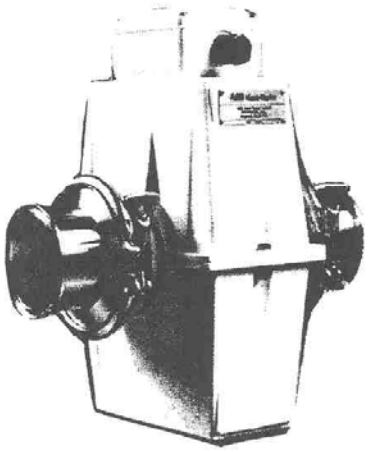
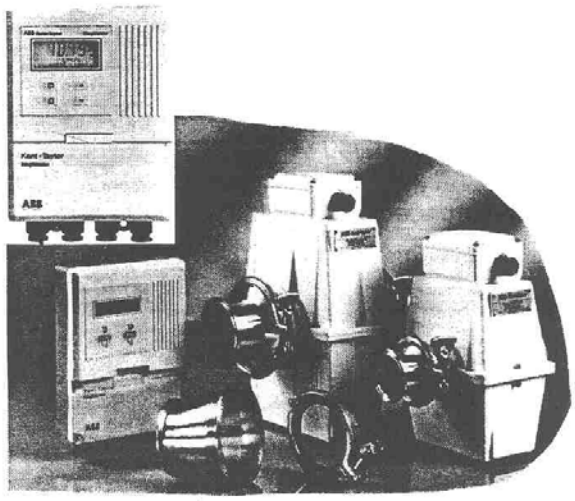
Table of Contents

Chapter V

METER BASED TIMING SYSTEMS





MAGNETIC FLOW METERS

PURPOSE: To describe the purpose of using a magnetic flow meter in a HTST pasteurization system, including, function, operation, and installation requirements.

OBJECTIVES:

- To understand the principles, function, and purpose of using a magnetic flow meter in an HTST pasteurization system.

- To become familiar with the public health controls and installation requirements of meter based systems as they relate to **time, temperature, and pressure,** relationships within the HTST pasteurization system.

- To become familiar with the required HTST tests for systems using magnetic flow meters within the system as a replacement for the conventional timing pump.

I. BACKGROUND AND THEORY

Early in 1980 the first **meter based system** was submitted for compliance review to the FDA's Milk Safety Branch. The proposal was for the use of a magnetic flow based system to be used **in lieu of the conventional timing pump in HTST systems.**

These systems presented a radical departure from conventional HTST systems, therefore the first installations in dairy plants were under close surveillance by the regulatory authorities. Initially, these systems were limited to use with non-regenerator systems processing milk products with a viscosity no greater than whole milk.

Meter based systems are based on the principles of **electromagnetic induction** first reported by Michael Faraday in 1839. Systems based on these theories were first applied in industrial use in the early 1950's.

The theoretical basis of a meter based system can be stated as follows:

a). A conducting fluid passing at right angles through a magnetic field induces a voltage across the conductor. This theory may be calculated using the following formula;

$$E_g = Bvd$$

where: E_g = generated signal
B = magnetic flux density
v = velocity
d = distance between electrodes

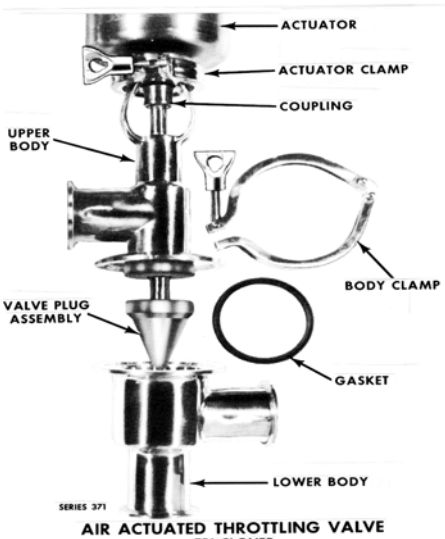
b). The electric voltage signal generated is directly proportional to the velocity of the conducting product. This signal is detected by the 316 SS or equivalent electrodes (sensors) installed within the internal pipe of the flow meter {installed vertical}.

c). This alternating signal is relayed to the electronic components of the meter based system. These components are comprised of an **electrical transmitter**, a **transducer (converts an electronic signal to a pressure value), a flow recorder-controller.**

d). The product velocity is controlled by either a **flow control valve** or an **AC drive variable speed centrifugal product pump**.

e). These components receive the generated signal from the magnetic flow meter, process the information, and **control the flow of the product through the system.**

On the following page illustrations of both a magnetic flow meter aow control or throttling valve used in milk systems is provided.



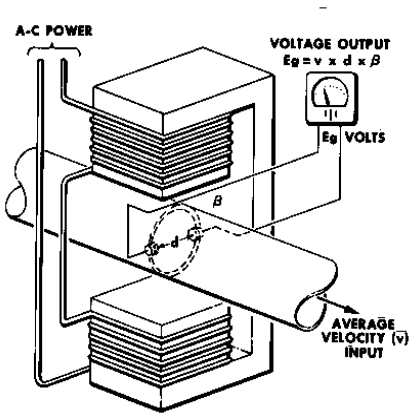


FIGURE 53

FLOW CONTROL VALVE AND METER

II. **APPLICATION IN HTST SYSTEMS**

Magnetic flow meter systems are used to replace the conventional timing (metering) pump in HTST, HHST and aseptic processing and packaging systems. In the previously discussed conventional systems **only the <u>temperature</u> is monitored to control the flow diversion device and the product flow remains at a constant set speed.** In meter based systems the **<u>flow rate</u>** of the product through the holding tube, metered prior to the product entering the holding tube, is also **constantly monitored and controlled**, resulting in forward flow **only** when a pre-set acceptable flow rate is achieved and maintained.

The system must be adjusted so that when the product flow **exceeds** a preset sealed value, the flow diversion device immediately assumes the **diverted flow position**. Also, **should the flow drop to a level that will not allow accurate flow rates,** the flow diversion valve must also assume the diverted flow position. Methods of testing these parameters will be discussed in the testing section of this manual. After the flow rate returns to an acceptable level a time delay is required before the flow diversion device is allowed to return to the forward flow position. The purpose of this is to **assure that all products in the holding tube have been held for the minimum required time(s).**

Although the initial installations were limited to use in systems without regenerators and less viscous products, current systems may now be **employed on all HTST systems for all milk products**.

Except for those requirements related to the physical presence of the metering pump, all requirements of the PMO are applicable.

II. BASIC COMPONENTS OF METER BASED SYSTEMS.

A. Centrifugal pump

1. Fixed speed

2. Variable speed

B. Magnetic flow meter

A short piece of sanitary tubing containing two electrodes surrounded by a housing, that contain coils which generate a magnetic field. The electrodes used are either Hastelloy C4 (Accurate Metering), or Carpenter 20 Cb3 SST(ABB Kent -Taylor). Both meters use Teflon as the pipe liner, as it is non-conducting, thus insulating the electrodes from the pipe. Both Accurate Metering and Taylor use PTFE (non-filled virgin teflon) for liners in food applications.

C. Flow control valve

Air operated, sanitary design, designed to regulate product flow.

D. Flow recorder (or SFLR, Safety Flow Limit Recorder/Controller) with high flow alarm.

E. Sanitary **check valve** or suitable fail safe air operated valve.

F. Electronic transmitter/transducer

Converts an electronic signal to a pneumatic value.

III. **TYPES OF SYSTEMS**

A. System utilizing a **single speed centrifugal product pump and flow control valve** to regulate product flow.

1. Magnetic flow meter.

2. Single speed centrifugal pump.

3. Sanitary check valve or suitable automatic fail safe valve.

4. Flow control valve.

5. Transmitter/transducer.

6. Flow recorder/controller with suitable alarms.

7. Suitable flow diversion device.

B. System utilizing **variable speed centrifugal pump** (AC drive).

1. Magnetic flow meter.

2. AC variable frequency motor control drive on a centrifugal pump.

3. Sanitary check valve or other suitable automatic valve.

4. Pneumatic transducer (I/P).

5. Flow recorder-controller with suitable alarms.

6. Suitable flow diversion device.

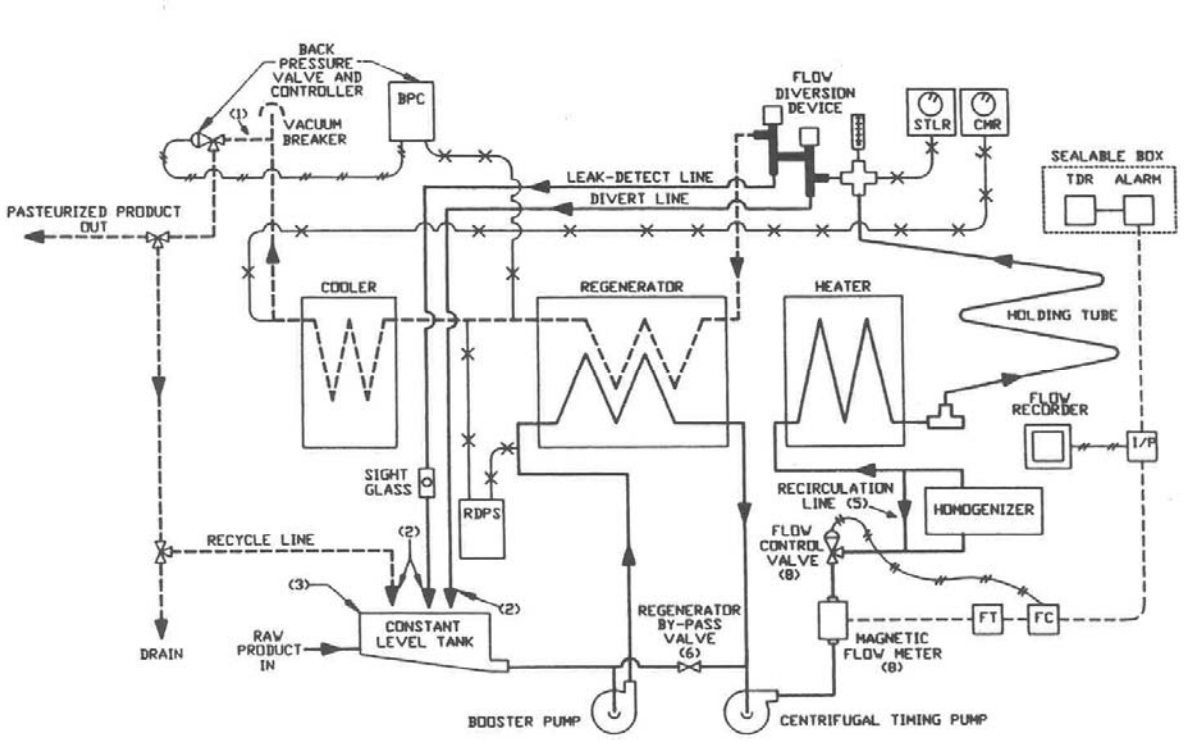


Figure 54: Meter Based System with flow control valves

(1) this line shall be at least 12 inches above any raw product piping in the HTST system
(2) all divert, leak detection and recycle lines which return to the constant level tank must break to atmosphere at lest two pipe diameters above the over flow level (3) the overflow level of the constant level tank must be lower that the bottom of the inlet of the raw regenerator (5) required if homo is greater capacity than timing pump (6) regenerator bypass valves must be installed to be drainable, and must prevent dead ends, or be drilled. A drilled check valve may be used between inlets of booster pump and timing pump. Air operated valves must be normally open, automatically operated and controlled to open if timing device stops. (8) straight pipe per manufacturers recommendations required on both sides of the centerline of the magnetic flow meter. Meter shall be located so electrodes are flooded. No product can enter or leave the system between the centrifugal timing pump and the flow diversion device. The flow control valves if used shall be normally closed, air to open. This valve may be replaced with a sanitary check valve for systems equipped with variable speed centrifugal timing pumps. A homogenizer downstream of the timing system (for example centrifugal timing pump, magnetic flow meter, and flow control valve or check valve) must be provided with a recirculation line.
Any other combination of modifications which are installed and operated with the above and with the detailed provisions of these practices may be utilized

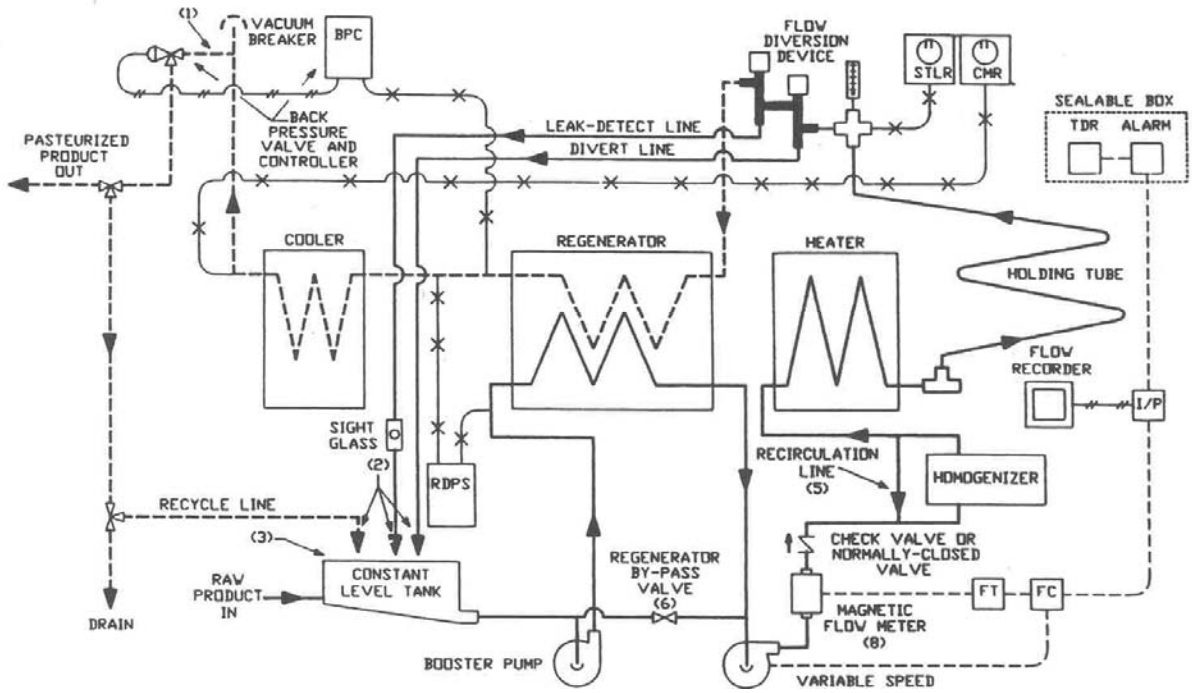


Figure 55: Meter based system with AC variable speed drive

(1) this line shall be at least 12 inches above any raw product piping in the HTST system
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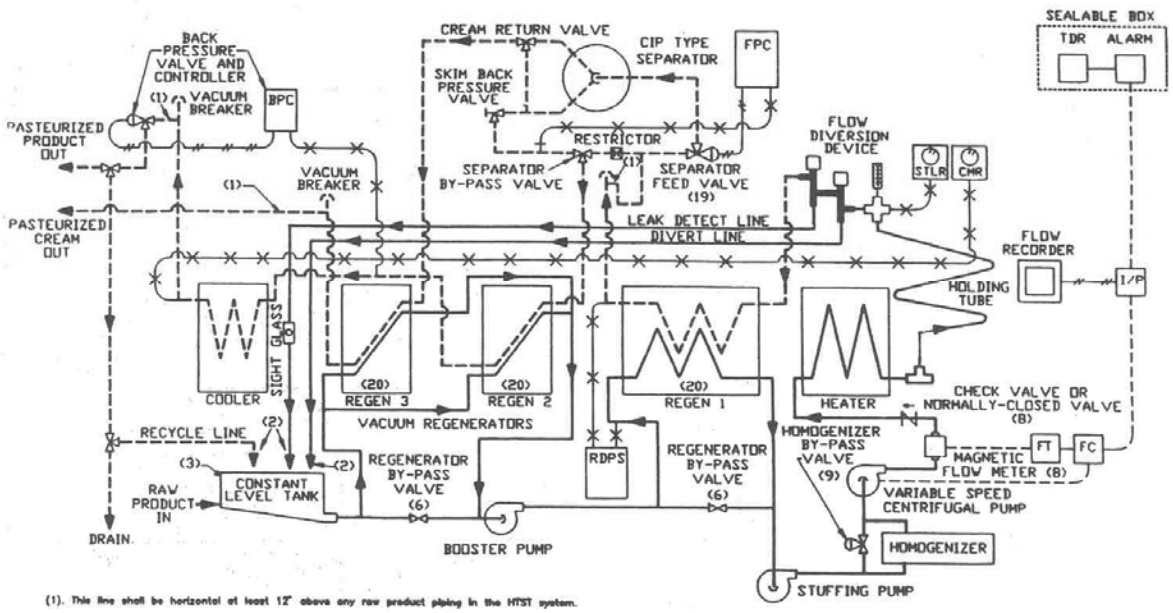

Gigure 56 meter based system with AC variable speed drive and Pasteurized milk separation

(1) this line shall be at least 12 inches above any raw product piping in the HTST system
(2) all divert, leak detection and recycle lines which return to the constant level tank must break to atmosphere at lest two pipe diameters above the over flow level (3) the overflow level of the constant level tank must be lower that the bottom of the inlet of the raw regenerator (6) regenerator bypass valves must be installed to be drainable, and must prevent dead ends, or be drilled. A drilled check valve may be used between inlets of booster pump and timing pump. Air operated valves must be normally open, automatically operated and controlled to open if timing device stops. (8) straight pipe per manufacturers recommendations required on both sides of the centerline of the magnetic flow meter. Meter shall be located so electrodes are flooded. No product can enter or leave the system between the centrifugal timing pump and the flow diversion device. The flow control valves if used shall be normally closed, air to open. This valve may be replaced with a sanitary check valve for systems equipped with variable speed centrifugal timing pumps. A homogenizer downstream of the timing system (for example centrifugal timing pump, magnetic flow meter, and flow control valve or check valve) must be provided with a recirculation line. (9) homogenizer by pass valve is optional and may be normally open or normally closed with all components of MBT system downstream. (19) when a separator or clarifier is an integral part of the HTST or HHST system an is located upstream of the timing pump or downstream of the flow diversion device it shall be automatically valved out of the system with fail safe valves properly interwired with the timing pump. (20) Regen 1 is the first section of a split milk to milk regenerator and Regen 2 is the subsequent second section . each requires a regenerator differential pressure switch. Regen 3 is a cream to milk regenerator operating at a negative pressure and requires no regenerator differential pressure switch.
Any other combination of modifications which are installed and operated with the above and with the detailed provisions of these practices may be utilized

IV. REGULATORY CONSIDERATIONS

NOTE: Meter based systems, in order to comply with the Ordinance, shall be installed as complete systems **as submitted and reviewed by FDA.** In other words, a complete system shall be deemed to mean a system consisting of those specific components, including wiring diagrams, that have been formally submitted and reviewed by the FDA. The installation of other components are to be reviewed and/or acceptable on an individual basis.

A. **CONSTRUCTION**

1. The centrifugal pump shall be located downstream from the raw milk regenerator, (if a regenerator is used in the system).

2. The magnetic flow meter shall be **downstream from the centrifugal pump.** There shall be **no intervening components** (valves or control devices) in the system other than normal sanitary piping.

3. Both the centrifugal pump and the magnetic flow meter (and the control valve when applicable) shall be located **upstream** from the holding tube.

4. All other flow promoting devices such as booster pump, stuffer pumps, separators, clarifiers, and homogenizer, as well as the centrifugal pump, **shall be properly interwired with the flow diversion device. These flow promoters may run and produce flow only when the flow diversion device is in fully forward or fully diverted flow position when in the product run mode.**

5. Homogenizers and separators installed in meter based systems must otherwise follow the same requirements as previously listed for conventional systems.

6. **There shall no product entering or leaving the system (i,e.,cream or skim from a separator or other product components) between the centrifugal pump and the flow diversion device. Also it is important that there shall be no flow promoting devices installed downstream from the meter based timing system.**

7. The magnetic flow meter shall be installed so that the product has contact with both electrodes at all times when there is flow through the system. This is accomplished by mounting the flow tube of the magnetic flow meter in a **vertical** position with the direction of flow from the bottom to the top. Also the meter must be installed to assure that the sensing probes are horizonally positioned on a within the meter which helps assure constant contact with the fluid within the piping.

8. The magnetic flow meter shall be piped in such a manner that **at least ten (10) pipe diameters of straight pipe** exists both upstream and downstream measured from the **center** of the meter.

9. There shall be an automatic means to assure proper pressure relationships in the milk to milk regenerator in cases of interruption in normal operation of the system. Acceptable methods are by installation of automatic fail safe valve at a location between the outlet of the raw regenerator and the holding tube. This will prevent back flow of product through the system which not only overflows the balance tank but more significantly could create positive pressure in the raw milk side of the regenerator.

10. There must be a sealed time delay installed which delays movement of the flow diversion device to the forward flow position following a diversion due to an excessive flow rate. This time delay must delay movement of the FDD to forward flow for at least 15 seconds (milk) or 25 seconds (egg nog or mix) after the legal rate has been established.

11. **Regulatory seals** must be provided in the following areas:

    a. **Flow alarm** (excessive flow alarm set point and loss-of-signal alarm)

    b. **Time delay #1** (Delay after divert for **excessive flow** rate)

    c. **Time delay #2** (10 minute **CIP**)

B. **OPERATIONAL**

Generally, we can say that a magnetic flowmeter is used in a pasteurization system to accurately measure the volume of flow rate of a wide range and viscosity of liquids. The only requirement of the product is that it must have a minimum level of conductivity.

A meter based timing system has some advantages over a conventional timing system in that it has few moving parts (as does a positive displacement pump), does not obstruct the product flow, and is not affected by changes in conductivity, temperature, viscosity, or density.

Flow meter systems are required to have high and low flow or loss of signal alarms. The purpose of these alarms are to assure the system will assume the divert position in those cases of excessive or inadequate product flows.

The purpose of the low flow or loss of signal alarm is to prohibit produce false readings on the flow controller or when there is a signal interruption to the flow meter. The setting of the low flow alarm should be left to the discretion of the processor. This may be accomplished by the installation of a power interrupt switch located between the meter and the flow recorder/controller.

When the flow meter system is powered and at rest (no flow condition), the flow rate alarm event marker must show an unsatisfactory (diverted flow) condition and the FDD must be in the diverted flow position regardless or product temperature. This loss of signal alarm is described in the testing procedures, however may be evaluated by disrupting the power to the magnetic flow meter by electronic deactivation switch.

The signal may be disrupted at any location which simulates interruption of power in the flow meter system and may be done at any location convenient for the equipment vendor and processor.

Another important point to remember is that the 15 second time delay is not required in those instances of **diverted flow as a sole result of inadequate temperature. Moreover, it would be impossible to properly conduct the recording thermometer thermometric response test if the 15 second delay is installed to occur on both excessive flow conditions and on temperature diversions. This will be addressed more thoroughly in the testing chapter of this manual.**

Regulatory testing of this system precludes the necessity for determining water:milk conversion flow rates, divert flow rates, and the flush time delay between the divert and leak detect valve on dual flow diversion valve systems.

CHAPTER REVIEW

1. a). What is a magnetic flow meter?

b). The basic components of a variable speed (AC drive)meter based systems are:

1.
2.
3.
4.
5.

2. T F Centrifugal pumps may be used to replace the timing pump in a magnetic flow system.

3. Three seals are required in the testing procedures for magnetic flow meters. What are they?

a)
b)
c)

4. The purpose of the required automatic shut off valve downstream from the mag meter and upstream from the holding tube is:

5. The purpose of the I/P Transducer in a Mag Flow system is to convert _____to_____.

6. In case of diversion resulting from excessive flow rates, the system must have a built in _____of _____seconds. The reason for this is_____
_____
_____.

7. One of the requirements for mag flow meter installation is that they be installed downstream from the timing pump and preferably in the_____position

which helps eliminate foam and assures a contact of the sensors with the conducting fluid, thus eliminating air pockets. There shall be a minimum of _____pipe diameters on each side of the mag meter, measured from the _____
of the _____.

8. A 2 ½ inch magnetic flow meter would need a minimum of _____inches of uniform straight product flow piping on each side of the meter to meet the PMO requirements.

9. T___F___ In all cases meter based systems are required to have flow control valves which function to control rate of flow through the system.

10. Raw milk separators may not be located between the timing pump and the holding tube since;(check all that apply)

a.___ proper pressure relationships in the milk to milk regenerator could be affected.
b.___ fluctuations in minimum required holding time may occur in the system.
c.___ loss of temperature is probable during the separation process.
d.___ stuffing pumps will exert positive pressure on the flow diversion device.
e.___ raw cream is illegal according to the FD&C federal code.
f. ___ product may not be added or removed after the timing system.

Notes:

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Note: The use of trade names or equipment photographs is for training and educational purposes only and does not constitute endorsement by the U.S. Department of Heath and Human Services, Public Health Service, Food and Drug Administration.

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