Milk sanitation authorities have long been concerned with the need for safeguards to prevent possible contamination of pasteurized milk by raw milk in regenerators. Their concern arises from the possibility that flaws in the metal plates or tube walls separating raw milk from either pasteurized milk or a heat-exchange medium would permit leakage of raw milk or the heat-exchange medium into the pasteurized product. Although the hazard is common to all the most frequently used type, milk-to-milk regenerators, it is particularly significant in those, heat transfer occurs directly through metal plates separating opposed streams of cold raw milk and hot pasteurized milk.

In 1938, Fuchs (1) described in detail specifications governing the design, installation, and operation of regenerators of all types which would assure the maintenance of pressures on the pasteurized product higher than those on the opposed raw milk or heat-exchange medium. The basic principle of these specifications was to provide conditions which would result in sub-atmospheric pressure on the raw milk side of the regenerator, and pressure above atmospheric on the pasteurized milk side. The specifications were incorporated in detail in the 1939 edition of the Milk Ordinance and Code recommended by the Public Health Service (2). It was also noted in the 1939 Code that other specifications could be developed which would assure proper relative pressures without requiring raw milk to be at sub-atmospheric pressure.

Since it was not uncommon for milk plant operators to experience difficulty when all raw milk was sucked through the regenerator, there was a desire on their part to use a small booster auxiliary pump at the raw milk inlet to the regenerator to facilitate flow. For this reason, specifications were developed and incorporated in the 1953 Milk Ordinance and Code (3) for the utilization of an auxiliary pump. The specifications are as follows:

"No pump shall be located between the raw milk inlet to the regenerator and the raw milk supply tank, unless it is so designed and so installed that it can operate only when milk is flowing through the pasteurized milk side of the regenerator, and when the pressure of the pasteurized milk is higher than the maximum pressure produced by the pump.

This may be accomplished by wiring the booster pump so that it cannot operate unless (a) the metering pump is in operation, (b) the flow-diversion valve is in the forward-flow position, and (c) a sanitary pressure switch located at the pasteurized milk outlet from the regenerator is so set and sealed as to complete the circuit only when the pasteurized milk pressure exceeds, by at least 1 pound per square inch, the maximum pressure developed by the booster pump."

The latter part of the above paragraph suggests specific means for controlling the operation of the booster pump. Clauses (a) and (b) limit its operation to those periods when milk or other fluid is flowing through the flow-diversion valve; clause (c) further restricts its operation until such time as the pressure at the pasteurized milk outlet of the regenerator exceeds by 1 pound the maximum pressure developed by the booster pump.

Pressure switches have not, in all cases, proven entirely satisfactory. To respond to the small changes in pressure involved, the diaphragms must be thin and sometimes these rupture at the peripheral junction. In addition, operating difficulties have been experienced when short-circuiting of the switch occurred from moisture or other means. Accordingly, there has been a desire on the part of some operators to use alternate means to control booster pump operation, and the discussion which follows is derived from observation of several experimental installations where a time-delay relay has been used in lieu of a pressure switch.

Suitable time-delay relays with settings adjustable up to several minutes are available through most of the larger manufacturers of electrical equipment. They have been extensively used for many years in a variety of applications and have proven dependable. Their cost is nominal, approximating that of a suitable pressure switch. They are compact and may be readily mounted on the back of the HTST control panel by brackets available from the manufacturers. If not provided with a means for sealing, a satisfactory seal can be provided by drilling holes at appropriate places and using a standard wire and lead seal. Manufacturers should be consulted as to the type of relay best suited for this purpose.

The function of the time-delay relay is to provide automatically a predetermined elapsed length of time between the moment when the flow-diversion valve...
assumes the forward-flow position and the moment when the booster pump is energized. The time lapse required is that necessary for the forward flow of liquid through the regenerator, cooler, and subsequent piping to rise to a height sufficiently above the liquid through the regenerator, cooler; and subsequent measurement of forward flow and the moment when the pasteurized liquid reaches the point in the milk circuit downstream from the flow-diversion valve should rise above the booster pump outlet pressure as determined under (1) above. This determination can provide a 1-pound excess pressure differential on the pasteurized side of the regenerator plus a differential equivalent of 0.7 feet of water column to compensate for the difference in specific gravity between water at 161° F. and raw milk at 40° F. Thus, under the example cited in (1), the pasteurized liquid level should rise to 9.9 feet (6.9 plus 3) above the elevation of the discharge of the booster pump before the booster pump begins operation. To provide this pressure, the pasteurized liquid level must be vented to the atmosphere at or above this required elevation as by means of a covered pasteurized product balance tank or by installing a sanitary vertical standpipe in the line with its upper end fully open to the atmosphere but protected against contamination.

3. Establishment of Time Interval: The time interval between the moment of establishment of forward flow and the moment when the pasteurized liquid level rises to the elevation specified in (2) above, should next be determined. This time measurement should be made at the beginning of the run when there is no water in the pasteurized circuit downstream from the flow-diversion valve; otherwise the circuit should be drained so that a true timing determination can be made. (A diverting

Establishment of Necessary Time Lapse

The determination of the time lapse necessary for the milk to reach the point in the HTST system where proper pressure differentials between the pasteurized and raw milk are assured, requires that the four steps described below be performed in the sequence indicated (See Figure 1).

**Figure 1. Diagram showing required minimum height of liquid level before booster pump cuts in.**

1. **Determination of Booster Pump Pressure:** This determination should be made under operating conditions which will provide the maximum discharge pressure by the booster pump. Operate pasteurizer with water, with the flow-diversion valve in forward-flow position, the metering pump operating at minimum speed possible, and the booster pump operating at its rated speed. If vacuum equipment is located between the regenerator and the metering pump, it should be by-passed while this determination is being made.

The pressure in pounds per square inch at the discharge of the booster pump may be determined by means of a pressure gauge or suitable mercury manometer. The reading in pounds per square inch should then be converted to an equivalent height of water column by multiplying the reading by 2.3. For example, a reading of 3 pounds per square inch would be equivalent to a vertical water column of 6.9 feet. The vertical height of the equivalent water column may also be determined directly and more simply by connecting an open-ended piping or hose arrangement to the booster pump discharge and elevating the open end to the point where the flow in the open pipe end is reduced to zero and the rated speed of the booster is merely supporting the column of water. While this determination is being made, flow will, of course, continue through the HTST unit.

2. **Determination of Pasteurized Milk Elevation:** The height to which the liquid level in the pasteurized milk circuit downstream from the flow-diversion valve should rise above the booster pump outlet level, after establishment of forward flow and before the booster pump begins operating, should be at least three feet greater than the vertical water column equivalent of the maximum booster pump pressure as determined under (1) above. This will provide a 1-pound excess pressure differential on the pasteurized side of the regenerator plus a differential equivalent of 0.7 feet of water column to compensate for the difference in specific gravity between water at 161° F. and raw milk at 40° F.

Thus, under the example cited in (1), the pasteurized liquid level should rise to 9.9 feet (6.9 plus 3) above the elevation of the discharge of the booster pump before the booster pump begins operation. To provide this pressure, the pasteurized liquid level must be vented to the atmosphere at or above this required elevation as by means of a covered pasteurized product balance tank or by installing a sanitary vertical standpipe in the line with its upper end fully open to the atmosphere but protected against contamination.
Use of Time-Delay Relay

4. Setting of Time Delay Relay: The time-delay relay should be installed in the reconnected circuit to the booster pump. This circuit must, of course, also be interlocked to permit operation of the booster pump only during periods when the metering pump is operating and the system is in forward flow. The time setting on the time-delay relay is then adjusted to provide the time interval as determined in (3) above.

The adequacy of this adjustment to prevent starting of the booster pump until the proper pasteurized fluid level is attained, should be checked before this setting is sealed. This may be done by draining the pasteurized side of the regenerator, and then observing whether the required pasteurized liquid level is actually reached before the booster pump starts. During this test the pasteurizer should be operated under the same conditions as were specified in (3) above for determining the time interval.

Operating Sequence

When the HTST pasteurizer is started, raw milk is circulated through the regenerator by the metering pump without the booster pump in operation. During this recirculating period, the milk on the raw side of the regenerator is under sub-atmospheric pressure. The pasteurized side of the regenerator is empty and, therefore, under atmospheric pressure. After pasteurization temperature is reached and forward flow established, the control circuit to the time-delay relay is energized and the pre-determined cycling interval started. Upon completion of the time interval the booster pump is energized. This assures proper relative pressures in the regenerator. Should the HTST pasteurizer for any reason go into diverted flow or the metering pump stop, the time-delay relay control circuit is de-energized and the booster pump stopped. After forward flow is resumed, the time-delay relay is energized and complete recycling occurs.

Summary

A procedure for the installation of a time-delay relay in connection with a HTST pasteurizer which can be used in lieu of a pressure switch for controlling booster pump operation, is presented. The cycling interval principle of this relay assures proper pressure differentials in milk-to-milk regenerators with both sides closed to the atmosphere.

References