Cold Sterilization
by Pulsed Electrical Fields (PEF)
in brief:

- works on an entire liquid (or mash) flow,
- **No wearing parts,**
- Keeps the product temperature almost unchanged,
- **No dependence on optical properties,**
- No side effects,
- **Cost-effective because uses the latest advances in pulsed power technology.**

PEF sterilizes by two major processes:

#1: by stretching bacteria to its disruption by a strong electrical field 10-40 kV/cm
and
#2: by impacts of electrons released during numerous tiny electrical breakdowns through bacteria or spores.

Its is possible with square wave pulses at pulse duration from 1 to about 50 µsec or longer and steep 100 ns fronts and tails of pulses, as SteriBeam offers.

Step-by-step PEF process #1:
- pulse shape: electrical fields from a few kV/cm to 40 kV/cm in a form of short (a few µsec) square pulses are applied to coaxial or parallel electrodes, confining a moving liquid (or mash) media.
- Electrical fields polarize and stretch bacteria cells up to a break-up of its membranes. (bacteria get from 3V to 5V across its length (ca. 1-3 µm), sufficient for this process). resulting rapture of cell walls releases a liquid content of cells by that making a bacterial no longer active.

Note: This PEF process #1 does not work on spores, since spore cannot be polarized and stretched. Spore is like a dried micro-egg.

Bi-Polar pulsing will enhance cells break-up:
Stretching bacteria in one direction can be immediately followed by its stretching in the opposite direction by a pulse with the same parameters but of the opposite polarity. In such a case a bacterial literally is "thorn" since its wall endures a much higher stress. It is about the same effect as one for wearing mechanical metal parts by alternating load.

This bi-polar pulsing is possible due to the latest advances in HV switching technology, which SteriBeam offers as an option.

PEF Mechanism for #2:
works by electron impacts by electrons released during micro-discharges over bacteria (or over spore) in a treated media. This condition is in fact a sort of "a cold plasma" (also known as a barrier discharge, etc) in a semi-conductive media with electrical field strong enough to cause numerous electrical streams of a very short durations (in nano-seconds). These streams do not form direct breakdowns between electrodes.

Energy consumption differs for these two PEF processes:

PEF #1 process inactivates simple bacteria in a liquid at about 1-2 cal/cm³ (4-8 J/cm³), or for 1 sec duration **4-8 w/cm³;**
PEF #2 process inactivates spores and viruses at up to 35 cal/cm³ (up to 150 J/cm³, or **up to 150 w/cm³**).

Such a high energy deposition for the #2 PEF process will heat up a treated liquid (or vegi –or fruit mash).
To off-set this heating, treated liquid has to be cooled (or pre-cooled) to prevent this temperature rise above whatever the target is (say above 25°C).

In both cases the process requires a direct contact of PEF electrodes with a treated media.

Limitations for PEF process:

PEF will not work on a fully conductive media, neither on a fully insulated media (like on a liquid enclosed in a plastic bag).

PEF sterilization functions at small currents flowing through a treated media.

PEF sterilization method is well known since decades as a cold sterilization of bacterial species at comparatively low consumable energy of a few w/kg for treated liquids. Yet up to recently it is mostly used for small scale processes. Reasons:

-. it depends on a treated media and
-. some electrode erosion in large systems.

Since PEF sterilization is media dependent, it requires a regulatory (FDA or EFSA) approval for each usage in production.

By contrast, well established sterilization methods with gamma or electron beams depend only on a size and on a density of treated media, which values are tabulated for a usage as "radiation dose" >>"size"x"density" and do not require approvals.

Advantages of PEF become more evident with growing restrictions for gamma, heat and other invasive sterilization techniques due to their side effects, costs and time for logistics. Also important, that gamma and major (like 10 MeV) e-beam systems are not applicable for a continuous in-line process flow.

Details on known applications you can find e.g. in the FDA Review on PEF basics and applications for preservation of foods:
http://www.fda.gov/Food/ScienceResearch/ResearchAreas/SafePracticesforFoodProcesses/ucm101662.htm

It is also on our database: FDA-Review-on-PEF ;

SteriBeam offers standard and customized PEF systems, described in our sections: sterilization Systems and Extraction systems.

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