Pasteurization Units & Sterilization Units

- Temp1000FP
- Temp1000S
- HiTemp150
- HiTemp140

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Introduction

Bacteria can be remarkably useful. It is used in the production of cheese, pickles, yogurt, wine, beer and even manufacture Vitamin K for us in our intestines. However, there exists an excess of bacteria and other micro-organisms that are simply bad. Although impossible to assure the elimination of all bacteria, it must be reduced to acceptable levels in food and medical applications.

Food Application – Pasteurization

In food applications, the total elimination of bacteria is desirable but not practical or necessary. The goal is to destroy enough of them to yield safer food with a longer shelf life without adversely affecting the taste of the product. The commonly used method of heating the food to kill pathogens is known as Pasteurization (named after the method's inventor, Louis Pasteur). The name given to quantify the amount of pasteurization is Pasteurization Units.

One Pasteurization Unit (PU) is defined as 1 minute of heating at 60ºC. The number of PUs applied to a food product depends a great deal on the product, specific bacteria, its packaging and anticipated shelf life and use.

The formula for calculating PUs with MadgeTech data loggers requires setting several variables:

Time base	1 minute
Sample interval time	Chosen by the user
Reference temperature	60ºC (140ºF)
Minimum temperature	50ºC (*Below this temperature, no contribution is made to PU*)
Z-value	7ºC (*temperature change required to reduce bacteria by a factor of 10*)

The formula for Pasteurization Units is as follows:

$$PU = \sum \left(L(T) \times \frac{\Delta time}{timeref} \right)$$

where…

$$L(T) = 10^{\frac{(T - Tempref)}{Z}} \quad \text{for } T \geq Tmin$$

$L(T) = 0$ for $T < Tmin$

Tmin = 50°C
T = current temperature in °C
Tempref = 60°C
Δtime = time between samples in minutes
timeref = 1 minute

The PU equation essentially says: Add up all the temperature samples (T) at or above 50°C (Tmin), they are logarithmically compared to a reference temperature (Tempref) and divided by a temperature change (Z), this drops the bacteria population by a factor of ten. The value in using Pasteurization Units is to compare similar slight variations between process runs. For example, if a process calls for the pasteurization of milk at 63°C for 30 minutes the PUs can be calculated for the process. When the real process is run which will see variations in temperature and time, the data can be easily analyzed in the MadgeTech software to compare your measured PU with the guideline.

Unfortunately, as with all models, Pasteurization Units has its limitations. A PU calculation is a figure-of-merit and must account for the desire to decimate not only bacteria but often enzymes (which have a different Z factor) as well. Thus, in the above paragraph where it is pointed out that comparing PUs for a similar process makes sense, it is not necessarily correct to compare the PU of a 63°C for 30-minute process to a 72°C for a 16 seconds process. However, one can reasonably claim that if your goal is to achieve 10PU that by raising the temperature by one Z factor (in this case raising the temperature by 7°C) for the same amount of time, your process will yield 100PU and you will destroy (theoretically)ten times the amount of bacteria as with the previous process.

The final caution on Pasteurization Units is this: It is only a theoretical calculation and to ascertain the actual amount of bacterial and enzyme destruction, samples of the matter must be tested both before and after to verify the process.

Medical/Pharmaceutical Application – Sterilization (F_o)

In the medical and pharmaceutical worlds, ridding medical devices of bacteria, viruses and spores is not mitigated by the need to preserve taste. The goal is to eliminate the bacteria, spores and anything else that can cause infection and illness.

One Sterilization Unit (F_o) is defined as one minute of heating at 121.111ºC. The quantity of F_o applied to medical/pharmaceutical products is dependent on the desired Thermal Destruction of the microorganism expressed in "log cycles". One log cycle is defined as the time and temperature required to kill 90% of the microorganisms and is given the designation "D". Additional "D" cycles would logarithmically kill more and more microorganisms. For example, original microorganisms would be reduced by 99% for a 2D cycle and 99.999% for a 5D cycle.

The formula to calculate F_o with MadgeTech dataloggers requires setting several variables:

Time base	1 minute
Sample interval time	Chosen by the user
Reference temperature	121.111°C (250°F)
Minimum temperature	100°C (*Below this temperature, no contribution is made to F_o*)
Z-value	10°C (*temperature change required to reduce bacteria by a factor of 10*)

$$F_0 = \sum \left(L(T) \times \frac{\Delta time}{timeref} \right)$$

where...

$$L(T) = 10^{\frac{(T - Tempref)}{Z}} \quad \text{for } T \geq Tmin$$

$$L(T) = 0 \quad \text{for } T < Tmin$$

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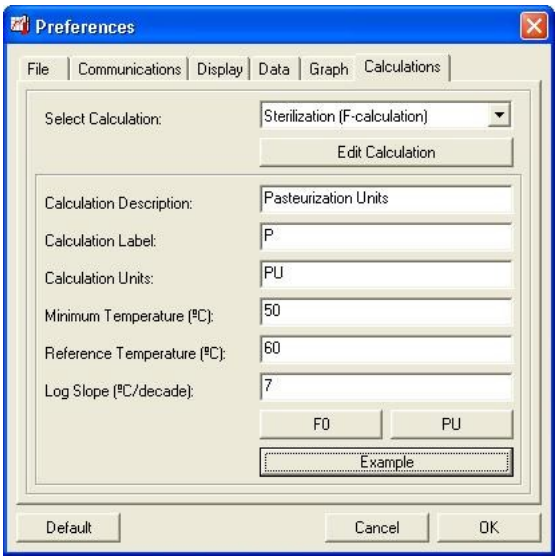
Practicum

Let's presume we need to quantify the PU of a given process. Begin with milk at room temperature and run it through a pasteurization process: two minutes exposed to 67°C (152.6°F) then cooled to room temperature. How many Pasteurization Units will the milk be subject to?

A Temp1000FP (probe temperature measuring device) was programmed to record data every two seconds. It was then exposed to a pasteurization process. At the end of the process, the data off-floaded and graphed is as follows:

The Pasteurization Units set-up: *(Menu select: View | Preferences)*



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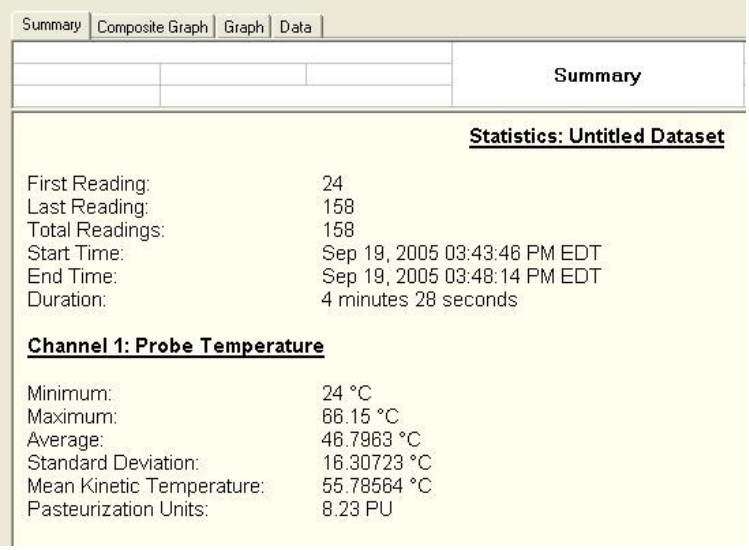
Here you can change the default parameters (such as minimum temperature, reference temperature, log slope) to match your process needs. The default values, however, are considered standard values in the industry.

Having verified proper settings, by clicking in the summary tab, you can now see the calculated PU in the summary window:



In this example, the process was exposed to 8.23PU. With these MadgeTech tools, you can build an understanding of the relationship between the process temperature and the amount of time exposed to the process without the headache of spreadsheets and formulas.

Note the summary data summarizes the data shown in the graph tab. If you zoom into a small section of data, the summary tab will reflect only the data, which falls between the beginning and end times shown on the graph. This is useful in learning the various phases of the process as they contribute to the calculated PU.

The MadgeTech temperature dataloggers combined with the powerful software means the PU and SU processes can now be measured, and the changes soundly quantified with ease.

MadgeTech products, which support the PU and SU calculations, are as follows:

- HiTemp150
- HiTemp140
- Temp1000
- Temp1000IS
- Temp1000S
- Temp1000P
- Temp1000FP
- MicroTemp
- TCTemp1000
- QuadTemp
- OctTemp
- TC101A
- RTDTemp101A
- ThermoVault
- QuadThermoVault
- QuadRTD
- OctRTD
- OT1000
- Therm.A.Lert
- Therm.A.Lert-P
- Therm.A.Lert-RH

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