

Eliminating Cross-Connections Between Raw and Pasteurized Products in Dairy Plants

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ABSTRACT

A method was developed to identify cross-connections between raw and pasteurized products in dairy plants. A flow diagram of the dairy plant is used to identify post-pasteurization pumps, storage tanks, fillers or other post-pasteurization processing equipment. An envelope is drawn on the flow diagram around all post-pasteurization equipment. Only the few pipelines that penetrate the envelope have the potential of a cross-connection. Each pipeline is traced to its origin to determine if it is a cross-connection.

Several major outbreaks of illness in recent years have been associated with the dairy industry. In the first outbreak of listeriosis in Massachusetts (3) in 1983, 49 cases were culture-confirmed and 14 people died. Epidemiological studies implicated pasteurized milk from one dairy, but *Listeria monocytogenes* was not found in the pasteurized product. *L. monocytogenes* was found in raw milk obtained from a group of farms on which listeriosis in dairy cows occurred during the 1983 outbreak.

The world's largest foodborne outbreak of salmonellosis occurred in northern Illinois in the spring of 1985. At least 16,284 cases were culture-confirmed and 2 deaths were reported (5). A cross-connection between raw and pasteurized milk was identified as the most probable cause of the outbreak (1,6).

The second outbreak of listeriosis occurred in Los Angeles in May and June of 1985. By the end of the summer, 142 cases were culture-confirmed and 47 deaths were reported (2). The cause of the outbreak was traced to one manufacturer of Mexican-style cheese, and *L. monocytogenes* was found in the cheese.

A number of smaller incidents have occurred in the past several years (4,7), including contamination of milk with cleaning solutions. No overall pattern of contamination can be attributed to these outbreaks, which occurred in both large and small and old and new plants. One instance of nonpathogenic *Listeria innocua* occurred in a newly installed plant with computer-controlled systems.

Many changes have occurred in all dairy plants in the last 20 years. Even the small plants have added some automation. When automatic controls are used, additional permanent pipelines are required to automate routine dairy operations. Some of these pipelines may have the potential of being a cross-connection between raw and pasteurized product, or between cleaning chemicals and milk products.

Because of the continuing problems with contaminated milk products, FDA announced its Dairy Program Initiatives (4). One of the goals of this program is to determine if review of plant systems is adequate, to ensure that the design of the plant system incorporates no cross-connections between post-pasteurization equipment and raw product equipment, and to provide adequate protection against product contamination from cleaning and/or sanitizing solutions. Public health authorities will require more up-to-date diagrams of plant systems, including revised diagrams of proposed modifications.

Every designer and plant manager has the obligation to determine that the system is free of cross-connections before it is installed. However, cross-connections have been installed in dairy plants. Inspecting every pipeline in a dairy plant is a long and arduous task. This paper describes a method of rapid identification of those pipelines that have the potential of being a cross-connection.

METHOD

The drawing of a plant includes an orderly arrangement of equipment in specific groups. All raw milk storage tanks are in one group, raw product batching tanks in another, pasteurizers in a third and all post-pasteurization equipment in yet another group. The term "post-pasteurization equipment" is defined as all equipment used to store, pump, and fill pasteurized products. The pasteurizers are the only acceptable connection between raw and post-pasteurization equipment, and the discharge of the pasteurizers lead to the post-pasteurization storage tanks, fillers and other post-pasteurization equipment. This arrangement produces an orderly graphic representation that sig-

nificantly reduces the number of instances where one pipeline must cross another on the drawing. With fewer crossovers, the drawing is easier to read.

The tendency to place all post-pasteurization equipment in one group on a drawing may be used advantageously to identify cross-connections. By drawing an envelope around all of the post-pasteurization equipment, it is relatively easy to identify those pipelines that penetrate the envelope. The pipelines that do penetrate the envelope are the only ones that have the potential of being a cross-connection.

Many pipelines connect raw product equipment and many others connect post-pasteurization equipment, but there are very few pipelines between the raw product equipment and the post-pasteurization equipment. The plant involved in the large salmonellosis outbreak in northern Illinois was a large plant with more than 1000 pipelines; however, when the method was applied to the drawing, only 14 pipelines penetrated the envelope, including both the process and cleaned-in-place (CIP) lines.

The method of identifying cross-connections consists of three steps: (a) identify the post-pasteurization equipment on the drawing and draw an envelope completely around the group of post-pasteurization equipment; (b) mark the pipelines that penetrate the envelope and trace each one, away from the envelope, toward its origin in the group of raw product equipment; (c) if a cross-connection is found on the drawing, confirm its existence in the plant.

Only the pipelines that penetrate the envelope can carry raw milk into the pasteurized milk product. Once they are identified on the drawing, they are traced, away from the envelope, toward the raw product equipment. If one of these lines is traced to any termination except the discharge of a pasteurizer, an open balance tank or equivalent, or if it is traced back inside the envelope to another piece of post-pasteurization equipment, it is a cross-connection.

In tracing pipelines, one would stop at the pasteurizer discharge, if there are no other connections to the pasteurizer. However, if there are connections to the pasteurizer, between the holding tube and the pasteurizer discharge, such as a pasteurized cream separator, the flow of pasteurized product between the holding tube and the pasteurizer discharge must be inspected for cross-connections.

Cross-connections sometimes occur when pipelines are installed to solve operational problems. A pipeline may be installed to permit pumping of leftover pasteurized product to raw product storage tanks at the end of the production day. However, the pressure generated by raw milk in a tall silo will push raw milk backwards through a centrifugal pump (not running) through a leaking valve into the pasteurized storage tank.

Plug valves, automatic valves and one-way check valves cannot be relied upon to provide the safety required in milk pasteurization. A single drop of contaminated milk leaking into the pasteurized product can cause an outbreak.

APPLICATION OF THE METHOD

The method has one drawback: It requires the use of the flow diagram of the plant. However, the task of reading a drawing can be simplified considerably by explaining a few symbols and conventions.

The symbols used on drawings are standardized to some degree. Figure 1 presents a flow diagram of a plant, showing the identification of these symbols. Most

flow diagrams do not have a legend of symbols; however, these symbols (or slight variations of them) are used on most drawings. Furthermore, it is not necessary to understand every detail of a drawing. It is only necessary to be able to identify the equipment used to process the pasteurized product so that an envelope may be drawn around the equipment.

Review of the drawing

The flow diagram shown in Fig. 1 is reviewed to identify the major equipment. Raw milk delivery and raw milk storage are in the upper left region of the drawing; the pasteurizers are in the left middle region; cream storage is in the lower left region; pasteurized storage is in the upper right region and filling of pasteurized product is shown in the lower right region.

Horizontal round tanks are shown as circles (R1 to R3), vertical round tanks as rectangles with curved tops (P1 to P3) and square tanks as rectangles (C1 to C4). A series of small circles connected in a matrix depicts a valve cluster.

The cream tanks in Fig. 1 show a common method of connecting multiple pipelines to multiple tanks. Full-length pipelines, called "headers," are placed at the top and bottom of the tanks, and a single "swing" pipe connection is used to connect any tank to any header. The multiple "headers" and "swing" connections serve as an alternative to the large cluster of automatic valves.

Despite the orderly arrangement of equipment, some pipelines must cross one another on the drawing. This is shown in Fig. 1 as a break in one of the lines at the crossover point.

Placement of the envelope

There is no right or wrong placement of the envelope; however, the method will be most useful when the following guidelines are applied. (a) Include all post-pasteurization equipment inside the envelope. (b) Exclude from the envelope all equipment used to process raw product. (c) Draw more than one envelope if necessary. (d) Do not attempt to include the pasteurizer inside the envelope. The pasteurized product line back to the pasteurizer discharge is easily traced. If there are connections to the pasteurizer, between the pasteurizer discharge and the holding tube, such as a cream separator, these lines must also be traced. (e) The most useful placement of the envelope occurs when the minimum number of pipelines are crossed by the envelope and there is no raw product equipment inside the envelope. Account for a piece of post-pasteurization equipment outside the envelope by drawing a small envelope around the single piece of equipment. (f) The envelope may be drawn in any shape and any configuration necessary to include the post-pasteurization equipment and exclude the raw product equipment. On drawings with closely spaced equipment and pipelines, draw the envelope with frequent sharp turns in any direction necessary to follow the pipe runs. However, the envelope must close on itself to com-

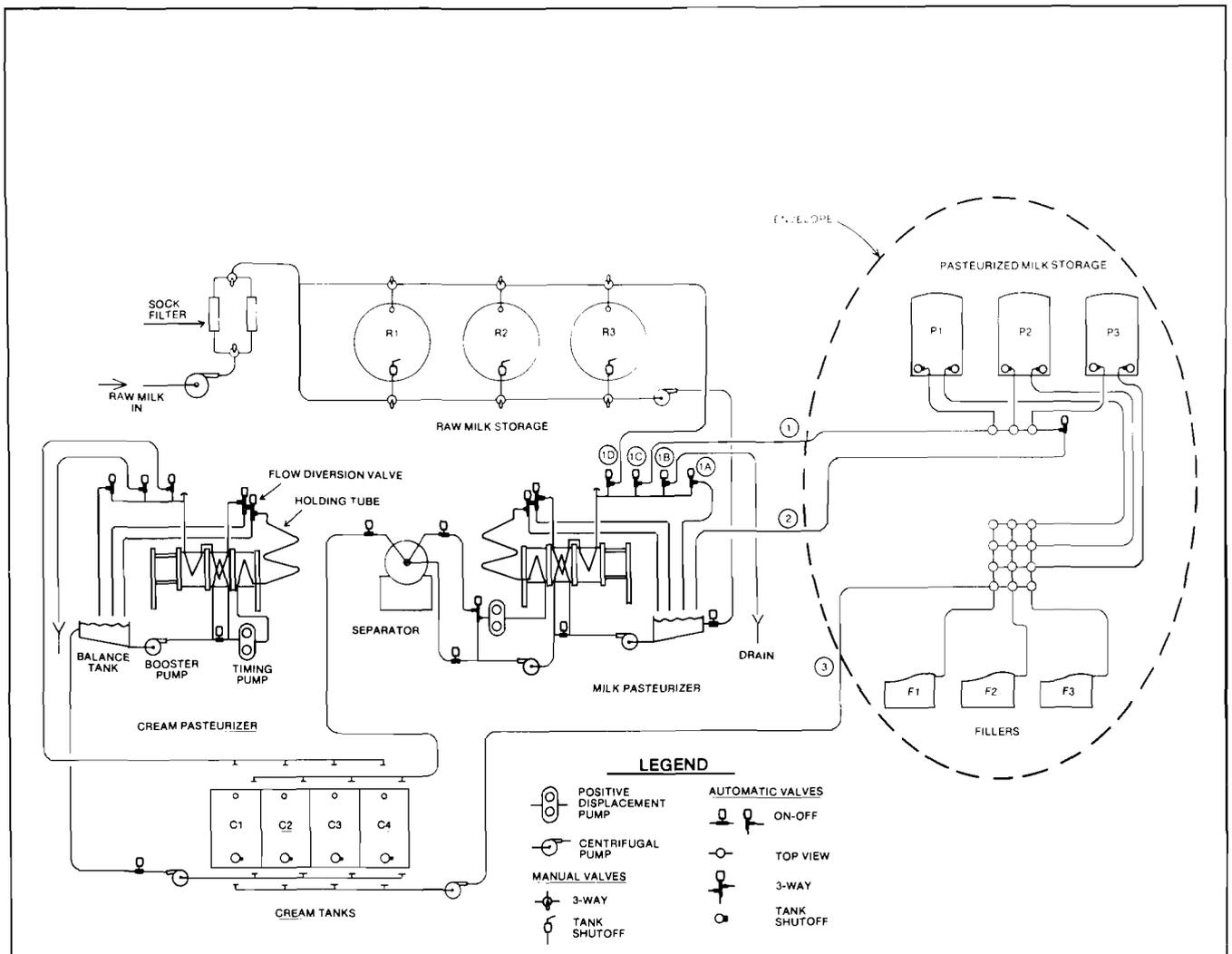


Figure 1. Flow diagram for milk processing.

plete an uninterrupted boundary around the post-pasteurization equipment.

A sample envelope is shown in Fig. 1 as a bold dashed line, and all pipelines crossing the envelope are marked by a number in a small circle. Three pipelines are identified as crossing the envelope. It is not necessary to know which direction the product is flowing at any given moment. Except for the pasteurizer and the open balance tank, the pipeline can move product in both directions. Consequently, each line is traced away from the envelope, toward its origin, in the group of raw product equipment.

Line 1 is traced to a group of valves at the pasteurizer discharge and, consequently, each line leaving the valve group must be traced.

Line 1A is a return line to the open raw milk balance tank. This line is satisfactory if the design, construction and installation of the balance tank are satisfactory to prevent back siphonage.

Line 1B is a discharge line to the drain. This line is satisfactory if the installation prevents back siphonage from the drain.

Line 1C is the pasteurizer discharge to the post-pasteurization storage tanks, and is satisfactory.

Line 1D terminates in the top of the raw milk storage tanks. Because this connection is not the equivalent of an open balance tank, it is a cross-connection. Any post-pasteurization piping arrangement that permits raw milk foam or splashing to move into it, even though liquid may not, must be considered a cross-connection. Finally, this piping arrangement presents a more serious problem than foam or splashing. Line 1D runs not only to the top ports of the raw milk tanks, but continues on to the raw milk receiving pump. If raw milk is received and pumped to one of the raw milk storage tanks, and the operator forgets to turn the plug valve at the top of the tank, or the plug valve leaks, raw milk may be pumped past the raw milk storage tanks into the post-pasteurization milk line. If the automatic valve at the pasteurizer discharge leaks or is open, raw milk may be pumped into the line connected to the post-pasteurization storage tanks. As soon as the pasteurizer is started in forward flow, on pasteurized milk, the raw milk lying in the discharge line of the pasteurizer may be pushed into a post-

pasteurization storage tank. Consequently, line 1D represents one of the most serious cross-connections.

Line 2 is a return line to the open raw milk balance tank, and is satisfactory.

Line 3 is traced to a bottom header on the cream tanks. Because the operator may choose any of the four tanks as a post-pasteurization storage tank or a raw product storage tank, the bottom header becomes a pipeline that is common to raw and pasteurized products. If the operator inadvertently connects the pasteurized cream pump to a raw product storage tank, the pasteurized product lines to the cream filler may become contaminated with raw product. To correct this problem, the cream tanks must be identified as raw or pasteurized, and then segregated to prevent inadvertent manual cross-connections.

Figure 1 does not represent any plant, but the individual cross-connections shown in Fig. 1 are typical of those that have been found in dairy plants.

CIP lines

For purposes of clarity, CIP lines are not shown on Fig. 1; however, the same technique may be used to identify problems with CIP lines. If a single CIP system is used, CIP lines will cross the envelope and these lines may be investigated for potential problems.

When the group of post-pasteurization equipment has a dedicated CIP system, the envelope may be located to exclude the CIP system. In this way, all CIP lines will penetrate the envelope and may be identified as specific lines that must be disconnected during product processing. Usually, the designer will differentiate CIP lines from product lines on the drawing by showing CIP pipelines as dashed lines and product pipelines as solid lines.

DISCUSSION

There is no singularly correct placement of the envelope for any given drawing. An envelope that aids one person in identifying cross-connections may not be helpful to another. Each reviewer will draw the envelope in a manner that he believes provides the most insight. A single reviewer may draw the envelope several different ways and use each one to investigate different aspects of the drawing.

Cross-connections must be confirmed in the plant. Questionable pipelines must be identified by tracing them to their terminations. Drawings are seldom completely up-to-date and can be significantly different from the physical plant.

Some plants submit drawings to the cognizant health authority, making them available for mark-up and recommendations. In other instances, the Health Officer may have the only copy, on loan from the plant. In these instances, an erasable marker or a clear plastic overlay may be used on the drawing.

Use of this method by designers and plant managers does not relieve them of the responsibility of knowing the purpose and location of every pipeline in the dairy. However, it does provide them with an alternate check method of reviewing proposed designs for cross-connections. A plant designer may use it to identify unintentional cross-connections that may have escaped notice during execution of the drawing. A plant manager may use it during the review and approval of proposed installations. The technique permits the review of a large number of pipelines by focusing attention on the few that have the potential of being a cross-connection.

To obtain additional drawings, with cross-connections, for training purposes, send requests to Roger Dickerson, Food and Drug Administration, 1090 Tusculum Avenue, Cincinnati, OH 45226.

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