

Decontamination by Hydrogen Peroxide: Use and Technical developments

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This article compares the concepts of sterilization, disinfection and decontamination with reference to the different scopes thereof. Decontamination by hydrogen peroxide vapor and its use for conditioning the Sterility Test Isolators are discussed. A technologically new method for the vaporization of the hydrogen peroxide and its dosage control is presented.

Sterilization, disinfection, and decontamination: a terminological review

For a long time, the word **sterilization** has been used to indicate those processes, in food and pharma-industry or in hospital care, targeting the complete inactivation of viable microbial species on the surface and/or in the bulk of an object, including bacterial spores. According to a widely accepted definition, an object is *sterile* when completely free of contamination due to viable organisms. Therefore, sterility could be seen as an absolute concept: an object is sterile, or it is non-sterile. However, if we move from the rather abstract field of definitions to every day practice, things grow more complex: how can we *objectively* state that an object is sterile?

A common feature of all the known methods for testing sterility condition is the destruction of the sterility, if any, of the object being tested, thus making it no longer usable for its intended scope: in other words, no sterility test methods are known for a given object, that completely respect the integrity of it, without affecting its properties and damaging, more or less, the condition, if any, of sterility. In the case of packaged sterile products, it is even possible to say that *no non-destructive sterility tests exist*. This paradox can be expressed by saying that *sterilization is a special process, where the results of processes (efficacy of sterilization) cannot be verified by subsequent inspection and testing of the product (the items sterilized) (Publmed, US National Library of Medicine, PMID: 10402868)*.

Therefore, a statistical verification of a successful sterilization is the sole economically sustainable alternative which implies the necessity of attaining a very high probability that a batch of the sterilized product does not contain non-sterile items. For these reasons, the industrial sterilization is defined as *'a process used to render a product free of viable organisms with a specified probability'* (PDA, TR#1 revised 2007).

Disinfection

Let's now say something about **disinfection**: the meaning of this word is not unequivocal. In most cases, it describes a process that eliminates the pathogenic microorganisms from lifeless objects, except for bacterial spores, down to a specified level of assurance. But down to which level? Pragmatically, FDA defines *high level-disinfection* a six Log reduction of an appropriate species of *Mycobacterium* within a *shorter* contact time. The *Guideline for Disinfection and Sterilization in Healthcare Facilities* states that, following a disinfection treatment, items and equipment for patient care non entering sterile tissues or the vascular system, but contacting mucous membranes or nonintact skin *'should be free from all microorganisms; however, small numbers of bacterial spores are permissible'*. This criterion underlines the difference between items to be sterilized prior to enter the human body (*'critical items'*), and those demanding only disinfection (*'semicritical items'*); this distinction is essentially

related to clinical practice and is referred to the different capability of different parts of the human body, external and internal, to withstand the presence of small numbers of bacterial spores. All the above does not contrast with the definition of the European Standard EN-ISO 15883, relevant to *washer-disinfectors*. According to this Standard, disinfection is the '*reduction of the number of viable microorganisms on a product to a level previously specified as appropriate for its intended further handling or use*'. Disinfection is a '*special process*' just as sterilization, so it has to be validated, as well. Both sterilization and disinfection may be obtained either by thermal or chemical processes or even in different ways (filtration, irradiation, etc.). Pharmacopoeias recommend as best choice, whenever possible, the moist heat treatment, that inactivates viable microorganism and bacterial spores by *contact with condensing steam and/or superheated water for a specified exposure time and under strictly controlled conditions*. The enormous variety of products to be sterilized, and packaging thereof, has given rise to a parallel development of very differentiated, sophisticated and flexible sterilization autoclaves (see Figure 1).

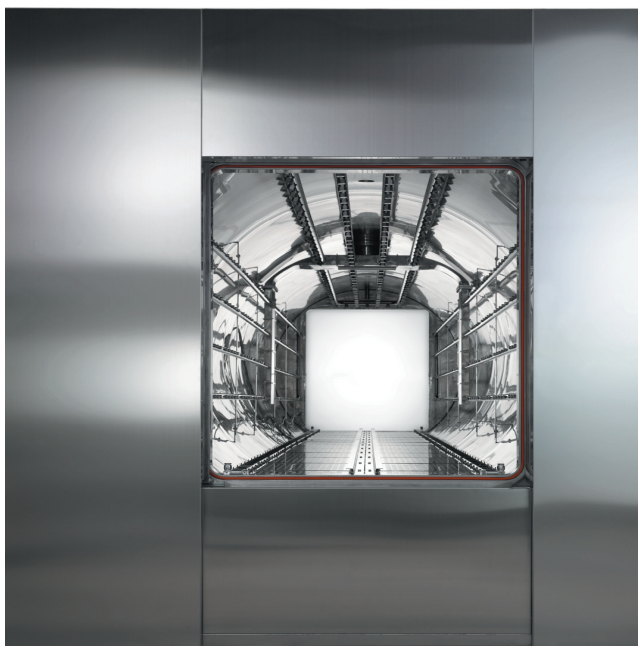


Fig. 1 – Internal view of a *sterilization autoclave*

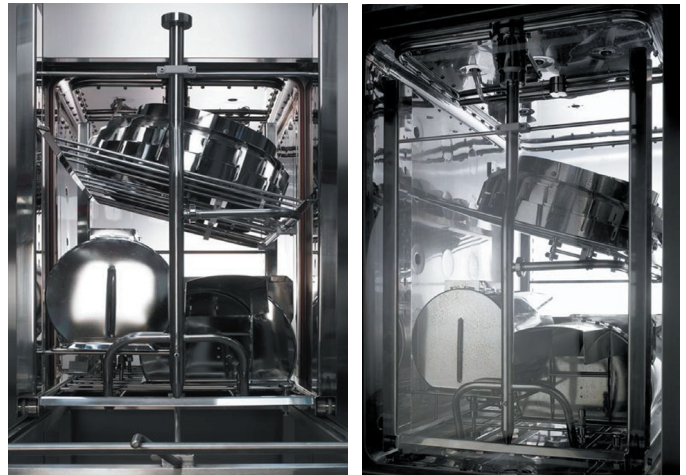


Fig. 2 – Internal view of a *washer-disinfector* (including sterilizing function)

Washer-disinfectors may be designed following two different approaches: the disinfection function may be integrated in a washing apparatus, or the washing function in a sterilizer. As the materials to be washed and disinfected are usually well specified, the sterilizer is, in general, of a rather simple type (see Figure 2).

The design choice of Fedegari Group for washer-disinfectors is the second one; this preserves all the flexibility of a traditional steam sterilizer also from the point of view of the reduction level of microorganisms. The intimate contact between steam and items required by the moist heat sterilization/disinfection has also proven to be very useful for the washing function. Finally, according to the definition by Columbia University, decontamination is '*any activity that reduces the microbial load to prevent inadvertent contamination or infection. The appropriateness of a decontamination procedure is situation dependent. For example, surgical instruments must be sterile but this level of microbial killing is unnecessary for Environmental surfaces such as floors and walls*'. The word decontamination may thus be referred both to sterilization and washing and disinfection.

Decontamination treatment by chemical agent: an example

A typical application of decontamination by chemical agent are the *Sterility Test Isolators*, i.e. the *Isolators for Aseptic Processing/Sterility Testing*.

According to the 2007 PIC (Pharmaceutical Inspection Convention) definition, ‘an isolator is an arrangement of physical barriers that the isolator can be sealed in order to carry out a routine leak test based on pressure to meet specified limits. Internally it provides a workspace, which is separated from the surrounding environment. Manipulations can be carried out within the space from the outside without compromising its integrity’. Rather obviously, leak test is not a scope, but the method to ascertain that the working space is tightly separated from the environment. ‘Industrial isolators for aseptic processing are isolators in which the internal space and the exposed surfaces are microbiologically controlled’. One of the methods to obtain this microbiological control is the so-called *sporicidal process*, i.e. a ‘gaseous, vapor or liquid treatment applied to surfaces, using an agent that is recognized as capable of killing bacterial and fungal spores. This process is normally validated using biological indicators containing bacterial spores. The number of spore log reductions is not specified in this definition, but a target of six log reductions is often applied’. In other words, a *Sterility Test Isolator* (see Figure 3) is a leak-proof space in which an operator may manipulate object inserting her or his hands in the so called ‘gloves’: neither the hands, nor the environment come in contact with the items being manipulated. Treating the internal space of an isolator aims to prevent the bacterial contamination of the samples under test. Among the most reliable sporicidal agents, vaporized hydrogen peroxide (H_2O_2) is nowadays one of the most popular: its antibacterial, antimycotic and antiviral properties are well known and scientifically documented. The effectiveness of the treatment depends both on the overall concentration and the even distribution of the hydrogen peroxide inside the isolator. In order to vaporize the hydrogen peroxide before dispersing it into the working space of the isolator, a controlled amount of liquid peroxide is sprayed onto a heated plate above which an air stream is flowing. In the isolators manufactured by Fedegari Group, one or more circulation fans are installed in the ceiling of in the working space to obtain an even distribution of the sterilant and sporicidal agent.



Fig. 3– General view of a Sterility Test Isolator

Technological improvements

In the traditional isolators, the vapor concentration is controlled by the so called “recipe”. This means that a prefixed total amount of liquid hydrogen peroxide is sprayed onto the vaporizing plate: this method implies an indirect concentration control, but *during* the decontamination treatment itself (i. e. during the exposure period) no control is possible. Fedegari Group have designed and developed a completely new method, based on their half-century experience in sterilization control. This method is based on the continuous measuring of the hydrogen peroxide concentration inside the working space during all the phases of the treatment. The difference between actual and set concentration is continuously measured and determines the flow rate of the liquid hydrogen peroxide released onto the evaporation plate. This control is performed both during the make-up and the exposure period, in order to avoid the small progressive concentration decay of the sterilant and sporicidal agent by consumption. Therefore, this method provides real time feedback control of the hydrogen peroxide concentration during the process and grants for the steadiness of it during the critical phase of the treatment.