Personal Protective Equipment

White Paper: To Reuse or Not to Reuse–A Life Cycle Assessment of Reusable Garment Properties

Brought To You by DuPont | Mar 01, 2022

Introduction

Humans can be a source of contamination in cleanrooms and controlled environments; thus, cleanroom workers in aseptic environments are typically garbed head-to-toe in either sterile single-use or sterile reusable garments.

The process of wearing, laundering and sterilizing reusable garments can impact their physical properties and change garment functionality. Laundering and wear abrade garment fibers. Simultaneously, changes to the polymers that make up the garments can occur at the molecular level. Although routine visual inspection is often part of garment quality evaluation programs, nonvisible properties also change with time.

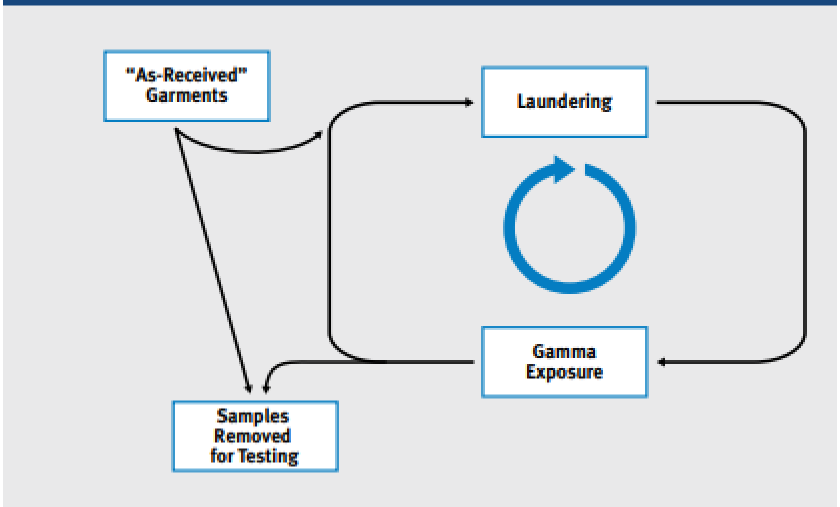
When selecting reusable garments for use in cleanroom environments, it is important to understand how they will perform over their intended life cycle. Consideration of these properties should be part of the decision process for when to take reusable garments out of service.

Physical property data are often available for new cleanroom garments; however, there are less data available throughout the entire garment life cycle. To aid in garment choice, DuPont conducted a study of the physical properties of reusable cleanroom garments after a set number of laundering and gamma radiation exposure (sterilization) cycles. The results are outlined here.

Methodology

Two sets of commercially branded, reusable coveralls were purchased for testing and designated as Garment A and Garment B. Garments were made of woven polyester with integral carbon fiber for electrostatic decay properties. Garments were laundered and subsequently exposed to gamma radiation; this was considered one cycle. This process was repeated for 30 cycles. Garments were removed for testing after pre-determined numbers of cycles *(Figure 1)*.

Figure 1. Garment Study Process Flow Diagram



Laundering and gamma exposure were conducted through 30 cycles.

Not all properties were tested at the same frequency. Initial properties of the garments were either measured on "as-received" garments or garments that had been laundered one time, but not exposed to gamma radiation. Parameters for garment laundering and gamma exposure were consistent throughout the study.

Garments were not worn or exposed to simulated work scenarios between cycles. The effect of routine garment "wear and tear" was not part of this study.

A summary of the garment testing methods is shown in *Table I*. Testing was done at third-party laboratories. Results for property testing are shown with the average and the Bonferroni confidence interval on the mean. Changes in both absolute performance and variability within the garment population may factor into formulation of end-of-life criteria.

Certificates of processing (COP) for each gamma radiation exposure were received. Dose range per cycle was target minimum of 25 kGy and target maximum of 40 kGy. Received dose was calculated by summing the minimum received and maximum received doses per cycle, as indicated on the COPs. Mid-dose was calculated by averaging minimum and maximum dose per cycle *(Figure 2)*.

Table I. Test Method Summary

Test	Test Method[6]
Particle Shedding via Helmke Drum	IEST RP-CC003.4
Particle Dispersion (Body Box)	IEST RP-CC003.4
Frazier Air Permeability	ASTM D737
Hydrostatic Head	AATCC TM127
Trapezoidal Tear Strength	ASTM D5587

Results and Discussion

Properties related to protection, durability and comfort are shown below to indicate trends in garment and fabric performance after laundering and exposure to gamma radiation.

Figure 2. Cumulative Gamma Radiation Dose by Cycle (kGy)

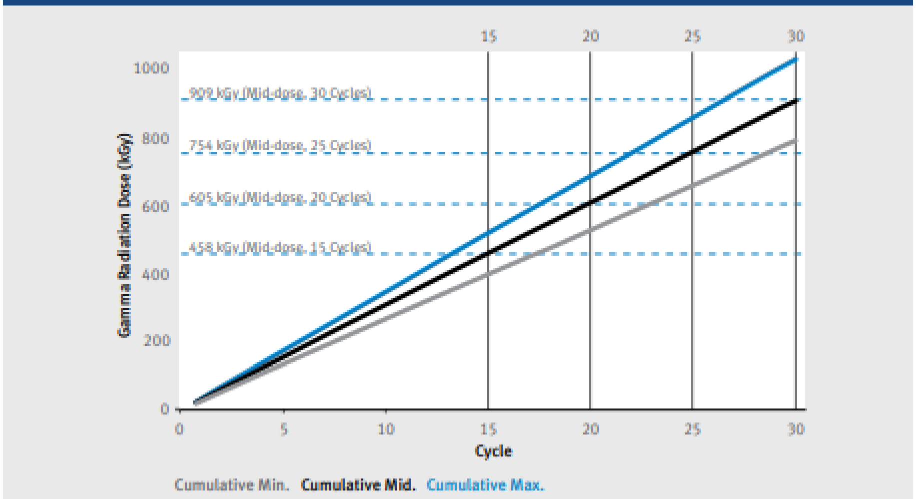


Chart of cumulative minimum, maximum and mid radiation dose as a function of exposure cycle. Mid-dose was calculated by averaging minimum and maximum dose.

Radiation Dose and Polymer Molecular Weight

The impact of gamma radiation exposure on a variety of polymers is well studied. Although multiple reaction mechanisms can occur simultaneously, there is typically a predominating reaction type. The extent and type of each reaction depend on many factors and combinations of factors, including:

- polymer composition (different polymers behave differently)
- presence or absence of air during irradiation
- crystallinity of the polymer and changes in crystallinity
- physical configuration (e.g., fiber, film or tubing)
- additional processing (e.g., laundering, calendering or surface treatment)
- presence of antioxidants or other additives in the polymers
- cumulative radiation dose

*To continue reading this white paper in its entirety and learn about the recommended guidelines for reusable garments in cleanroom applications, download a **PDF**.*

Previously Featured on Critical Environment Solutions Ltd.

