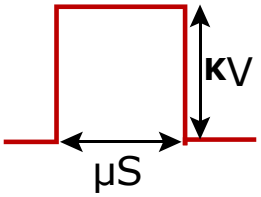
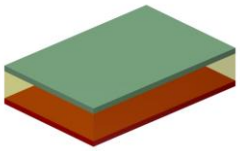
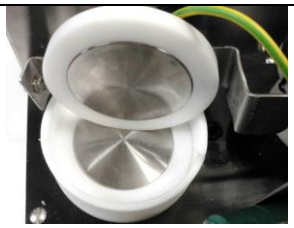
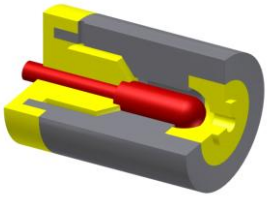
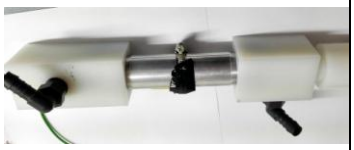
Sterilization
by Pulsed Electrical Fields (PEF):

Advantages:



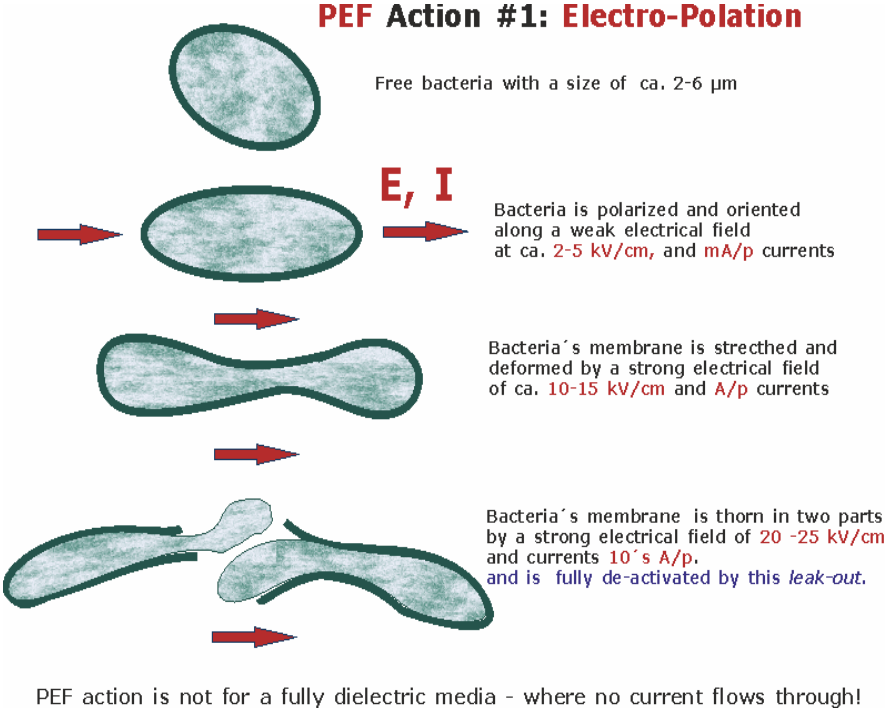
- works uniformly on an flowing liquid, cream-jell or grinded mash,
- *has no wearing parts*,*
- keeps the product temperature almost unchanged,
- *has no dependence on optical properties,*
- does not degrade nutrient properties of a treated media,
- *does not produce harmful or any by-products,*
- cost-effective because uses the latest advances in pulsed power technology,
- *can be integrated into production lines,*
- No labeling in contrast to "radiation and heat" sterilization.

PEF sterilizes *stretching* all bacteria to its disruption (electro-polation) in high electrical fields of 20 to 35 kV/cm applied between two evenly distances electrodes. A gap between electrodes is usually from 5 to 15 mm and pulsed voltage is 20 to 40kV:

			
parallel electrodes is for still samples	Parallel PEF cell used in Steribeam systems	Coaxial cells: for moving liquids/creams	Coaxial PEF cell used in Steribeam systems

All bacteria have a thin membrane ("a skin bag"), filled with a fluid substance, containing DNA and other live-materials, water and some minerals. This complex fluid (like a jell) is a bit conductive which allows to polarize it along an applied electrical filed. It is sufficient a few (3- 5 V) volts across bacteria to polarize it. When it is polarized, it orients itself along the applied electrical field.

With a bacteria size of a few micron, $(1\text{-}5)x10^{-4}$ cm, a few volts across it translates to the strength of an electrical field of 5-15kV/cm. Stronger electrical fields (20-40 kV/cm) stretch bacteria cells so much that its membrane breaks-up. The rapture of membrane releases a liquid content out into a treated media making bacteria no longer active.



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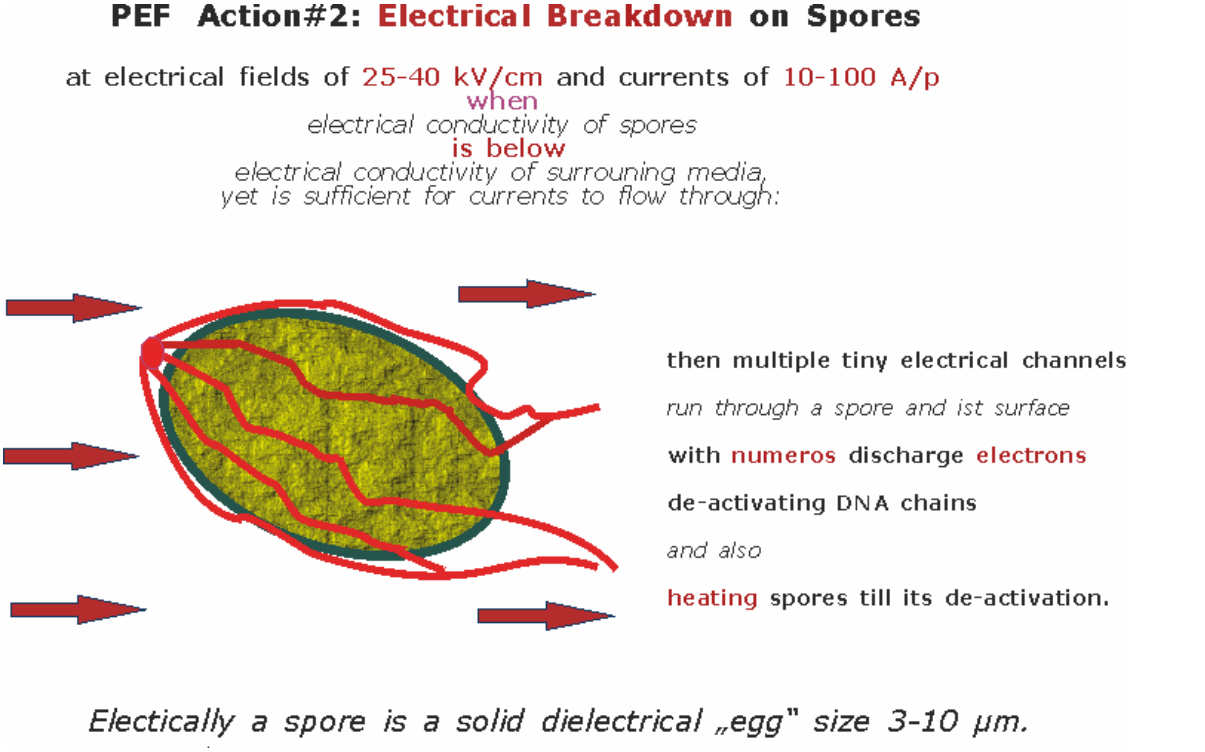
PEF sterilization by impacts of freed electrons

released during micro-discharges over bacteria (or over a spore) in a treated media. This condition is a sort of "a cold plasma" (also known as a barrier discharge) in a poor-conductive media with an electrical field strong enough to cause numerous electrical streams of a very short durations (in a fractions of μsec). These el streams do not create direct breakdowns between electrodes.

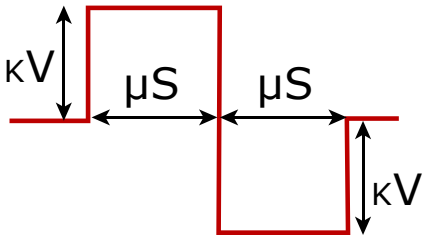


This mechanism is not so well studied as the first one, yet it is the only one to explain why PEF method works on spores and fungi in a treated media.

It also deactivates bacteria by electron impacts of the same origin, yet its effect on bacteria evidently much weaker than the electro-polation.

Bi-Polar pulsing enhances a break-up of a membrane:

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. This causes an additional mechanical stress - a wearing by an alternating load known e.g. for metal parts in equipments. As a result a bacterial membrane is torn apart with a lesser strength of electrical fields and with lesser pulses then with one-polar square fields. This it is a far more effective PEF method.



This bi-polar pulsing is possible to arrange due to the latest advance in the HV switching technology, which SteriBeam incorporates into its systems as an option. See our PEF brochure in the section "Sterilization systems" for technical details.

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Energy consumption for these two PEF processes in a treated liquid
for 1 sec pulsing and 2 to 3 logs reduction in micro-organisms concentration:

PEF #1: 1-4 cal/cm³ (4-16 w/cm³),
PEF #2: up to 35 cal/cm³ (up to 150 w/cm³).

A much higher energy deposition for the #2 PEF process causes a treated liquid to heat up to possibly 40 to 80°C. To off-set this heating, a treated liquid has to be cooled.

Conditions for PEF process:

- a direct contact of PEF electrodes with a treated media,
- *applied el pulses have to have sharp fronts of about 50-200 ns and to have a rectangular square shape,*
- pulse durations have to be from 2 to 40 μsec, depending on a treated media and sterilization goals,
- *a treated media has to have a small electrical conductivity which allows small el. currents flowing through a treated media during pulsing. No conductivity makes it act as a capacitor, whereas a very good el. conductivity results in heating of a media,*
- a shape of electrodes is also important,
- *electrode materials must assure minimal losses due to its erosion.*

The PEF sterilization method is well known since quite a few decades
yet up to recently it is mostly used for small scale processes because:

- it depends on a treated media,
- *some electrode erosion in large systems,*
- former high costs of HV sub-systems and components for required square pulses.

Note: sin-wave electrical fields used in original PEF works decades ago, because it was only equipment available that time, mostly heated treated media, and greatly reduced effects of the electro-polation.

Unless the application is known, any other product has to be evaluated on its applicability to PEF treatment. This is done with evaluation tests by finding an optimal pulsed voltage, a gap between electrodes, a fluid throughout (l/h), a pulse duration and the Pulse Forming Network (PFN).

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

Advantages of the PEF sterilization become now more evident with growing restrictions for gamma, heat and other invasive sterilization techniques.

Currently widely used "radiation and heat" methods have the following negative side effects:

For gamma rays and electron beams:

- Creating harmful by-products (dioxins, 1,2-Dichloroethane, benzenes, etc),
- Degrading a quality of nutrients of a treated media, up to 70 % of it,
- since it is not suitable for a continuous in-line process flow, it requires costly long logistics and processing in "bunkers", taking altogether up to 2 weeks,
- degrades a plastic packaging (it becomes bristle) so then often cannot be used more than 3 times as much,
- bleaching of packaging and food staffs,

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- packaging degrades and its harmful by-products contaminate packed food staffs,
- a necessity to put warning labels, that it was "radiation treated", which sways customers away,
- costly in comparison with PEF treatment.

For heat in autoclaves including usage of chemicals:

- Degrading a quality of nutrients of a treated media, up to 70 % of it,
- since it is not suitable for a continuous in-line process flow, it can be batch processed at the production facility, taking up to 6 -12 h, and then ventilating treated products for another 24 h to get rid of used vapor chemicals,
- degrades a plastic packaging and its harmful by-products contaminate packed food staffs,
- a necessity to put warning labels, that it was "heat and chemically treated",
- costly as well in comparison with PEF treatment.

Therefore sited on the front page of this brochure PEF Advantages come in a striking positive contrast with above methods.

Details on known applications you can find e.g. in the FDA-Review-on-PEF copied from the FDA website (dated 2009) to our database.

SteriBeam offers standard and customized PEF systems, described in our Section: "Sterilization Systems".

We work with advanced HV vendors of HV power supplies and HV switchers, who help us to locate the most appropriate their products for our customized PEF systems.

We are looking forward to your selection of our PEF systems, which can be customized to your application.

Gotlieb-Fecht 32
D-77694 Kehl-Kork am Rhein
Tel. Prod. Lab: +49 7851/ 99 47 68 - 13
Secretary Nadine: - 14,
Office #2 direct : 07851 899 330
www.steribeam.com info@steribeam.com