinese Sugar Industry, one was tried for a few hours at Guangzhou on the sulfitation station and seemed to work perfectly. So a combination Antimony-Silver chloride electrode and a suitable indicating amplifier transmitter will soon be sent to the Research Institute so they can test it for suitability on a variety of juices and hopefully find it to be a practical solution to the ever present pH control problem.