POSSIBLE MEASUREMENT ERRORS

The 970-M Oversaturation Monitor measures the temperature of vapor leaving the massecuite surface. Since the vapor is superheated, certain problems can occur in obtaining an accurate and precise temperature measurement. Precise temperature is important because full scale on the monitor represents only 6 to 9°C change, depending on purity settings. Boiling point elevation is a sound method for determining oversaturation, once all the sources of error are eliminated. This section discusses possible pan deficiencies and suggests ways to eliminate them.

Even small additions to or subtractions from pan vapor temperature between the massecuite surface and the point of measurement will cause intolerable errors. For example, a 3" steam out valve open only 0.005" will leak enough to raise pan vapor 1°C and increase the reading about 15%. As little as 150 ml/minute of water leakage into the vapor stream ahead of the measuring point can drop it a like amount.

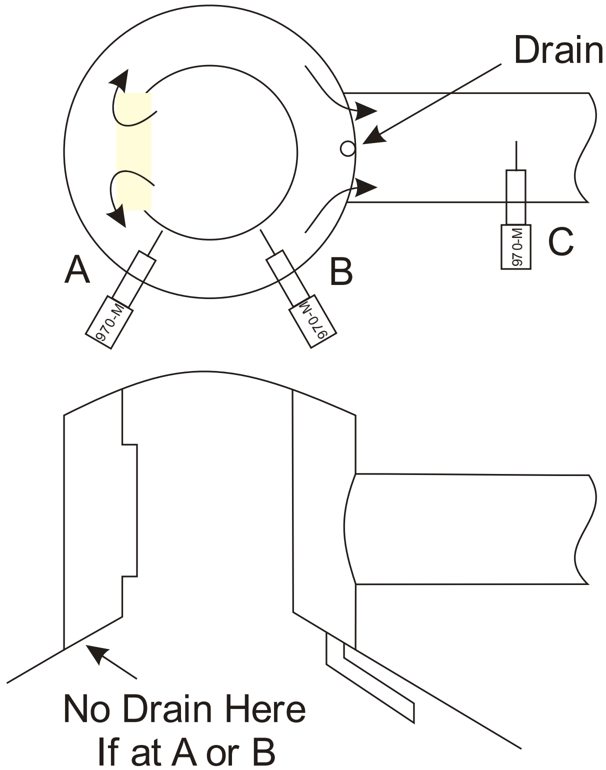
UPSCALE ERRORS will be caused if pan heating surface venting of non-condensibles is carried to the pan itself. They should be vented to atmosphere or to some point beyond the measuring bulbs. Leaking steam-out valves must be replaced or double-valved. Even live steam entering the pan below the massecuite surface will not be absorbed as it bubbles upward, although the error will diminish with increasing massecuite level in the pan. A leaking calandria tube or leaking discharge valve steam out connection has been found responsible for errors of this nature.

On coil pans, check all steam supply valves for leakage because a hot coil or coils above the massecuite surface will add heat to the ascending vapor and the resulting upscale error will not be corrected until that coil is covered. Check the condensate system of such pans for the possibility of backflow through the traps to unused coils. A small vent valve on each coil can be opened to check for leakage from either the supply or condensate and to locate the bad coils.

An upscale error will result from either low flow or low temperature of water to the reference bulb. Be sure that adequate quantity of water is being delivered to the flash chamber at a temperature high enough to flash at the prevailing pan vacuum. A good rule is to have it at least as hot as the massecuite in the pan which will be 8 to 15°C higher than the flashing temperature. Do not worry about having the supply water too hot since it can never flash to dryness at any attainable pan vacuum. As previously noted, a persistently high oversaturation will be indicated if air is leaking into the line supplying water to the reference bulb between the metering valve and the measuring element.

A temporary upscale error is usually present when a new strike is started soon after steaming out a pan due to stored heat in pan walls and entrainment separator. Actually little heat is added to the vapor by pan walls due to the relatively low vapor velocity, but some is picked up as it is accelerated in the separator. In steel pans, this represents little problem as the surfaces quickly fall to vapor temperature after boiling starts. But on older pans with heavy cast iron domes and separators, it can retard the temperature drop to equilibrium and it becomes more desirable to locate the element near the entrance end of the separator where the vapor first reaches an adequate velocity, points A or B in Figure 5. Alternatively, a short spray of water can be introduced when boiling starts and the lower temperature vapor will quickly cool the internal pan surfaces below the boiling temperature of the concentrating syrup.

Figure 5: Locating the Sensor Element on Pans with Cast Iron Domes and Separators



DOWNSCALE ERRORS are generally caused by water addition to the vapor stream before it reaches the vapor bulb. Even small quantities of water can appreciably desuperheat the vapor and destroy monitor accuracy and reliability. Here are some of the places where this can occur, with suggestive corrective measures:

Overhead spray systems for washing pans are a common source of trouble. If any water remains in the spray header, it can be heated by the superheated vapor during the strike to its boiling point and periodically spurt out to mix with the vapor. Each time this happens, the oversaturation reading will drop suddenly, often below zero, and slowly recover toward a correct reading. A hole should be drilled at the lowest point of such a spray system, 3/8” or so in order that the header will drain completely before the next strike is started. Needless to say, wash water valves should be checked to be sure that they are leak-free.

Steam out valves should be located in a horizontal run near the pan to eliminate the possibility of vapor condensing in a riser outside the pan and accumulating to a level that would be heated to the boiling point and spurt into the pan vapor.

Minor water leaks at pan walls such as window wash sprays do not affect monitor readings as they quickly mix with boiling massecuite. Only those that can be shattered into the vapor stream ahead of the measuring point cause trouble.

Pans equipped with overhead drive circulators present a problem if the shaft packing is water-lubricated. A small flow of water will find its way down the shaft and mix safely with the boiling massecuite, but if the packing is not well maintained, increasing water leakage will flip off the rotating shaft and couplings and be picked up by the vapor. In this case, it is better to meter the flow of water to the packing by means of a needle valve or rotameter and keep it low enough to prevent vapor cooling.

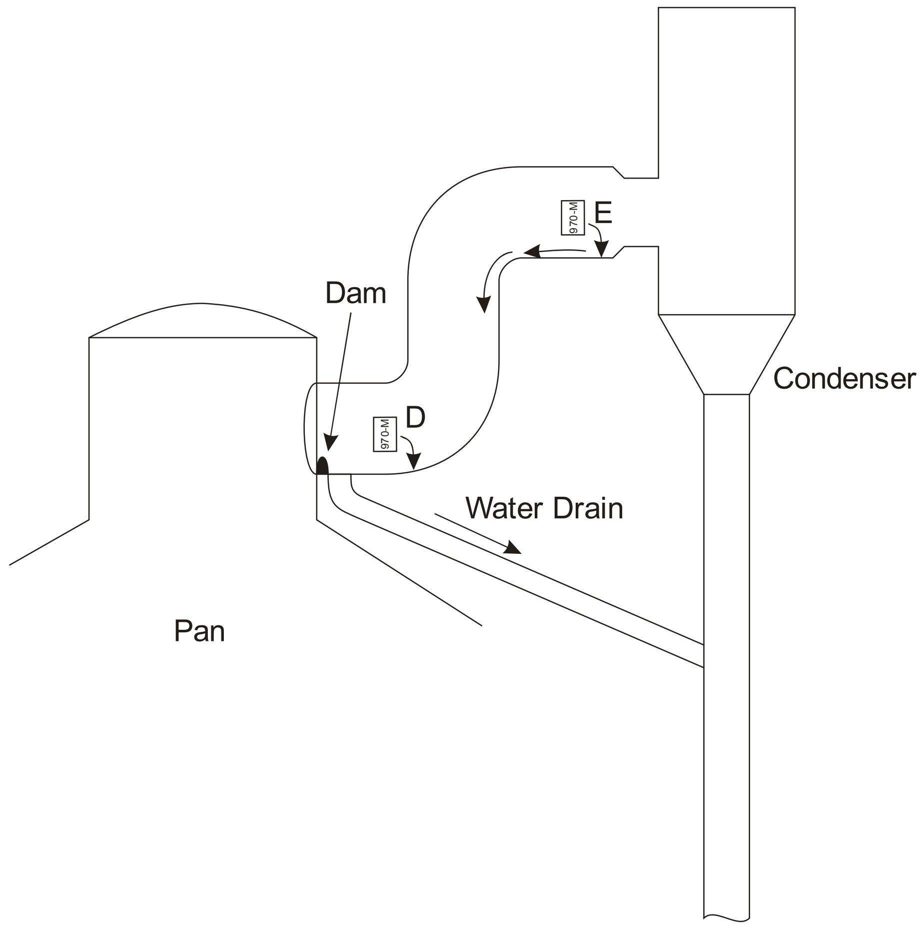
As noted earlier, excessive water flow or reference chamber temperature tmight make a small downscale error due to friction drop through the exit window, but this is unlikely if the connection is made with 1/4” OD tubing. This is easily checked by shutting off the water flow for a few seconds to see if there is any appreciable change in monitor reading.

Occasionally a barometric condenser with poor internal baffles allows water to splash back into the entering vapor line at high water flow rates. That water may find its way back into the pan separator, especially if the vapor line slopes toward the pan. If it mixes with vapor ahead of a bulb installed at point C, it will cause erratic downscale errors (see Figure 5). This situation can sometimes be improved by moving the element to point A or B, but eventually the condenser design should be improved. When condensers are located below the pan vapor outlet, the measuring element should be located in the vertical run so that the reference water definitely goes to the condenser.

Many different types of entrainment separators are used and it is not possible to cover all their design frailties in this manual, but here are a few typical problems. Vapor leaving the boiling surface will always contain a mist of fine syrup droplets, fine enough to be carried upward with the vapor stream. In the separator, the velocity is increased and the droplets made to impinge on surfaces to coalesce so that they can be removed from the main vapor stream. Separation is not enough and designers often provide inadequate means for returning the entrainment to a place of safety. In the typical centrifugal separator of Figure 5, the best method seems to be to run a line from the lowest point of the separator and seal it in a melter or tank downstairs. Most pans, however, only have a hole or a pipe in the deck through which the syrup can run back to the pan. Rivulets of syrup will indeed run down a hole of adequate size but against a flow of vapor coming up through the hole; the upward flow caused by the drop across the separator, often several inches of water. This upward flow will toss drops of syrup back up into the vapor stream. Obviously, any dilution of the syrup at this point will act to desuperheat the rising vapor before it reaches the vapor bulb.

The reference water flashing in the measuring element must not be allowed to mix and be picked up in the entrainment separator ahead of the vapor bulb. When the condenser is above the pan outlet, the vapor velocity will not be high enough to lift it to the condenser. One solution is to move the measuring element from C to A or B (Figure 5) provided that the only separator drains are beyond these points. With radial separators, the measuring element almost has to be in the vapor line (Point C) because that is the first point of reasonably high velocity. A more universal solution is to locate the element in the vapor line and prevent any possibility of water from condenser splash or reference water flash from finding its way back to the separator by installing a low dam in the vapor line (Figure 6) and providing a drain line to the condenser or its barometric leg line. Measurement may then be made at points D or E.

Figure 6: Installing a Low Dam in the Vapor Line



DYNAMIC ERRORS in temperature measurement are always present and are caused by the inability of any measuring element to follow rapid temperature variations. The monitor vapor bulb is designed for the minimum lag consistent with adequate mechanical strength but still has a time constant around 20 seconds in normal vapor velocities. The water bulb responds very quickly due to the higher rate of heat transfer. So any sudden change in pan vacuum will cause a temporary error in oversaturation reading. Precision sugar boiling cannot tolerate abrupt variations, at least when syrups are being held near the upper safe limit of oversaturation, because any increase in vacuum can easily carry them into the danger zone (above 65%). Reasonably good regulation of pan vacuum is therefore highly recommended.

A sudden increase in vacuum will increase evaporation at the massecuite surface, lowering the syrup temperature and thereby increasing the actual oversaturation. The monitor will read high because of the difference in response time of the two bulbs. The reading will fall back to the correct value shortly, but monitor readings should be ignored during such sudden transient conditions. When pans are regulated manually, steam flow and condenser water flow should be changed gradually so that pan vacuum remains relatively constant or drifts gradually to prevent getting erratic oversaturation readings especially during critical stages of a strike. Under automatic vacuum or absolute pressure control, it is better to reduce controller gain or sensitivity so that there will be no periodic oscillation in vacuum because they would create corresponding varying indications on the monitor. It is better to allow the control to float around the desired value and get proper readings of oversaturation.

Factories with central condenser systems should cut in empty pans very gradually so as to minimize vacuum disturbances on operating pans.

The monitor circuitry is designed to compensate for boiling pressures between 4” and 10” Hg. Abs (10 to 25 cm Hg.Abs) Outside of these limits, the oversaturation reading will be on the high side for the actual conditions and, although a corrective zero adjustment can be made with “MET” compensation will only be good over a limited range of vacuums.

Troubleshooting of 970-M Oversaturation Monitor installations centers around pan problems. Sometimes these problems can be quite difficult to locate by observing only the monitor indications, since oversaturation is a differential temperature measurement. One can use an accurate ohmmeter to measure vapor and reference water temperatures separately, thus isolating the measurement in error. Calculate the temperature of each bulb using the following equation: **T**(°C) = (**R**(ohm) – 585)/3.3

FEED DISTRIBUTION

In order for the 970-M Oversaturation Monitor to read the maximum value in a massecuite, it is essential that the maximum value be at the upper surface. As heated material boils and moves toward the surface, its temperature falls due to the lower hydrostatic head and it reaches a maximum oversaturation at the surface; its boiling point then corresponds to the vapor pressure, and this is the temperature measured by the monitor vapor bulb. Syrup or water feed introduced into the pan at a low level must mix thoroughly with the massecuite before it reaches the surface. If feed does not mix well, it can float to the surface, boil there, and naturally the monitor will indicate its concentration rather than that of the massecuite. This can be especially apparent on strikes started from a massecuite “footing” if diluting syrup is introduced to reduce its viscosity and boiling started with the non-homogeneous mixture. A proof sample will show a heavy massecuite, but the monitor will indicate the low syrup concentration at the surface.

Good feed distribution is essential in all pans. It should be introduced at several points under the calandria about halfway between the center well and the outside wall whether or not a mechanical circulator is used. This gives it the best chance to mix as it rises through the tubes. Under no circumstances should the feed enter the center well even with mechanical circulation. Excessive feed flow at any time during a strike should be avoided to reduce the possibility of poor mixing; a steady flow is better.

TECHNICAL INFORMATION

ELECTRICAL TESTS

The monitor electronics are very reliable and unlikely to have problems. However, the power supply voltage can be measured across terminals C and + (+15 volts) and across C and – (-15 volts). Page 19-21 show the circuit board layout and the circuit diagrams.

Measuring element damage or wiring errors can be located by a few simple tests. When the element is at normal pan operating temperature, disconnect the V and W wires from terminals 1 and 2 and measure the resistance of each bulb to common terminal 3. Both should measure around 800 ohms. If the temperatures are known, the resistance should equal 585 + 3.3T where T is the temperature in °C; i.e. 832 ohms at 75°C.

In operation with the measuring element connected, the voltage drop between terminals 1 and 3 will be close to 1.85 volts and 2.0 volts from 2 to 3. The regulated power supply voltages for the amplifier appear on the two test points marked + and - in the upper center of the circuit board. Relative to terminal 3 (or Test Point C), they should remain very close to +15 and -15 volts. Supply for the output transistor will be on terminal 4 and should be around 30 volts.

The 970-M Monitor may be checked on the bench without the measuring element as follows: Put a jumper between terminals 1 and 3 and connect a 60 ohm resistor between terminals 2 and 3. With both purity dials set at 100P, the meter should read close to 100% oversaturation. With both dials set at 50P on the outer (cane syrup) scale, the reading will be near 5% oversaturation.