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Technical Support Package

Sterilizing Surfaces by Irradiation With Microwaves

NASA Tech Briefs
MSC-22484



National Aeronautics and
Space Administration

Technical Support Package

for

STERILIZING SURFACES BY IRRADIATION WITH MICROWAVES

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for sufficient exposure of all desired surfaces. The innovative means of surface sterilization using microwave irradiation stems directly from the initial stage of the MSAP development effort.

Section II. Technically Complete and Easily Understandable Description of the New Technology that was Developed to Solve the Problem or Meet the Objective.

Microwave irradiation equipment and methods have been developed for the sterilization of surfaces within closed systems which are contaminated with a variety of viable bacteria, yeasts and molds. Surfaces to be sterilized are bombarded with 2.45 GHz microwaves in the presence of traces of water (approximately $9 \mu\text{L}\cdot\text{cm}^{-2}$ of surface). Total microwave exposure of 13.1 W-hr at an exposure rate of $3.6 \text{ W}\cdot\text{cm}^{-2}$ of surface area has been proven effective at surface sterilization. The microwave surface sterilization system consists of a power supply, microwave source, waveguide or other conduit for conducting the electromagnetic energy to the contaminated surfaces, one or more antennas, and a trace water introduction system. One of a variety of viable configurations of the microwave irradiation system is schematically illustrated in Figure 1.

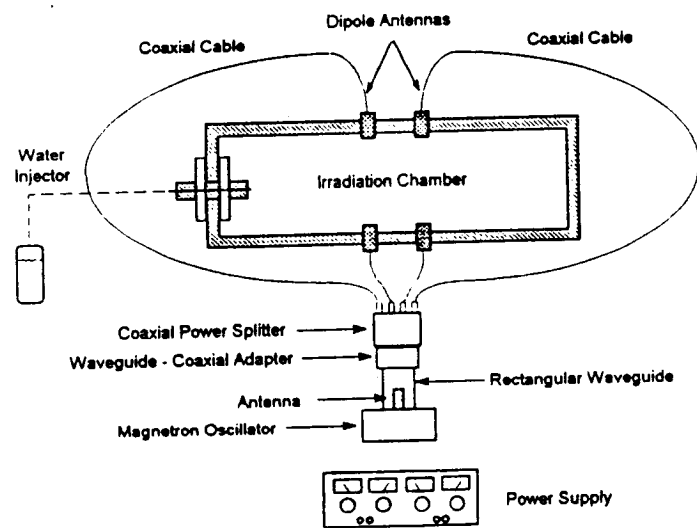


Figure 1. Microwave Sterilization System.

Experimental results indicate that all challenge microorganisms can be destroyed by microwave irradiation of damp surfaces or in the presence of microwave induced steam. Results indicate that the efficiency of the microbial kill is dependent upon duration and intensity of the microwave exposure, the amount of water present, and the kind and number of microorganisms. Microbial kill curves for a mixed surface population of *Bacillus pumilus*, *Escherichia coli*, and *Pseudomonas cepacia*, at an exposure rate of 3.6 W-cm⁻² are shown in Figure 2.

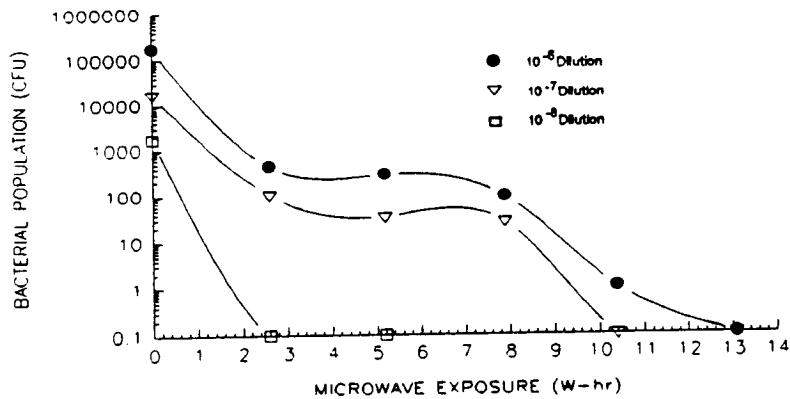


Figure 2. Mixed Contaminants - Microwave Exposure versus Population.

Section III. Unique or Novel Features of the Technology and Results (or Benefits) of its Application.

Current technology for the sterilization or disinfection of surfaces involves autoclaving, irradiation with ultraviolet light (UV) or gamma rays, and the use of chemical disinfectants such as ethylene oxide, alcohols, quaternary amines, hydrogen peroxide, or elemental iodine.

The use of microwave energy for the sterilization of surfaces is an entirely unique application of this region of the electromagnetic spectrum. Using suitable frequencies of microwaves, such as 2.45 GHz, which directly couple with the rotational transitions of dipolar water molecules, sterilization of surfaces can be achieved in the

presence of small quantities of water with minimal thermal impact to the surface. Thus the innovation is particularly attractive for use with thermally labile systems. Microwave irradiation of dry surfaces has proven capable of killing all but the most resistant of microorganisms. Active vegetative microbial cells contain water. Microwaves of sufficient intensity and duration penetrate the microbial cell wall, couple with the intrinsic water and kill the organism. Spores are relatively resistant to dry microwave irradiation, due to the absence of free water for the microwaves to couple with. These relatively resistant organisms can be effectively destroyed by enhancement of the microwave sterilization process through the introduction of small quantities of water, on the order of $9 \mu\text{L}\cdot\text{cm}^{-2}$ of contaminated surface. By direct microwave absorption, the water then flashes to steam, contacting all exposed surfaces, and producing the desired microbial kill. This effect is localized, and due to the small amount of water, little energy is added to the system. Using this novel technique, microwaves have been proven effective for the sterilization of surfaces contaminated with a variety of viable bacteria, yeast and mold. Initial surface populations of 2×10^5 Colony Forming Units (CFU) have been reduced to 0 after a 13.1 W-hr microwave exposure to 2.45 GHz at a rate of $3.6 \text{ W}\cdot\text{cm}^{-2}$. Using this method microwave radiation has been shown to sterilize surfaces after first penetrating elastomeric materials, and therefore can be used to sterilize fully enclosed systems.