

US EPA ARCHIVE DOCUMENT

5.0 NONIONIZING RADIATION TREATMENT

5.1 GENERAL DESCRIPTION OF TECHNOLOGY

Nonionizing irradiation of medical waste to thermally inactivate microorganisms is an adaptation of an existing technology for a new function. The irradiation may be microwave frequencies or shortwave radiofrequencies.

Two types of microwave treatment systems may be used to treat medical waste. Waste in small clinical or research laboratories may be treated onsite in small, unsophisticated, benchtop microwave ovens. Large hospitals or commercial waste treatment facilities may purchase large special purpose units that shred the waste and then irradiate it with microwaves.

Radiofrequency irradiation is also an adaptation of an existing technology to the treatment of medical waste. Shredded medical waste in insulated containers is exposed to high frequency, short radio waves to heat the waste to the desired temperature. The heated waste is then stored in insulated containers for a specified time after which it may be disposed in a landfill if permitted by local authorities, used for refuse derived fuel, or the plastic portion may be recycled.

There is no evidence at the present time that any intrinsic property of nonionizing irradiation other than thermal heating effect is responsible for microbiological inactivation.

5.1.1 Operational Parameters

5.1.1.1 Frequency/Duration/Direction of Propagation

The factors which affect nonionizing irradiation treatment of medical waste include frequency and wavelength of the irradiation, the duration of the exposure, composition and moisture content of the waste material, and the process temperature of the waste achieved and maintained during treatment.

5.1.1.2 Waste Characteristics/Destruction/Moisture

Refer to Section 1.1 of this document for a general discussion on the description of medical waste and the specific classes that are suitable for each specific medical waste treatment technology.

Microwave treatment units can treat most infectious waste generated at the hospital with the exception of radioactive waste, chemotherapy wastes, human organs or body parts and mixed medical and hazardous wastes.

Ground, shredded, or otherwise destroyed metal items (e.g. hypodermic needles, scalpel blades) are suitable for treatment in microwave treatment systems with the exception of bulk metal materials (metal hip replacements, etc.).

It is advisable that the waste have a significant moisture content to insure effective treatment.

5.1.1.3 Residuals

Nonionizing radiation treatment processes have only solid treated waste residuals. These wastes may be disposed of with municipal wastes where this is permitted. Recycling of portions of treated waste is a possibility for nonionizing radiation treatment residuals, however the waste must be properly segregated into individual materials prior to the treatment process if recycling is to be considered as a viable option. Glass, metal, and properly segregated nonchlorinated plastics may be recycled.

5.1.2 Standard Operating Conditions

5.1.2.1 Microwave Systems

The large microwave units are designed to treat waste at a rate approaching 220 pounds per hour. The waste is placed in a hopper and may be fed by batch mode or continuous mode into a grinding chamber. The grinding process serves a multiple purpose of reducing the volume of waste by approximately 80 percent, rendering the waste unrecognizable, and making the waste more homogeneous. The ground waste is sprayed with steam to increase its moisture content and intensify the heating process.

5.1.2.2 Shortwave Radiofrequency Systems

The shredded waste is compacted into large insulated polyethylene treatment containers. The containers are moved by conveyor out of the processing room and into the dielectric heating area. Low frequency radio waves (11 to 13 MHz) carry the electric energy which are absorbed by the waste materials, heating them uniformly to at least 90 °C as the containers move slowly through the heating area. When the treatment process is complete, the containers are stored for a prescribed period after which the waste material may be disposed of in a sanitary landfill where permitted, recycled as refuse derived fuel, or the plastic portion may be recycled. Because of the size of the equipment, RF treatment currently is limited to commercial waste treatment.

5.2 OPERATION EVALUATION

5.2.1 Test Organism Selection

Non-ionizing radiation as presently utilized cannot achieve Level IV microbial

inactivation. It has, however, the ability to achieve Level III inactivation. Thus, the appropriate indicator organism is *B. subtilis*. Additionally, *B. subtilis* has a thermal death profile very similar to the pathogenic *Clostridium* species which are resistant to thermal inactivation.

5.2.2 Test Organism Procurement

B. subtilis (globigii) ATCC 9372 is the indicator organism of choice. Commercial suspensions may be used to prepare discs or strips containing viable, dried spores. Prepared spore strips of *B. subtilis* (10^4 - 10^8) are available commercially.

5.2.3 Test Organism Quality Control

Commercially prepared spore strips and spore suspensions should be stored according to manufacturers' directions and used before their expiration dates.

5.2.4 Test Challenge Preparation and Loading

A test challenge containing individual *B. subtilis* spore strips of 10^4 or greater should be used. Each challenge of test organisms should be placed in a retrievable, heat and moisture permeable (such as fabric) pouch. The use of spore suspensions in sealed vials is not acceptable, as the treatment will create artificial conditions of temperature and pressure that will not accurately reflect actual waste treatment conditions.

The test pouches should not be ground up with the waste stream. The test pouches should be placed in with the shredded waste and treated in the nonionizing radiation system under normal operating conditions.

5.2.5 Test Load Exposure

5.2.5.1 Microwave System

The test pouches are moved with the moist ground waste by means of a screw conveyor through the microwave treatment chamber over a two hour treatment period. The internal temperature of the treated waste should be maintained at ≥ 90 °C throughout the cycle in order to ensure proper treatment.

The test pouches may be recovered from the treated waste upon discharge. In the laboratory the spore strips are removed and any viable microorganisms are recovered by the method described below.

5.2.5.2 RF Treatment

The test pouches are included in the waste containers before the waste is heated in the RF treatment system. The containers of waste are treated with the RF irradiation and then allowed to stand for a period of time after which the test pouches are removed from the waste and any viable microorganisms are recovered according to the method described below.

5.2.6 Organism Recovery

Recovery of test organisms requires aseptic inoculation of test discs or strips into 5.0 mL soybean-casein digest broth medium (or equivalent) followed by incubation for at least 72 hours. Additional samples are processed as viability, media, and incubation controls. All *B. subtilis* samples are incubated at 32 °C.

At the end of the required incubation time, media that were inoculated with the test organisms are examined for turbidity as an indicator of growth. If growth is noted, it is a preliminary indication that some indicator spores survived the treatment process. To confirm the identity of the organisms present in the media demonstrating growth, all positive test cultures including control cultures are subcultured onto soybean-casein digest agar plates (or equivalent) and incubated at the appropriate temperature (32 °C) for at least 24 hours. The colonies are then identified to determine if the growth is the indicator organism. Level III microbial inactivation is indicated by the inactivation of a minimum of 10^4 *B. subtilis* spores.

5.2.7 Treatment Validation and Routine Testing

To validate the treatment process, duplicate trials should be tested on each of three different days, with no surviving *B. subtilis* spores. If results show surviving spores, then the treatment process parameters (frequency, exposure time, water content, waste temperature) should be checked and/or modified and the validation testing repeated until results are satisfactory. Once the appropriate operating parameters are established that insure adequate waste treatment, at least one cycle of the process should be monitored routinely on a bi-weekly basis unless the operational parameters are changed or major repairs of the equipment are performed. The microwave and radiofrequency systems have visual readouts of the treatment process. The radiofrequency system also monitors the temperature in the waste load. These can be used to monitor the daily waste processing for upset conditions.

5.2.8 Quality Control Procedures

Quality control procedures presented in Section 1.3.7 should be followed.