WHITE PAPER

Consumption milk pasteurizers can be run much longer than 8 hours

New assessment methodology allows extended running time for milk pasteurizers.

June 2017

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Introduction

Who is this booklet for?

This booklet is intended for professionals within the dairy processing industry:

- **Plant managers and production managers** who are interested in reducing the total cost of ownership (TCO) and the carbon footprint of their dairy operations.
- **Quality assurance specialists** who are interested in assessing production runs and methods.

It is also of interest to risk **assessment managers** and **general managers** who ultimately have the responsibility for major changes to plant production methods – as well as many **food researchers** in the global dairy community.

We at Tetra Pak would like to share what we know about the effects of extending pasteurization running times on different dairy beverages.

We present the results of large-scale experiments on dairy pasteurization. The major finding is that the traditional running time limitation of 8 hours is still valid for products such as cheese and powders, but in the case of consumption milk, running time can be extended – even doubled or more – reducing the frequency of cleaning in place (CIP).

About running times

The most important part of the total of 24 hours that are available each day is when the equipment works by processing food products or outputting consumable goods. Many industries refer to this as “running time” or “production time”, as we do in the diagram below.

From a dairy plant management perspective, it is desirable that running times of processing equipment are maximized to increase or optimize plant efficiency and hold operating costs down.

But from a hygienic and product safety point of view, it is also important that the equipment is cleaned as frequently as required by regulations or good manufacturing practice.

And from a maintenance point of view, there always should be planned maintenance time available to keep the equipment in top technical condition, in order to prevent unplanned stops due to technical issues.

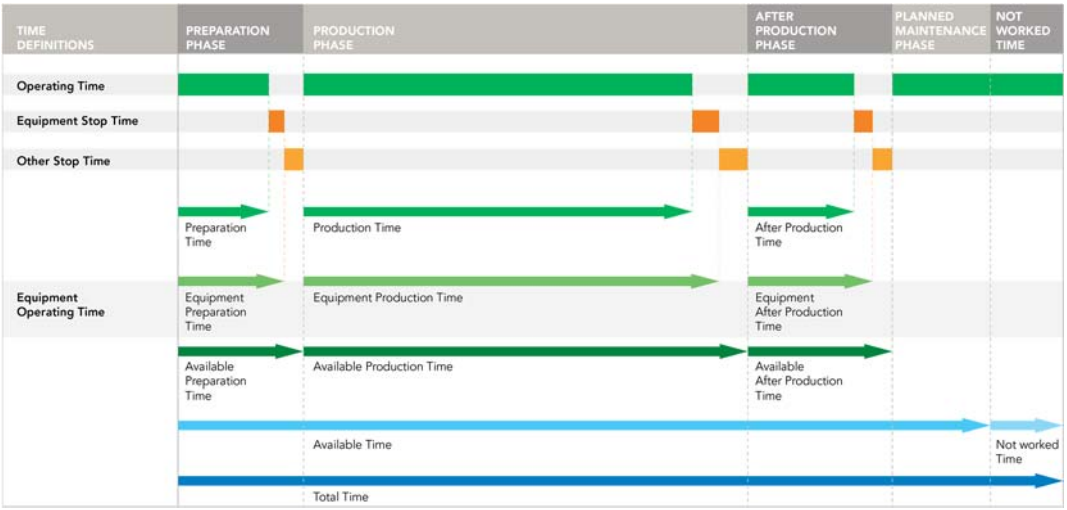

Figure 1 A graphic definition of different industrial time concepts

The running time of processing equipment can be limited by many factors:

- Organizational limitations
  Certain periods are designated to be completely idle (e.g. holidays) or idle for production (e.g. nights)
- Technical limitations
  Equipment needs to be serviced and maintained (planned maintenance), but can also suffer from unpredictable technical issues, short stops, breakdowns, etc.

- Technological limitations
  Based on product behaviour and its propensity to soil surfaces of the equipment and create localized fouling (e.g. heat-induced fouling in heat exchangers or biofilms).

Plate heat exchangers in milk pasteurizers

All heat exchangers are prone to fouling. The speed of fouling depends on the temperature range of the heat treatment, the type of product and its propensity to foul, and the design of the system.

In most cases fouling leads to higher temperature differentials (dT) in the high temperature sections and/or to higher system pressure. Thus dT and system pressure are typically used as STOP parameters: if one of them reaches a critical value, then the system must stop processing and CIP must be started.

White milk pasteurizers working with temperature programs in the range of 74°C /15-30 s normally do not develop enough fouling to trigger standard STOP parameters when working with milk that meets the quality levels recommended by Tetra Pak design criteria, so neither dT nor pressure are the actual limiting factors for the running time.

What happens at the level of microorganisms?

It has been demonstrated in several research publications and confirmed in industrial practice that some parts of milk pasteurization lines (e.g. integrated separators and regenerative sections of the plate heat exchangers (PHEs)) may become sources of thermoduric thermophilic bacteria[1], if they have enough time to establish a layer on the surface and to create an active formation that releases viable cells or spores. This growth layer can be described as a pre-stage of bio-film formation and is typically removed by CIP. If the time between CIP cycles is long enough, a fully developed, undesirable bio-film can be established.

[1] Thermoduric thermophilic bacteria in milk survive pasteurization (63 C/30 min and 74 C/20s) and are enumerated by plating on TPC agar and incubation for 72h at 55 C. They never grow at temperatures below 10 C.

The mechanism of this phenomenon is the following

- Raw milk typically contains some thermoduric thermophilic bacteria. They have the ability to survive standard pasteurization and the ability to colonize and grow on the stainless steel surfaces in separators and in the regenerative section of milk pasteurizers.
- Starting with a clean PHE, it takes about 6-8 hours for a newly formed layer of the thermoduric flora to start releasing new bacteria or spores.
- During the first 6-8 hours of production, the thermoduric bacteria count in the pasteurized milk is equal to that of incoming (raw or thermized) milk
- After 6-8 hours of production, the thermoduric bacteria count in the pasteurized milk starts to increase, due to release of bacteria from the surface layer. When the total count of thermoduric bacteria exceeds the accepted limit, CIP must be activated.

In this sense, the thermoduric count in the pasteurized milk becomes a specific STOP parameter for milk pasteurizers.

Different requirements for different dairy products

The behaviour of thermoduric flora and the consequences of their growth for cheese and powder manufacturing have been known for a long time. The cheese and milk powder industries require low counts of thermoduric bacteria in the pasteurized milk input, in order to secure high quality of their end products This is the origin of the 8-hour running time limitation.

Due to lack of any other evidence or studies, this microbiological run-time limitation has typically been applied to all milk pasteurizers, regardless of the intended application or product.

The requirements of consumption milk are completely different. This product is typically stored at temperatures below 8°C, and in these conditions thermoduric thermophilic bacteria remain completely inactive – they do not grow nor multiply and they do not change the milk’s properties. This means that they create neither product quality risk nor food safety risk, and in this sense they are technologically unimportant.

Consumption milk is typically tested for total plate count (TPC) by plating on TPC agar or 3M film and incubating at 30°C for 72 hours. In those testing conditions, thermoduric thermophilic bacteria will not grow and will therefore not be visible. They will remain uncounted, as this standard testing procedure enumerates only mesophilic bacteria.

Measured effects of extending running times

The effect of extending the production (run) time of a typical consumption milk pasteurizer was assessed on an industrial scale in a pasteurized milk dairy in the UK.
In those tests we measured:

- TPC of the raw milk
- Thermoduric count of the raw milk
- Plate count of pasteurized milk on TPC agar from the same sample incubated at 30, 37 and 55°C for 72 hours.

The following three graphs show the number of thermoduric bacteria (cfu/ml) in the pasteurized milk, tested at the pasteurizer outlet. Milk samples were taken every 3 hours during production runs of up to 18 hours. Seven production runs were monitored.

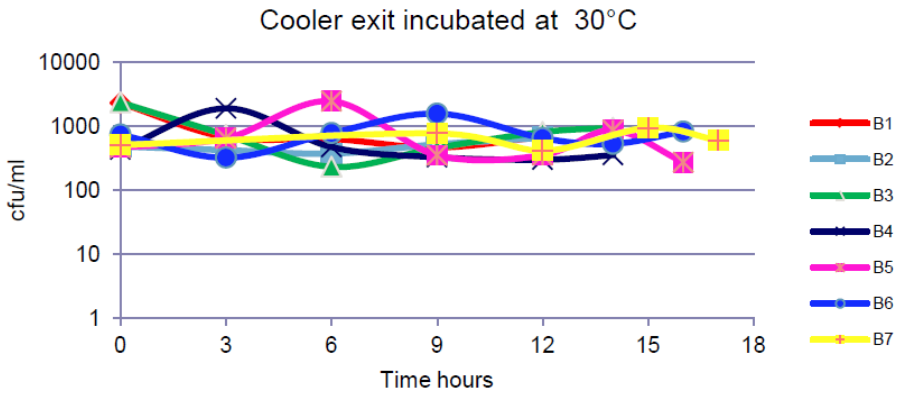

Figure 2 Bacteria count in pasteurized milk at the exit from the pasteurizer as measured by incubating at 30°C, seven different production runs, B1-B7.

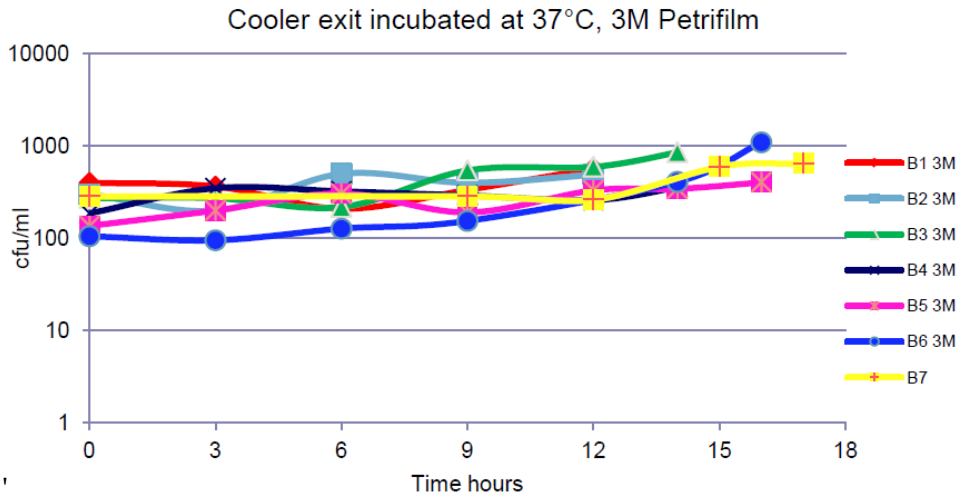

Figure 3 Bacteria count in pasteurized milk at the exit from the pasteurizer as measured by incubating at 37°C, seven different production runs, B1-B7.

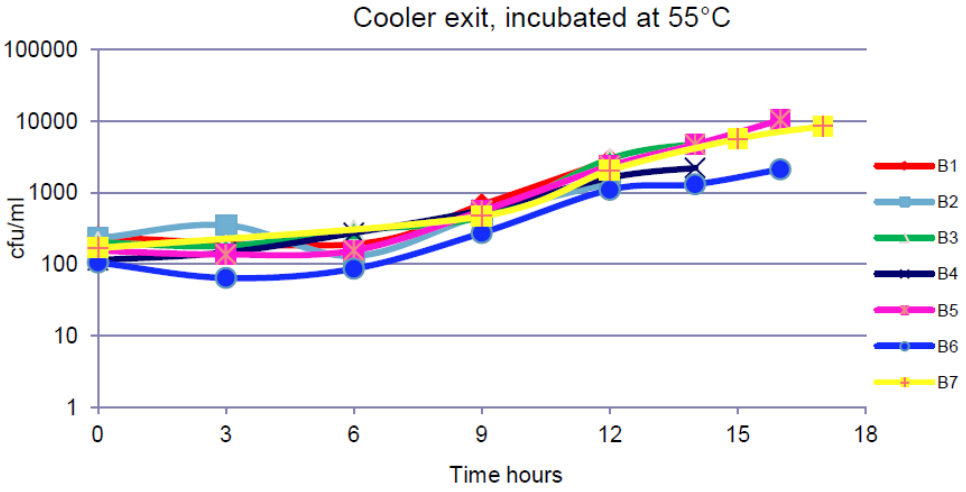

Figure 4 Bacteria count in pasteurized milk at the exit from the pasteurizer as measured by incubating at 55°C, seven different production runs, B1-B7.

As shown in these experiments, the number of thermoduric mesophilic bacteria in the pasteurized milk, tested at pasteurizer outlet, stays stable and equal to input, during processing time up to 18 hours. Lack of any visible growth allows extrapolation of this trend well beyond 20 hours. Using TPC plating and incubation at 30°C confirms microbiological stability of the prolonged process as typically assessed by producers of pasteurized consumption milk.

This research supports a proposed extension of the running time available for consumption milk pasteurizers to 20 hours ± 2.

Conclusions

We do not assume that pasteurization is a one-size-fits-all situation. We propose that it is possible to differentiate pasteurization line running times, based on different product requirements with regard to critical microorganisms. Thermoduric thermophiles are critical for cheese and powder quality and not significant for consumption milk.

The traditional limitation of approximately 8 hours running time is still appropriate for cheese and milk powder products, because of the need to limit the growth of thermoduric thermophilic microorganisms

But our experimental results show that consumption milk can be run for 20 ±2 hours with no risk to food safety and quality. Thus we propose the following classification of running times for milk and cream pasteurizers.

Application	Heat treatment	Max. run time (h)	Limiting factor	STOP parameter	Comments
Pasteurized consumption white milk	72 - 74°C / 15 -30 s	20 h ± 2	Customer production time schedule (PTS)		Low pasteurized consumption milk has no obvious stop parameter other than PTS. Neither heat induced fouling nor thermoduric growth are critical (assuming good quality milk up to TPC of 300 000 cfu/ml and pH 6.6 - 6.8)
Milk for cheese or powder	72 C / 15 s	8 h ± 2	Growth on PHE-surface of thermoduric thermophilic bacteria	Number of thermoduric thermophilic bacteria in the outgoing milk.	Depending on actual number of thermoduric bacteria in raw milk, it may take 6 to 10 hours before the number of thermoduric thermophilic bacteria (analysed by plating and incubation at 55°C) starts to increase above allowed level in the outgoing milk.
Pasteurized Consumption cream (any fat content)	82°C / 15 s	12 h ± 2 (may be longer for fat content below 25%)	PTS and/or heat induced fouling	If applicable - dT or pressure in PHE.	Growth in cream is similar to milk

Table 1: Classification of running times for milk and cream pasteurizer

Our findings open up opportunities for increased productivity and cost savings. For consumption milk processing, this change will allow saving at least one CIP cycle for each pasteurizer, every day.

For dairies producing large volumes of pasteurized consumption milk, this means saving about 50% of the cost of CIP per milk pasteurizer per day.

Furthermore, the longer running times and reduced number of CIPs may have additional beneficial effects on equipment investment, maintenance costs, production shift management and other key parameters.

Benefits of eliminating one CIP cycle per day and line:

- Reduced CIP cost by approximately 50% (electricity, media, detergents for the specific pasteurizer)
- Increased processing availability by 2-4 hours per day
- Possibility to finish daily production circle within 24 hours, e.g. 20 hours processing + 3 hours CIP + 1 hour preparation time… and the line is then ready to go for next day.

Tetra Pak – your partner in processing

Our continuing experience in the dairy industry indicates that pasteurization – like many other processes – can be a highly variable area where optimal processing and running times can vary depending on individual products or their raw materials. Tetra Pak stands ready to help you determine what that optimal process is, based on practical field trials, our calculation tools, and our years of expertise.

Tetra Pak's food chemists and process engineers are very knowledgeable in the field of thermal treatment, mixing, deaeration, packaging and storage. If you would like to gain more insights into optimization of beverage quality – particularly if you need advice when specifying processing parameters or integrating processing equipment into a line – feel free to contact your Tetra Pak representative at http://www.tetrapak.com/contact