

Recording and Control

C1900 in pasteurization processes



The complete recording and control solution for pasteurization processes

Measurement made easy

From milk to beer, there are a large number of everyday foodstuffs that must undergo pasteurization before they can be packaged and sold to the public for consumption

Introduction

Pasteurization is a process that is designed to kill harmful microorganisms that reside in some foods. Unlike sterilization, it is not intended to kill all the microorganisms within the product; instead its aim is to reduce the number of harmful pathogens and thus limit the product's potential to cause disease.

This document focuses on using ABB's C1900 circular chart recorder/ controller series in the pasteurization process. It explains what the process is, why it must be controlled and monitored, which legislation must be followed and which of ABB's products is suitable for the application.

The history of pasteurization

The process of heating products in order to prolong the time before they spoil has been widely used since the 10th century when the Chinese and Japanese used such a process to prevent wine from spoiling. The theory of heating foodstuffs to kill bacteria was experimentally proven in the 18th century by an Italian scientist who discovered that if a product was hermetically sealed in a package after being heated, bacteria no longer developed. Over the course of the next 50 years, other scientists used the theory to develop different techniques for storing food, firstly in glass jars as an experiment for the French Military and later the technique was adapted and the process of canning was born.

The process we call pasteurization today was named after its creator, a French chemist called Louis Pasteur. Pasteur developed a less aggressive technique of killing the bacteria that involved heating the product to a lower temperature for a brief time. His primary reason for this was to prevent the spoiling of wine; he discovered that heating a young wine would kill the harmful bacteria enabling the wine to be aged to perfection without fear of it spoiling during the process.

However, it would be many years before the process would be adapted and used on milk and other dairy products.

Before the widespread urban growth caused by industrialization, people would keep dairy cows in urban areas. This limited the amount of time between production and consumption thus minimizing the risk of disease from the raw milk. However, as space within urban centers diminished, supply chain distances increased which in turn increased the risk of the milk spoiling. As a result, raw milk (often days old) became a recognized source of disease, especially tuberculosis (for example, in the early 1900s some 65,000 people died from tuberculosis in the UK alone). A document highlighting the link between infant mortality and contaminated milk was published around this time and it is believed that this heavily influenced the dairy industry's decision to start pasteurizing milk and milk products.

Processes

Older pasteurization techniques involved heating the product to a temperature below boiling, primarily because at very high temperatures, proteins that occur naturally in milk can curdle. However, modern techniques now use a much higher temperature but for a shorter time that prevents irreversible damage to the proteins. Three main pasteurization processes are used today to treat milk, High Temperature / Short Time (HTST or 'Flash'), Extended Shelf Life (ESL) and Ultra-High Temperature Processing (UHT).

HTST

In this process, the milk is heated to 72 °C (161 °F) for 15 seconds before being cooled. Milk labeled as 'Pasteurized' has been treated by this method.

ESL

In this process, the milk is heated to a higher temperature than traditionally pasteurized milk. The process also includes a microbial filtration step that extends the milk's shelf life.

UHT

In this process, the milk is heated to a higher temperature of around 140 °C (284 °F) for 4 seconds. This results in the milk being sterilized, not pasteurized, due to the amount of microorganisms that are killed. UHT milk can be stored unrefrigerated for up to 9 months.

Regulations

Pasteurization methods are standardized and controlled by national food safety agencies such as the FDA in the USA and the Food Standards Agency in the United Kingdom. These standards require that milk be HTST pasteurized to qualify for the 'pasteurized' label and vary only slightly around the globe.

For example, the USA and Canada conform to the Pasteurized Milk Ordinance legislation, published and controlled by the FDA. This states that for HTST systems, the milk must be heated to 72 °C (161 °F) and held under pressure at that temperature for at least 15 seconds. The legislation also details the path the milk must take through the system during that process.

In contrast, UK legislation states that the milk must be heated to at least 71.7 °C for 15 seconds or any equivalent combination, meaning it is acceptable to use any pasteurization process that involves a combination of time and temperature that results in the same degree of pasteurization.

Once the milk has undergone pasteurization, it must meet a set of microbiological standards during random sampling checks. This means that in any one random sample, the numbers of pathogenic micro organisms must not exceed a certain level and that after an incubation period of 5 days at a temperature of 6 °C (42.8 °F), the numbers of those pathogens must remain within a documented acceptable amount (applicable only to UK law).

Pasteurization methods vary greatly depending on the product undergoing the process. For example, standards for cream differ to standards for regular drinking milk and standards for pasteurizing cheese differ entirely as certain enzymes, crucial to not only the taste and texture but also the actual process of making the cheese, must be preserved. However, the process must still be hot enough and for long enough to kill the harmful bacteria. These standards are also included in detail as part of the local legislation.

There are, of course, many other products that require pasteurization but the regulations and legislation related to these are not covered as part of the milk pasteurization legislation.

The HTST pasteurization process

The HTST pasteurization process uses a heat exchanger unit to transfer heat to the product being passed through it. An overview of the process is shown in Figure 1.

Typically, unpasteurized or 'raw' milk is held momentarily in a storage tank located close to the process. The raw product is then pumped through the heat exchanger. Due to the nature of the product, this process is performed as quickly as possible after milking has taken place.

The first stage of the process is often referred to as regeneration. It is where the raw milk passes into the first stage of the heat exchanger. A thin plate separates the raw product from the already pasteurized milk and it is here that the heating process begins. Heat from the pasteurized milk passes through the thin separation plate to the raw milk. This stage in the process is relatively new compared to the age of the process itself. The idea is to make the heat exchanger as energy efficient as possible to compensate for the rising costs of energy and to reduce the environmental impact associated with energy production. Preheating the cold, raw milk with the hot, pasteurized milk can save the manufacturer thousands in production and energy costs.

The milk is passed through the system and kept under pressure at all times. After pasteurization, the milk is held at a slightly higher pressure than before. This ensures that raw product cannot contaminate the pasteurized product in the event of a breakdown of the thin separation plate in the regenerator.

After passing through the regeneration section, the preheated raw product is piped into the heating section, where steam is introduced to heat the raw milk to the correct pasteurizing temperature. After heating, the milk is then passed through a holding tube under pressure, the length of which is precisely determined to ensure the milk is held for the designated time period required for pasteurization. The temperature of the milk is now taken. If the temperature after the holding period is not high enough, a 3-way valve diverts the product back to the initial storage tank for re-processing. If the temperature is high enough, the milk continues through the system, this time passing through the opposite side of the regeneration section to preheat the raw product.

Finally, the milk passes through the cooling section of the pasteurizer unit and its temperature is then measured to ensure that it has been cooled to the correct temperature for packaging before being sent to the packaging plant.

All of this happens within a short time period of the product arriving at the processing site.

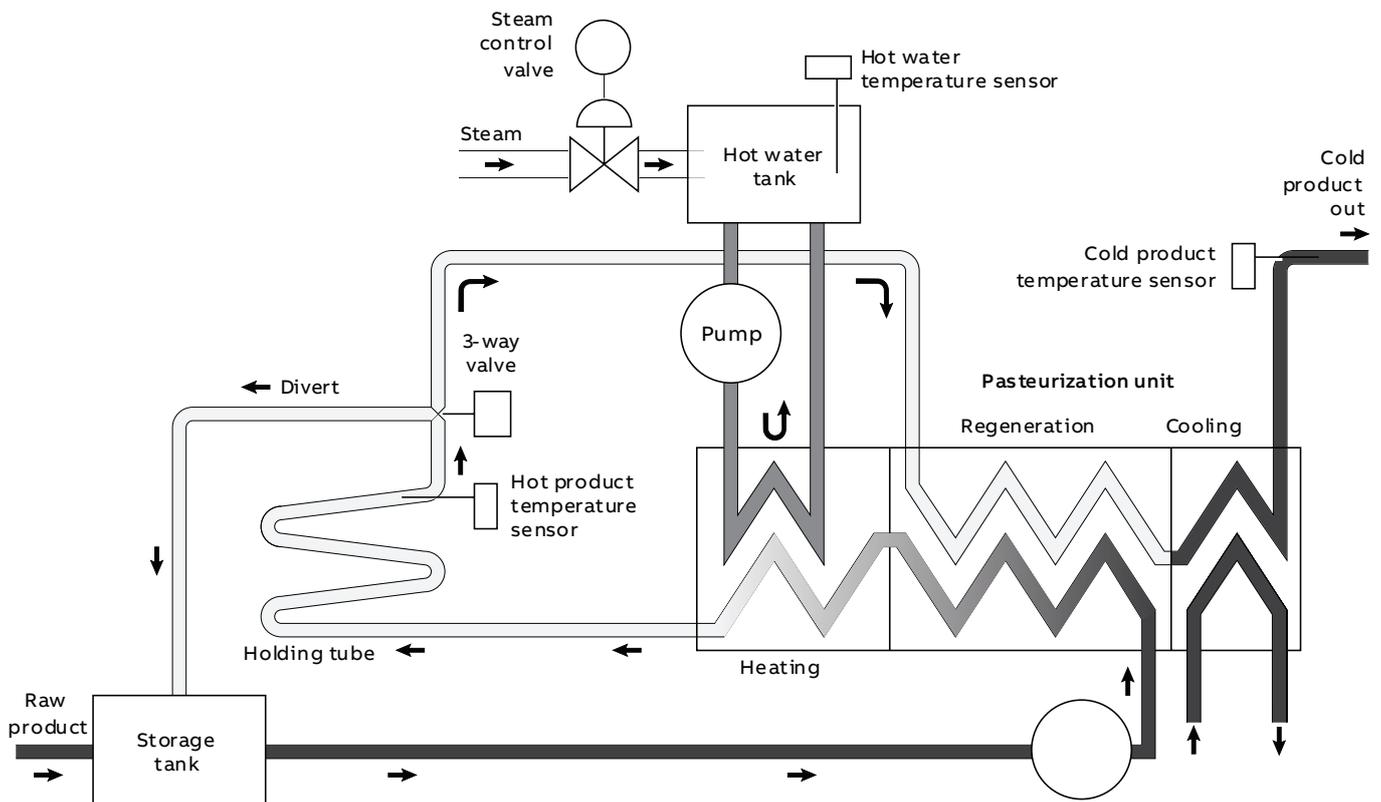


Figure 1 HTST pasteurization overview

Cleaning in place

While not a direct part of the pasteurization process, cleaning in place (CIP) is a critical step. Up until the 1950's, closed systems (such as those used for pasteurization) were disassembled and cleaned manually. This was a labor-intensive procedure that required lengthy plant shut downs. Pasteurization requires high levels of hygiene so the advent of CIP was a huge boost to the industry as it meant that the cleaning process would be faster, less labor intensive and more repeatable. It also reduced the risk to people involved in the cleaning process by limiting their exposure to the chemicals used. What started as a manual process involving pumps connected to the system has evolved into a fully automated process involving PLCs, valves, sensors and data acquisition. However, because these systems are separate to the pasteurizer itself, when the CIP system is running, the instrumentation on the pasteurizer records errors or incorrect states. Therefore, it is necessary to be able to indicate on the process records that CIP has taken place.

Instrumentation requirements and record keeping

Typically, a pasteurizer has a number of requirements for instrumentation. Pressure and temperature transmitters and flow meters are fairly typical and are often fitted as part of the pasteurizer system, that are normally manufactured by a company that specializes in producing complete, standalone systems (for example, pasteurizers and retorts). External to that is the requirement for recording and control equipment – this won't always be part of a standalone system.

The legislation surrounding the Food & Beverage production is comprehensive owing to the potential of harm to human health and wellbeing. Records relating to the production of food and beverage products must be kept for time periods in excess of those of the lifespan of the product. For example, records for juices that require pasteurization are kept for 1 year after the production of the product, extending to 2 years if they have undergone extended shelf life treatment processes or are stored frozen. Dairy product records are retained for at least 1 year after the product is pasteurized extending to 2 years based on the treatment process and storage medium.

These records can be documented and stored in a number of ways; the chosen method is usually dependent on local preferences. For example, the PMO legislation in the USA and Canada names a number of circular chart recorders as being suitable for the record keeping requirements of Dairy products. However, the FDA code from where the PMO legislation is born contains provision allowing the use of paperless recorders and electronic record keeping, but the use of paperless recorders within this type of application locally, while not prohibited, is uncommon. Elsewhere in the world it is not unusual to see paperless recorders (for example, ABB's RVG200) used in this type of application.

The recorder of choice in pasteurization worldwide for the main recording and control requirements is circular and this is why they continue to be sold into these applications in large numbers. There is also a requirement in some systems to install a booster pump controller. This is a separate device that monitors the difference in pressure between the raw and pasteurized products within the regenerator. If the pressure differential falls below a preprogrammed level, the controller supplies a signal to drive the pump and increase the pressure. If the pressure differential falls even lower, separate outputs from the controller can inform the system that there is a problem and stop the process to prevent raw milk from leaking into the pasteurized side of the system. Depending on the plant, other opportunities exist within the system for individual local indication as well. The focus of this document is on the product most widely used, ABB's C1900 circular chart recorder and controller series. For more information on the booster pump controller application, refer to Technical Description [TD/RandC/017](#).

C1900 series recorder and recorder/ controller

The C1900 is ABB's circular chart recorder and its proven technology mean that it is still a popular choice in the dairy industry worldwide today. In fact, ABB have designed and developed a range of dedicated pasteurization instruments solely for pasteurization applications – the C1950 series.



The C1950 series of pasteurizer recorders and recorder/ controllers are a complete recording and control solution for the pasteurization process. Designed to meet the requirements of the pasteurization process and meet the PMO requirements, the C1950 range is available in 3 instrument variants:

- **1951** – records the hot product temperature and either the divert set point, or cold product temperature. There is no process PID control available in this product.
- **1952** – is a recorder / controller product. Records the hot product temperature while controlling the temperature of the hot water in the heat cycle of the plant. It also records either the divert setpoint or the cold product temperature.
- **1953** – is the most comprehensive recorder / controller product. It combines all of the functionality of the 1952 with cold water temperature control from a cold product temperature probe.

All 3 versions are fitted with a 4-position true-time event pen that indicates forward flow, divert, CIP (cleaning in place) and secondary divert (if required) and up to 8 divert setpoints are available on each unit to drive the event pen – see Figure 2. The controller variants also have up to 8 hot water control setpoints together with selection of these via digital signal, so the customer can remotely operate sterilizing and CIP temperature from their control panel.

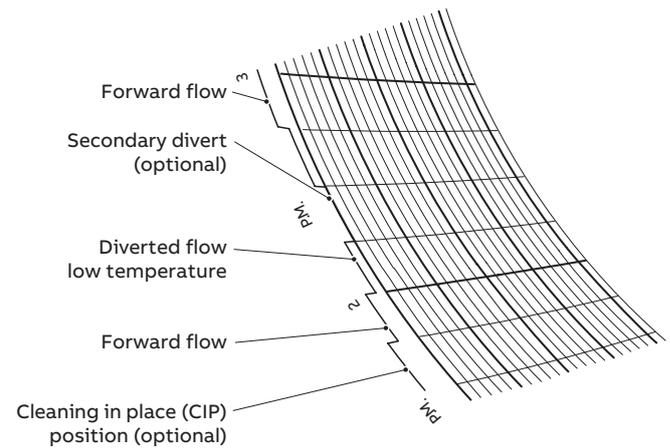


Figure 2 Pasteurization chart example

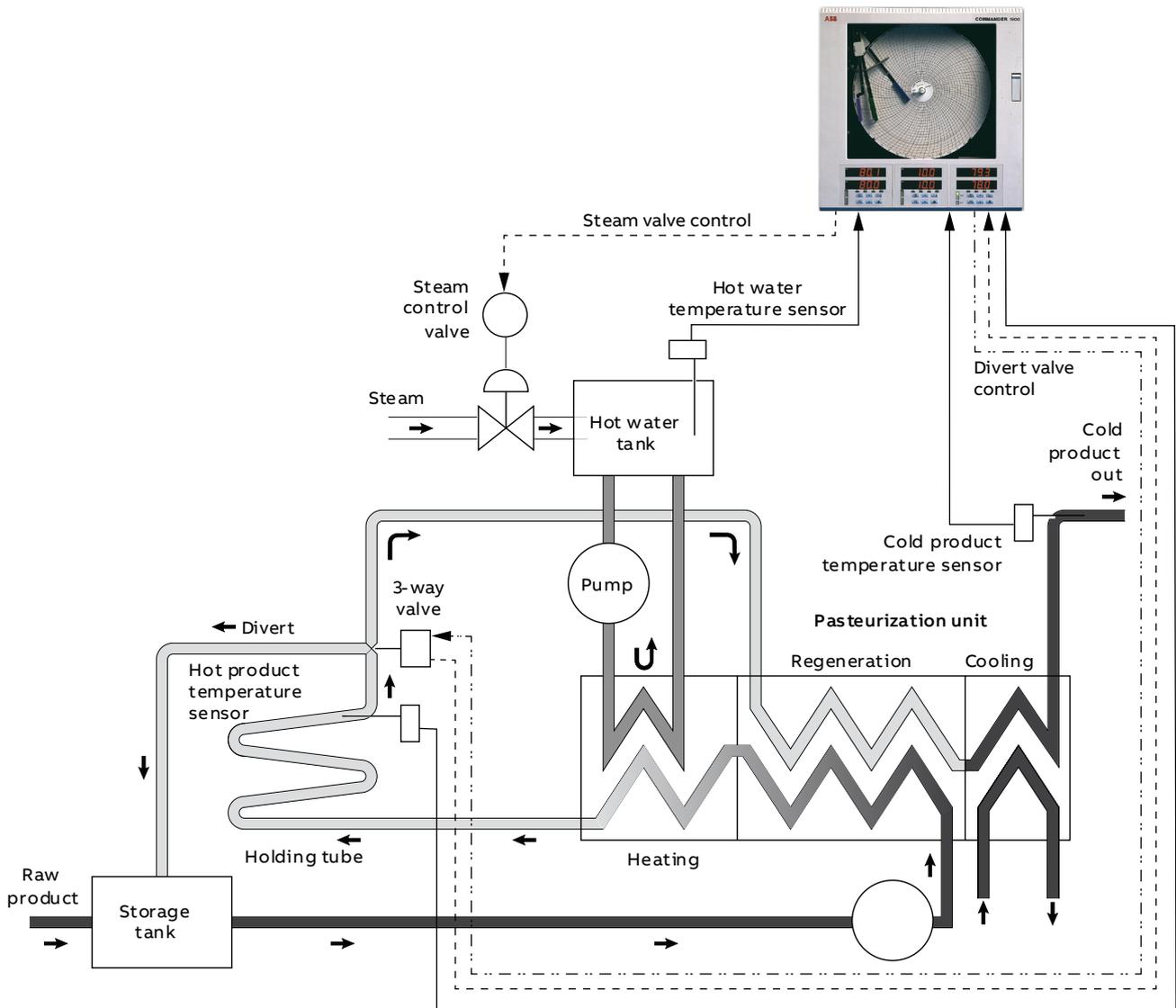


Figure 3 Pasteurization using the C1950

A dedicated pasteurizer faceplate is fitted to the front panel of each recorder showing the hot product temperature and divert set point temperature. A special LED indicator shows at a glance the status of the process (whether in divert or not) – see Figure 4.

The green section LED indicates at a glance that the process is in forward flow, amber indicates forward flow but the temperature is approaching the divert temperature enabling correction of any issues. The red LED section indicates that the process flow has entered the divert stage.

The C1950 is rated IP66 / NEMA 4X as standard and can be panel-, wall- or pipe-mounted, making it suitable for use in almost any location within a modern dairy where cleaning of all surfaces is required.

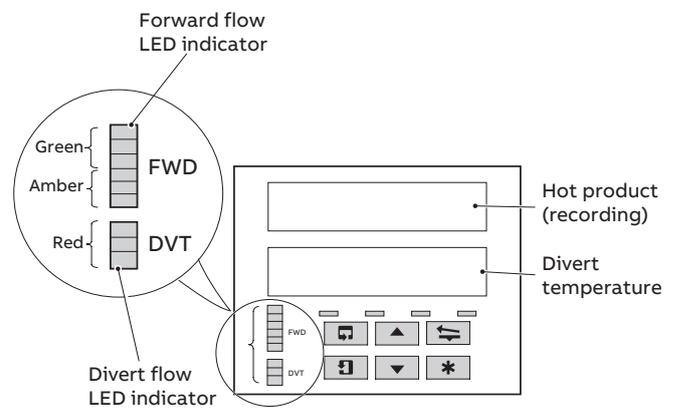


Figure 4 Dairy / Pasteurizer faceplate

Benefits of using the C1950 for pasteurization applications

- Dedicated pasteurizer recorder / controller
 - designed to meet requirements of pasteurization processes
- High clarity digital displays
 - continuous indication of hot product and divert temperature
- Compliance review
 - meets PMO requirements
- Pasteurizer status indicator
 - LED indication to show forward or diverted flow
- True time event pen
 - 4-position event, records divert and forward flow plus optional CIP (clean in process) and secondary divert
- Up to eight diversion set points
 - local or remote selection of hot product divert temperature settings
- Hot product pen calibration
 - optimization of pen reading to independent thermometer

For further information, refer to data sheet [DS/C1950-EN](#)

Configuring the C1950 series for pasteurization processes

The C1950 series come from the factory preconfigured, making set up and installation on the process simple and requiring minimal time. This is a standard configuration for all and although slight adjustments may be required based on individual customer requirements, the main set up of the unit is already done at the factory. The configuration is available in 2 versions, one aimed specifically at the North American market and the other aimed at the rest of the world. The main difference is in the input ranges and pen assignments; traditionally the USA operates in degrees F, not degrees C, and specific FDA requirements as to what must be displayed govern pen assignments. There is also a physical difference in that C1950s manufactured for the USA have an extra board fitted containing a number of relays that are used to drive the process as per FDA requirements. This board is ordered from the factory and fitted to the unit in a very specific way including wiring – see Figure 5.

The power to the process is supplied via the relays on the extra board. The signals telling these relays when to become active are sent from the instrument itself:

- 1 Relay 1 (A) on the option board is powered when the hot product reaches the correct pasteurization temperature and relay 1.1 on the C1900 is energized.
- 2 Power is fed to the milk pump (B) and the flow diversion valve (C).
- 3 The diversion valve is switched to forward flow and the milk pump switched on. Power is then fed to relay 2 (D).
- 4 Relay 2 is energized, the event pen moves to the forward flow position and the green forward flow LEDs on the front panel display are lit. Relay 3 (E) is de-energized.

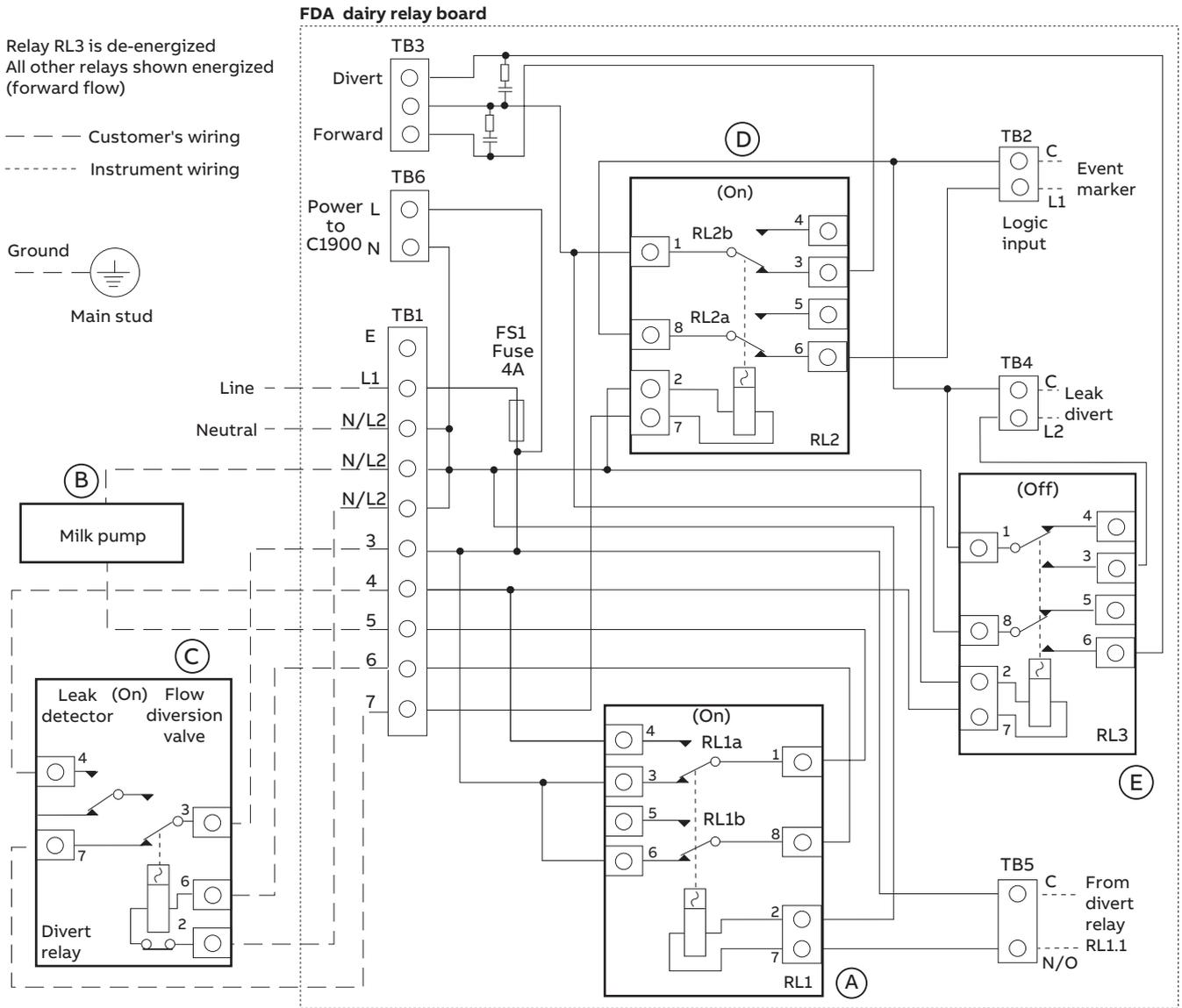
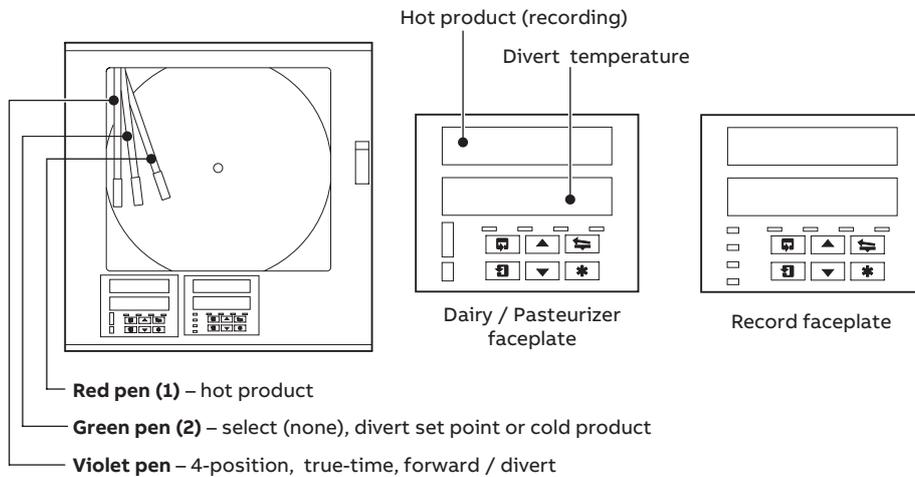


Figure 5 FDA dairy relay board wiring

...Configuring the C1950 series for pasteurization processes

C1951 configuration



The 1951 has 2 faceplates fitted to the front panel. The left-hand faceplate is the dedicated dairy faceplate with two displays. The top display shows the hot product temperature that is being recorded by pen 1 (red pen) from an input signal connected to the recorder’s input 1. The bottom display shows the divert temperature setpoint; if the hot product temperature falls to this value, the 3-way divert valve is activated and diverts the product back to the holding tank to go through the pasteurizer again.

The right-hand faceplate shows the cold product temperature on the upper display that is being recorded by pen 2 (green pen) from an input signal connected to the recorder’s input 2. The bottom display is not used.

The factory set up includes the input assignment, process variables and pens:

- PV1 = input 1 = pen 1 (red pen)
- PV2 = input 2 = pen 2 (green Pen)

Pen 4 is assigned automatically as the true-time event pen and associated with the divert status.

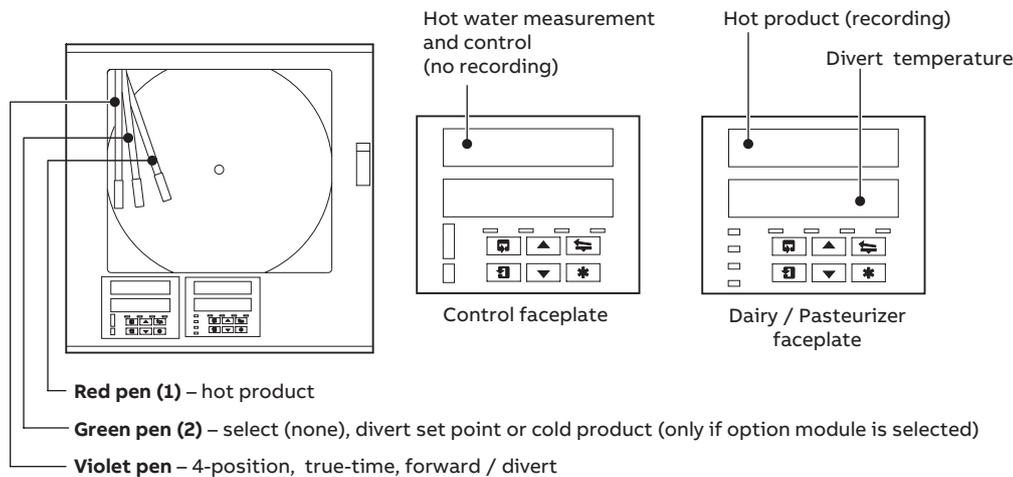
Inputs 1 and 2 are configured identically as RTD input types. The engineering range configured depends on the shipment destination, either 0 to 100 °C or 0 to 300 °F, with a broken sensor direction of Down, indicating that should an input fail the pen is driven to the center of the chart below 0 to prevent interference with the true-time event pen operation. The analog outputs on each I/O card are assigned to retransmit their associated input as a 4 to 20mA signal.

The final set of parameters that are preconfigured by the factory can be found in the [SETUP dIUERt](#) page. This page contains the pasteurizer specific parameters that are included especially for dairy applications:

- [d-DE](#)
[-ULtI](#)
[SINGLE](#) The instrument can be configured to operate in one of 2 divert modes:
Multi – with up to 8 divert setpoints available to program.
Single – A single divert setpoint can be programmed.
- [OP-LEU](#)
[EnbL-y](#) Enables the divert setpoint number to be selected from the operator level.
- [Ed-Src](#)
---- Diverts the event pen on any assigned digital signal (Internal and external).
- [L IPSrc](#)
---- The digital source responsible for the clean in place event.
- [LM-Src](#)
---- The digital source responsible for a divert event in addition to the programmed divert setpoint. (Digital input 1.2 MUST be used).
- [dUrt-1](#)
---- Setpoints (1 to 8) used for divert events. Setpoint 1 is set by default to 70.0 °C or 162.0 °F.
- [HYSE](#)

or
[L-HYSE](#)
---- A hysteresis value in both engineering units and time can be applied to the divert setpoints. Only applied to values above the divert temperature and by default is set at either 0.0 °C or 0.5 °F.

C1952 configuration



The 1952 has 2 faceplates fitted to the front panel. The left-hand faceplate is the dedicated control loop faceplate with two displays. The top display shows the hot water temperature and the bottom display shows the desired control setpoint. No pen recording is associated with the control setpoint value and it is measured using the recorder's input position 3 (there is no option module fitted in position 2).

The right-hand faceplate is the dedicated dairy faceplate. The top display shows the hot product temperature connected to the recorder's input 1 position and recorded using pen 1 (red pen). The bottom display shows the divert setpoint.

The 1952 has the option to fit a third input module to position 3 to measure and record the cold product temperature (if required) using pen 2 (green pen). This can be specified in the product code when ordering.

The factory set up includes the input assignment, process variables and pens:

- PV1 = input 3 = not recorded
- PV2 = not fitted as standard (if fitted: input 2 = pen 2 (green pen) if not fitted pen 2 = divert temperature)
- PV3 = input 1 = pen 1 (red pen)

Pen 4 is assigned automatically as the true-time event pen and associated with the divert status.

Inputs 1 and 2 are configured identically as RTD input types. The engineering range configured depends on the shipment destination, either 0 to 100 °C or 0 to 300 °F, with a broken sensor direction of Down, indicating that should an input fail the pen is driven to the center of the chart below 0 to prevent interference with the true-time event pen operation. The analog outputs on each I/O card are assigned to retransmit their associated input as a 4 to 20mA signal.

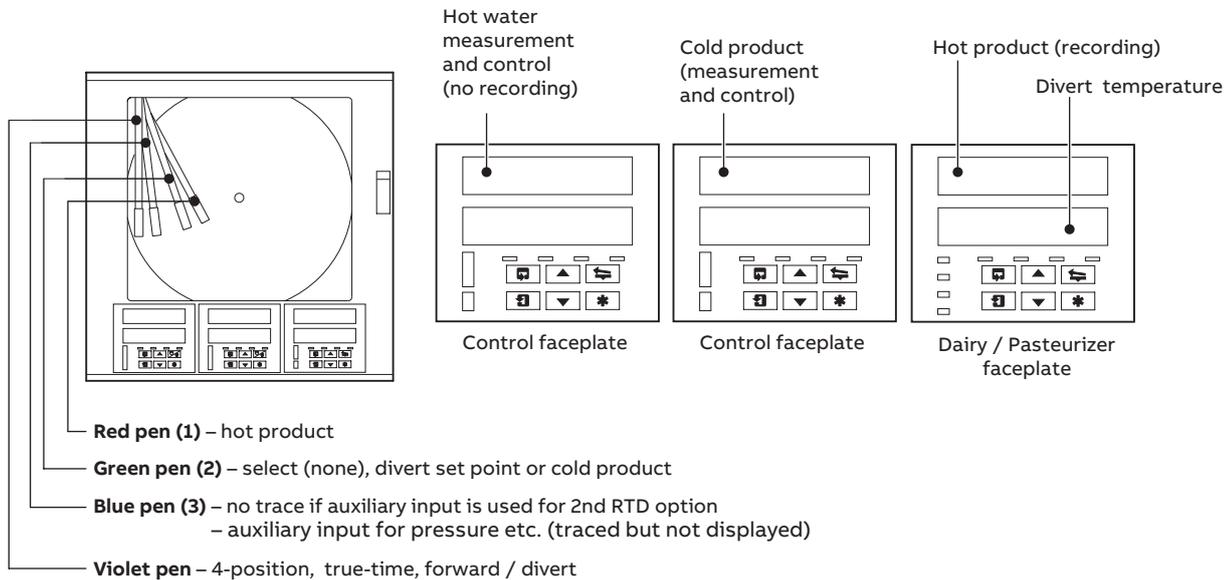
The final set of parameters that are preconfigured by the factory can be found in the [SETUP](#) page. This page contains the pasteurizer specific parameters that are included especially for dairy applications. The parameters are the same as those available for the 1951 except that due to the added control functionality, 2 further parameters are available:

[HOT - 1](#) Set the hot water control temperature for the associated divert setpoint.

[SRCE - 1](#) Select the digital source used to engage the associated setpoint.

...Configuring the C150 series for pasteurization processes

C1953 configuration



The 1953 has 3 faceplates fitted to the front panel. The left-hand faceplate is the dedicated control loop faceplate with two displays. The top display shows the hot water temperature and the bottom display shows the desired control setpoint. No pen recording is associated with the control setpoint value and it is measured using the recorder's input position 3.

The center faceplate is a dedicated control loop faceplate used for control of the cold product temperature. This value is recorded on the chart using pen 2 (green), and shown on the faceplate with the actual temperature in the top display and the desired setpoint in the bottom display. The temperature is measured via the recorder's input 2.

The right-hand faceplate is the dedicated dairy faceplate. The top display shows the hot product temperature connected to the recorder's input 1 position and recorded using pen 1 (red pen). The bottom display shows the divert setpoint.

The 1953 has the option to fit an auxiliary input that can be used to record another variable in the system (for example, the pressure). This value can then be recorded using pen 3 (blue) of the recorder. If not fitted this pen is not used.

The factory set up includes the input assignment, process variables and pens:

- PV1 = input 3 = not recorded
- PV2 = input 2 = pen 2 (green pen)
- PV3 = input 1 = pen 1 (red pen)

Pen 4 is assigned automatically as the true-time event pen and associated with the divert status.

Inputs 1 and 2 are configured identically as RTD input types. The engineering range configured depends on the shipment destination, either 0 to 100 °C or 0 to 300 °F, with a broken sensor direction of Down, indicating that should an input fail the pen is driven to the center of the chart below 0 to prevent interference with the true-time event pen operation. The analog outputs on each I/O card are assigned to retransmit their associated input as a 4 to 20mA signal.

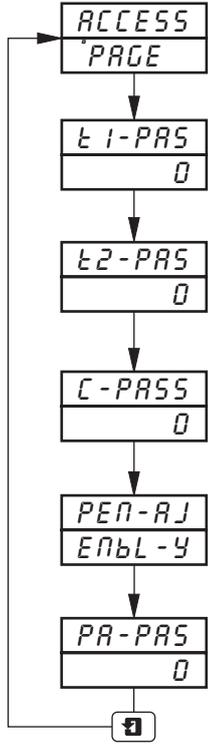
The final set of parameters that are preconfigured by the factory can be found in the [SELECT DIVERT](#) page. This page contains the pasteurizer specific parameters that are included especially for dairy applications. The parameters are the same as those available for the 1952 unless the auxiliary input option is selected when extra input must be configured. This is configured in the [BAS IC CONF IG](#) level:

[SELECT INPUT](#) Select the input associated with the auxiliary input option and configure the electrical signal type to measure, together with the engineering range etc.

[SELECT PEN-RNG](#) Set up pen 3 measuring range.

Securing the recorder

All models are fully password protected and can be fitted with a tamper evident seal as is required by the FDA. Once configured, a password can be enabled to prevent unauthorized access to the configuration parameters. To do this, enter the Basic Config level and select the 'Access Page':



Use the key to scroll down to the C-PASS page and set the required password. Once the password has been set, exit the Basic Config level and power down the recorder. Open the chart plate and move the security link to enable the password – see Figure 6.

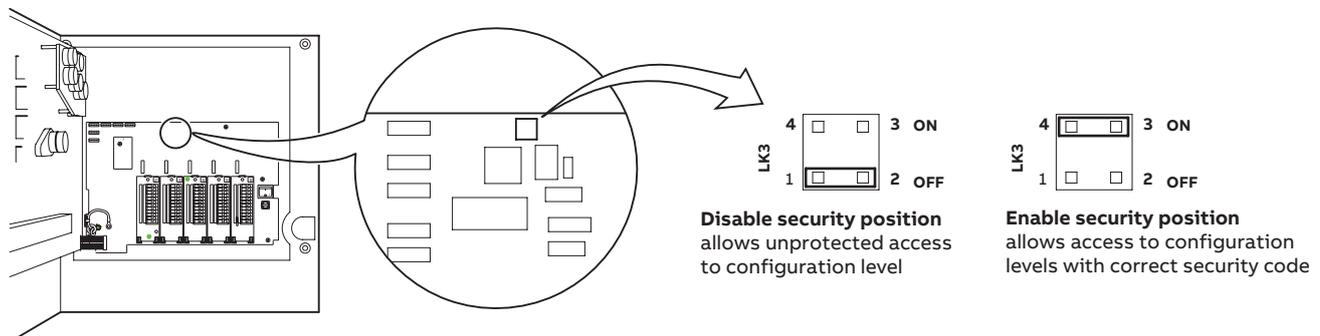


Figure 6 Setting the security link

Once the security link has been set, shut and secure the chart plate and fit the tamper evident seal – see Figure 7.

Close the door and power up the recorder. Access to the configuration level is now only possible by entering the password or repositioning the internal link. The tamper evident seal is fitted by the FDA inspector and enables them to see if the recorder has been accessed during the time between inspections.

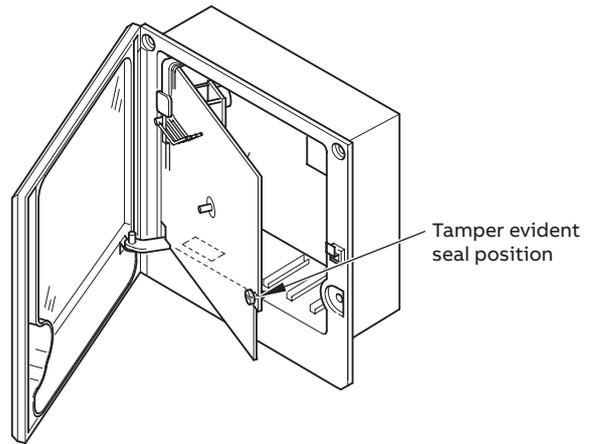


Figure 7 Fitting a tamper evident seal

Alternative solutions

Although the C1900 product range includes 3 recorders designed specifically for pasteurization applications, personal or site preferences may lead to paper recorders being either unsuitable or not the preferred method used for process recording.

When paper records are unsuitable a paperless recorder (for example, ABB's RVG200) can be used instead. Designed to meet the requirements of 21 CFR part 11, the RVG200 is perfectly suited for use in Food & Beverage applications.



Figure 8 RVG200

Notes

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