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EVALUATING THE PERFORMANCE OF REUSABLE LEVEL 2 ISOLATION GOWNS

Susan I. Dabbain
University of Kentucky, suzie_dabbain@ymail.com
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Susan I. Dabbain, Student

Dr. Elizabeth Easter, Major Professor

Dr. Scarlett Wesley, Director of Graduate Studies

EVALUATING THE PERFORMANCE OF REUSABLE LEVEL 2 ISOLATION GOWNS

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in
Retailing and Tourism Management
in the College of Agriculture, Food, and Environment
at the University of Kentucky

By

Susan Ishaq Dabbain

Lexington, Kentucky

Director: Dr. Elizabeth Easter

Professor of Merchandising, Apparel, and Textiles

Lexington, Kentucky

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ABSTRACT OF THESIS

EVALUATING THE PERFORMANCE OF REUSABLE LEVEL 2 ISOLATION GOWNS

The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2. The performance of the gowns was evaluated to determine if they met the required specifications of the AAMI and ASTM standards. Seventy-two commercially available Level 2 reusable gowns from six sample groups were evaluated. The results of testing the barrier and durability performance were compared to the specification of ANSI/AAMI PB70:2012 and ASTM F3352 – 19. Gowns were evaluated initially, and after 5, 10, 25, 50, and 75 laundering cycles. All evaluations were completed in a Textile Testing Laboratory according to AATCC and ASTM standard test methods. Five out of six sample groups met specifications for ANSI/AAMI PB70:2012 over their lifecycle, whereas one out of six groups met specifications for ASTM F3352 – 19. In conclusion, commercially available reusable Level 2 isolation gowns are protecting at an AAMI Level 2; however, specifications could be improved.

KEYWORDS: PPE, Reusable, Isolation Gowns, Performance Evaluation, Laundering

Susan Ishaq Dabbain

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By

Susan Ishaq Dabbain

Dr. Elizabeth Easter

Director of Thesis

Dr. Scarlett Wesley

Director of Graduate Studies

August 30, 2021

Date

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Chapter One

Due to the coronavirus that caused the COVID-19 pandemic, shortages of personal protective equipment (PPE) across the world have negatively impacted the health and safety of healthcare workers (HCWs). PPE is an "item of clothing that is specifically designed and constructed for the purpose of isolating all or part of the body from a potential hazard or isolating the external environment from contamination by the wearer of the clothing" (AAMI, 2012, p. 3). Which includes, but is not limited to, gloves, face masks and shields, goggles, head and feet protective materials, and gowns. PPE plays an essential role in preventing blood, bodily fluids, and other potentially infectious materials (OPIM) from being transferred to HCWs during patient care (CDC, 2004).

Problem Statement

As the global demand for PPE rose at the start of the pandemic, HCW's supplies of proper equipment were spread thin. The supply of PPE in the United States (U.S.) was severely limited at the start of this research in 2020. With the shortages faced by HCWs, the Centers for Disease Control and Prevention (CDC) provided a series of strategies to optimize PPE use in healthcare settings when supplies are limited. One of these strategies is to identify surge capacity, referring "to the ability to manage a sudden increase in patient volume that would severely challenge or exceed the present capacity of a facility" (CDC, 2020, "Optimizing Supply of PPE," para. 3). With three capacity options: conventional, contingency, and crisis capacity, HCWs can prioritize where their PPE is used. In March of 2020, healthcare facilities in the U.S. reached crisis capacity, taking various avenues to reprocess and re-sterilize their disposable PPE to extend the PPE's life. Unfortunately, reprocessing disposable PPE is almost always not an option. The purpose of disposable PPE is only to be used once and then discarded. Some facilities took CDC recommendations to shift from disposable PPE to reusable, another attempt at extending the life of their PPE during this surge influx of patients (CDC, 2020). However, supplies of any variation of PPE were out of reach for many.

According to Mehrotra, Malani, and Yadav., "…more than 70% of respiratory protection supplies used in the US are manufactured in China" (2020, "Personal Protective Equipment," para. 3). With a heavy reliance on China's medical gear exports and China also dealing with the pandemic during this time, it was expected to see a decline in medical exports (Mehrotra *et al*., 2020). This situation equally put pressure and opportunities on suppliers and distributors in the U.S. to bridge the gap from relying on exports from other countries to producing and supplying in the same country. Hospitals took the initiative to purchase supplies; however, with an inability to examine the quality of unvetted suppliers and new asking prices for PPE, distributors were slow to supply the demand. Hospitals were taking risks where HCW's expect safety (Mehrotra *et al*., 2020). The PPE supply chain is "not designed with the primary objective of protecting health care professionals. Rather, it is designed to fulfill demand while focusing on efficiency and price" (Mehrotra *et al*., 2020, "Personal Protective Equipment," para. 6). Other sourcing initiatives, such as GetUsPPE.org or ProjectN95.com, where health care professionals, infection prevention teams, and scientists have attempted to help solve PPE shortages across the U.S. However, the problem of PPE shortages and only one major supply exporter cannot be solved by the help of volunteers through these sourcing initiatives.

Although it is not the responsibility of the PPE supply chain to determine standards of safety performance, it is of organizations like the American National Standards Institute (ANSI) and the Association for the Advancement of Medical Instrumentation (AAMI). The ANSI/AAMI PB70:2012 *Liquid barrier performance and classification of protective apparel and drapes for use in health care facilities* "establishes a system of classification for protective apparel and drapes used in health care facilities based on their liquid barrier performance and specifies related labeling requirements and standardized test methods for determining compliance" (AAMI, 2012, p. 1). This standard establishes minimum barrier performance specification for various protective apparel and drapes, including isolation gowns. In their specifications, all critical zones, including the entire isolation gown including seams but excluding cuffs, hems, and bindings, are required to have a barrier performance of at least a Level 1. In Annex A: *Rationale for the development and provisions of this standard*, it is noted that active work for developing this standard did not begin until 1998 (AAMI, 2012). Through research, only seven articles, ranging from 2000-2020, have been published regarding the performance of isolation gowns. Based on AAMI's diligent work in developing PB70:2012, research before 1998 has been deemed irrelevant. In consideration of this, very little research on the performance of reusable isolation gowns has been studied. Health care facilities are looking for alternatives to reprocess their PPE, looking into reusable PPE, and heavily relying on reusable PPE's functionality and performance.

Purpose

The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2. The performance of the gowns to meet required protection specifications per ANSI/AAMI PB70:2012 and American Society for Testing and Materials (ASTM) F3352 – 19 *Standard Specification for Isolation Gowns Intended for use in Healthcare Facilities* were investigated. Commercially available Level 2 reusable gowns from six sample groups were evaluated using hydrostatic pressure and impact penetration from American Association of Textile Chemists and Colorists standard test methods and results compared to ANSI/AAMI PB70:2012 requirements. The fabric's breaking, tearing, and seam strength from ASTM test methods were also determined and compared to ASTM F3352 – 19.

Research Objectives

1. Evaluate the performance of Level 2 reusable isolation gowns over their lifecycle.
2. Measure and compare the performance of Level 2 reusable isolation gowns currently on the market to current AAMI and ASTM standards.
3. Identify and evaluate any performance issues regarding Level 2 reusable isolation gowns.

Research Questions

1. Are commercially available reusable Level 2 isolation gowns providing adequate protection and durability throughout their intended lifecycle?
    a. Are the gowns meeting AAMI standards for barrier performance consistently at a Level 2 protection through their intended lifecycle?
    b. Are the gowns meeting ASTM standards for durability consistently at a Level 2 protection through their intended lifecycle?
2. Was there a decline in the performance of the gowns over wash intervals?

3. Was there a difference in performance between fabric locations and seam locations in barrier performance?
    a. Should there be a separate standard performance for seams?
4. Is there a difference in performance between gowns laundered with oxygen bleach versus without bleach?
5. Are the current standards held for Level 2 reusable isolation gowns protecting the lives of HCWs?

Assumptions

The samples used in this research are assumed to be accurately labeled and packaged correctly as reusable Level 2 isolation gowns per ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards. The samples used in this research are assumed to accurately represent reusable Level 2 isolation gowns in the U.S. market. Finally, the samples in this research are assumed to follow standard specifications per ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards.

Justification

With growing concerns over the supply and shortage of PPE, options of reprocessing or re-sterilizing are limited due to the composition of PPE materials. Disposable PPE, which makes up 80 percent of the market, is manufactured and marketed only to be used once (Jenkins, 2018). Disposable PPE is made of synthetic nonwoven materials, such as polypropylene, polyester, or polyethylene. Reusable PPE is laundered between each use and made of cotton, polyester, or a blend of the two (Kilinc, 2016). PPE is rated in various standards based on performance levels. Isolation and surgical gowns, for example, are rated according to AAMI standards, which define four levels of protection (Levels 1, 2, 3, and 4). Each protection level requires a standard barrier performance regarding each test considered, detailed in the ANSI/AAMI PB70:2012 standard, and requires a standard durability performance regarding each test considered, detailed in the ASTM F3352 – 19 standard (AAMI, 2012; ASTM, 2019).

From the Ebola crisis of 2014, it was found that some PPE used was defective; this allowed bodily fluids of patients to leak through HCW's gowns and infecting them (Cooper, 2017). Because of this, the market is slowly turning to support the use of reusable PPE since these materials are intended for reuse and therefore have higher barrier properties (Leonas, 1998). A study done at Florida State University tested and compared the performance of disposable and reusable medical gowns. In her findings, reusable PPE provided higher levels of protection for HCWs and proved to be more economically friendly than disposable PPE (McQuerry, Easter, & Cao, 2020). Comfort studies are not widely available; however, specific testing criteria, such as the product's breathability, are quantifiable measurements to determine comfort (Overcash, 2012). Only one study by Conrardy, Hillanbrand, Myers, & Nussbaum (2010) found direct evidence comparing comfort between disposable and reusable PPE, finding that surgeons and other HCWs preferred reusable PPE over disposable ones. Regarding the economic impact of disposable versus reusable PPE, various factors are considered: cost of the products, reimbursements in large quantity orders (this applies primarily to disposable PPE), laundering of reusable PPE, and contracts (Overcash, 2012). However, an economic impact comparison is difficult to pursue due to different costs associated with each type of PPE, contracts associated with health care companies and their suppliers, the lack of access to these contracts to the public, and preferences of the workers wearing PPE (Overcash, 2012).

Consideration of a PPE's lifecycle is vital to the performance and protection of HCWs and its environmental impact. Reusable PPE is considered more cost-effective and sustainable over their lifecycle regarding production costs, waste, and ecological footprints (Baykasoğlu, Dereli, & Yilankirkan, 2009; Jenkins, 2018; Overcash, 2012; Vozzola, Overcash, & Griffing, 2018). There have been very few studies conducted which tests the performance of reusable PPE. Leonas (1998) examined the barrier properties of reusable gowns after 50 commercial wash cycles, finding that frequent laundering reduced the gown's barrier properties over its lifecycle. However, depending on the thickness (i.e., layered fabrics), she found that gowns with thicker materials would have better repellency. Other studies highlighted reusable gowns as a tool that offers higher protection, economic, and ecological benefits than disposable gowns (Conrardy *et al*., 2010; Overcash, 2012; Vozzola *et al*., 2018). Besides these past studies, little research has been performed on reusable gowns after multiple commercial launderings, especially concerning serviceability components beyond protection, including comfort, durability, and appearance retention.

Demand for PPE is universal, yet supply is limited and overtaken by one country. With limited studies depicted throughout the analyses of reusable PPE, little is known of the true impact of PPE has on the protection of HCWs. There needs to be more research that will aid purchasers and HCWs in feeling more comfortable in the selection process and use of reusable isolation gowns.

Limitations

The limitations of this research include the method of sample selection. Due to financial and time limitations, only commercially available reusable Level 2 isolation gowns were obtained for this study. The study replicated laundering the gowns and testing their performance after various intervals; however, it did not account for wear studies. In addition, laboratory testing of performance may not mimic actual in-use testing. Certain areas of the body are subjected to stress and pressure, resulting in an increased chance of penetration of bodily fluids or OPIM to the wearer. Lastly, with the multitude of products on the market and in this study, sample groups may have various product designs, making the comparison against isolation gown brands and their barrier effectiveness difficult.

Chapter Two

Literature Review

The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2. A review of relevant literature provides information on the historical background of PPE, as well as the discussion on the types of PPE gowns, their composition, design requirements, care and maintenance of reusable isolation gowns, federal regulations, performance standards, prior research done on the performance of isolation gowns, barriers to selection and use of isolation gowns, performance and design issues of isolation gowns, and the lack of research regarding isolation gowns.

Background

PPE goes as far back as the eighth century B.C., where it was documented, that gardeners used gloves to protect themselves from thorns (Da Silva, 2017). Throughout history, gloves found themselves as a fashion statement on the hands of the wealthy, to the use of protecting the hands of workers and hunters. Situations of war propelled the use of protective equipment, like helmets and body armor, to help shield oneself from strikes of impact and other dangers (Da Silva, 2017). It was not until the 1760s that gloves were utilized in the medical industry (Mitchell, 2014). By the 1900s, masks made their way into operating rooms to prevent surgical wounds from becoming infected (Da Silva, 2017). Fast forward to the modern-day: the use of medical PPE is vital in protecting from illnesses and infections to HCWs and their patients and keeping their environment clean and sterile. PPE used in a healthcare setting includes, but is not limited to, gloves, face masks and shields, goggles, head and feet protective materials, and gowns.

PPE Gowns

Aside from gloves, PPE gowns are the second most used product for protection in healthcare settings (Kilinc, 2015). There are three major types of gowns used: cover gowns, isolation gowns, and surgical gowns. Because of confusion of terminology in the marketplace, suppliers use the terms "cover" and 'isolation" interchangeably; however, the two serve different purposes (Kilinc, 2016). Cover gowns are "an article of clothing worn over an operating room (OR) scrub suit-dress when OR personnel leave the OR suite (e.g., to go to lunch) to prevent soiling of the OR scrubs outside of the OR" (Kilinc, 2016, p. 3). Cover gowns do not serve any purpose in preventing the transmission of microorganisms, such as body fluids, bacteria, or viruses, the way isolation and surgical gowns do. According to the Food and Drug Administration (FDA), isolation and surgical gowns are intended to protect the wearer from the transmission of microorganisms and body fluids in low to high-risk patient isolation situations (FDA, 2021). Surgical gowns, however, still serve a different purpose than isolation gowns. In contrast, both types of gowns are used to reduce the transmission of infections and OPIM from patients to HCWs, and vice versa, but surgical gowns are only worn in the operating room (Kilinc, 2016).

Composition. All PPE gowns can either be single-use, disposable gowns or multi-use, reusable gowns. Due to the nature of their use and purpose, textile materials used in producing disposable PPE gowns are constructed using synthetic fibers with low moisture retention, such as polypropylene, polyester, or polyethylene. Reusable gowns are usually made of cotton, polyester, or a blend of the two. Nonwoven fiber bonding techniques are also heavily used in producing PPE gowns. The random nature of bonding the fibers together gives a higher liquid repellency than woven or knitted fabrics. Other finishes can also be added to the gowns to add extra protection for the wearer (Kilinc, 2015).

Finishes. Special finishes can be added to PPE to provide even better protection throughout its lifecycle. Popular finishes added to gowns are fluid repellent finishes, providing another barrier of protection from liquid penetration. Working in healthcare, HCWs are more at risk for disease and OPIM transmission, such as Ebola Virus and Human Immunodeficiency Virus (HIV). Karim *et al*. (2020) state "[a]ntimicrobial finishes can be highly effective against such pathogens in preventing infections either by killing or by inhibiting viruses and bacteria and could be applied onto protective medical clothing via various highly scalable and cost-effective fabrication techniques" (p. 12314).

Design requirements. Isolation gowns are required to have 360 degrees of protection, ensuring arms and the front, sides, and back of the body, from the knees up to the top of the chest, are covered. In addition to this, reusable isolation gowns are also required to have a means of recording the number of processing cycles (laundry cycles) on the gown by use of a "laundry grid," according to the ASTM F3352 – 19 (2019).

Care and Maintenance

ANSI/AAMI ST65:2008/(R)2018 *Processing of Reusable Surgical Textiles for use in Health Care Facilities* provides guidelines for properly handling, processing, and preparing reusable surgical textiles in health care facilities (AAMI, 2018). Although there are no recommended processing practices outlined by standard development organizations such as AAMI or ASTM for reusable isolation gowns, there are recommended practices in the care and maintenance of reusable surgical gowns. Textile companies can provide their recommendations of processing PPE; however, it is noted that what is outlined is just a starting point and to consult with chemical and equipment providers.

The CDC provides general guidelines and recommendations for infection control in health care facilities. Per the CDC's Guidelines for Environmental Infection Control in Health-Care Facilities, a hot water wash should be conducted at a temperature of at least 71ºC for a minimum of 25 minutes to destroy microorganisms (CDC, 2003b). A series of rinse cycles at the end of the wash cycle typically involves the addition of a mild acid, or sour, to neutralize potential alkalinity in the water supply or detergent. The shift in pH created by this additive inactivates some microorganisms (Blaser, Smith, Cody, Wang, & LaForce, 1984; CDC, 2003b; McQuerry, Easter, & Cao, 2020). Chlorine or oxygen bleach may be added if needed; however, it is not an appropriate laundry additive for all fabrics (CDC, 2003b, McQuerry, Easter, and Cao, 2020).

Regulations of PPE Isolation Gowns

The FDA classifies isolation gowns and surgical gowns as Class I and Class II medical devices, respectively, because these gowns are intended to prevent diseases from spreading. While the FDA requires Class II medical devices to go through premarket notification requirements, a process involving PPE suppliers to show surgical gowns are safe and effective, Class I medical devices only need to meet standards for good manufacturing processes (FDA, 2021).

The Occupational Safety and Health Administration (OSHA) only regulates the proper use of PPE in health care facilities. This regulation, specifically 29 CFR

1910.1030, *Bloodborne pathogens.*, is intended to minimize exposure to blood and OPIM in the workplace. This OSHA regulation is only a "universal precaution" and allows employer discretion to determine which PPE is required and when it needs to be used (OSHA, 2019).

In 2007, the CDC published *Guidelines for Isolation Precautions: Preventing Transmission of Infectious Agents in Health Care Settings*. The CDC recommends HCW's to wear gowns and other PPE appropriate for the task being performed where contamination or OPIM are anticipated (CDC, 2019). The CDC also gives instructions on proper donning and doffing (putting on and taking off) of PPE to avoid the risk of self-contamination to the wearer (CDC, 2020).

Performance Standards

Isolation gowns are rated on various standards based on performance levels. Gowns are rated according to the ANSI/AAMI PB70:2012 standard, defining four protection levels (Levels 1, 2, 3, and 4). Gowns can be unrated; however, if suppliers claim a level of protection, standard performance tests are required to claim barrier performance. Level 1 and 2 isolation gowns are used in minimal and low-risk situations, respectively, and provides a liquid barrier. Levels 3 and 4 are surgical gowns, providing the highest level of liquid repellency. All areas of isolation gowns, including the seams but excluding the bindings, cuffs, and hems, are required to have the highest barrier performance regarding their performance level. The gown should also cover the wearer's body appropriately intended for their use, usually down to the wearer's knees (AAMI, 2012; FDA, 2021).

Barrier properties. Each protection level must meet specific standard performance requirements, detailed in the ANSI/AAMI PB70:2012 standard. The level of protection, or classification of barrier performance, is determined by the performance of all critical zone components, including seams. AAMI defines critical zones as areas "…where direct contact with blood, body fluids, and OPIM is most likely to occur" (AAMI, 2012, p. 2). The critical zones of isolation gowns, as shown in Figure 2.1, are the front area of the gown, from chest to knees and the sleeves but excluding cuffs, hems, and bindings. Therefore, the required protection testing should be performed in the critical zone areas of the gown (AAMI, 2012).

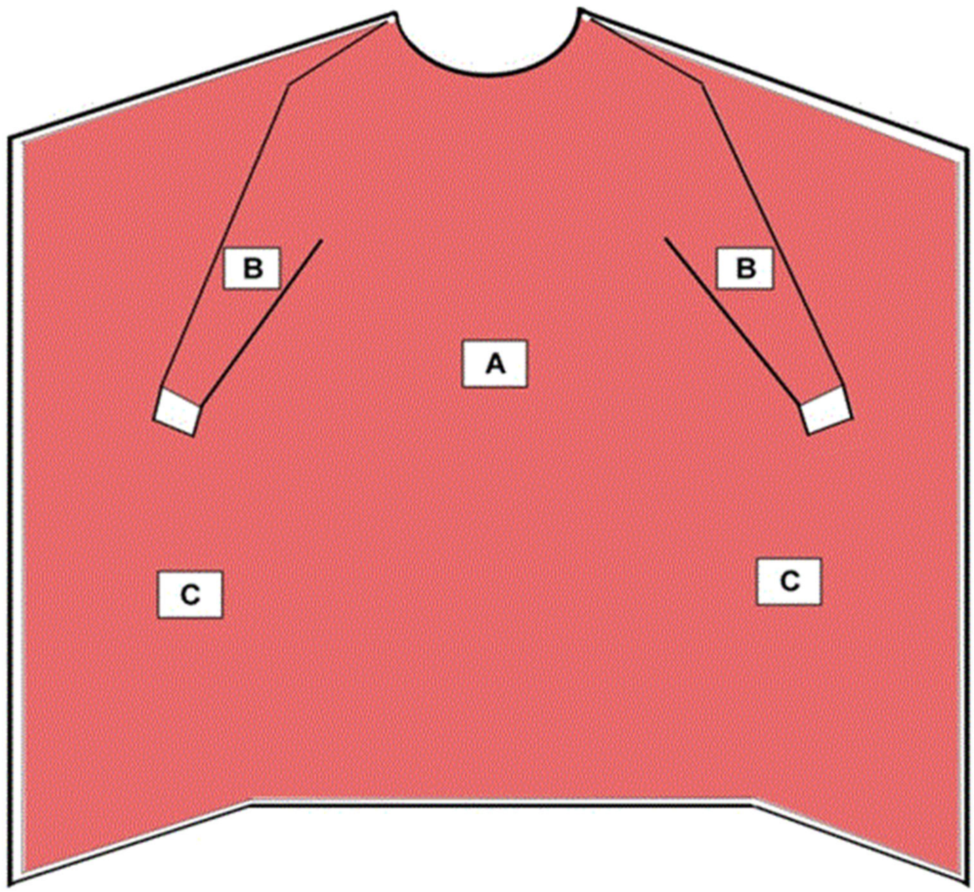

Figure 2.1 Critical Zones for Isolation Gowns (AAMI, 2012, p. 17).

Hydrostatic pressure. AATCC TM 127 – 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test* measures the liquid resistance of fabric by increasing pressure, with higher numbers reflecting better resistance (Davis, 2000). For level 2 gowns, the minimal pressure resistance is 20 cm (AAMI, 2012).

Impact penetration. AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test* measures a fabric's resistance to water penetration by impact, with lower numbers reflecting better resistance (Davis, 2000). For Level 2 gowns, blotting paper requires 1 gram increase maximum to pass (AAMI, 2012).

Durability properties. In addition to the barrier performance, minimum durability requirements for tensile strength, tear strength, and seam strength are also required for isolation gowns. All Levels of isolation gowns should meet the same minimum strength requirement, according to the ASTM F3352 – 19 standard (2019). These tests ensure that while HCW's are performing duties, their PPE does not rip, tear, or break.

Tensile strength. ASTM D5034 – 21 *Standard Test Method for Breaking Strength (Grab Test)* measures the force required to rupture or break material under specified conditions (ASTM, 2017). Isolation gowns should meet a minimum requirement of 7 lbf (pounds of force) in both the warp and fill direction (ASTM, 2019).

Tear strength. ASTM D5587 – 15 Standard *Test Method for Tearing Strength of Fabrics by Trapezoid Method Procedure* measures the force required to propagate a tear in a material under specified conditions (ASTM, 2015). Isolation gowns require a minimum of 2.3lbf in both the warp and fill direction (ASTM, 2019).

Seam strength. ASTM D1683/D1683M – 17 *Standard Test Method for Failure in Sewn Seams of Woven Fabrics* measures the force required to break seams under specified conditions (ASTM, 2017). Isolation gown seams require a minimum of 7 lbf (ASTM, 2019).

Performance/Design Issues

Comparing the performance of different isolation gowns has been difficult, considering the variety of gown selections. The most important deciding factor is their barrier effectiveness, but other considerations, such as comfort, fit, and finishes, also come into play.

A variety of factors influences the overall comfort of isolation gowns: design, fit, breathability, weight, hand (or feel), color, odor, and skin sensitivity (AAMI, 2015). Although comfort factors are only optional to test in isolation gowns, it is essential for purchasing agents to consider them to ensure HCWs comply with the proper use of isolation gowns.

Design issues are apparent in the current selection of isolation gowns. Open backs clasped together with ties or snap buttons, seams that do not perform at the same consistency as the rest of the fabric, and “one size fits most” tagging, purchasers of isolation gowns are unaware these designs can still allow fluids and OPIM to transfer to HCWs (Kilinc, 2015). Appropriate sizing plays a pivotal role in protective garments, as the possibility of snagging and damaging PPE that is too large is considerable (Karim *et al*., 2020). Balci (2016) has raised concerns regarding the PPE gown design and the overall effectiveness of barrier performance test methods. AAMI’s highest level (level 4) of protection only requires simulated bacterial penetration testing. Laboratory testing also does not mimic actual wear testing, like bending and kneeling, and is not required by AAMI; yet these characteristics should be considered when determining the right AAMI level (Balci, 2016).

Antimicrobial agents and finishes have been a popular option among suppliers and choices for purchasing agents of health care facilities. Still, “once wet, they no longer provide an effective barrier against pathogen[s]” (Karim *et al*., 2020, p.12318). Bacteria and OPIM are found to penetrate fabrics still even when there is no visible penetration (Karim *et al*., 2020). Depending on the textile materials of the PPE, whether it be from natural fibers such as cotton and wool or made from blends, the possibility of growth of bacteria, fungi, or OPIM can survive from 1-90 days even with these antimicrobial finishes and even greater odds without them (Karim *et al*., 2020). Several studies have examined the use of finishes on PPE fabrics, with some finishes showing to be highly effective (Karim *et al*., 2020; Monmaturapoj, Sri-on, Klinsukhon, Boonnak, & Prahsarn, 2018; Imaj *et al*., 2012). However, some studies reflected issues in finishing agents diminishing after multiple launders on reusable textiles (Karim *et al*., 2020; Periolatto, Ferrero, Vineis, Varesano, & Gazzelino, 2017).

Limited Research

There have been minimal and conflicting studies conducted on PPE gowns’ required performance and durability over their lifecycle. There were no studies found which researched the performance and barrier effectiveness of isolation gowns. Multiple studies reviewed and compared the performance of disposable and reusable surgical gowns (Balci, 2016). One study examined the barrier properties of reusable surgical gowns after 50 commercial wash cycles, finding that frequent laundering reduced the gown’s barrier properties over its lifecycle (Leonas, 1998).

Other studies (Rutala & Weber, 2001; Vozzola *et al*., 2018) reviewed the barrier properties of various PPE gowns and drapes. Some found that disposable PPE made of mostly laminate or polypropylene treated fabrics provided the most significant protection against the transmission of fluids and OPIM. Gowns with two layers versus one single layer provide better protection, and gowns comprised of a woven construction had the least protection. In 2020, McQuerry, Easter, and Cao conducted a study comparing the performance of reusable and disposable surgical gowns, finding that reusables are costsaving and perform better over their lifetime than single-use disposable surgical gowns (2020). More studies in the early 1990s showed that reusable gowns provided less protection than new or disposable gowns (Rutala & Weber, 2001; Leonas, 1998; Smith & Nichols, 1991; McCullough, 1993). With new standards set in place by the AAMI in 2004, any study examining isolation gown's barrier performance before that year is obsolete.

Summary

The use of PPE has evolved throughout history; gardeners protected their hands by wearing gloves to health care workers protecting themselves from OPIM. Over time, the knowledge around PPE and protection from OPIM's has kept regular people to surgeons from being exposed to harm.

When focusing on gowns, various attributes can be added to protect the lives of patients and HCWs. Nonwoven fiber bonding techniques and antimicrobial finishes give a higher liquid repellency than woven or knitted fabrics without added finishes (Kilinc, 2015; Karim *et al*., 2020; Monmaturapoj et al., 2018; Imaj *et al*., 2012). 360 degrees protection is essential in protecting all parts of the wearer's body (ASTM, 2019). With the option of reusable isolation gowns, yet limited studies depicting the safety of reusing over time, it is critical to study and evaluate their performance over its lifecycle. The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2.

Chapter Three

Methodology

The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2. This chapter describes the research design, sampling process, and evaluation of the samples in more detail.

This study evaluated the barrier effectiveness and durability properties of 72 reusable Level 2 isolation gowns from six sample groups over their wash lifecycle. A laboratory evaluation was conducted to evaluate the performance of the gowns against the ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards, including AATCC standards and ASTM standards, by assessing their ability to provide durability and adequate barrier effectiveness at a Level 2 protection across the product's wash lifecycle.

Research Design

The research considered for this study is a quantitative research design, using a quasi-experimental design approach to evaluate the gowns against industry standards. The 72 gowns from six sample groups served as independent variables. Dependent variables were generated from test results of and barrier performance through impact penetration and hydrostatic pressure tests and various strength testing methods such as tensile, tear, and seam strength.

Methodology: Laboratory Evaluation

The laboratory evaluation of reusable Level 2 isolation gowns consisting of six sample groups was conducted in the University of Kentucky Textile Testing Laboratory. Standard test methods from AATCC and ASTM defined evaluation and measurement procedures for each test.

Sample. Isolation gowns were selected based on market availability. The selection was based on what was commercially available to health care facilities and the gown's characteristics, such as its protection level based on ANSI/AAMI PB70:2012 standard, reusability over the product's lifecycle, finishes, and popularized construction methods advertised. Twelve gowns were sourced for each sample group. The groups, referred to as Group A, B, C, D, E, and F, in Table 3.1 detail their use type, protection level, construction, fiber content, fabric weight, size, wash cycles advertised, and color.

Table 3.1

Summary of the Samples

Sample Group	Use Type	Protection Level	Weave Construction	Fiber Content	Fabric Weight (g/m2)	Size	Wash Cycles Advertised	Color
A	Reusable	Level 2	Plain weave	100% polyester	89.51	XL	100	Solid yellow
B	Reusable	Level 2	Plain weave	99% polyester/ 1% carbon	93.43	OSFA	75	Yellow with gray carbon stripe
C	Reusable	Level 2	Plain weave with coating	99% polyester/ 1% carbon	106.3	OSFA	100	Yellow with gray carbon stripe
D	Reusable	Level 2	Plain weave with coating	99% polyester/ 1% carbon	107.52	OSFA	100	Yellow with gray carbon stripe
E	Reusable	Level 2	Twill weave with coating	99% polyester/ 1% carbon	107.09	OSFA	100	Yellow with gray carbon stripe
F	Reusable	Level 2	Plain weave	100% polyester	108.04	L	100	Solid blue

Procedures. The gowns were conditioned before testing to ensure consistency in performing tests according to ASTM D1776/D1776M – 20 *Standard Practice for Conditioning and Testing Textiles* (ASTM, 2020). Samples were placed in an atmospheric chamber at 75° ± 4° Fahrenheit and relative humidity of 65% ± 5% for a minimum of four hours before each test.

Twelve gowns from each sample group were included: one sample served as a control, one sample was used to measure tensile strength, tear strength, seam strength, and fabric weight, and ten samples were evaluated initially and after laundering intervals 0, 5, 10, 25, 50, and 75 washes for impact penetration and hydrostatic pressure. After 75 washes, one gown from each load will be tested for durability again. The performance of the gowns were evaluated against ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards. Table 3.2 provides the minimum requirements for Level 2 isolation gowns per ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards.

Table 3.2

Minimum Requirements for Level 2 Isolation Gowns

Level	Test	Result
2	AATCC TM 42	< 1.0 g
	AATCC TM 127	≥ 20 cm
	ASTM D5034	≥ 7 lbf
	ASTM D5587	≥ 2.3 lbf
	ASTM D1683/D1683M	≥ 7 lbf

(AAMI, 2012, p. 6; ASTM, 2019, p. 4)

Laundering. Two formulas were utilized in this study. Formula 1 included a standard industrial laundry detergent, oxygen bleach additive, and a supply of sour to the final wash, drain, and spin. Formula 2 included a standard industrial laundry detergent, no bleach additive, and a supply of sour to the final wash, drain, and spin. The gowns were divided into four loads, which consisted of 15 gowns/load, and laundered together in a UniMac® 18lb commercial washer and UniMac® 35lb commercial dryer.

Two loads were utilized in this study according to the formula used: loads 1 and 2 used formula 1's wash cycle, which included a wash at varying temperatures of 90ºF, 140ºF, 120ºF, 100ºF, and 90ºF, respectively, for a total of 58 minutes. Loads 3 and 4 used formula 2's wash cycle, which included a wash at varying temperatures of 90ºF, 160ºF, 140ºF, 120ºF, and 90ºF, respectively, for a total of 51 minutes. All loads were dried at 140ºF heat for 30 minutes, with a cool-down cycle of 2 minutes. Table 3.3 summarizes the wash cycles and tests performed at their respective wash intervals.

Table 3.3

Description and Testing Intervals of the Samples

<table>
<tr><th rowspan="4">Tests Performed</th><th colspan="12">Samples</th></tr>
<tr><th colspan="3">Load 1/Formula 1 (with bleach)</th><th colspan="3">Load 2/Formula 1 (with bleach)</th><th colspan="3">Load 3/Formula 2 (without bleach)</th><th colspan="3">Load 4/Formula 2 (without bleach)</th></tr>
<tr><td>B1 – 5A</td><td>B1 – 5B</td><td>B1 – 5C</td><td>B1 – 5D</td><td>B1 – 5E</td><td>B1 – 5F</td><td>6 – 10A</td><td>6 – 10B</td><td>6 – 10C</td><td>6 – 10D</td><td>6 – 10E</td><td>6 – 10F</td></tr>
<tr><th colspan="12">Wash Intervals</th></tr>
<tr><th>AATCC TM 127 Hydrostatic Pressure</th><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td></tr>
<tr><th>AATCC TM 42 Impact Penetration</th></tr>
<tr><th>ASTM D5034 Tensile Strength</th><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td></tr>
<tr><th>ASTM D4487 Tear Strength</th></tr>
<tr><th>ASTM D1683/D1683M Seam Strength</th></tr>
</table>

Barrier properties. The level of protection, or classification of barrier performance, is determined by the performance of all critical zone components, including seams (AAMI, 2012).

Hydrostatic pressure. Hydrostatic pressure was measured using AATCC TM 127 – 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test* (AATCC, 2017). The hydrostatic pressure test was used to determine the resistance of the gown to the penetration of water under hydrostatic pressure. This test was performed on a Textest FX 3000 Hydrostatic Head Tester. Five locations from each gown were tested: back left and right panels, sleeve, and front top and bottom. Two seam locations on the left and right sleeves were also tested. Samples were placed face down over the test head. The samples were subjected to pressure at a constant rate until three leakage points appeared on the opposite surface. This test was performed on a Textest FX 3000 Hydrostatic Head Tester II, with a test area of 100 cm2 and an increase in pressure of 60mBar/min. Hydrostatic pressure (mBar) results given by the tester were converted to find the height of the water column (mm and cm). The conversion rate was 1 mm H_2O = 0.0980665 mBar (AATCC, 2017).

Impact penetration. Impact penetration was measured using AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test* (AATCC, 2019). This test was used to determine the resistance of the gown to penetration of water by impact. This test was performed on an SDL Atlas Impact Penetration Tester. Five locations from each gown were tested: back left and right panels, sleeve, and front top and bottom. Two seam locations on the left and right sleeves were also tested. A sheet of AATCC PPE Grade Textile Testing Blotting Paper was weighed and then placed under each specimen location, with the face side of the specimen facing up, on the impact penetration tester. A weight was clamped onto the bottom edge of the specimen to pull the surface taut. After 500 mL of deionized water is sprayed on the surface of the specimen, the blotting paper was immediately weighed, determining the amount of water that penetrated the surface of the specimen and was absorbed by the blotting paper (AATCC, 2019).

Durability properties. For isolation gowns, minimum strength requirements for tensile strength, tear strength, and seam strength are required (ASTM, 2019).

Tensile strength. Tensile strength was measured using ASTM D5034 – 21 *Standard Test Method for Breaking Strength (Grab Test)* (ASTM, 2021). This test is used to determine the amount of force required to break the yarns of a specimen. Four 4 x 7 in. specimens were cut in the warp and fill direction. Breaking strength was performed by the Grab Test, a tensile test in which the central part of the width of a specimen is gripped in the machine clamps. Breaking force is the maximum force applied to a material carried to rupture. Results are given in pounds of force (lbf) (ASTM, 2021).

Tear strength. Tear strength was measured using ASTM D5587 – 15 Standard *Test Method for Tearing Strength of Fabrics by Trapezoid Method Procedure* (ASTM, 2019). The tearing strength test determines the average force required to continue a single-rip tear from a cut in a piece of fabric. A 3 x 6 in. outline of an isosceles trapezoid is marked on five rectangular specimens in the warp and fill directions. The specimen is slit 15 mm at the center of the smallest base of the trapezoid to start the tear. The nonparallel sides of the marked trapezoid are clamped in parallel clamps of a tensile testing machine. The separation of the clamps is increased continuously to apply force to propagate the tear across the specimen. The results were given in lbf (ASTM, 2019).

Seam strength. Seam strength was measured using ASTM D1683/D1683M – 17 *Standard Test Method for Failure in Sewn Seams of Woven Fabrics* (ASTM, 2018). This test measures the sewn seam strength in woven fabrics by applying a force perpendicular to the sewn seams. Sewn fabric sections are placed in a tensile testing machine so that an applied force, perpendicular to the stitching, can be exerted until one of the following phenomena occur: (1) failure of sewing thread stitch line without damage to the fabric (sewn seam strength); or (2) failure caused by force sufficient to stress in the sewn seam and displace one or more fabric yarns from their original position to cause the fabric failure due to difference in alignment, spacing, or both. Results are given in lbf (ASTM, 2018).

Data Analysis

Product evaluation data were entered into Microsoft Excel software. Determining the statistical significance between gown performance initially (before washings) and after multiple wash intervals, the data was imported into JMP statistical software. Descriptive statistics and t-tests were utilized, followed by Tukey's HSD test to specify differences between wash intervals within grouped gowns, including fabric and seam locations and wash formulas used. Statistical significance was determined using a 95 percent confidence interval with a significance level (a) of 0.05. Each gown's seven locations and standard deviation were averaged at every wash interval.

Chapter Four

Results

The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2. This research evaluated the garment's barrier and durability performance against ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards. Gowns were comprised of a single-piece, long sleeve, large, extra-large, or one-size-fits-all garment and either made of a polyester or polyester/carbon blend. The sample groups included groups A, B, C, D, E, and F. To evaluate the garment's protection and durability over laundering cycles, 72 gowns were obtained for this study. Ten gowns from each sample group were used for performance evaluations over wash cycles, two gowns from each group were used for durability testing, and one gown from each group was kept as a control.

Evaluation of the gowns included laboratory analysis of barrier performance with hydrostatic pressure and impact penetration tests and durability performance in tensile strength, tear strength, and seam strength over laundry cycles. Two formulas were utilized in this study. Formula 1 included a standard industrial laundry detergent, oxygen bleach additive, and a supply of sour to the final wash, drain, and spin. Formula 2 included a standard industrial laundry detergent, no bleach additive, and a supply of sour to the final wash, drain, and spin. Ten gowns from each sample group were laundered using both formulas, where five gowns were laundered with bleach and five gowns without bleach. According to Vozzola *et al*. (2018), "[r]eusable or multi-use gowns are typically rated by the manufacturer for 75-100 uses before downgrade" (p. 3). The gowns have laundered a total of 75 cycles to replicate a typical gown lifecycle. Barrier performance testing was done initially (labeled as wash interval 0) and after five, 10, 25, 50, and 75 laundry cycles. Durability testing was evaluated initially and at wash interval 75.

ANSI/AAMI PB70:2012 *Liquid barrier performance and classification of protective apparel and drapes for use in health care facilities* (AAMI, 2012) and ASTM F3352 – 19 *Standard Specification for Isolation Gowns Intended for Use in Healthcare*

Facilities (ASTM, 2019) were used to evaluate the results of the laboratory analysis when applicable.

Barrier Performance

A barrier performance evaluation was conducted for gowns laundered with bleach and without bleach. A total of seven locations were tested: five fabric locations on the left and right back panels, sleeve, and top and bottom of the front; two seam locations were also tested. Hydrostatic pressure and impact penetration were measured initially and after 5, 10, 25, 50, and 75 laundry cycles. The results for barrier performance are presented below.

Hydrostatic pressure. The gowns were measured according to AATCC 127 – 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test* (AATCC, 2017). This test was performed on a Textest FX 3000 Hydrostatic Head Tester II, with a test area of 100 cm^2 and an increase in pressure of 60 mBar/min. Samples were placed face down over the test head and subjected to pressure at a constant rate until three leakage points appeared on the opposite surface. Hydrostatic pressure (mBar) results given by the tester were converted to find the height of the water column in centimeters (cm). The locations of each gown were averaged together after every testing interval. The resulting data is presented in Figures 4.1 and 4.2.

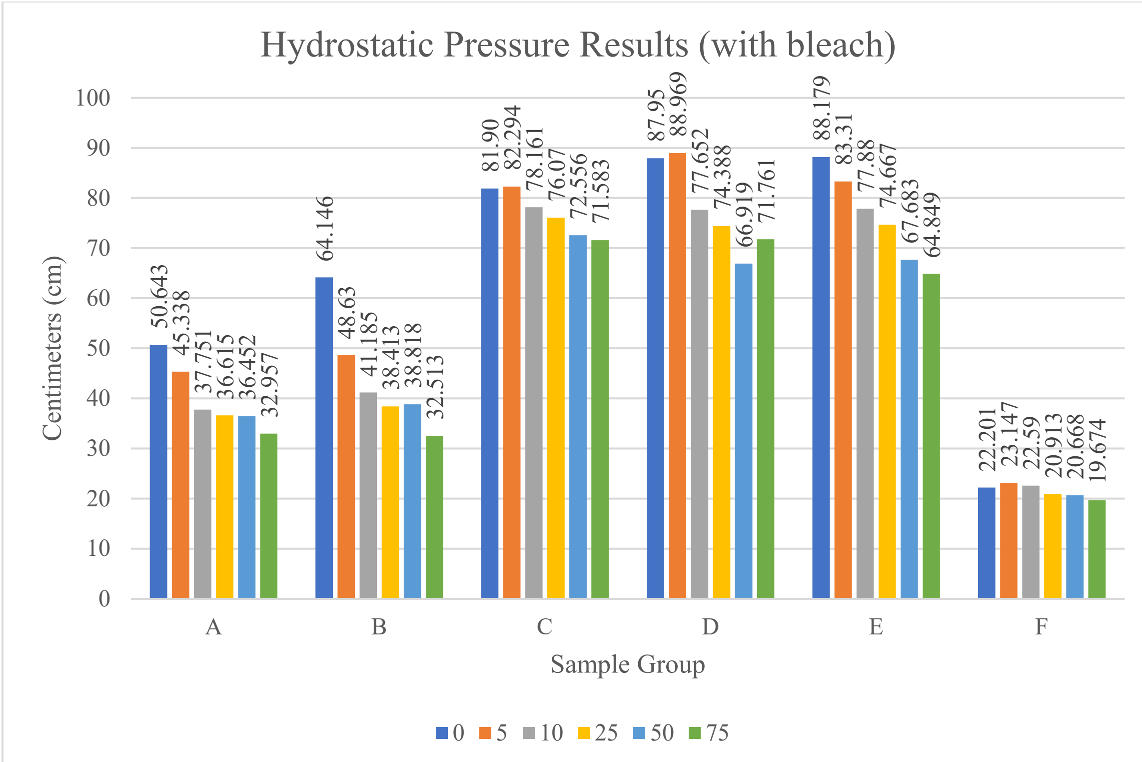

Figure 4.1 Hydrostatic Pressure Results with bleach over Wash Intervals.

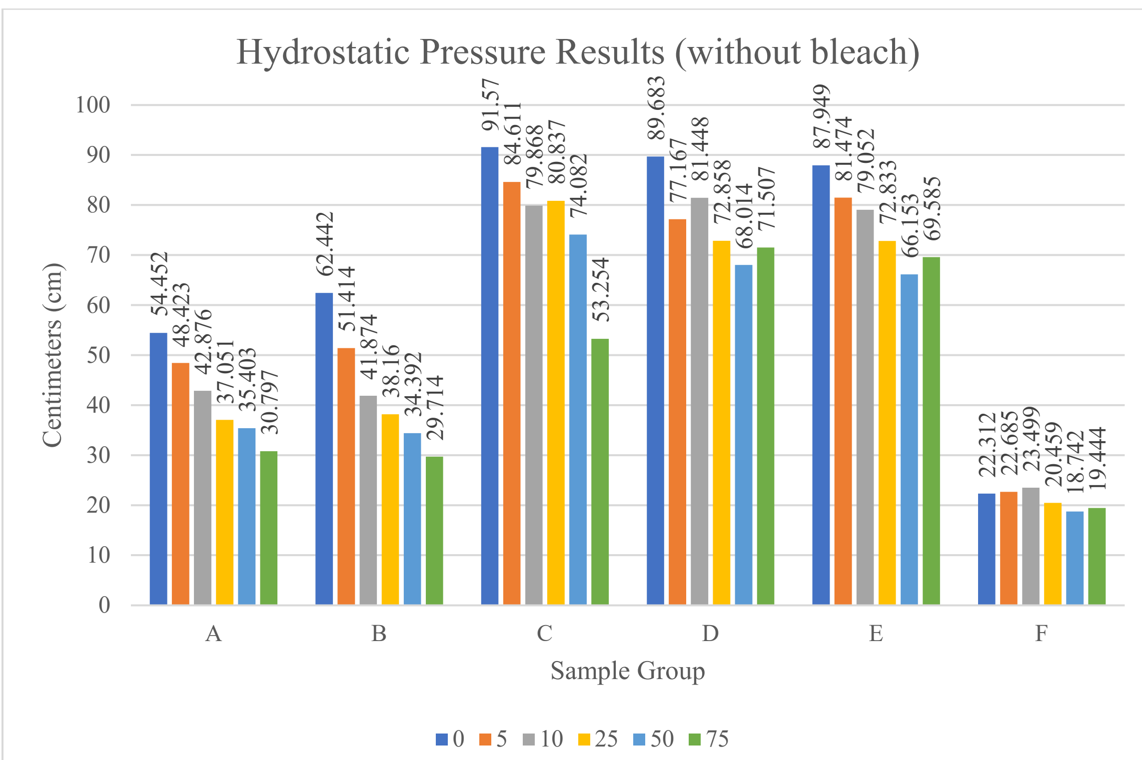

Figure 4.2 Hydrostatic Pressure Results without bleach over Wash Intervals.

According to the ANSI/AAMI PB70:2012 (2012) standard, a minimum of 20 cm is required for a Level 2 protection. Gowns from groups A, B, C, D, and E met and exceeded performance standards over wash interval testing. Gowns in group F failed performance standards.

Examining hydrostatic pressure of the gowns laundered with bleach, gowns from groups C, D, and E demonstrated the highest and most consistent resistance to leakage over wash intervals. Gowns in group F also had consistent results, but barely met specification over wash intervals. Group F had the lowest performance compared to gowns in the other sample groups. A t-test on the mean confirmed gowns in group F failed to meet specifications at wash interval 75 (p-value = 0.9564). Gowns in groups A and B have a noticeable decline in hydrostatic pressure after wash interval 5 and 75; however had unvarying hydrostatic pressure after wash intervals 10, 25, and 50. Tukey's Honest Significant Difference (HSD) test, which finds out which specific wash interval results (compared with each other) are different, displays that in wash intervals 10, 25, and 50 with bleach gowns from groups A and B presented consistent results.

Gowns in groups C, D, and E laundered without bleach demonstrated the highest and most consistent performance over wash intervals. Gowns in group F failed specifications at wash interval 50 (18.74 cm) and 75 (19.44 cm). A t-test on the mean confirmed gowns in group F failed to meet specifications at wash interval 50 (p-value = 0.9968) and 75 without bleach (p-value = 0.9764). Groups A and B gowns presented a noticeable decline in hydrostatic pressure over wash intervals, though gowns in group A had higher hydrostatic pressure over wash intervals compared to gowns washed with bleach.

McQuerry *et al*. (2020) tested the performance of reusable Level 2 and 3 isolation gowns over wash intervals. Their findings showed that reusable gowns met specification after each wash interval tested. However, it was found that there was significant difference after wash intervals, as seen in this study as well.

Impact penetration. The gowns were measured according to AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test* (AATCC, 2019). This test was used to determine the resistance of the gown to penetration of water by impact. This test was performed on an SDL Atlas Impact Penetration Tester. A sheet of AATCC PPE Grade Textile Testing Blotting Paper was weighed and then placed under each specimen location, with the face side of the specimen face side up, on the impact penetration tester. A weight was clamped onto the bottom edge of the specimen to pull the surface taut. After 500 mL of deionized water is sprayed on the surface of the specimen, the blotting paper was immediately weighed, determining the amount of water that penetrated the surface of the specimen and was absorbed by the blotting paper (AATCC, 2019). The data of each gown location was averaged together after every testing interval. The resulting data is presented in Figures 4.3 and 4.4.

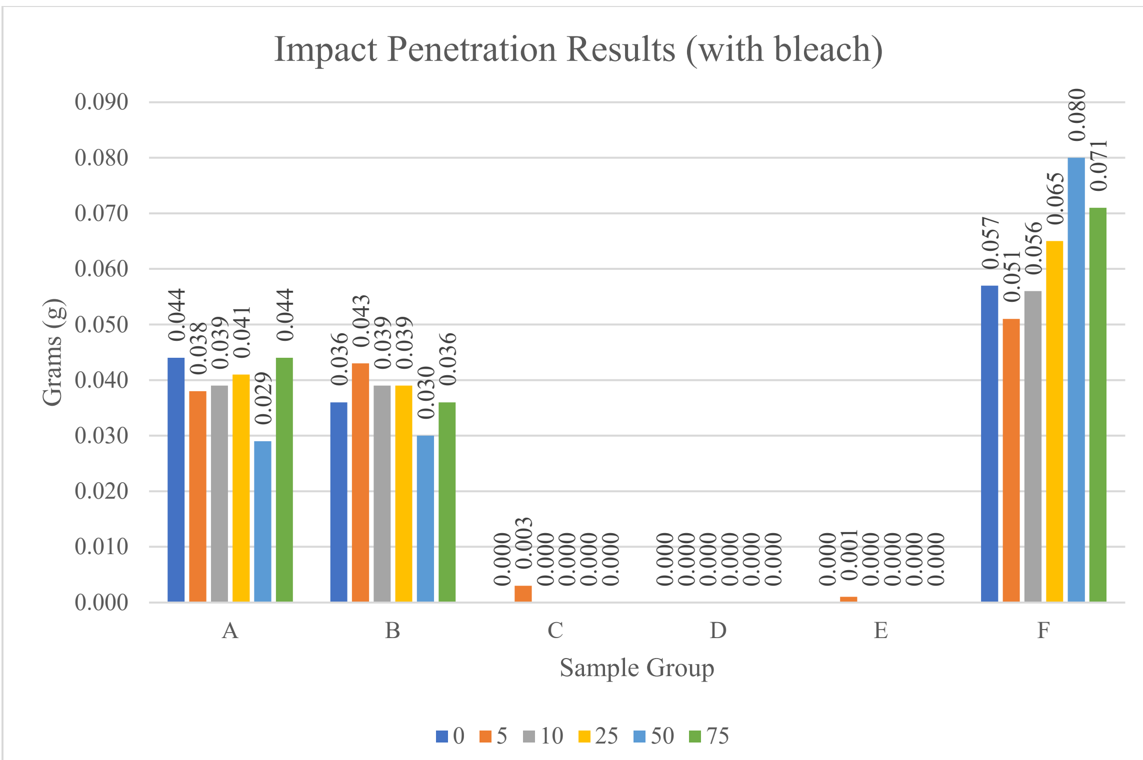

Figure 4.3 Impact Penetration Results with bleach over Wash Intervals.

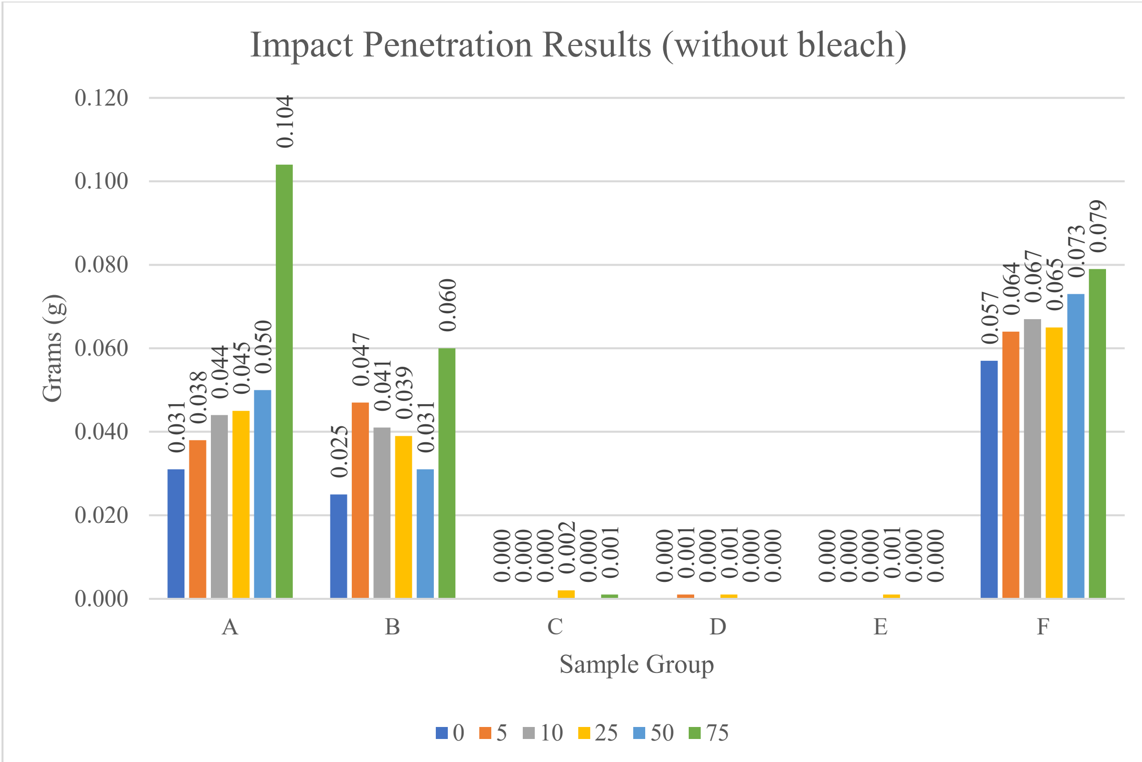

Figure 4.4 Impact Penetration Results without bleach over Wash Intervals.

According to ANSI/AAMI PB70:2012 (2012), for a Level 2 protection, blotting paper should not exceed a 1 g weight increase for each gown. Based on this criterion, all gowns washed with and without bleach passed at each interval.

Based on the results from gowns laundered with bleach, groups C, D, and E showed the highest resistance to penetration by impact, resulting in an approximately 0 g increase in the blotting paper over wash intervals. Groups A and B gowns also showed similar resistance to liquid penetration over wash intervals (0.044 g and 0.036 g, respectively) when tested initially and after wash interval 75. Group A, B, and F gowns had varying resistance over wash intervals; however, this could be due to surfactants in detergent clinging onto the fabric and lowering the surface tension throughout their lifecycle. Gowns in group F had the lowest resistance to impact penetration than the other groups, recording the highest increase before laundering and after wash interval 75 (0.057 g and 0.071 g, respectively). A t-test on the mean confirmed impact penetration over wash intervals for each sample group are significantly different from 1 g, resulting in a p-value of less than 0.05.

Examining gown performance laundered without bleach, gowns in group A had the lowest resistance to liquid penetration after wash interval 75 (0.104 g). Gowns from groups C, D, and E had the highest resistance of impact penetration, resulting in an approximately 0 g increase over wash intervals. Tukey's HSD test showed liquid resistance over wash intervals were consistent for gowns in A, except for wash interval 50, where resistance of liquid penetration it slightly improved. Gowns in groups B and F had varying performance over wash intervals. The resistance of impact penetration for Group B gowns performed worse at wash interval 5 than at wash intervals 10, 25, and 50. A t-test on the mean confirmed impact penetration over wash intervals for each sample group are significantly different from 1 gram, resulting in a p-value of less than 0.05. McQuerry *et al*. (2020) also performed impact penetration on reusable gowns, finding that both gowns tested met specification over wash intervals. Similarly to this study, gowns tested by McQuerry did not significantly differ over wash intervals.

Durability Performance

To evaluate durability performance, tensile, tear, and seam strength was conducted. One gown from each group was measured initially and after being laundered with and without bleach (picked at random) and measured after wash interval 75. The results of durability performance are presented below.

Tensile strength. Tensile strength was measured using ASTM D5034 – 21 *Standard Test Method for Breaking Strength (Grab Test)* (ASTM, 2021). This test is used to determine the amount of force required to break the yarns of a fabric specimen. Four 4 x 7 in. specimens were cut from one gown from each supplier in the warp and fill direction. Breaking strength was performed by the Grab Test, a tensile test in which the central part of the width of a specimen is gripped in the machine clamps. Breaking force is the maximum force applied to a material carried to rupture. Results are given in pounds of force (lbf) (ASTM, 2021). The resulting data is presented in Figure 4.5.

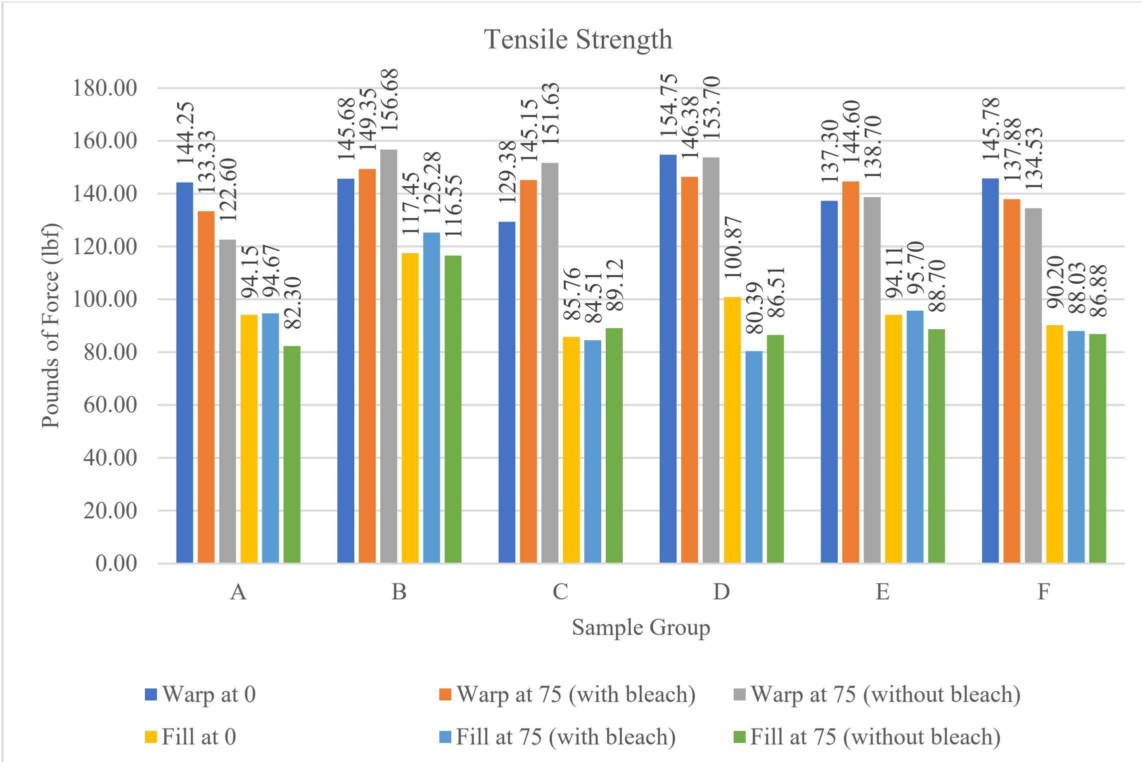

Figure 4.5 Tensile Strength Results over Wash Intervals.

According to ASTM F3352 – 19 (2019), the required tensile strength for gowns is a minimum of 7 lbf in both the warp and fill direction. Gowns in each group met and exceeded this requirement in the warp and fill direction when tested before laundering and after wash interval 75 with and without bleach. In groups B, C, and E, tensile strength increased in the warp direction after being laundered with and without bleach. Gowns in groups A, D, and F had decreased tensile strength in the warp direction; however, these groups still exceeded the minimum specification. In the fill direction of groups A, B, and E gowns laundered with bleach, tensile strength increased compared to *fill at 0*. Group C gowns laundered without bleach had an increased performance result in the fill direction, where gowns from groups D and F decreased in lbf. Gowns in group B had the highest and most consistent tensile strength over wash intervals compared to the other groups.

For the gowns in group A, there was a significant difference in tensile strength after wash intervals in the warp (p-value = 0.000) and fill (p-value = 0.000) directions. Tukey’s HSD test displayed significant differences in tensile strength after wash intervals in the warp direction, and a significant difference after wash interval 75 without bleach and before laundering and laundering with bleach in the fill direction. For group A, laundering with bleach maintained its strength over time compared to laundering without bleach.

There was a significant difference in tensile strength after wash intervals in the warp (p-value = 0.0044) and fill (p-value = 0.219) direction for group B gowns. In the warp direction, Tukey's HSD test showed a significant difference in tensile strength after wash interval 75 without bleach and before laundering and laundering with bleach. There was a significant difference after wash interval 75 with bleach and before laundering and laundering without bleach in the fill direction. Group B maintained and had an increase in strength regardless of being washed with bleach and without bleach.

For gowns in group C, there was a significant difference in strength after wash intervals in the warp direction (p-value = 0.000); however, there was no significant difference in the fill direction (p-value = 0.219). Group C gowns increased in tensile strength after being laundered without bleach in both directions.

For gowns in group D, tensile strength was significantly different in the warp direction (p-value = 0.019) before laundering after wash interval 75 with and without bleach. In the fill direction, there was a significant difference before laundering and after wash interval 75 with and without bleach (p-value = 0.000). Both directions decreased in tensile strength after laundering, but gowns laundered without bleach had a less of a decrease than gowns laundered with bleach.

Gowns in group E significantly differed after wash intervals in the warp direction (p-value = 0.016). There was a significant difference after wash interval 75 with bleach compared to before laundering and wash interval 75 without bleach. There was no significant difference after wash intervals the fill direction (p-value = 0.454). Gowns laundered with bleach performed better than gowns laundered without bleach; however, both directions decreased overall.

There was a significant difference after wash intervals in the warp direction (p-value = 0.000) for group F gowns but not in the fill direction (p-value = 0.341). In Tukey's HSD test, all three intervals were significantly different in the warp direction.

Even with a significant decrease in the warp direction, both wash intervals after laundering did not dramatically decrease.

McQuerry *et al*. (2020) resulted in a decrease in tensile strength after laundering. In their study, reusable isolation gowns met specifications before laundering, though after 75 wash intervals, there was a reduction in tensile strength. However, all isolation gowns still met and exceeded specifications.

Tear strength. Tear strength was measured using ASTM D5587 – 15 Standard *Test Method for Tearing Strength of Fabrics by Trapezoid Method Procedure* (ASTM, 2019). The tearing strength test determines the average force required to continue a single-rip tear from a cut in a piece of fabric. A 3 x 6 in. outline of an isosceles trapezoid is marked on five rectangular specimens in the warp and fill directions. The specimen is slit 15 mm at the center of the smallest base of the trapezoid to start the tear. The nonparallel sides of the marked trapezoid are clamped in parallel clamps of a tensile testing machine. The separation of the clamps is increased continuously to apply force to propagate the tear across the specimen. The results were given in lbf (ASTM, 2019). The resulting data is presented in Figure 4.6.

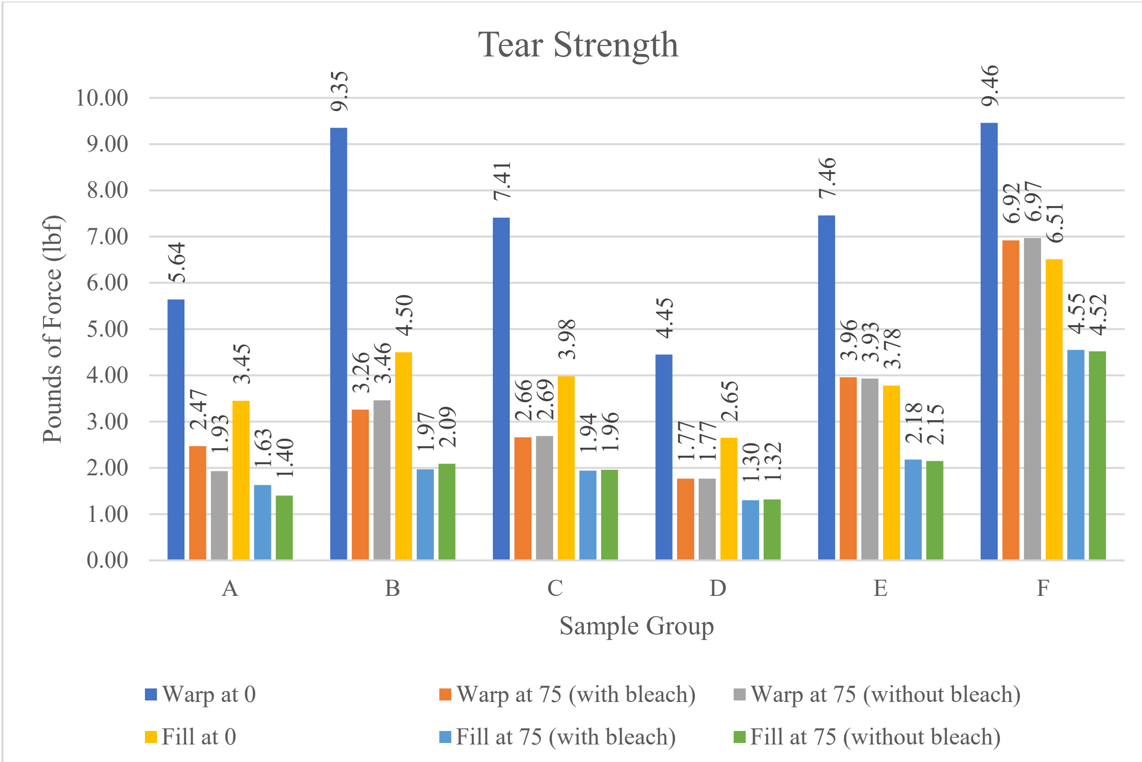

Figure 4.6 Tear Strength Results over Wash Intervals.

According to ASTM F3352 – 19 (2019), the required tear strength for gowns is a minimum of 2.3 lbf in both the warp and fill direction. Gowns in each sample group exceeded this requirement in the warp and fill direction when tested before laundering. Gowns in groups A, B, C, D, and E failed this requirement in the fill direction after laundering with and without bleach. Group D gowns failed this requirement in both directions after laundering with and without bleach. Gowns in group F is the only sample group that met the specification after laundering with and without bleach. McQuerry *et al*. (2020) did not find similar results regarding tear strength. In their study, reusable isolation gowns met specifications before laundering, and after wash interval 75, there was a reduction in tear strength; however, all reusable isolation gowns tested still met specifications.

Gowns in group A showed a significant decrease over wash intervals in the warp and fill directions, and a significant difference in performance between gowns laundered with bleach and gowns without bleach (p-value = 0.000). Gowns laundered without bleach failed specifications for both the warp and fill direction. Gowns laundered with bleach met specifications only in the warp direction and failed in the fill direction.

Group B, C, and E gowns met specifications in the warp direction after laundering but failed in the fill direction. Gowns in groups C, E, and F had similar tear strengths in the warp and fill direction after being laundered with and without bleach; bleach did not make a difference in the resistance of tear in a specimen for these groups. Gowns in group D did not meet specifications in either the warp or the fill direction after laundering with and without bleach.

Seam strength. Seam strength was measured using ASTM D1683/D1683M – 17 *Standard Test Method for Failure in Sewn Seams of Woven Fabrics* (ASTM, 2018). This test measures the sewn seam strength in woven fabrics by applying a force perpendicular to the sewn seams. Fabric sections of the specimen are placed in a tensile testing machine so that an applied force, perpendicular to the stitching, can be exerted until one of the following phenomena occur: (1) failure of sewing thread stitch line without damage to the fabric (sewn seam strength); or (2) failure caused by force sufficient to stress in the sewn seam and displace one or more fabric yarns from their original position to cause the fabric failure due to difference in alignment, spacing, or both. Results are given in lbf (ASTM, 2018). The resulting data is presented in Figure 4.7.

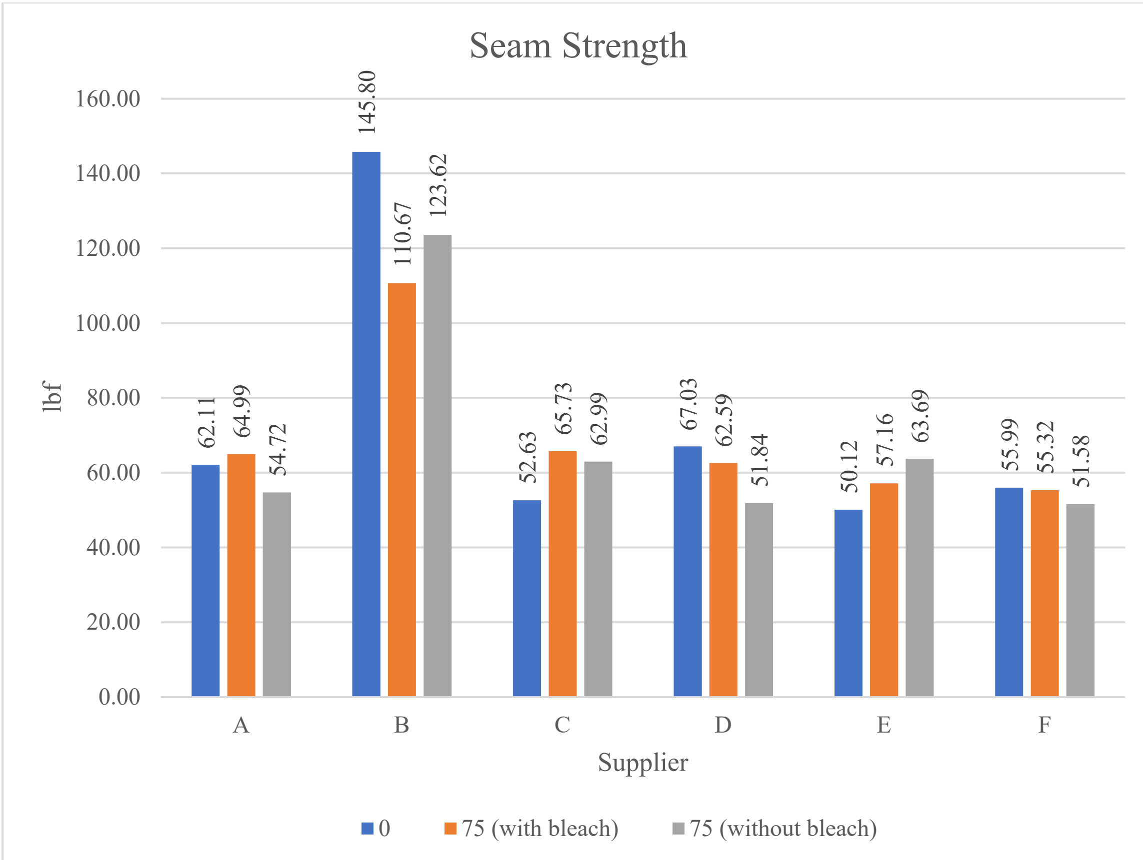

Figure 4.7 Seam Strength Results over Wash Intervals.

According to ASTM F3352 – 19 (2019), the required seam strength for gowns is a minimum of 7 lbf. Seams in each group met and exceeded this requirement before laundering and after wash interval 75 with and without bleach. The seams in each group had the first phenomena occur, a failure of sewing thread stitch lines without damage to the fabric. McQuerry *et al*. (2020) tested for tear strength on reusable isolation gowns and had similar results; gowns exceeded specifications before and after laundering. After wash interval 75, there was a reduction in seam strength; however, all isolation gowns still met and exceeded specifications.

Gowns in groups A and C had a stronger seam strength in the gowns laundered with bleach compared to before laundering and after laundering without bleach. There was a significant difference in seam performance after all three wash intervals in group A (p-value = 0.000). Seams had a significant difference before laundering and after being laundered with bleach (p-value = 0.018).

Group B gowns had the highest seam strength after all three wash intervals compared to the other groups. Seams laundered without bleach in this group had a higher seam strength compared to seams laundered with bleach, but both still exceeded specifications.

For group D, seam strength after laundering decreased for seams laundered with and without bleach; however, seams laundered with bleach had stronger resistance to seam failure than gowns laundered without bleach. The seams laundered without bleach were significantly different before laundering and after laundering with bleach (p-value = 0.000).

For group E gowns, seam strength before laundering and laundered without bleach were significantly different from each other (p-value = 0.002). The seams laundered without bleach performed better than seams that were laundered with bleach.

Group F seam strength results were not significantly different from each other (p-value = 0.413). Laundering did not make a significant difference in seam strength for this group.

Research Questions

Results from the laboratory evaluation were used to answer research questions 1 – 5. Discussion regarding each research question is presented below.

Research question 1. Are commercially available reusable Level 2 isolation gowns providing adequate protection and durability throughout their intended lifecycle?

Research question 1a. Are the gowns meeting AAMI standards for barrier performance consistently at a Level 2 protection through its intended lifecycle?

Hydrostatic pressure. Hydrostatic pressure determines the resistance of the gown to the penetration of water under pressure, with higher results reflecting higher resistance (AATCC, 2017). Gowns washed with and without bleach from sample groups A, B, C, D, and E not only met AAMI's standard of 20 cm for hydrostatic pressure, but exceeded the minimum performance, consistently after wash intervals. Gowns in group F laundered with and without bleach failed AAMI's standard of 20 cm for hydrostatic pressure.

The gowns laundered with and without bleach in groups A and B had similar performance in hydrostatic pressure; between 50 – 60 cm before laundering and approximately 30 cm after wash interval 75. Gowns in group C laundered with bleach had the highest hydrostatic pressure, with minimal variation over wash intervals (0 = 81.91 cm; 75 = 71.58 cm). Group B and C gowns washed without bleach had the worst resistance to leakage over wash intervals. Group B gowns averaged a 32.73 cm decrease between wash intervals 0 and 75, and group C gowns averaging a 38.32 cm decrease between the wash intervals 0 and 75.

Group D gowns washed without bleach varied in pressure heights after wash intervals; wash interval 50 decreased in hydrostatic pressure (68.01 cm) but increased to 71.51 cm after wash interval 75. Gowns washed with bleach in this group had a similar performance variation, with a 4.84 cm height increase from wash interval 50 (66.92 cm) to 75 (71.76 cm).

Gowns in sample group F failed after wash interval 75 with bleach (19.67 cm) and after wash interval 50 without bleach (18.74 cm). Product claims for gowns in group F have contradicting statements that gowns are reusable for a minimum of 100 washes, but laundering recommendations in group F only claim 50 washes. While the claim in laundering recommendations proved true in this study, claims of 100 washes may need to be reevaluated.

Although statistical analysis indicated laundering significantly declined hydrostatic pressure results, gowns from groups A, B, C, D, and E still met specification over wash intervals.

Impact penetration. Impact penetration determines the resistance of the gown to penetration of water by impact, with lower weight increases reflecting better resistance (AATCC, 2019). Gowns in each sample group washed with and without bleach met AAMI's standard of 1 g for impact penetration consistently throughout over wash intervals.

Gowns in groups C, D, and E washed with and without bleach had the highest resistance to liquid penetration, having little to weight increase in the blotting paper regardless of wash interval. Gowns washed with bleach in groups A and B had varying resistance to liquid penetration over wash intervals but resulted in the same resistance at before and after laundering.

Group A gowns washed without bleach had a significant decline in impact penetration, which resulted in a decrease resistance of 0.05 g at wash interval 50 to 0.104

g at wash interval 75. However, the gowns in this group still meet the AAMI's standard of 1 g increase in blotting paper weight (AAMI, 2012). Tukey's HSD test also showed that the gowns laundered without bleach in this group had no significant difference over wash intervals until the wash interval 75.

Gowns in group B laundered with bleach had a significant difference in wash interval 5 (0.043 g), its lowest resistance to liquid penetration over wash intervals, and wash interval 50 (0.030 g), the highest resistance over wash intervals. For the gowns laundered without bleach, there was a decrease in resistance before laundering and after wash interval 5 (0.025 g to 0.047 g), then an increase after wash intervals 10, 25, and 50 (0.041 g, 0.039 g, and 0.030 g). At wash interval 75, the average resistance to liquid penetration decrease significantly (0.070 g).

Group F gowns washed with bleach varied in weight over wash intervals, especially after wash interval 50 (0.08 g). However, impact penetration improved by the wash interval 75 (0.07 g). Group F gowns washed with bleach only saw a significant difference before laundering (0.06 g) and after wash interval 75 (0.08 g), according to Tukey's HSD test. Intervals 5, 10, 25, and 50 were not significantly different.

Research question 1b. Are the gowns meeting ASTM standards for durability consistently at a Level 2 protection through its intended lifecycle?

Tensile strength. Tensile strength determines the amount of force required to break the yarns of a specimen, with higher results reflecting a stronger fabric (ASTM, 2021). The minimum requirement is 7 lbf in the warp and fill direction of the fabric (ASTM, 2019). Gowns washed with and without bleach exceeded ASTM's standard for tensile strength consistently over wash intervals.

Group A gowns had similar tensile strength after being laundered with bleach (94.67 lbf) and before laundering (94.14 lbf) in the fill direction, resulting in only a 0.57 lbf difference. Consequently, gowns laundered without bleach (82.30 lbf) were significantly different before laundering and after laundering with bleach. Tukey's HSD test showed a significant difference over wash intervals in the warp direction. Gowns in this group had a higher tensile strength before laundering (144.25 lbf), compared to a tensile strength of 133.22 lbf for gowns laundered with bleach and 122.60 lbf for gowns laundered without bleach.

Group B gowns washed without bleach had a higher tensile strength in the warp direction (156.68 lbf) compared to the tensile strength before laundering (145.68 lbf) and with bleach (149.35 lbf). In the fill direction, the gowns washed with bleach had a higher tensile strength (125.27 lbf) than before laundering and wash interval 75 without bleach (117.45 lbf and 116.55 lbf, respectively). The gowns after laundering had a higher tensile strength in the warp direction than in the fill direction, compared to the tensile strength before washes.

For gowns in group C, the tensile strength was significantly different in the warp direction but were not in the fill direction. In the warp, the tensile strength was higher after wash interval 75 with and without bleach (145.15 lbf and 151. 62 lbf, respectively) compared to before washes (129.38 lbf). In the fill direction, the gowns laundered without bleach had a higher tensile strength (89.12 lbf) compared to washes with bleach (84.51 lbf) and before laundering (85.78 lbf). Overall, the gowns in Group C washed without bleach had a higher tensile strength in both directions than before laundering and wash interval 75 with bleach.

Tear strength. The tearing strength test determines the average force required to continue a single-rip tear from a cut in a piece of fabric, with higher results reflecting better resistance to tear (ASTM, 2019). Before washes, gowns in all sample groups met ASTM F3352-19 (2019) standard for tear strength in the warp and fill direction (2.3 lbf). After 75 wash cycles, only gowns in group F laundered with and without bleach met tear strength standards in both directions.

Gowns in groups B, C, and E laundered with and without bleach met the tear strength standard in the warp direction after wash intervals. Gowns in groups B and C had a higher tear strength in the warp direction for gowns laundered without bleach (3.46 lbf and 2.69 lbf, respectively) compared to the average of gowns laundered with bleach (3.26 lbf and 2.66 lbf, respectively). However, these numbers were significantly different before laundering (9.35 lbf and 7.41 lbf, respectively) (p-value = 0.000), but are not significantly different between the gowns washed with and without bleach, according to Tukey’s HSD test. In the fill direction, gowns in groups B and C laundered without bleach also averaged a higher tear strength (2.09 lbf and 1.96 lbf, respectively) than those laundered with bleach (1.97 lbf and 1.94 lbf, respectively). These averages were significantly different before being laundered (4.50 lbf and 3.98 lbf, respectively) (p-value = 0.000) but were not significantly different between wash formulas. For gowns in group E, the tear strength before laundering in the warp and fill direction (7.46 lbf and 3.78 lbf) were significantly different after being laundered with bleach (3.96 lbf and 2.18 lbf, respectively) and without bleach (3.93 lbf and 2.15 lbf, respectively) (p-value = 0.000). Gowns in this group had a higher strength average in the warp and fill direction after being laundered with bleach compared to the average tear strength of the gowns washed without bleach.

Group A gowns laundered with bleach met specifications of tear strength in the warp direction (2.47 lbf) but not in the fill direction (1.63 lbf). Gowns laundered without bleach did not meet specifications in the warp (1.93 lbf) and fill (1.40 lbf) direction. According to Tukey's HSD test, all three intervals in both directions are significantly different from each other (p-value = 0.000).

Gowns in group D in the warp and fill directions performed similarly washed with bleach (1.77 lbf and 1.30 lbf, respectively) compared to gowns washed without bleach (1.77 lbf and 1.32 lbf, respectively). Although these two formulas are not significantly different from each other, they were significantly different before laundering (warp = 4.45 lbf; fill = 2.65 lbf) (p-value = 0.000).

Group F gowns had the highest tear strength compared to gowns in other sample groups. Gowns in this group met specifications in the warp direction before washes (9.46 lbf) and after the gowns laundering with bleach (6.92 lbf) and without bleach (6.97 lbf). Tear strength before laundering was significantly different from gowns after laundering in either formula (p-value = 0.000). The same was true in the fill direction before laundering (6.51 lbf) and gowns washed with bleach (4.55 lbf) and without bleach (4.52 lbf) (p-value = 0.000). In the warp direction, the tear strength in gowns laundered without bleach had a higher resistance to tear than the gowns laundered with bleach. However, the gowns laundered with bleach a higher tear strength in the fill direction than gowns laundered without bleach.

Seam strength. This test determines the sewn seam strength in woven fabrics by applying a force perpendicular to the sewn seams, with higher pounds of force reflecting stronger seams (ASTM, 2018). According to ATSM F3352 – 19 (2019), the average seam strength to meet is 7 lbf. Gowns from all sample groups met and exceeded specifications before laundering and after laundering with and without bleach.

Gowns in group B had the highest seam strength after all three wash intervals (before laundering = 145.80 lbf; wash interval 75 with bleach = 110.67 lbf; wash interval 75 without bleach = 123.62 lbf). There was a significant difference between wash interval 75 with bleach and before laundering (p-value = 0.064).

Seams from groups A and C had similar seam strength, with seams laundered with bleach having a higher seam strength (64.99 lbf and 65.73 lbf, respectively) compared to before laundering (62.11 lbf and 52.63 lbf, respectively) and gowns laundered without bleach (54.72 lbf and 62.99 lbf, respectively). There was a significant difference over wash intervals from gowns from group A (p-value = 0.000). For gowns in group C, seam strength before washes was significantly different in seams laundered with bleach. However, seam strength for gowns laundered without bleach was not significantly different from the average of gowns laundered with bleach and before laundering, according to Tukey's HSD test.

Gowns in groups D and F had higher seam strength before laundering (67.03 lbf and 55.99 lbf, respectively) compared to laundering with bleach (62.59 lbf and 55.32 lbf, respectively) and without bleach (51.84 lbf and 51.58 lbf, respectively). There was no significant difference over wash intervals for group F gowns (p-value = 0.413). For group D gowns, gowns laundered without bleach were significantly different from those with bleach and before laundering (p-value = 0.001).

According to Tukey's HSD test, seam strength for Group E gowns laundered without bleach (63.69 lbf) was the strongest seam strength and significantly different from the seam strength before launderings (50.12 lbf). The seam strength for the gowns laundered with bleach (57.16 lbf) was not significantly different between either wash interval.

Research question 2. Was there a decline in the performance of the gowns over wash intervals?

Averages of gowns laundered with and without bleach are combined to evaluate the performance of each sample group.

Sample group A. For hydrostatic pressure, gowns in this group significantly declined over wash intervals (p-value = <.0001). According to Tukey's HSD test, gowns from group A declined in hydrostatic pressure from wash interval 0, 5, 10, and 25 and wash interval 50 and 75. Wash intervals 25 and 50 did not have a significant difference (36.83 cm and 35.93 cm). For impact penetration, there was a significant difference at wash interval 75 compared to the rest of the wash intervals (p-value = 0.000). The gowns had similar resistance to liquid penetration up to wash interval 50; however, resistance decreased from 0.04 g to 0.074 g in wash intervals 50 and 75.

Tensile strength in the warp direction increased after wash interval 75 but weakened in the fill direction after 75 washes. There was a significant difference in tensile strength before washes (144.25 lbf) and after laundering (127.96 lbf) in the fill direction. Tear strength declined and failed after wash intervals in the warp and fill directions (p-value = 0.000). Seam strength was not significantly different over wash intervals (p-value = 0.389); however, there was a decline in strength after 75 washes (59.85 lbf) compared to before laundering (62.11 lbf).

Sample group B. For hydrostatic pressure, there was a significant decline over wash intervals (p-value = 0.000). According to Tukey's HSD test, gowns from group B declined in performance from wash intervals 0, 5, 10, and 25 and wash intervals 50 and 75. Wash intervals 25 and 50 did not have a significant difference (38.28 cm and 36.61 cm). For impact penetration, gown performance was significantly different over wash intervals (p-value = 0.000). The resistance of liquid penetration declined from 0.031 g before laundering and wash interval 5 (0.045 g); at wash interval 50, the performance improved (0.031 g); however, it declined at wash interval 75 (0.048 g).

Tensile strength improved significantly after laundering in the warp direction (153.02 lbf) than before washes (145.67 lbf) (p-value = 0.017). In the fill direction, tensile strength also increased after laundering (120.91 lbf) than before washes (117.45 lbf); though this improvement was not significantly different (p-value = 0.318). Tear strength declined and failed after laundering in the fill direction (p-value = 0.000). In the warp direction, tear strength declined significantly before laundering (9.35 lbf) to wash interval 75 (3.36 lbf). In seam strength, gowns significantly declined (109.15 lbf) compared to seam strength before washes (145.80 lbf), but these performances were not significantly different (p-value = 0.0573).

Sample group C. Hydrostatic pressure was significantly different over wash intervals (p-value = 0.000). Gown performance significantly declined between before laundering (86.74 cm) and wash interval 10 (79.01 cm) and between 50 (73.32 cm) and 75 (62.42 cm). For impact penetration, there was no significant difference or decline over wash intervals (p-value = 0.078).

Tensile strength was significantly different over wash intervals in the warp direction (p-value = 0.000). Gown performance increased from 129.37 lbf before washes to 148.39 lbf after washes. There was no significant difference between tensile strength over wash intervals in the fill direction (p-value = 0.0667). However, there was a slight increase in strength from 85.76 lbf before laundering to 86.81 lbf after laundering. Tear strength declined and failed specifications after wash intervals in the fill direction (p-value = 0.000). In the warp direction, tear strength was significantly different over wash intervals (p-value = 0.000). Tear strength in the warp direction declined from 7.41 lbf before laundering to 2.67 lbf after laundering. In seam strength, there was a significant difference over wash intervals (p-value = 0.004). Seams were stronger after laundering (64.36 lbf) than before washes (52.63 lbf).

Sample group D. For hydrostatic pressure, resistance to leakage over wash intervals was significantly different (p-value = 0.000). According to Tukey's HSD test, hydrostatic pressure declined at wash interval 5 (83.06 lbf), 25 (73.62 lbf), and 50 (67.46 lbf). However, at wash interval 75, gown resistance increased to 71.63 lbf. For impact penetration, gown performance was not significantly different over wash intervals (p-value = 0.552); the performance of the gowns did not decline.

Gown performance for tensile strength was not significantly different over wash intervals in the warp direction (p-value = 0.138). In the fill direction, tensile strength over wash intervals was significantly different (p-value = 0.000). After laundering, gown performance declined significantly (83.44 lbf) compared to tensile strength before washes (100.87 lbf). Tear strength declined and failed after wash intervals in the warp and fill directions (p-value = 0.000). Seam strength was also significantly different over wash intervals (p-value = 0.01). Gowns after laundering declined in seam strength (57.22 lbf) compared to before laundering (67.03 lbf).

Sample group E. Hydrostatic pressure was significantly different over wash intervals (p-value = 0.000). Resistance to leakage significantly declined from before laundering (88.06 cm) to wash interval 50 (66.91 cm), but the performance increased from wash interval 50 to 75 (67.22 cm). Impact penetration was not significantly different over wash intervals (p-value = 0.552); the performance of the gowns did not decline.

Tensile strength in the warp direction was not significantly different over wash intervals (p-value = 0.096). Tensile strength improved after laundering (141.65 lbf) compared to performance before washes (137.30 lbf). Tensile strength in the fill direction was not significantly different from each other (p-value = 0.71). Results slightly declined after laundering (92.20 lbf) compared to before laundering (94.11 lbf). For tear strength, there was a significant difference between before and after laundering in the warp and fill directions (p-value = 0.000). Tear strength declined in the warp direction after laundering (7.46 lbf to 3.94 lbf) and declined and failed standard specifications in the fill direction after laundering (3.78 lbf to 2.16 lbf). For seam strength, the performance of the gowns was significantly different over wash intervals (p-value = 0.003). Seam performance increased before laundering (50.12 lbf) to wash interval 75 (60.42 lbf).

Sample group F. For hydrostatic pressure, there was a significant difference over wash intervals (p-value = 0.000). Gown performance increased before laundering (22.26 cm) to wash interval 10 (23.04 cm), but then declined and failed by wash interval 50 (19.71 lbf). For impact penetration, there was a significant difference over wash intervals (p-value = 0.000). Impact penetration significantly declined from wash interval 25 (0.065 g) to wash interval 50 (0.077 g) but slightly improved after wash interval 75 (0.075 g).

Tensile strength in the warp direction was significantly different over wash intervals (p-value = 0.000). Performance declined after laundering (136.20 lbf) compared to before laundering (145.78 lbf). There was no significant difference over wash intervals in the fill direction (p-value = 0.341). Tensile strength slightly declined from 90.20 lbf before laundering to 87.46 lbf after laundering. For tear strength, there was a significant difference over wash intervals in the warp and fill directions (p-value = 0.000). Tear resistance in warp direction declined after laundering to 6.95 lbf compared to performance before laundering at 9.46 lbf. In the fill direction, the performance also declined from 6.51 lbf to 4.54 lbf after laundering. There was a slight decline in seam strength from 55.99 lbf to 53.45 lbf; however, statistical analysis indicated there was no significant difference over wash intervals (p-value = 0.414).

Research question 3. Is there a difference in performance between fabric locations and seam locations for barrier performance?

Fabric locations and seam locations were tracked and reported separately to evaluate the locations independently to establish a difference in performance between the two.

Sample group A. Hydrostatic pressure had no significant difference between the fabric and seam locations of gowns laundered with and without bleach (p-value = 0.074). However, fabric and seam locations over wash intervals in general were significantly different (p-value = 0.000). Seam locations performed worse than fabric, failing standard specifications for hydrostatic pressure by wash interval 10 (17.93 cm), where fabric locations averaged a pressure increase of 62.69 cm after wash interval 10. For impact penetration, there was a significant difference between fabric and seam locations laundered with and without bleach over wash intervals (p-value = 0.000). The fabric and seam locations in gowns laundered without bleach had similar blotting paper weight increases over wash intervals. Locations laundered with bleach had a significant difference between fabric and seam locations after wash interval 75 (0.036 g and 0.052 g, respectively).

Sample group B. For hydrostatic pressure, there was no significant difference between the fabric and seam locations of gowns laundered with and without bleach (p-value = 0.052). However, fabric and seam locations in general were significantly different over wash intervals (p-value = 0.000). Seam locations performed worse than fabric, failing standard specifications for hydrostatic pressure after wash interval 25 (15.71 cm), where fabric locations averaged a pressure increase of 60.87 cm after wash interval 25. There was no significant difference between locations over wash intervals for impact penetration (p-value = 0.346). Fabric and seam location performance did not vary over wash intervals with either formula (p-value = 0.489).

Sample group C. There was no significant difference between the fabric and seam locations of gowns laundered with and without bleach (p-value = 0.197). The performance of fabric and seam locations were significantly different over wash intervals for hydrostatic pressure (p-value = 0.000). Seam locations performed worse overall but still met specifications of 20 cm (AAMI, 2012). For impact penetration, there was no significant difference between the fabric and seam locations of gowns laundered with and without bleach (p-value = 0.226). There was a significant difference in performance between fabric and seam locations over wash intervals (p-value = 0.025). After wash interval 5, seams performed worse (0.004 g) than fabric (0.000 g). The fabric and seam locations in all other wash intervals performed similarly.

Sample group D. For hydrostatic pressure, fabric and seam locations laundered with bleach performed significantly differently than fabric and seam location laundered without bleach over wash intervals (p-value = 0.000). Seam locations performed worse overall but did not fail AAMI specifications. After wash interval 5, seams laundered without bleach performed worse (52.36 cm) than those with bleach (75.97 cm). Aside from this instance, there was no significant difference in the performance of fabric locations laundered with and without bleach and the performance of seam locations laundered with and without bleach (p-value = 0.240). For impact penetration, there was no significant difference between fabric and seam location performance over wash intervals (p-value = 0.552).

Sample group E. For hydrostatic pressure, there was no significant difference between the fabric and seam locations of gowns laundered with and without bleach (p-value = 0.171). However, there was a significant difference between the performance of fabric locations and seam locations over wash intervals (p-value = 0.000). Seam locations performed worse than fabric locations but did not fail AAMI specifications. For impact penetration, there was no significant difference between fabric and seam location performance over wash intervals (p-value = 0.315).

Sample group F. There was no significant difference between fabric and seam location performance over wash intervals for hydrostatic pressure (p-value = 0.318). For impact penetration, there was no significant difference between the fabric and seam locations of gowns laundered with and without bleach (p-value = 0.796). However, there was a significant difference between the performance of fabric locations and seam locations over intervals (p-value = 0.008). Seam locations performed worse than fabric locations but did not fail AAMI specifications.

Research question 3a. Should there be a separate standard performance for seams?

Based on the fabric and seam location results, ANSI/AAMI PB70:2012 should reconsider standard seam specifications for isolation gowns. Seam locations were identified as a significant weak point throughout evaluating gown performance over wash intervals. Seam locations for hydrostatic pressure from groups A and B failed specifications in the middle of their lifecycle, where fabric locations were still meeting specifications. Seam locations in gowns from groups C, D, and E had significantly different performances than fabric locations and performed worse overall than fabric locations. There were also significant differences in impact penetration performance in fabric and seam locations for groups A, C, and F.

Research question 4. Is there a difference in performance between gowns laundered with oxygen bleach versus without bleach?

Sample group A. For hydrostatic pressure, there was a significant difference in the performance of gowns laundered with bleach and gowns laundered without bleach over wash intervals (p-value = 0.000). Gowns laundered with bleach only significantly declined after wash intervals 5 (45.33 cm) and 10 (37.75 cm), whereas the gowns laundered without bleach significantly declined after wash intervals 0, 5, 10, 25, and 50 and 75. Wash intervals 25 and 50 did not have a significant difference in performance. Overall, hydrostatic pressure for gowns laundered with bleach started at 50.64 cm and ended at 32.97 cm; hydrostatic for gowns without bleach started at 54.45 cm and ended at 30.80 cm. It is important to note that results before laundering will always have higher results than after laundering. By comparing the end results of the two formulas, gowns laundered with bleach resulted in a higher hydrostatic pressure than gowns laundered without bleach. The gowns laundered with bleach also had a steadier decline than gowns laundered without bleach.

There was a significant difference in the performance of gowns laundered with and without bleach for impact penetration (p-value = 0.000). The gowns laundered with and without bleach performed similarly throughout their intended lifecycle, except for a significant difference in blotting paper weight for the gowns laundered without bleach at wash interval 75 (p-value = <0.000). Overall, the weight increase in blotting paper for gowns laundered with bleach started at 0.044 g and ended at 0.044 g, and gowns laundered without bleach started at 0.031 g and ended at 0.104 g. Gowns with bleach started and ended with the same amount of resistance, whereas gowns laundered without bleach increased in blotting paper weight by 0.073 g. Overall, gowns laundered with bleach had better resistance to liquid penetration than gowns laundered without bleach.

There was a significant difference in performance in the warp direction for tensile strength between gowns laundered with bleach and gowns without bleach over wash intervals (p-value = 0.032). Gowns laundered with bleach had stronger resistance to breaking (133.33 lbf) compared to gowns laundered without bleach (122.60 lbf). There was also a significant difference in performance in the fill direction (p-value = 0.001); gowns laundered with bleach had a higher tensile strength (94.67 lbf) compared to gowns laundered without bleach (82.30 lbf). There was a significant difference in tear strength in the warp (p-value = 0.000) and fill (p-value = 0.000) directions. Gowns laundered with bleach had a higher resistance to tear in the warp (2.47 lbf) and fill (1.63 lbf) directions compared to gowns laundered without bleach (1.93 lbf and 1.40 lbf). For seam strength, gowns laundered with bleach had a significantly stronger seam (64.99 lbf) than gowns laundered without bleach (54.72 lbf) (p-value = 0.000). Overall, the gowns laundered with bleach had better barrier and durability performance over wash intervals than those without bleach.

Sample group B. There was a significant difference in hydrostatic pressure between gowns laundered with and without bleach (p-value = 0.000). Gowns from both formulas performed and declined similarly until wash interval 50, where gowns laundered with bleach had a higher hydrostatic pressure (38.81 cm) than gowns laundered without bleach (34.39 cm). Gowns laundered with bleach had a higher hydrostatic pressure after wash interval 75 (52.51 cm) than gowns without bleach (29.71 cm). There was no significant difference in performance for impact penetration between gowns laundered with bleach and gowns without bleach (p-value = 0.631).

There was a significant difference in tensile strength between gowns laundered with bleach and gowns without bleach in the warp and fill direction (p-value = 0.018 and 0.004, respectively). Gowns laundered without had a higher tensile strength (156.68 lbf) than the gowns laundered with bleach (149.35 lbf) in the warp direction. In the fill direction, gowns laundered with bleach had a higher tensile strength (125.28 lbf) than those without bleach (116.55 lbf). In tear strength, there was no significant difference between gowns laundered with bleach and without bleach in the warp (p-value = 0.094) and fill (p-value = 0.076) direction. There was also no significant difference for seam strength (p-value = 0.257). Based on the results, there is no clear indication of whether gowns laundered with bleach have better barrier and durability performance than gowns without bleach and vice versa.

Sample group C. For hydrostatic pressure, there was a significant difference in the performance between gowns laundered with bleach and gowns without bleach (p-value = 0.000). Gowns laundered with bleach had better resistance (71.58 cm) than gowns without bleach (53.35 cm) after wash interval 75. There was no significant difference in impact penetration of gowns laundered with and without bleach (p-value = 0.226).

For tensile strength, there was a significant difference between gowns laundered with bleach (145.15 lbf) and gowns laundered without bleach (151.62 lbf) in the warp direction (p-value = <0.000). However, there was no significant difference in the tensile strength between gowns laundered with and without bleach in the fill direction (p-value = 0.219). There was no significant difference in tear and seam strength performance in either the warp or fill directions for gowns laundered with and without bleach (tear p-value = 0.779; seam p-value =0.589). Based on the results, there is no clear indication of whether gowns laundered with bleach have better barrier and durability performance than gowns without bleach and vice versa.

Sample group D. The hydrostatic pressure of gowns laundered with bleach is significantly different from gowns without bleach (p-value = 0.002). The differences lie in wash interval 5; gowns laundered with bleach performed at a higher resistance (88.97 cm) than those without bleach (77.17 cm). However, after wash interval 75, gowns laundered with bleach did not have a significantly different hydrostatic pressure (71.76

cm) than gowns laundered without bleach (71.51 cm) (p-value = 0.916). For impact penetration, there was no significant difference between gowns laundered with and without bleach (p-value = 0.552).

Regarding tensile strength, there was no significant difference between gowns laundered with and without bleach in the warp (p-value = 0.491) and fill (p-value = 0.208) direction. For tear strength, there was no significant difference between gowns laundered with and without bleach in the warp (p-value = 1.00) and fill (p-value = 0.252) direction. There was a significant difference in seam strength between gowns laundered with and without bleach (p-value = 0.001). Gowns laundered with bleach had a higher seam strength (62.59 lbf) than gowns laundered without bleach (51.84 lbf). Based on the results, there is no clear indication of whether gowns laundered with bleach have better barrier and durability performance than gowns without bleach and vice versa.

Sample group E. For hydrostatic pressure, there is no significant difference between gowns laundered with and without bleach (p-value = 0.902). For impact penetration, there was no significant difference between the performance of gowns laundered with and without bleach (p-value = 0.315).

For tensile strength, there was a significant difference between gowns laundered with and without bleach in the warp direction (p-value = 0.0223) but not in the fill direction (p-value = 0.324). In the warp direction, gowns laundered with bleach had a higher tensile strength (144.60 lbf) than those without bleach (138.70 lbf). There was no significant difference in tear strength between gowns laundered with and without bleach in the warp (p-value = 0.674) and fill (p-value = 0.747) direction. There was not a significant difference in seam strength either between gowns laundered with and without bleach (p-value = 0.0576). Based on the results, there is no clear indication of whether gowns laundered with bleach have better barrier and durability performance than gowns without bleach and vice versa.

Sample group F. Hydrostatic pressure for the gowns laundered with bleach was significantly different than the gowns laundered without bleach (p-value = 0.000). The gowns laundered without bleach failed standard specifications after wash interval 50, whereas those with bleach failed after 75. For impact penetration, there was no significant difference between the performance of gowns laundered with and without bleach (p-value = 0.180).

There was a significant difference in tensile strength between gowns laundered with and without bleach in the warp direction (p-value = 0.032). Gowns laundered with bleach had a higher tensile strength (137.87 lbf) than gowns laundered without bleach (134.53 lbf). However, there was no significant difference in the fill direction (p-value = 0.676). In tear strength, there was no significant difference between gowns laundered with and without bleach in the warp (p-value = 0.782) and fill (p-value = 0.882) direction. There was also no significant difference in seam strength for gowns laundered with and without bleach (p-value = 0.267). Based on the results, there is no clear indication of whether gowns laundered with bleach have better barrier and durability performance than gowns without bleach and vice versa.

Research question 5. Are the current standards held for Level 2 reusable isolation gowns protecting the lives of HCWs?

According to these results, the current standard in place for Level 2 isolation gowns are protecting the lives of HCWs, but specifications could be improved. There were some notable differences between the performance of fabric and seam locations. ANSI/AAMI should consider and evaluate a separate specification for seam performance to determine if seam locations should have a separate specification or if a required seam construction should be considered to meet current specifications over the gown's lifecycle.

When evaluating the barrier performance of the gowns in each sample group, the only group that failed standard specifications for barrier performance was sample group F. By wash interval 50, gowns in group F were failing specifications of 20 cm for a Level 2 protection (AAMI, 2012). Gowns from the other sample groups were still meeting specifications after wash intervals. Product claims for gowns in group F have contradicting statements that gowns are reusable for a minimum of 100 washes, but laundering recommendations in group F only claim 50 washes.

When evaluating durability performance, gowns from each sample group met tensile and seam strength specifications before and after laundering in both the warp and fill directions. Gowns from sample groups A, B, C, D, and E met specifications for tear strength before laundering but failed specifications after wash intervals. Gowns in groups A and D failed tear strength in both directions, and gowns from groups B, C, and E failed in the fill direction. Gowns in group F met specifications for tear strength in both the warp and fill directions before and after laundering. Standard specifications for durability only require gowns to meet specifications before use; however, tear strength declined significantly over wash intervals. It is noted in ANSI/AAMI ST65:2008/(R)2018 (2018) that gowns that have any tears, rips, or damage at any time throughout their lifecycle are to be discarded.

Chapter Five

Conclusion

The purpose of this research was to evaluate the performance of commercially available reusable Level 2 isolation gowns over the product's lifecycle by assessing the ability to protect at an AAMI Level 2. The sample comprised six groups, each containing 12 gowns: one gown was used as a control, one gown was used to test durability properties, and ten gowns were used to evaluate barrier performance over wash intervals. The gowns were constructed of a single-piece, long sleeve, large, extra-large, or one-size-fits-all garment. Each gown group was made of a polyester or polyester/carbon blend. Measurements for barrier performance were collected at specific intervals over 75 wash cycles, and durability performance measurements were taken initially and after 75 wash cycles.

The data for barrier performance was analyzed at six wash intervals: initially (labeled *0*),and after wash intervals 5, 10, 25, 50, and 75. The tests used to determine barrier performance were AATCC TM 127 – 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test*, which measures the liquid resistance of fabric by increasing pressure, and AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, which measures a fabric's resistance to water penetration by impact. Results for barrier performance were compared to ANSI/AAMI PB70:2012 standard, outlining specifications for Level 2 isolation gowns. Durability properties were measured initially from one gown from each group, and one gown was picked at random after wash interval 75. Three tests used to determine durability performance: ASTM D5034 – 21 *Standard Test Method for Breaking Strength (Grab Test)*, which measures the force required to rupture or break material under specified conditions; ASTM D5587 – 15 Standard *Test Method for Tearing Strength of Fabrics by Trapezoid Method Procedure*, which measures the force required to propagate a tear in a material under specified conditions; and ASTM D1683/D1683M – 17 *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*, which measures the force required to break seams under specified conditions. These tests were compared to ASTM F3352 – 19 *Standard Specification for Isolation Gowns Intended for Use in Healthcare Facilities*. This standard outlines the durability specifications of isolation gowns. The research objectives of this study were to:

1. *Evaluate the performance of Level 2 reusable isolation gowns over their lifecycle.*

Isolation gowns are essential garments that protect the lives of HCWs. After the COVID-19 pandemic, disposable PPE and isolation gowns were difficult to source, and reusable PPE are not popular options among hospital purchasing agents. With an inability to examine the quality of unvetted suppliers, distributors were slow to supply the demand (Mehrotra et al., 2020). This research evaluated the barrier and durability performance of reusable Level 2 isolation gowns over their lifecycle utilizing a laboratory analysis.

Barrier performance in hydrostatic pressure and impact penetration over wash intervals did not vary significantly among gown groups laundered with and without bleach. Dependence on finishes was apparent in hydrostatic pressure and impact penetration results. The gowns from groups C, D, and E, which do have a water repellent coating, had the highest and most consistent barrier performance over wash cycles. Gowns from groups A and B performed similarly in hydrostatic and impact penetration over wash intervals. The gowns in these two groups showed an average decline in performance, something similarly expected of gowns commercial available. Group F gowns had the lowest barrier performance over wash intervals. The group did not have exceptional performance initially, only meeting specifications for hydrostatic pressure by approximately 2 cm and failing barrier performance by wash intervals 50 and 75.

Durability performance varied among strength tests. Tensile and seam strength in gowns met and exceeded specifications outlined in ASTM F3352 – 19 initially and after wash interval 75. However, tear strength performance significantly declined in all groups laundered with and without bleach. Gowns in groups A, B, C, D, and E failed tear strength after laundering. Gowns in group F also significantly decline, but are the only gowns that met specifications in the warp and fill directions after laundering. These results show that gown construction weakens over time and is subject to not withstand tearing as well after being laundered than if they were not laundered.

Fabric and seam locations varied significantly in gowns. Seam locations were identified as a weak point throughout evaluating gown performance over wash intervals. Groups C, D, and E had low performance in their seams than in fabric for hydrostatic pressure and impact penetration; however, seams did not fail specifications. Gowns in group F also did not have variation fabric and seam locations in hydrostatic pressure, but variation was seen in impact penetration. Groups A and B seams failed specifications in the middle of wash intervals for hydrostatic pressure but could maintain specifications through wash intervals in impact penetration.

The decline over wash intervals was steadier in gowns laundered with bleach than without bleach. Results in gowns with bleach after wash interval 75 were also higher compared to 75 without bleach. For impact penetration, gowns washed without bleach showed a more significant decline to the resistance of liquid penetration than gowns washed with bleach. After wash interval 75, gowns without bleach in groups A, B, and F had increased liquid penetration than gowns with bleach. In groups C and D, results showed a slight increase in blotting paper weight in gowns laundered without bleach than with bleach.

2. *Measure and compare the performance of Level 2 reusable isolation gowns currently on the market to current AAMI and ASTM standards.*

Overall findings show that reusable gowns commercially available on the market meet ANSI/AAMI PB70:2012 and ASTM F3352 – 19 standards. Out of the six sample groups, gowns in group F, failed ANSI/AAMI PB70:2012 specifications before the end of their intended lifecycle. All gown groups technically met specifications for durability in ASTM F3352 – 19, but further research showed tear strength after laundering weakened substantially.

Gowns in groups A, B, C, D, and E could maintain a Level 2 protection throughout their intended lifecycle. Even though there was a noticeable decline throughout laundering, these gown groups could still able to meet specifications after wash intervals. Tear strength evaluation was the only test in which these groups failed after 75 washes; however, tear strength determines how well a material can withstand the effects of tearing. In actual use, any damage caused to PPE is discarded. Gowns in group F were not able to maintain Level 2 protection over wash intervals. This group failed specifications for hydrostatic pressure by 50 wash cycles. Group F gowns met and exceeded specifications for durability properties; however, durability properties do not account for the primary function of isolation gowns.

3. *Identify and evaluate any performance issues regarding reusable Level 2 isolation gowns.*

The most prevalent issue regarding gowns was the performance of fabric and seam locations. Fabric and seam locations were tracked and reported separately to evaluate the locations independently to establish a difference in performance between the two. In hydrostatic pressure, results for seams failed at wash interval 10 in group A and continued to decline further through the rest of their lifecycle. In group B, seams failed early in laundering (wash interval 25) and continued to decline further after wash intervals 50 and 75. For gowns C, D, and E, seams did not fail specifications in hydrostatic pressure but still had significantly lower performance compared to their fabric locations after each interval. Gowns in group F were the only sample that did not vary between fabric and seam locations in hydrostatic pressure. Impact penetration was slightly different; seam locations met specifications in all gown groups. In groups A, C, and F, there were significant differences between the performance of fabric locations and seam locations. Conversely, groups D and E did not have significant differences between the two locations.

Laundering recommendations were another issue regarding the performance of Level 2 isolation gowns. No standard recommends laundering instructions for isolation gowns. Other sources, like ANSI/AAMI ST65:2008 (2012), the CDC, and other textile industry leaders, were used to determine a laundry cycle for this study. Gowns in each group were divided evenly between wash cycles with an oxygen bleach additive and wash cycles that do not have a bleach additive to establish a difference in performance between the two independently. Only gowns in group A benefitted from a wash cycle with bleach. In contrast, groups B, C, D, E, and F did not have a clear indication of whether the addition of bleach (or lack thereof) was beneficial to the performance. In addition to this, surfactants in detergent play a crucial role in surface tension of water. Surfactants are amphiphilic molecules that have hydrophobic and hydrophilic parts. They are a primary component of cleaning detergents. Surfactant molecules on the water's surface the detergent is in make it spread out. An accumulation of surfactants working together makes it possible to remove soil that cannot be handled by water alone. Surfactants will reduce the surface tension of water, allowing more water to spread across the entire fabric to trap soil and remove them from the surface being cleaned. In the process lowering surface tension, liquids are more likely to penetrate the fabric in order to clean it correctly (Laurén, 2018). Consequently, a build of surfactants over time will allow other liquids (like blood and OPIM) to penetrate the fabric and diminish the performance qualities of PPE. Including rinse cycles over the gowns' lifecycle is crucial in removing residual chemicals from the gowns to keep consistent barrier results. Lastly, it is important to note there was a decline in performance in every test after being laundered compared to results before laundering. Isolation gowns should be labeled according to their end-of-life protection level rather than how they perform before laundering.

Recommendations for Future Research

Laboratory analysis was conducted using commercially available reusable Level 2 isolation gowns. Future studies should consider expanding the sample to other protection levels and other types of PPE gowns, like surgical and cover gowns. The ability to obtain a variety of samples would aid in the randomization of research design. Many gowns are made up of polyester, polyester blends, and other synthetic materials. Future studies should include other fabric types as well. In future research, different types of seam stitching should be evaluated over wash intervals to find a stitch type able to withstand their respective protection level over wash intervals. Wear studies should also be considered, as laboratory analysis of durability performance may not mimic actual in-use testing. Lastly, recommendations to introduce variables in laundering, such as including rinse cycles to remove residual surfactants, should be considered.

Appendix A

Definition of Terms

Association of the Advancement Instrumentation®: abbreviated to AAMI, an organization for advancing the development and safe and effective use of medical technology (AAMI, 2012).

American National Standards Institute: abbreviated to ANSI, a private non-profit organization that oversees the development of voluntary consensus standards for products, services, processes, systems, and personnel in the United States.

Barrier Properties: the ability of a protective product to resist the penetration of liquids and liquid-borne microorganisms (AAMI, 2012).

Disposable PPE: single-use personal protective equipment; designed and manufactured to only be used once (Jenkins, 2018). These materials comprise synthetic nonwoven materials, such as polypropylene, polyester, or polyethylene (Balci, 2016).

Health care workers: abbreviated to "HCW."

Isolation gowns: a specific type of personal protective equipment, which aids in the prevention of blood, bodily fluids, and, or other potentially infectious materials to be transferred to HCWs during patient care (Balci, 2016).

Other potentially infectious materials: abbreviated to "OPIM," any materials other than blood containing bloodborne pathogens or materials that have been linked with the potential transmission of infectious disease (AAMI, 2012, p. 3).

Penetration: movement of matter, on a nonmolecular level, through porous materials, closures, seams, or imperfections (such as pinholes) in a protective product (AAMI, 2012).

Personal Protective Equipment: abbreviated to "PPE," an item of clothing that is specifically designed and constructed for the purpose of isolating all or part of the body from a potential hazard or isolating the external environment from contamination by the wearer of the clothing (AAMI, 2012, p.3).

Reusable PPE: multi-use personal protective equipment, which is laundered between each use and are made up of cotton, polyester, or a blend of the two (Balci, 2016).

Surfactants: amphiphilic molecules that have hydrophobic and hydrophilic parts; they are a primary component of cleaning detergents. Surfactant molecules on the water's surface the detergent is in make it spread out (Laurén, 2018).

Surge Capacity: the ability to manage a sudden increase in patient volume that would severely challenge or exceed the present capacity of a facility (CDC, 2020).

Appendix B

Table B1

Summary of the Samples

Sample Group	Use Type	Protection Level	Weave Construction	Fiber Content	Fabric Weight (g/m2)	Size	Wash Cycles Advertised	Color
A	Reusable	Level 2	Plain weave	100% polyester	89.51	XL	100	Solid yellow
B	Reusable	Level 2	Plain weave	99% polyester/ 1% carbon	93.43	OSFA	75	Yellow with gray carbon stripe
C	Reusable	Level 2	Plain weave with coating	99% polyester/ 1% carbon	106.3	OSFA	100	Yellow with gray carbon stripe
D	Reusable	Level 2	Plain weave with coating	99% polyester/ 1% carbon	107.52	OSFA	100	Yellow with gray carbon stripe
E	Reusable	Level 2	Twill weave with coating	99% polyester/ 1% carbon	107.09	OSFA	100	Yellow with gray carbon stripe
F	Reusable	Level 2	Plain weave	100% polyester	108.04	L	100	Solid blue

Table B2

Minimum Requirements for Level 2 Isolation Gowns

Level	Test	Result
2	AATCC TM 42	< 1.0 g
	AATCC TM 127	≥ 20 cm
	ASTM D5034	≥ 7 lbf
	ASTM D5587	≥ 2.3 lbf
	ASTM D1683/D1683M	≥ 7 lbf

(AAMI, 2012; ASTM, 2019)

Table B3

Description and Testing Intervals of the Samples

<table>
<tr><th rowspan="4">Tests Performed</th><th colspan="12">Samples</th></tr>
<tr><th colspan="3">Load 1/Formula 1 (with bleach)</th><th colspan="3">Load 2/Formula 1 (with bleach)</th><th colspan="3">Load 3/Formula 2 (without bleach)</th><th colspan="3">Load 4/Formula 2 (without bleach)</th></tr>
<tr><td>B1 – 5A</td><td>B1 – 5B</td><td>B1 – 5C</td><td>B1 – 5D</td><td>B1 – 5E</td><td>B1 – 5F</td><td>6 – 10A</td><td>6 – 10B</td><td>6 – 10C</td><td>6 – 10D</td><td>6 – 10E</td><td>6 – 10F</td></tr>
<tr><th colspan="12">Wash Intervals</th></tr>
<tr><th>AATCC TM 127 Hydrostatic Pressure</th><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td><td colspan="3" rowspan="2">Initial (0), 5, 10, 25, 50, and 75</td></tr>
<tr><th>AATCC TM 42 Impact Penetration</th></tr>
<tr><th>ASTM D5034 Tensile Strength</th><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td><td colspan="3" rowspan="3">Initial (0) (with 11th sample obtained from each set) & 75</td></tr>
<tr><th>ASTM D4487 Tear Strength</th></tr>
<tr><th>ASTM D1683/D1683M Seam Strength</th></tr>
</table>

Table B4

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group A (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	67.5	70.67	2.12	67.0	74.34	4.90	83.5	87.29	2.56	72.5	75.36	4.83	71.5	77.29	6.72
	2	67.0			71.0			82.5			73.0			68.5		
	3	72.0			80.0			87.0			68.5			73.5		
	4	70.5			72.0			88.5			74.0			82.5		
	5	69.5			74.5			86.5			81.5			83.0		
	6	22.5	22.94	0.00	22.0	23.20	1.08	31.5	32.38	0.36	33.0	30.08	5.05	25.5	25.49	2.16
	7	22.5			23.5			32.0			26.0			26.5		
5	1	61.0	62.32	1.37	62.5	64.55	1.28	70.5	68.93	2.80	71.5	71.38	3.22	69.5	70.36	1.30
	2	61.5			61.5			64.5			64.5			68.0		
	3	63.0			64.0			70.5			70.5			68.5		
	4	61.0			64.5			66.0			72.5			68.0		
	5	64.0			64.0			66.5			71.0			71.0		
	6	22.5	22.69	0.36	21.5	22.43	0.72	29.0	28.04	2.16	20.5	21.41	0.72	26.0	27.53	1.44
	7	22.0			22.5			26.0			21.5			28.0		
10	1	55.5	59.25	2.87	59.0	57.82	2.12	57.0	60.37	2.61	55.5	59.04	1.67	55.5	58.43	3.34
	2	62.5			54.5			57.0			58.5			53.0		
	3	59.0			58.0			60.5			60.0			60.0		
	4	57.5			54.5			58.5			57.5			57.0		
	5	56.0			57.5			63.0			58.0			61.0		
	6	13.5	13.77	0.00	14.5	15.81	1.44	17.0	17.08	0.36	19.5	20.14	0.36	21.5	21.67	0.36
	7	13.5			16.5			16.5			20.0			21.0		
25	1	51.0	53.94	1.46	58.0	57.10	2.57	62.5	62.51	2.94	61.5	65.77	2.70	63.5	62.71	3.08
	2	55.0			55.0			58.0			67.0			61.0		
	3	53.0			52.0			59.5			62.0			65.5		
	4	52.5			57.5			61.0			67.0			58.0		
	5	53.0			57.5			65.5			65.0			59.5		
	6	11.5	11.22	0.72	14.5	13.26	2.16	14.0	13.26	1.44	17.0	16.83	0.72	14.0	14.49	0.72
	7	10.5			11.5			12.0			16.0			15.0		
50	1	52.0	55.06	1.94	57.0	55.68	2.63	63.0	62.71	1.44	63.0	62.92	2.15	63.0	64.55	3.09
	2	54.5			51.5			60.5			61.0			61.0		
	3	55.5			54.0			61.0			59.0			65.0		
	4	52.0			57.5			60.0			64.5			67.5		
	5	56.0			53.0			63.0			61.0			60.0		
	6	11.5	11.22	0.72	11.0	10.96	0.36	13.0	13.26	0.00	17.0	17.08	0.36	15.5	15.81	0.00
	7	10.5			10.5			13.0			16.5			15.5		
75	1	42.0	45.58	1.89	46.5	46.80	3.13	59.5	54.66	3.58	56.0	57.61	2.47	60.0	66.28	3.46
	2	44.0			46.0			53.5			54.0			64.0		
	3	47.0			41.0			53.0			54.5			69.0		
	4	45.0			46.5			50.5			59.5			65.0		
	5	45.5			49.5			51.5			58.5			67.0		
	6	10.0	9.94	0.36	12.0	11.22	1.44	12.0	12.24	0.00	15.0	14.79	0.72	14.0	14.79	0.72
	7	9.5			10.0			12.0			14.0			15.0		

Table B5

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group A (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	78.0			75.5			81.0			86.0			87.0		
	2	78.0			85.5			83.5			92.5			84.0		
	3	85.0	84.53	5.54	86.0	83.21	4.62	81.0	84.53	2.32	79.0	86.57	5.24	88.5	85.35	4.61
	4	82.5			78.5			86.5			81.5			77.0		
	5	91.0			82.5			82.5			85.5			82.0		
	6	21.5	21.67	0.36	26.5	26.77	0.36	24.0	24.47	0.00	30.0	30.34	0.36	25.5	24.73	1.80
	7	21.0			26.0			24.0			29.5			23.0		
5	1	61.5			68.0			76.0			78.5			76.5		
	2	60.5			66.0			70.5			74.5			70.5		
	3	63.5	63.32	1.22	74.5	71.99	3.56	79.0	75.26	4.34	79.0	78.31	1.93	73.0	76.17	2.94
	4	63.0			72.5			68.5			76.0			76.0		
	5	62.0			72.0			75.0			76.0			77.5		
	6	26.5	26.77	0.36	23.5	23.71	0.36	25.0	25.75	0.36	26.5	26	1.44	23.0	24.47	1.44
	7	26.0			23.0			25.5			24.5			25.0		
10	1	59.0			66.5			63.0			68.0			65.5		
	2	59.0			71.0			67.5			66.0			65.5		
	3	58.5	62.20	3.28	69.0	69.03	2.51	58.5	64.45	3.56	68.0	69.34	1.44	68.5	67.00	2.74
	4	62.5			64.5			65.5			70.0			61.5		
	5	66.0			67.5			61.5			68.0			67.5		
	6	19.0	18.86	0.72	21.0	21.92	0.72	16.5	18.35	2.16	23.0	23.45	0.00	19.5	20.90	1.44
	7	18.0			22.0			19.5			23.0			21.5		
25	1	63.0			58.5			60.5			60.5			61.0		
	2	58.0			58.5			63.5			56.0			63.5		
	3	55.0	60.57	3.41	55.0	58.74	1.55	61.0	62.92	2.30	62.0	60.78	2.78	68.0	65.57	3.60
	4	62.5			58.5			64.5			57.5			68.0		
	5	58.5			57.5			59.0			62.0			61.0		
	6	11.0	11.22	0.00	12.0	12.24	0.00	13.0	13.51	0.36	14.5	0.36	0.36	13.0	13.26	0.00
	7	11.0			12.0			13.5			14.0			13.0		
50	1	48.5			63.0			61.5			63.0			57.0		
	2	49.0			59.0			57.5			62.0			57.0		
	3	52.0	52.52	2.79	59.5	62.61	2.08	62.0	62.71	2.57	59.0	61.39	2.21	58.0	59.86	2.03
	4	53.0			63.5			62.0			58.0			60.0		
	5	55.0			62.0			64.5			59.0			61.5		
	6	10.5	10.96	0.36	12.0	12.49	0.36	10.0	10.71	0.72	12.0	12.24	0.00	12.0	12.24	0.00
	7	11.0			12.5			11.0			12.0			12.0		
75	1	43.0			52.0			57.0			56.0			53.0		
	2	43.5			48.0			53.0			48.0			52.0		
	3	43.5	44.46	0.84	46.0	50.37	3.77	55.0	55.27	1.96	50.0	52.62	3.72	50.0	53.64	1.85
	4	43.0			46.5			52.0			49.0			55.0		
	5	45.0			54.5			54.0			55.0			53.0		
	6	9.5	9.69	0.00	10.0	10.20	0.00	11.5	11.22	0.72	11.0	11.47	0.36	10.5	10.71	0.00
	7	9.5			10.0			10.5			11.5			10.5		

Table B6

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group B (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	96.0	92.69	4.80	106.0	105.03	4.14	108.0	109.11	7.03	100.0	99.12	7.99	102.0	100.65	5.09
	2	91.5			101.0			117.0			98.5			103.0		
	3	88.0			104.0			109.0			101.0			102.0		
	4	84.5			97.0			100.0			83.5			93.5		
	5	94.5			107.0			101.0			103.0			93.0		
	6	31.0	29.32	3.24	26.0	28.04	2.16	22.5	21.92	1.44	26.5	27.79	1.08	29.0	27.79	2.52
	7	26.5			29.0			20.5			28.0			25.5		
5	1	68.5	66.49	3.84	77.0	75.76	2.92	73.5	72.91	2.52	70.0	65.95	2.08	72.0	69.65	3.63
	2	61.5			70.5			68.5			65.5			62.5		
	3	69.5			76.0			74.5			70.0			69.0		
	4	61.5			76.0			70.0			67.5			68.0		
	5	65.0			72.0			71.0			70.0			70.0		
	6	27.0	27.02	0.72	24.5	23.2	2.52	26.0	26.00	0.72	26.0	27.79	1.80	27.5	27.53	0.72
	7	26.0			21.0			25.0			28.5			26.5		
10	1	59.5	59.55	2.46	58.0	62.3	2.46	60.0	59.96	1.93	64.0	63.83	2.87	60.5	56.63	2.57
	2	57.5			63.0			56.0			61.0			55.0		
	3	61.5			64.0			58.5			65.5			57.5		
	4	55.0			60.5			58.5			58.5			59.5		
	5	58.5			60.0			61.0			64.0			55.0		
	6	24.0	22.69	2.52	22.0	21.67	1.08	17.5	18.86	1.44	23.0	23.71	0.36	20.5	20.65	0.36
	7	20.5			20.5			19.5			23.5			20.0		
25	1	54.5	57.00	2.20	61.5	61.18	2.19	55.5	60.37	2.46	61.5	61.79	2.63	58.0	60.16	1.94
	2	58.5			59.0			61.0			61.0			61.5		
	3	54.5			63.0			61.0			64.0			60.0		
	4	58.0			58.5			58.0			57.0			56.5		
	5	54.0			58.0			60.5			59.5			59.0		
	6	18.0	17.34	1.44	16.5	17.85	1.44	14.0	13.51	1.08	17.0	17.85	0.72	15.5	17.08	1.80
	7	16.0			18.5			12.5			18.0			18.0		
50	1	56.0	58.74	2.48	62.0	63.63	0.76	62.5	60.88	2.49	59.0	62.3	2.51	58.5	60.78	2.73
	2	57.5			62.5			62.0			62.0			56.0		
	3	54.5			63.5			59.0			63.5			62.5		
	4	60.0			61.5			58.0			58.0			62.0		
	5	60.0			62.5			57.0			63.0			59.0		
	6	18.0	16.83	2.16	18.0	18.61	0.36	12.0	13.77	2.16	14.0	15.3	1.44	16.0	17.34	1.44
	7	15.0			18.5			15.0			16.0			18.0		
75	1	48.5	48.74	2.24	48.0	49.15	1.82	48.0	47.93	1.49	44.0	48.84	2.51	49.5	51.19	1.47
	2	46.0			50.0			45.5			47.5			51.0		
	3	50.0			46.0			49.0			48.0			51.5		
	4	49.5			47.0			46.0			50.0			51.0		
	5	45.0			50.0			46.5			50.0			48.0		
	6	14.5	16.57	2.52	20.0	19.37	1.44	14.5	14.79	0.00	15.5	16.06	0.36	11.0	12.49	1.80
	7	18.0			18.0			14.5			16.0			13.5		

Table B7

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group B (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	104.0	99.42	4.97	110.0	99.83	8.00	109.0	104.01	5.25	104.0	102.99	5.82	95.5	101.16	4.98
	2	95.5			97.0			102.0			93.5			103.0		
	3	101.0			89.5			100.0			107.0			103.0		
	4	92.0			93.0			104.0			96.5			92.5		
	5	95.0			100.0			95.0			104.0			102.0		
	6	22.5	22.94	0.00	26.0	24.73	2.52	23.5	22.18	2.52	24.0	24.73	0.36	21.0	22.43	1.44
	7	22.5			22.5			20.0			24.5			23.0		
5	1	80.0	78.93	3.65	79.0	75.15	4.50	78.5	79.54	1.49	79.0	81.07	2.22	78.0	77.09	2.61
	2	78.0			70.0			77.5			80.0			75.5		
	3	76.0			78.0			80.0			78.0			71.5		
	4	72.0			71.0			78.0			83.0			75.5		
	5	81.0			70.5			76.0			77.5			77.5		
	6	25.0	26.00	0.72	23.5	22.69	1.80	25.0	27.02	2.16	23.0	23.71	0.36	23.0	22.94	0.72
	7	26.0			21.0			28.0			23.5			22.0		
10	1	68.0	65.98	3.74	64.5	64.45	2.35	68.0	66.59	2.49	62.0	60.16	3.97	64.5	61.90	2.94
	2	60.0			65.0			62.5			61.5			58.0		
	3	61.5			60.0			63.0			54.5			58.5		
	4	67.0			61.5			67.0			55.0			59.5		
	5	67.0			65.0			66.0			62.0			63.0		
	6	17.0	19.88	3.61	18.5	20.14	1.80	23.0	24.22	1.08	14.0	15.81	2.16	18.5	18.61	0.36
	7	22.0			21.0			24.5			17.0			18.0		
25	1	60.0	61.90	1.79	61.5	61.28	3.32	58.5	62.20	3.32	56.0	60.47	2.12	62.0	63.32	0.84
	2	62.5			57.5			64.0			60.5			61.5		
	3	58.0			62.0			65.0			61.5			62.0		
	4	61.5			58.5			59.5			59.0			63.5		
	5	61.5			61.0			58.0			59.5			61.5		
	6	13.5	13.51	0.36	12.5	13.51	1.44	16.0	15.30	1.44	13.0	13.51	0.36	18.5	17.59	1.80
	7	13.0			14.0			14.0			13.5			16.0		
50	1	55.5	55.98	0.98	57.5	56.49	1.41	55.0	53.43	1.99	55.5	57.31	3.22	57.0	58.53	2.15
	2	53.5			56.0			53.0			59.5			58.0		
	3	55.0			54.0			53.0			53.0			59.5		
	4	54.5			55.0			50.0			53.5			58.5		
	5	56.0			54.5			51.0			59.5			54.0		
	6	10.5	10.71	0.00	12.5	11.73	1.44	12.5	12.75	0.00	11.5	11.22	0.72	13.5	13.77	0.00
	7	10.5			10.5			12.5			10.5			13.5		
75	1	49.5	48.13	2.03	45.0	47.82	1.85	48.5	46.80	2.76	42.0	45.68	3.01	45.5	48.03	1.50
	2	44.5			47.5			43.0			48.0			45.5		
	3	48.5			48.0			48.0			48.0			48.5		
	4	46.0			45.0			43.0			43.0			48.0		
	5	47.5			49.0			47.0			43.0			48.0		
	6	10.0	10.71	0.72	12.0	12.24	0.00	12.0	11.98	0.36	13.0	12.75	0.72	13.5	13.00	1.08
	7	11.0			12.0			11.5			12.0			12.0		

Table B8

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group C (with bleach)*

		Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
Wash Interval	Location	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	52.0	51.50	2.16	50.0	50.73	0.36	45.0	46.14	0.36	78.5	78.77	1.80	82.0	82.09	2.16
	7	49.0			49.5			45.5			76.0			79.0		
5	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	44.5	48.18	3.97	56.0	58.38	1.80	85.0	86.42	0.36	55.0	58.12	2.88	65.5	63.99	3.97
	7	50.0			58.5			84.5			59.0			60.0		
10	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	48.0	48.95	0.00	47.5	49.97	2.16	66.5	65.26	3.61	50.0	53.54	3.61	51.0	54.04	2.88
	7	48.0			50.5			61.5			55.0			55.0		
25	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	47.0	46.91	1.44	41.5	42.06	0.36	58.5	60.67	1.44	49.0	49.46	0.72	52.0	51.75	1.80
	7	45.0			41.0			60.5			48.0			49.5		
50	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	43.5	43.08	1.80	43.0	43.08	1.08	43.0	43.59	0.36	41.5	42.57	0.36	43.5	44.10	0.36
	7	41.0			41.5			42.5			42.0			43.0		
75	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	54.0	53.54	2.16	32.0	31.61	1.44	42.0	42.83	0.00	36.0	36.45	0.36	34.0	36.71	2.88
	7	51.0			30.0			42.0			35.5			38.0		

Table B9

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group C (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
0 (initial)	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	78.0	77.5	2.88	75.0	76.22	0.36	83.5	88.46	4.69	82.0	85.15	2.16	77.0	78.52	0.00
	7	74.0			74.5			90.0			85.0			77.0		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
5	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	67.5	69.61	1.07	53.5	57.36	3.97	65.5	65.26	2.16	68.0	68.32	1.44	73.5	75.71	1.08
	7	69.0			59.0			62.5			66.0			75.0		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
10	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	65.0	69.09	3.97	52.5	55.83	3.24	55.0	54.55	2.16	57.0	55.57	3.61	51.0	53.79	2.52
	7	70.5			57.0			52.0			52.0			54.5		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
25	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	69.5	70.62	0.36	62.5	62.71	1.44	55.5	57.61	1.44	53.5	54.81	0.36	52.5	52.77	1.08
	7	69.0			60.5			57.5			54.0			51.0		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
50	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	40.0	41.3	0.72	50.0	50.22	1.08	50.0	50.99	0.00	44.5	45.63	0.36	43.5	42.83	2.16
	7	41.0			48.5			50.0			45.0			40.5		
	1	75.0			78.0			70.0			76.0			80.0		
	2	76.5			75.0			69.0			76.0			86.0		
	3	72.0	74.64	2.61	70.5	75.66	2.90	77.0	73.01	3.50	74.5	76.99	0.72	81.0	84.64	2.88
75	4	70.0			72.5			69.0			75.0			82.0		
	5	72.5			75.0			73.0			76.0			86.0		
	6	29.0	30.08	0.72	25.0	28.04	3.61	31.0	31.1	0.72	30.5	30.85	0.36	26.0	27.53	1.44
	7	30.0			30.0			30.0			30.0			28.0		

Table B10

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group D (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	71.0	74.44	2.88	82.0	80.81	3.97	68.5	70.62	1.08	81.5	82.60	0.72	60.0	61.18	0.00
	7	75.0			76.5			70.0			80.5			60.0		
5	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	78.0	78.26	1.80	70.0	71.38	0.00	73.0	75.97	2.16	75.0	75.46	1.44	76.0	78.77	1.80
	7	75.5			70.0			76.0			73.0			78.5		
10	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	60.5	61.44	0.36	54.0	53.03	2.88	46.0	46.40	0.72	47.0	47.93	0.00	55.0	57.87	2.52
	7	60.0			50.0			45.0			47.0			58.5		
25	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	47.5	47.16	1.80	42.0	44.36	2.16	48.0	47.42	2.16	43.5	42.57	2.52	53.0	52.52	2.16
	7	45.0			45.0			45.0			40.0			50.0		
50	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	29.0	29.32	0.36	29.0	28.81	1.08	35.5	36.20	0.00	34.5	34.16	1.44	30.0	30.85	0.36
	7	28.5			27.5			35.5			32.5			30.5		
75	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	40.5	41.81	0.72	38.5	40.02	1.08	38.5	40.02	1.08	40.5	41.04	0.36	43.0	44.87	1.44
	7	41.5			40.0			40.0			40.0			45.0		

Table B11

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group D (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	80.5	84.13	2.88	75.0	77.50	1.44	92.0	92.54	1.80	55.0	56.59	0.72	75.0	76.22	0.36
	7	84.5			77.0			89.5			56.0			74.5		
5	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	62.5	62.71	1.44	50.0	50.22	1.08	49.0	49.97	0.00	47.0	46.91	1.44	52.0	52.01	1.44
	7	60.5			48.5			49.0			45.0			50.0		
10	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	57.0	58.12	0.00	38.5	37.98	1.80	79.0	80.30	0.36	56.5	58.38	1.08	69.0	69.85	0.72
	7	57.0			36.0			78.5			58.0			68.0		
25	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	40.0	42.32	2.16	49.5	50.73	0.36	37.0	37.47	0.36	40.0	39.26	2.16	49.5	48.95	2.16
	7	43.0			50.0			36.5			37.0			46.5		
50	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	27.5	26.77	1.80	38.5	38.49	1.08	32.0	31.61	1.44	33.5	33.91	0.36	39.0	39.51	0.36
	7	25.0			37.0			30.0			33.0			38.5		
75	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	48.0	47.42	2.16	38.0	38.75	0.00	35.0	37.22	2.16	37.5	39.51	1.80	43.0	42.32	2.16
	7	45.0			38.0			38.0			40.0			40.0		

Table B12

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group E (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
0 (initial)	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	75.0	78.01	2.16	76.5	75.71	3.24	78.5	78.01	2.88	62.5	65.26	2.16	75.0	74.95	2.16
	7	78.0			72.0			74.5			65.5			72.0		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
5	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	65.0	64.75	2.16	65.0	65.52	1.08	66.0	66.79	0.72	60.0	61.18	0.00	63.0	65.01	1.08
	7	62.0			63.5			65.0			60.0			64.5		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
10	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	51.0	53.79	2.52	43.5	42.57	2.52	61.0	63.73	2.16	55.0	55.83	0.36	51.0	53.03	1.44
	7	54.5			40.0			64.0			54.5			53.0		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
25	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	44.0	43.59	1.80	42.5	42.06	1.80	52.5	52.77	1.08	43.0	43.34	0.72	56.0	55.06	2.88
	7	41.5			40.0			51.0			42.0			52.0		
	1	100.0			100.0			100.0			100.0			100.0		
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
50	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	29.0	28.81	1.08	37.0	37.22	0.72	36.5	35.94	1.80	32.0	31.87	1.08	34.0	33.14	2.16
	7	27.5			36.0			34.0			30.5			31.0		
	1	78.0			100.0			83.0			89.0			83.0		
	2	83.0			100.0			85.0			93.0			85.0		
	3	80.0	82.60	2.97	100.0	101.97	0.00	88.0	87.08	1.85	87.0	90.35	3.02	81.0	84.84	1.82
75	4	79.0			100.0			86.0			85.0			82.0		
	5	85.0			100.0			85.0			89.0			85.0		
	6	40.5	40.02	1.80	38.0	37.22	2.16	41.0	41.81	0.00	38.0	39.77	1.44	42.0	42.83	0.00
	7	38.0			35.0			41.0			40.0			42.0		

Table B13

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group E (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	73.5	73.16	2.52	76.5	75.20	3.97	74.5	76.22	0.36	73.0	76.99	3.61	69.5	68.07	3.97
	7	70.0			71.0			75.0			78.0			64.0		
5	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	59.0	61.18	1.44	63.0	63.73	0.72	65.5	65.52	1.80	55.5	54.30	3.24	58.0	60.16	1.44
	7	61.0			62.0			63.0			51.0			60.0		
10	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	58.0	60.16	1.44	58.0	60.16	1.44	53.5	53.28	1.80	52.0	53.03	0.00	52.0	54.04	1.44
	7	60.0			60.0			51.0			52.0			54.0		
25	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	38.0	40.25	2.16	38.0	40.79	2.88	47.0	49.46	2.16	45.0	44.87	1.44	41.5	43.08	1.08
	7	41.0			42.0			50.0			43.0			43.0		
50	1	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00	100.0	101.97	0.00
	2	100.0			100.0			100.0			100.0			100.0		
	3	100.0			100.0			100.0			100.0			100.0		
	4	100.0			100.0			100.0			100.0			100.0		
	5	100.0			100.0			100.0			100.0			100.0		
	6	30.5	29.57	2.16	32.0	32.12	0.72	33.5	32.38	2.52	30.0	30.08	0.72	27.0	27.53	0.00
	7	27.5			31.0			30.0			29.0			27.0		
75	1	100.0	100.95	2.28	94.5	493.30	2.28	100.0	101.56	0.91	100.0	96.67	4.04	100.0	101.97	0.00
	2	100.0			90.0			100.0			92.0			100.0		
	3	100.0			93.0			98.0			90.0			100.0		
	4	100.0			89.0			100.0			95.0			100.0		
	5	95.0			91.0			100.0			97.0			100.0		
	6	31.5	32.38	0.36	44.0	43.85	1.44	40.0	42.06	1.80	44.0	43.34	2.16	40.0	39.77	1.44
	7	32.0			42.0			42.5			41.0			38.0		

Table B14

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group F (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	21.5	21.82	0.43	23.5	22.84	1.27	21.5	21.41	0.51	23.0	22.13	1.12	24.0	22.94	1.49
	2	21.0			23.5			20.5			21.5			23.5		
	3	22.0			20.5			20.5			22.0			20.5		
	4	21.0			22.0			21.0			20.0			23.0		
	5	21.5			22.5			21.5			22.0			21.5		
	6	21.5	21.16	1.08	20.5	21.92	1.44	22.0	22.18	0.36	23.5	22.94	1.44	20.5	21.67	1.08
	7	20.0			22.5			21.5			21.5			22.0		
5	1	23.5	23.45	0.81	23.0	23.35	0.76	23.0	22.74	0.85	22.0	22.13	0.85	25.0	23.56	1.16
	2	22.5			22.5			21.0			21.0			23.0		
	3	23.0			24.0			22.5			21.5			22.5		
	4	22.0			22.0			22.0			21.0			22.0		
	5	24.0			23.0			23.0			23.0			23.0		
	6	21.5	22.69	1.08	21.0	22.18	1.08	23.0	22.94	0.72	25.0	24.98	0.72	23.5	23.45	0.72
	7	23.0			22.5			22.0			24.0			22.5		
10	1	23.5	23.25	0.77	23.5	22.94	0.81	23.0	23.15	0.93	22.5	22.74	0.85	22.0	23.45	1.02
	2	23.5			21.5			22.5			22.0			22.0		
	3	23.0			22.5			21.5			23.0			24.0		
	4	22.0			23.0			22.5			21.0			23.0		
	5	22.0			22.0			24.0			23.0			24.0		
	6	20.0	20.90	0.72	21.0	21.92	0.72	19.5	21.16	1.80	22.0	22.43	0.00	24.0	23.96	0.72
	7	21.0			22.0			22.0			22.0			23.0		
25	1	20.0	21.31	0.56	22.0	21.11	0.99	21.0	20.90	0.62	19.0	20.70	0.85	21.5	21.11	0.77
	2	21.0			20.0			19.5			20.0			20.0		
	3	21.0			20.0			20.5			21.0			20.5		
	4	21.0			20.0			21.0			21.0			20.0		
	5	21.5			21.5			20.5			20.5			21.5		
	6	20.5	21.16	0.36	21.0	20.65	1.08	21.0	20.90	0.72	19.0	19.88	0.72	22.0	21.41	1.44
	7	21.0			19.5			20.0			20.0			20.0		
50	1	21.0	20.90	1.49	21.0	20.60	0.58	21.0	20.90	0.95	21.0	20.60	0.85	20.0	21.21	0.77
	2	18.0			20.0			19.5			20.0			20.5		
	3	21.5			20.5			21.5			20.0			20.5		
	4	20.5			20.0			19.5			19.0			21.0		
	5	21.5			19.5			21.0			21.0			22.0		
	6	20.0	20.65	0.36	20.0	20.65	0.36	20.5	20.91	0.00	20.0	20.39	0.00	19.0	19.88	0.72
	7	20.5			20.5			20.5			20.0			20.0		
75	1	18.5	19.37	1.49	20.0	19.99	0.56	21.0	21.11	0.68	18.5	19.37	0.36	19.0	20.29	0.76
	2	20.0			19.0			20.0			19.0			20.0		
	3	21.0			20.0			21.0			19.5			19.5		
	4	17.5			19.0			20.0			19.0			21.0		
	5	18.0			20.0			21.5			19.0			20.0		
	6	19.0	19.63	0.36	19.5	19.37	0.72	17.5	19.12	1.80	20.0	19.63	1.08	18.5	18.86	0.00
	7	19.5			18.5			20.0			18.5			18.5		

Table B15

AATCC TM 127– 2017 (2018)e *Water Resistance: Hydrostatic Pressure Test, Sample Group F (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*	Average Pressure (mBar)	Average Height (cm vs. mBar)	*SD*
0 (initial)	1	21.0	23.43	0.81	22.0	22.54	0.56	22.5	22.13	1.38	22.0	22.13	0.99	20.0	21.21	0.77
	2	22.0			22.0			21.0			20.0			22.0		
	3	21.5			21.5			20.0			22.0			20.5		
	4	23.0			22.0			21.5			22.5			21.0		
	5	22.5			23.0			23.5			22.0			20.5		
	6	22.0	22.18	0.36	21.0	22.43	1.44	22.0	22.18	0.36	23.0	23.20	0.36	22.0	22.69	0.36
	7	21.5			23.0			21.5			22.5			22.5		
5	1	22.0	22.84	0.66	22.5	22.33	1.22	23.0	23.05	0.98	21.5	23.05	1.16	22.0	22.94	1.44
	2	23.0			23.0			23.0			21.5			24.0		
	3	21.5			21.5			23.5			22.5			24.0		
	4	23.0			20.0			22.5			24.0			21.5		
	5	22.5			22.5			21.0			23.5			21.0		
	6	21.0	21.41	0.00	21.0	22.43	1.44	21.5	22.18	0.36	20.5	21.92	1.44	23.0	23.71	0.36
	7	21.0			23.0			22.0			22.5			23.5		
10	1	24.0	23.96	0.72	24.0	23.56	0.91	25.0	24.27	1.17	24.0	23.56	0.91	22.5	23.66	0.85
	2	22.5			22.5			23.0			24.0			23.5		
	3	24.0			23.0			23.5			22.5			23.0		
	4	24.0			22.0			22.5			23.0			24.5		
	5	23.0			24.0			25.0			22.0			22.5		
	6	23.5	24.47	0.72	21.5	22.69	1.08	20.5	22.43	2.16	20.0	21.92	2.16	23.5	24.47	0.72
	7	24.5			23.0			23.5			23.0			24.5		
25	1	20.5	21.11	0.46	20.0	20.39	0.95	20.0	20.29	0.76	20.5	20.70	1.06	20.5	20.39	0.81
	2	21.0			18.5			20.0			22.0			19.5		
	3	21.0			20.0			19.0			19.5			21.0		
	4	20.0			21.0			19.5			20.0			20.0		
	5	21.0			20.5			21.0			19.5			19.0		
	6	21.0	20.90	0.72	19.5	20.14	0.36	19.5	20.39	0.72	20.0	20.14	0.36	19.5	20.14	0.36
	7	20.0			20.0			20.5			19.5			20.0		
50	1	20.0	19.78	0.98	19.0	18.66	0.46	18.0	18.86	0.51	18.0	18.35	0.62	17.0	18.46	0.76
	2	18.0			18.0			18.0			17.5			18.0		
	3	19.0			18.0			19.0			17.5			18.5		
	4	20.5			18.5			19.0			18.0			19.0		
	5	19.5			18.0			18.5			19.0			18.0		
	6	18.5	19.12	0.36	17.0	17.34	0.00	18.0	18.61	0.36	19.5	19.63	0.36	18.5	18.61	0.36
	7	19.0			17.0			18.5			19.0			18.0		
75	1	20.5	20.29	0.91	19.0	19.48	0.23	20.0	20.09	0.46	20.0	19.88	1.02	18.0	19.37	0.81
	2	19.0			19.0			20.0			21.0			18.5		
	3	19.0			19.0			20.0			19.0			19.5		
	4	20.0			19.5			19.5			18.5			19.0		
	5	21.0			19.0			19.0			19.0			20.0		
	6	20.0	20.39	0.00	17.5	18.10	0.36	18.0	18.61	0.36	18.5	18.86	0.00	18.5	19.37	0.72
	7	20.0			18.0			18.5			18.5			19.5		

Table B16

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group A (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.03	0.05	0.02	0.02	0.04	0.03	0.03	0.05	0.02	0.01	0.05	0.03	0.04	0.04	0.00
	2	0.07			0.03			0.04			0.05			0.04		
	3	0.03			0.03			0.04			0.04			0.05		
	4	0.07			0.05			0.05			0.08			0.04		
	5	0.07			0.09			0.08			0.06			0.04		
	6	0.05	0.06	0.01	0.04	0.07	0.04	0.03	0.03	0.01	0.03	0.03	0.00	0.04	0.04	0.01
	7	0.07			0.10			0.02			0.03			0.03		
5	1	0.06	0.05	0.02	0.04	0.04	0.01	0.05	0.04	0.01	0.03	0.03	0.01	0.04	0.05	0.01
	2	0.03			0.06			0.04			0.03			0.05		
	3	0.03			0.04			0.05			0.04			0.06		
	4	0.06			0.04			0.03			0.03			0.06		
	5	0.07			0.03			0.03			0.04			0.03		
	6	0.02	0.02	0.00	0.05	0.03	0.03	0.04	0.05	0.01	0.04	0.04	0.00	0.04	0.04	0.00
	7	0.02			0.01			0.05			0.04			0.04		
10	1	0.03	0.04	0.01	0.06	0.05	0.01	0.03	0.04	0.01	0.05	0.04	0.01	0.04	0.05	0.03
	2	0.02			0.06			0.03			0.03			0.03		
	3	0.04			0.07			0.04			0.04			0.03		
	4	0.04			0.04			0.05			0.05			0.04		
	5	0.05			0.04			0.04			0.04			0.11		
	6	0.02	0.03	0.01	0.05	0.04	0.01	0.05	0.04	0.01	0.04	0.04	0.00	0.00	0.03	0.04
	7	0.04			0.03			0.03			0.04			0.05		
25	1	0.04	0.04	0.01	0.04	0.03	0.01	0.04	0.04	0.00	0.05	0.04	0.01	0.03	0.04	0.01
	2	0.05			0.03			0.04			0.04			0.03		
	3	0.04			0.03			0.03			0.04			0.05		
	4	0.04			0.04			0.04			0.03			0.04		
	5	0.03			0.03			0.04			0.03			0.04		
	6	0.05	0.06	0.01	0.04	0.05	0.01	0.03	0.05	0.02	0.03	0.03	0.00	0.04	0.05	0.01
	7	0.07			0.06			0.06			0.03			0.05		
50	1	0.03	0.04	0.02	0.03	0.03	0.00	0.04	0.02	0.01	0.03	0.03	0.01	0.02	0.02	0.01
	2	0.04			0.03			0.02			0.03			0.03		
	3	0.03			0.03			0.01			0.02			0.02		
	4	0.02			0.03			0.02			0.03			0.02		
	5	0.06			0.03			0.03			0.02			0.03		
	6	0.00	0.03	0.04	0.03	0.04	0.01	0.03	0.04	0.01	0.02	0.03	0.01	0.03	0.03	0.00
	7	0.05			0.04			0.04			0.03			0.03		
75	1	0.04	0.04	0.00	0.00	0.03	0.02	0.06	0.03	0.02	0.03	0.04	0.01	0.04	0.04	0.01
	2	0.04			0.04			0.03			0.05			0.03		
	3	0.04			0.05			0.04			0.04			0.05		
	4	0.03			0.04			0.02			0.04			0.02		
	5	0.04			0.01			0.02			0.03			0.04		
	6	0.04	0.06	0.02	0.05	0.06	0.01	0.04	0.05	0.01	0.04	0.04	0.00	0.05	0.06	0.01
	7	0.07			0.06			0.06			0.04			0.06		

Table B17

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group A (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.03	0.04	0.02	0.04	0.04	0.01	0.01	0.03	0.02	0.02	0.02	0.00	0.03	0.03	0.02
	2	0.07			0.05			0.03			0.02			0.06		
	3	0.03			0.02			0.05			0.02			0.03		
	4	0.04			0.03			0.04			0.01			0.02		
	5	0.02			0.04			0.04			0.02			0.03		
	6	0.05	0.04	0.01	0.02	0.04	0.02	0.04	0.03	0.01	0.02	0.02	0.01	0.02	0.02	0.01
	7	0.03			0.05			0.02			0.01			0.01		
5	1	0.05	0.05	0.00	0.04	0.04	0.00	0.03	0.04	0.01	0.04	0.04	0.00	0.05	0.05	0.00
	2	0.05			0.05			0.02			0.04			0.05		
	3	0.05			0.04			0.04			0.05			0.05		
	4	0.05			0.04			0.05			0.04			0.05		
	5	0.04			0.04			0.04			0.04			0.04		
	6	0.04	0.04	0.00	0.04	0.04	0.00	0.00	0.01	0.01	0.02	0.04	0.02	0.03	0.04	0.01
	7	0.04			0.04			0.02			0.05			0.05		
10	1	0.04	0.04	0.00	0.06	0.03	0.02	0.04	0.04	0.02	0.02	0.04	0.01	0.00	0.03	0.02
	2	0.05			0.04			0.03			0.04			0.05		
	3	0.04			0.01			0.07			0.05			0.04		
	4	0.04			0.03			0.02			0.05			0.04		
	5	0.04			0.02			0.02			0.03			0.04		
	6	0.06	0.06	0.01	0.02	0.04	0.02	0.06	0.08	0.02	0.03	0.04	0.01	0.04	0.05	0.01
	7	0.05			0.05			0.09			0.04			0.05		
25	1	0.04	0.03	0.01	0.04	0.03	0.01	0.02	0.03	0.01	0.03	0.04	0.01	0.03	0.03	0.01
	2	0.03			0.04			0.03			0.03			0.03		
	3	0.04			0.03			0.03			0.04			0.03		
	4	0.03			0.03			0.04			0.05			0.03		
	5	0.02			0.02			0.03			0.04			0.05		
	6	0.10	0.09	0.02	0.05	0.05	0.00	0.04	0.04	0.01	0.05	0.06	0.01	0.06	0.06	0.01
	7	0.07			0.05			0.03			0.07			0.05		
50	1	0.04	0.04	0.01	0.03	0.03	0.01	0.04	0.03	0.01	0.03	0.03	0.01	0.02	0.02	0.01
	2	0.04			0.04			0.04			0.04			0.03		
	3	0.04			0.03			0.02			0.04			0.03		
	4	0.04			0.02			0.03			0.03			0.02		
	5	0.02			0.04			0.04			0.03			0.01		
	6	0.10	0.10	0.01	0.10	0.09	0.01	0.06	0.08	0.02	0.06	0.06	0.01	0.04	0.04	0.00
	7	0.09			0.08			0.09			0.05			0.04		
75	1	0.07	0.05	0.02	0.05	0.04	0.01	0.03	0.04	0.01	0.06	0.04	0.01	0.03	0.04	0.01
	2	0.07			0.05			0.05			0.04			0.04		
	3	0.05			0.04			0.04			0.04			0.06		
	4	0.03			0.03			0.05			0.04			0.04		
	5	0.02			0.04			0.04			0.03			0.03		
	6	0.25	0.26	0.01	0.09	0.10	0.01	0.11	0.10	0.02	0.22	0.23	0.01	0.11	0.15	0.05
	7	0.27			0.10			0.08			0.24			0.18		

Table B18

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group B (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
	1	0.00			0.02			0.02			0.04			0.03		
	2	0.00			0.04			0.04			0.05			0.04		
	3	0.05	0.03	0.03	0.04	0.04	0.01	0.03	0.03	0.01	0.03	0.04	0.01	0.04	0.03	0.01
0 (initial)	4	0.02			0.06			0.04			0.03			0.02		
	5	0.06			0.05			0.04			0.03			0.03		
	6	0.05	0.06	0.01	0.04	0.04	0.00	0.04	0.04	0.00	0.03	0.02	0.02	0.03	0.03	0.00
	7	0.06			0.04			0.04			0.00			0.03		
	1	0.05			0.05			0.05			0.05			0.04		
	2	0.04			0.06			0.05			0.01			0.03		
	3	0.04	0.05	0.01	0.06	0.05	0.01	0.05	0.05	0.00	0.03	0.03	0.02	0.04	0.05	0.01
5	4	0.06			0.05			0.05			0.04			0.06		
	5	0.04			0.05			0.04			0.04			0.06		
	6	0.04	0.05	0.01	0.05	0.05	0.00	0.05	0.04	0.01	0.04	0.04	0.00	0.03	0.04	0.01
	7	0.05			0.05			0.03			0.04			0.04		
	1	0.06			0.03			0.06			0.03			0.06		
	2	0.04			0.03			0.05			0.04			0.06		
	3	0.02	0.04	0.01	0.05	0.03	0.01	0.03	0.05	0.01	0.05	0.04	0.01	0.02	0.04	0.02
10	4	0.05			0.03			0.05			0.04			0.05		
	5	0.04			0.03			0.06			0.06			0.01		
	6	0.06	0.04	0.03	0.03	0.05	0.03	0.03	0.03	0.01	0.03	0.04	0.01	0.04	0.04	0.01
	7	0.02			0.07			0.02			0.04			0.03		
	1	0.03			0.04			0.04			0.05			0.04		
	2	0.05			0.04			0.04			0.04			0.04		
	3	0.05	0.04	0.01	0.04	0.04	0.01	0.05	0.04	0.01	0.04	0.04	0.01	0.04	0.04	0.01
25	4	0.05			0.05			0.05			0.05			0.05		
	5	0.04			0.05			0.04			0.04			0.05		
	6	0.03	0.04	0.01	0.04	0.04	0.00	0.03	0.04	0.01	0.04	0.04	0.01	0.04	0.04	0.01
	7	0.05			0.04			0.04			0.03			0.03		
	1	0.05			0.03			0.03			0.04			0.04		
	2	0.04			0.03			0.05			0.03			0.04		
	3	0.02	0.04	0.01	0.04	0.03	0.01	0.03	0.03	0.01	0.02	0.03	0.01	0.03	0.03	0.01
50	4	0.04			0.03			0.02			0.04			0.03		
	5	0.04			0.02			0.04			0.02			0.03		
	6	0.03	0.03	0.00	0.03	0.03	0.00	0.03	0.03	0.00	0.02	0.02	0.00	0.03	0.03	0.00
	7	0.03			0.03			0.03			0.02			0.03		
	1	0.05			0.02			0.03			0.05			0.03		
	2	0.03			0.04			0.04			0.03			0.05		
	3	0.04	0.04	0.01	0.04	0.03	0.01	0.04	0.04	0.01	0.04	0.04	0.01	0.04	0.04	0.01
75	4	0.04			0.04			0.04			0.03			0.03		
	5	0.04			0.03			0.03			0.05			0.03		
	6	0.03	0.04	0.01	0.01	0.03	0.02	0.03	0.03	0.00	0.03	0.04	0.01	0.03	0.04	0.01
	7	0.04			0.04			0.03			0.04			0.05		

Table B19

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group B (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.02	0.03	0.03	0.00	0.02	0.01	0.01	0.03	0.01	0.03	0.02	0.01	0.04	0.03	0.02
	2	0.00			0.02			0.02			0.00			0.05		
	3	0.08			0.03			0.03			0.03			0.00		
	4	0.04			0.03			0.03			0.01			0.02		
	5	0.00			0.01			0.05			0.03			0.03		
	6	0.01	0.01	0.00	0.04	0.03	0.01	0.01	0.02	0.01	0.05	0.04	0.02	0.03	0.03	0.00
	7	0.01			0.02			0.02			0.02			0.03		
5	1	0.06	0.05	0.01	0.05	0.05	0.01	0.07	0.06	0.01	0.06	0.05	0.01	0.04	0.05	0.01
	2	0.04			0.05			0.06			0.06			0.03		
	3	0.05			0.04			0.07			0.06			0.04		
	4	0.05			0.05			0.05			0.04			0.06		
	5	0.04			0.06			0.04			0.05			0.06		
	6	0.04	0.04	0.01	0.05	0.06	0.01	0.04	0.05	0.01	0.04	0.04	0.00	0.05	0.04	0.01
	7	0.03			0.06			0.05			0.04			0.03		
10	1	0.07	0.05	0.01	0.04	0.04	0.02	0.05	0.03	0.02	0.07	0.06	0.01	0.01	0.02	0.01
	2	0.04			0.08			0.02			0.04			0.04		
	3	0.06			0.02			0.01			0.06			0.02		
	4	0.05			0.04			0.03			0.07			0.02		
	5	0.04			0.04			0.05			0.05			0.03		
	6	0.03	0.04	0.01	0.04	0.06	0.02	0.02	0.03	0.01	0.04	0.04	0.00	0.04	0.05	0.01
	7	0.04			0.07			0.04			0.04			0.05		
25	1	0.04	0.04	0.01	0.04	0.04	0.01	0.04	0.04	0.00	0.02	0.04	0.01	0.04	0.04	0.01
	2	0.03			0.03			0.03			0.05			0.05		
	3	0.05			0.06			0.04			0.05			0.04		
	4	0.04			0.05			0.04			0.04			0.05		
	5	0.05			0.04			0.04			0.03			0.04		
	6	0.03	0.04	0.01	0.05	0.05	0.01	0.04	0.04	0.01	0.05	0.04	0.01	0.03	0.04	0.01
	7	0.04			0.04			0.03			0.03			0.04		
50	1	0.02	0.03	0.01	0.03	0.03	0.01	0.04	0.04	0.01	0.04	0.03	0.01	0.03	0.03	0.01
	2	0.04			0.04			0.03			0.02			0.03		
	3	0.04			0.03			0.04			0.03			0.02		
	4	0.02			0.04			0.03			0.04			0.04		
	5	0.03			0.03			0.04			0.04			0.03		
	6	0.03	0.03	0.00	0.02	0.03	0.01	0.03	0.03	0.00	0.04	0.04	0.01	0.02	0.03	0.01
	7	0.03			0.04			0.03			0.03			0.04		
75	1	0.01	0.05	0.02	0.05	0.05	0.01	0.10	0.07	0.02	0.04	0.06	0.01	0.06	0.05	0.01
	2	0.05			0.07			0.06			0.05			0.04		
	3	0.05			0.04			0.07			0.06			0.07		
	4	0.07			0.04			0.07			0.07			0.04		
	5	0.06			0.05			0.06			0.06			0.06		
	6	0.07	0.07	0.00	0.07	0.07	0.00	0.07	0.06	0.02	0.05	0.06	0.01	0.06	0.06	0.00
	7	0.07			0.07			0.04			0.07			0.06		

Table B20

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group C (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.02	0.02	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	7	0.01			0.00			0.00			0.01			0.00		
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.01			0.00			0.00			0.00		
25	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
50	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.01			0.00			0.01			0.00		
	3	0.00			0.00			0.01			0.00			0.00		
	4	0.01			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
75	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.01			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		

Table B21

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group C (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
5	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.01			0.01			0.00			0.00			0.00		
10	1	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.01			0.00			0.01			0.00			0.00		
	5	0.00			0.01			0.00			0.00			0.00		
	6	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.01			0.00			0.00			0.00			0.00		
25	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.01			0.00			0.00		
	3	0.00			0.00			0.00			0.01			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.02	0.02	0.01
	7	0.00			0.00			0.00			0.01			0.01		
50	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.01			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
75	1	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	2	0.00			0.00			0.01			0.00			0.00		
	3	0.01			0.01			0.01			0.01			0.00		
	4	0.00			0.01			0.01			0.01			0.01		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		

Table B22

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group D (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.01			0.00			0.00			0.00		
	4	0.00			0.00			0.01			0.01			0.00		
	5	0.00			0.00			0.00			0.00			0.01		
	6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
5	1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	2	0.00			0.01			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
25	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00
	2	0.01			0.00			0.01			0.00			0.00		
	3	0.00			0.00			0.00			0.01			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
50	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.01			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
75	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		

Table B23

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group D (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.01			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.01			0.00			0.00			0.00			0.00		
5	1	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.01			0.01			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.01			0.00			0.00			0.00		
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	7	0.00			0.00			0.00			0.00			0.00		
25	1	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.01			0.00			0.01		
	3	0.02			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
50	1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
75	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.01			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		

Table B24

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group E (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
	1	0.00			0.00			0.00			0.00			0.00		
	2	0.00			0.01			0.00			0.01			0.00		
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0 (initial)	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
	1	0.00			0.01			0.01			0.01			0.00		
	2	0.00			0.00			0.01			0.01			0.00		
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00
5	4	0.00			0.00			0.00			0.01			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
	1	0.00			0.00			0.00			0.00			0.00		
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
	1	0.00			0.00			0.00			0.00			0.00		
	2	0.00			0.00			0.00			0.00			0.01		
	3	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
	7	0.00			0.00			0.00			0.00			0.00		
	1	0.00			0.00			0.00			0.00			0.01		
	2	0.01			0.00			0.00			0.00			0.00		
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
	1	0.00			0.00			0.00			0.00			0.00		
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		

Table B25

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group E (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.01			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
5	1	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
10	1	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.01			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
25	1	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01	0.01	0.01	0.00	0.00
	2	0.01			0.01			0.00			0.01			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
50	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.01			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		
75	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00			0.00			0.00			0.00			0.00		
	3	0.00			0.00			0.00			0.00			0.00		
	4	0.00			0.00			0.00			0.00			0.00		
	5	0.00			0.00			0.00			0.00			0.00		
	6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	7	0.00			0.00			0.00			0.00			0.00		

Table B26

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group F (with bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.10	0.08	0.02	0.08	0.07	0.01	0.07	0.09	0.04	0.08	0.08	0.02	0.09	0.07	0.03
	2	0.06			0.06			0.08			0.07			0.05		
	3	0.07			0.06			0.07			0.07			0.05		
	4	0.08			0.05			0.05			0.06			0.06		
	5	0.10			0.08			0.16			0.11			0.12		
	6	0.04	0.04	0.01	0.04	0.04	0.00	0.03	0.03	0.00	0.03	0.04	0.01	0.04	0.04	0.01
	7	0.03			0.04			0.03			0.05			0.03		
5	1	0.08	0.09	0.04	0.06	0.07	0.02	0.04	0.05	0.02	0.05	0.04	0.01	0.08	0.09	0.02
	2	0.07			0.06			0.05			0.03			0.06		
	3	0.06			0.07			0.05			0.04			0.08		
	4	0.08			0.05			0.04			0.05			0.10		
	5	0.16			0.11			0.08			0.02			0.11		
	6	0.04	0.03	0.02	0.04	0.04	0.00	0.02	0.03	0.01	0.04	0.05	0.01	0.03	0.05	0.02
	7	0.01			0.04			0.03			0.05			0.06		
10	1	0.07	0.06	0.01	0.05	0.07	0.03	0.06	0.07	0.02	0.07	0.06	0.02	0.12	0.08	0.03
	2	0.05			0.05			0.07			0.05			0.07		
	3	0.06			0.09			0.06			0.07			0.06		
	4	0.05			0.03			0.05			0.04			0.05		
	5	0.06			0.11			0.09			0.09			0.09		
	6	0.05	0.05	0.01	0.03	0.05	0.03	0.03	0.04	0.01	0.04	0.04	0.00	0.07	0.05	0.03
	7	0.04			0.07			0.04			0.04			0.03		
25	1	0.08	0.10	0.06	0.06	0.09	0.02	0.07	0.07	0.02	0.07	0.09	0.02	0.05	0.08	0.03
	2	0.08			0.10			0.05			0.07			0.06		
	3	0.07			0.08			0.08			0.12			0.08		
	4	0.06			0.10			0.07			0.07			0.07		
	5	0.21			0.12			0.10			0.11			0.13		
	6	0.06	0.07	0.01	0.03	0.03	0.00	0.05	0.05	0.01	0.05	0.06	0.01	0.04	0.04	0.00
	7	0.07			0.03			0.04			0.06			0.04		
50	1	0.10	0.12	0.05	0.07	0.11	0.05	0.07	2.46	5.33	0.10	0.08	0.03	0.08	0.12	0.08
	2	0.07			0.07			0.07			0.05			0.06		
	3	0.10			0.11			0.10			0.06			0.08		
	4	0.11			0.18			12.00			0.11			0.12		
	5	0.21			0.14			0.08			0.08			0.25		
	6	0.08	0.07	0.02	0.04	0.04	0.00	0.04	0.06	0.02	0.07	0.07	0.01	0.05	0.06	0.01
	7	0.05			0.04			0.07			0.06			0.06		
75	1	0.07	0.12	0.06	0.10	0.12	0.03	0.06	0.07	0.03	0.09	0.10	0.02	0.09	0.09	0.05
	2	0.07			0.08			0.04			0.07			0.05		
	3	0.10			0.12			0.11			0.10			0.08		
	4	0.13			0.13			0.07			0.12			0.07		
	5	0.22			0.16			0.08			0.13			0.18		
	6	0.04	0.04	0.01	0.05	0.04	0.02	0.04	0.04	0.01	0.07	0.05	0.03	0.05	0.06	0.01
	7	0.03			0.02			0.03			0.03			0.06		

Table B27

AATCC TM 42 – 2017e *Water Resistance: Impact Penetration Test*, *Sample Group F (without bleach)*

Wash Interval	Location	Gown 1			Gown 2			Gown 3			Gown 4			Gown 5		
		Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*	Increase in Blotting Paper Weight (g)	Average Increase (g)	*SD*
0 (initial)	1	0.08	0.08	0.04	0.08	0.07	0.01	0.07	0.06	0.02	0.06	0.07	0.02	0.09	0.09	0.02
	2	0.06			0.06			0.04			0.06			0.07		
	3	0.08			0.06			0.06			0.06			0.08		
	4	0.05			0.06			0.05			0.05			0.07		
	5	0.15			0.07			0.10			0.11			0.12		
	6	0.03	0.05	0.02	0.04	0.04	0.01	0.04	0.04	0.00	0.03	0.04	0.01	0.03	0.04	0.01
	7	0.06			0.03			0.04			0.04			0.04		
5	1	0.08	0.07	0.01	0.07	0.10	0.04	0.03	0.06	0.02	0.07	0.06	0.00	0.08	0.11	0.03
	2	0.07			0.10			0.07			0.06			0.09		
	3	0.06			0.07			0.06			0.06			0.09		
	4	0.07			0.07			0.08			0.06			0.14		
	5	0.06			0.17			0.07			0.06			0.13		
	6	0.04	0.05	0.01	0.04	0.05	0.01	0.06	0.06	0.00	0.06	0.05	0.02	0.03	0.04	0.01
	7	0.05			0.06			0.06			0.03			0.05		
10	1	0.07	0.08	0.02	0.12	0.09	0.03	0.08	0.08	0.02	0.08	0.08	0.01	0.06	0.09	0.03
	2	0.08			0.07			0.05			0.06			0.08		
	3	0.07			0.08			0.09			0.09			0.08		
	4	0.05			0.07			0.07			0.08			0.13		
	5	0.11			0.13			0.09			0.08			0.08		
	6	0.05	0.06	0.01	0.06	0.07	0.01	0.04	0.05	0.01	0.06	0.06	0.01	0.05	0.04	0.01
	7	0.06			0.07			0.05			0.05			0.03		
25	1	0.05	0.07	0.03	0.06	0.09	0.02	0.10	0.08	0.02	0.08	0.09	0.05	0.11	0.11	0.03
	2	0.05			0.07			0.07			0.07			0.08		
	3	0.04			0.12			0.07			0.05			0.10		
	4	0.09			0.09			0.07			0.07			0.11		
	5	0.11			0.09			0.11			0.17			0.16		
	6	0.02	0.03	0.01	0.07	0.06	0.01	0.04	0.05	0.01	0.04	0.04	0.00	0.03	0.05	0.02
	7	0.03			0.05			0.05			0.04			0.06		
50	1	0.08	0.11	0.06	0.10	0.10	0.04	0.10	0.08	0.02	0.08	0.10	0.02	0.07	0.13	0.05
	2	0.06			0.05			0.06			0.08			0.09		
	3	0.09			0.08			0.09			0.11			0.11		
	4	0.09			0.14			0.08			0.12			0.19		
	5	0.21			0.13			0.09			0.11			0.18		
	6	0.00	0.03	0.04	0.05	0.05	0.01	0.06	0.06	0.01	0.05	0.05	0.00	0.04	0.05	0.01
	7	0.06			0.04			0.05			0.05			0.05		
75	1	0.08	0.08	0.04	0.14	0.13	0.04	0.10	0.08	0.02	0.11	0.11	0.02	0.12	0.13	0.04
	2	0.06			0.07			0.07			0.09			0.09		
	3	0.13			0.13			0.10			0.12			0.18		
	4	0.02			0.15			0.06			0.14			0.16		
	5	0.11			0.16			0.09			0.10			0.12		
	6	0.05	0.06	0.01	0.04	0.05	0.01	0.05	0.06	0.01	0.06	0.05	0.02	0.04	0.06	0.02
	7	0.07			0.06			0.07			0.03			0.07		

Table B28

ASTM D5034 – 21 *Standard Test Method for Breaking Strength (Grab Test)*

Wash Interval	Specimen	A		B		C		D		E		F	
		Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)
0 (initial)	1	147.30	94.17	145.30	120.00	130.80	89.25	154.30	99.42	138.90	98.47	146.90	91.13
	2	140.80	95.30	147.40	109.50	133.40	86.28	157.90	103.40	135.60	94.35	145.20	90.55
	3	144.90	93.94	144.30	117.80	125.40	88.32	153.40	101.60	133.50	88.51	144.90	89.26
	4	144.00	93.17	145.70	122.50	127.90	79.18	153.40	99.04	141.20	95.09	146.10	89.87
	Average (lbf)	144.25	94.15	145.68	117.45	129.38	85.76	154.75	100.87	137.30	94.11	145.78	90.20
	SD	2.69	0.88	1.29	5.64	3.47	4.56	2.14	2.03	3.42	4.14	0.91	0.81
75 (with bleach)	1	133.90	95.18	147.00	124.10	145.90	89.09	144.50	83.81	143.70	95.45	83.16	140.90
	2	142.70	96.01	150.50	125.50	147.40	85.37	145.90	82.07	144.90	92.49	89.01	135.70
	3	132.10	90.22	152.40	126.80	143.60	82.95	145.20	71.27	146.50	97.57	92.34	136.80
	4	124.60	97.28	147.50	124.70	143.70	80.61	149.90	84.41	143.30	97.28	87.61	138.10
	Average (lbf)	133.33	94.67	149.35	125.28	145.15	84.51	146.38	80.39	144.60	95.70	88.03	137.88
	SD	7.44	3.09	2.55	1.17	1.84	3.62	2.42	6.16	1.44	2.34	3.80	2.24
75 (without bleach)	1	125.00	84.88	159.20	119.70	154.60	91.34	160.60	82.42	137.90	87.37	133.80	88.51
	2	123.50	80.26	152.30	114.60	153.10	86.71	155.50	83.75	134.00	71.25	135.20	82.24
	3	120.50	84.14	154.90	112.50	151.10	88.51	149.10	84.28	140.90	95.79	133.70	90.63
	4	121.40	79.92	160.33	119.40	147.70	89.91	149.60	95.57	142.00	100.40	135.40	86.15
	Average (lbf)	122.60	82.30	156.68	116.55	151.63	89.12	153.70	86.51	138.70	88.70	134.53	86.88
	SD	2.03	2.57	3.74	3.57	2.98	1.98	5.44	6.09	3.58	12.82	0.90	3.60

Table B29

ASTM D5587 – 15 Standard *Test Method for Tearing Strength of Fabrics by Trapezoid Method Procedure*

Wash Interval	Specimen	A		B		C		D		E		F	
		Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)	Warp (lbf)	Fill (lbf)
0 (initial)	1	4.98	3.68	8.82	4.52	7.77	4.11	4.37	2.87	7.39	3.81	9.78	6.33
	2	5.72	3.31	9.35	4.33	7.14	3.85	4.46	2.60	7.56	3.72	9.78	6.65
	3	6.03	3.20	9.30	4.76	7.17	4.16	4.54	2.80	7.48	3.59	9.05	6.52
	4	5.87	3.36	9.37	4.80	7.32	3.77	4.47	2.46	7.42	3.95	9.66	6.71
	5	5.62	3.69	9.91	4.08	7.65	4.04	4.44	2.51	7.46	3.82	9.03	6.35
	Average (lbf)	5.64	3.45	9.35	4.50	7.41	3.98	4.45	2.65	7.46	3.78	9.46	6.51
	SD	0.40	0.22	0.39	0.30	0.29	0.17	0.06	0.18	0.07	0.14	0.39	0.17
75 (with bleach)	1	2.42	1.68	3.39	1.73	2.89	2.01	1.74	1.31	3.98	2.41	7.15	4.74
	2	2.63	1.67	3.30	2.04	2.74	1.93	1.74	1.30	3.99	2.17	6.55	4.55
	3	2.51	1.58	3.55	2.04	2.58	1.88	1.77	1.33	4.05	2.16	6.96	4.48
	4	2.34	1.62	3.00	1.99	2.48	1.96	1.77	1.27	3.81	2.17	7.27	4.42
	5	2.47	1.59	3.08	2.03	2.62	1.90	1.84	1.28	3.96	1.99	6.65	4.55
	Average (lbf)	2.47	1.63	3.26	1.97	2.66	1.94	1.77	1.30	3.96	2.18	6.92	4.55
	SD	0.11	0.05	0.23	0.13	0.16	0.05	0.04	0.02	0.09	0.15	0.31	0.12
75 (without bleach)	1	1.83	1.44	3.40	2.04	2.65	1.93	1.83	1.34	3.74	2.42	6.40	4.23
	2	2.03	1.40	3.52	2.11	2.59	1.94	1.75	1.36	3.99	2.13	7.15	4.36
	3	1.97	1.43	3.55	2.11	2.63	1.99	1.83	1.34	4.03	2.06	7.09	4.61
	4	1.91	1.40	3.40	2.07	2.81	1.99	1.74	1.30	3.85	1.96	7.02	4.36
	5	1.91	1.34	3.45	2.13	2.75	1.93	1.71	1.27	4.03	2.16	7.21	5.06
	Average (lbf)	1.93	1.40	3.46	2.09	2.69	1.96	1.77	1.32	3.93	2.15	6.97	4.52
	SD	0.07	0.04	0.07	0.04	0.09	0.03	0.05	0.04	0.13	0.17	0.33	0.33

Table B30

ASTM D1683/D1683M – 17 *Standard Test Method for Failure in Sewn Seams of Woven Fabrics*

Wash Interval	Specimen	A (lbf)	B (lbf)	C (lbf)	D (lbf)	E (lbf)	F (lbf)
0 (initial)	1	61.80	144.60	52.83	67.54	51.67	64.22
	2	63.74	142.90	52.26	64.34	47.49	56.33
	3	60.98	145.80	50.59	70.35	45.11	50.49
	4	61.72	150.90	51.13	71.42	55.93	49.13
	5	62.33	144.80	56.34	61.48	50.39	59.77
	Average (lbf)	62.11	145.80	52.63	67.03	50.12	55.99
	SD	1.03	3.04	2.26	4.14	4.13	6.31
75 (with bleach)	1	67.21	149.30	70.71	60.49	52.46	53.01
	2	64.61	97.49	56.45	58.58	58.52	56.96
	3	64.40	92.36	60.91	60.91	66.67	59.26
	4	63.93	12.50	62.14	70.21	53.78	47.34
	5	64.82	121.70	78.44	62.77	54.36	60.05
	Average (lbf)	64.99	94.67	65.73	62.59	57.16	55.32
	SD	1.28	51.19	8.78	4.51	5.78	5.23
75 (without bleach)	1	54.66	146.70	63.21	47.61	60.85	53.63
	2	54.81	116.70	56.08	51.10	65.09	45.99
	3	55.98	111.10	57.13	54.00	66.37	48.31
	4	54.90	125.50	71.10	53.67	59.74	52.04
	5	53.25	118.10	67.41	52.82	66.38	57.94
	Average (lbf)	54.72	123.62	62.99	51.84	63.69	51.58
	SD	0.97	13.89	6.47	2.62	3.16	4.66

Table B31

ASTM D3776/D3776M – 20 *Standard Test Method for Mass Per Unit Area (Weight) of Fabric*

Sample Group	Specimen	Weight (Grams)	Weight (oz/yd²)	Average (oz/yd²)	Weight (g/m²)	Average (g/m²)
A	1	0.341	2.62	2.64	88.99	89.51
	2	0.344	2.65		89.77	
	3	0.344	2.65		89.77	
B	1	0.359	2.76	2.76	93.69	93.43
	2	0.358	2.76		93.43	
	3	0.357	2.75		93.17	
C	1	0.409	3.15	3.14	106.74	106.30
	2	0.405	3.12		105.69	
	3	0.408	3.14		106.48	
D	1	0.413	3.18	3.17	107.78	107.52
	2	0.412	3.17		107.52	
	3	0.411	3.16		107.26	
E	1	0.411	3.16	3.16	107.26	107.09
	2	0.411	3.16		107.26	
	3	0.409	3.15		106.74	
F	1	0.412	3.17	3.19	107.52	108.04
	2	0.416	3.20		108.56	
	3	0.414	3.19		108.04	

Table B32

Laundry Cycle with Bleach

Steps:	Description:	Time (min):
1	Cold Fill to High Level (90° F)	05:00
2	Wash	03:00
3	Drain	02:00
4	Cold Fill to High Level	05:00
5	Wash	03:00
6	Drain	02:00
7	Hot Fill to Low Level (140°F)	05:00
8	Detergent	00:45
9	Wash	05:00
10	Wash	05:00
11	Drain	02:00
12	Hot Fill to High Level	05:00
13	Wash	03:00
14	Drain	02:00
15	Spin	03:00
16	Warm Fill to High Level (120°F)	05:00
17	Oxygen Bleach	00:45
18	Wash	02:00
19	Drain	02:00
20	Warm Fill to High Level (100°F)	05:00
21	Wash	02:00
22	Drain	02:00
23	Cold Fill to High Level	05:00
24	Wash	02:00
25	Drain	02:00
26	Cold Fill to Low Level	05:00
27	Sour	00:45
28	Wash	05:00
29	Drain	02:00
30	Spin	03:00
DRY	Medium (140°F)	30:00

Table B32

Laundry Cycle without Bleach

Steps:	Description:	Time (min):
1	Cold Fill to High Level (90° F)	05:00
2	Wash	03:00
3	Drain	02:00
4	Cold Fill to High Level	05:00
5	Wash	03:00
6	Drain	02:00
7	Hot Fill to Low Level (160° F)	05:00
8	Detergent	00:45
9	Wash	05:00
10	Wash	05:00
11	Drain	02:00
12	Hot Fill to High Level	05:00
13	Wash	03:00
14	Drain	02:00
15	Spin	03:00
16	Warm Fill to High Level (140°F)	05:00
17	Wash	02:00
18	Drain	02:00
19	Warm Fill to High Level (120°F)	05:00
20	Wash	02:00
21	Drain	02:00
22	Cold Fill to High Level	05:00
23	Wash	02:00
24	Drain	02:00
25	Cold Fill to Low Level	05:00
26	Sour	00:45
27	Wash	05:00
28	Drain	02:00
29	Spin	03:00
DRY	Medium (140°F)	30:00

References

Association for the Advancement of Medical Instrumentation. (2018). ANSI/AAMI ST65:2008/(R)2018 Processing of reusable surgical textiles for use in health care facilities. Arlington, VA: AAMI.

Association for the Advancement of Medical Instrumentation. (2012). ANSI/AAMI PB70:2012 Liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities. Retrieved from https://www.aami.org/docs/default-source/products_store/standards/pb70_1206.pdf?sfvrsn=9d7b9544_2

American Association of Textile Chemists and Colorists. (2017). TM42-2017e test method for water resistance: impact penetration. Raleigh, NC: AATCC.

American Association of Textile Chemists and Colorists. (2018). TM127-2017(2018)e test method for water resistance: hydrostatic pressure. Raleigh, NC: AATCC.

American Society for Testing and Materials. (2017). ASTM D1230-17 standard test method for flammability of apparel textiles. West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2017). ASTM D5034-95 standard test method for breaking strength (grab test). West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2018). ASTM D1683/D1683M-17 (2018) standard test method for failure in sewn seams of woven fabrics.

American Society for Testing and Materials. (2018). ASTM D737-18 standard test method for air permeability of textile fabrics. West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2019). ASTM F3352-19 standard specification for isolation gowns intended for use in healthcare facilities. West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2019). ASTM D3776/D3776M-20 standard test methods for mass per unit area (fabric weight) of fabric. West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2019). ASTM D5587-15(2019) standard test method for tearing strength of fabrics by trapezoid method. West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2020). ASTM D1776/D1776M-20 standard practice for conditioning and testing textiles. West Conshohocken, PA: American Society for Testing and Materials.

American Society for Testing and Materials. (2021). ASTM D5034-21 standard test method for breaking strength and elongation of textile fabrics (grab test). West Conshohocken, PA: American Society for Testing and Materials.

Baykasoğlu, A., Dereli, T., & Yilankirkan, N. (2009). Application of cost/benefit analysis for surgical gown and drape selection: A case study. *American Journal of Infection Control*, *37*(3), 215–226. https://doi.org/10.1016/j.ajic.2008.10.031

Blaser, M. J., Smith, P. F., Cody, H. J., Wang, W. L. L., & LaForce, F. M. (1984). Killing of fabric-associated bacteria in hospital laundry by low temperature washing.

Journal of infectious diseases, 149(1), 48–57. https://doi.org/10.1093/infdis/149.1.48
Centers for Disease Control and Prevention. (2020). Using personal protective equipment. Retrieved from https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/isolation-gowns.html
Centers for Disease Control and Prevention (2004). Guidance for the selection and use of personal protective equipment (PPE) in healthcare settings. Retrieved from https://www.cdc.gov/hai/pdfs/ppe/ppeslides6-29-04.pdf
Centers for Disease Control and Prevention. (2003b). Guidelines for Environmental Infection Control in Health-Care Facilities. Atlanta, GA: Centers for Disease Control and Prevention (CDC). Retrieved from https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf
Centers for Disease Control and Prevention. (2019). Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings (2007). Retrieved from https://www.cdc.gov/infectioncontrol/guidelines/isolation/recommendations.html
Centers for Disease Control and Prevention. (2020, July 16). Optimizing supply of PPE and other equipment during shortages. Retrieved from https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/general-optimization-strategies.html
Conrardy, J., Hillanbrand, M., Myers, S., & Nussbaum, G. F. (2010). Reducing medical waste. *AORN journal*, 91(6), 711–721. https://doi.org/10.1016/j.aorn.2009.12.029
Cooper, A. (2017, August 6). 60 Minutes investigates medical gear sold during Ebola crisis. Retrieved from https://www.cbsnews.com/news/60-minutes-investigates-medical-gear-sold-during-ebola-crisis-3/
Da Silva, M. (2017, October 5). What is PPE? Prevention and regulation. Retrieved from https://www.hsimagazine.com/article/what-is-ppe-an-historical-overview/
Davis, D. (2000, June 1). Performance standards: measuring the effectiveness of protective clothing. Retrieved from https://www.infectioncontroltoday.com/view/performance-standards-measuring-effectiveness-protective-clothing
Food and Drug Administration. (2021). Medical gowns. Retrieved from https://www.fda.gov/medical-devices/personal-protective-equipment-infection-control/medical-gowns
Imaj, K., Ogawa, H., Buj, V.N., Inoue, H., Fukuda, J, Ohba, M, … Nakamura, K. (2012). Inactivation of high and low pathogenic avian influenza virus H5 subtypes by copper ions incorporated in zeolite-textile materials. *Antiviral research* 93, 225-233.
Jenkins, N. (2018, May 24). Importance of LCAs: now, in future (part 1). Retrieved from https://americanlaundrynews.com/articles/importance-lcas-now-future-part-1
Karim, N., Afroj, S., Lloyd, K., Oaten, L.C., Andreeva, D., Carr, C., … Novoselov, K. (2020). Sustainable personal protective clothing for healthcare applications: a review. *ACS nano*, 14, 12313 - 12340.
Kilinc F. S. (2016, January 1). Isolation gowns in health care settings: Laboratory studies, regulations and standards, and potential barriers of gown selection and use.

American journal of infection control, 44(1), 104–111. https://doi.org/10.1016/j.ajic.2015.07.042

Kilinc, F. S. (2015). A review of isolation gowns in healthcare: Fabric and gown properties. *Journal of engineered fibers and fabrics*, 10(3), 180–190.

Laurén, S. (2018) What are surfactants and how do they work? Retrieved from https://www.biolinscientific.com/blog/what-are-surfactants-and-how-do-they-work#:~:text=The%20cohesive%20forces%20between%20the,thus%20surface%20tension%20will%20decrease.

Leonas, K. K. (1998). Effect of laundering on the barrier properties of reusable surgical gown fabrics. *American journal of infection control*, 26(5), 495–501.

McCullough, E. A. (1993). Methods for determining the barrier efficacy of surgical gowns. *American journal of infection control*, 21(6), 368–374. https://doi.org/10.1016/0196-6553(93)90404-r

McQuerry, M., Easter, E., & Cao, A. (2021). Disposable versus reusable medical gowns: A performance comparison. *American journal of infection control*, 49(5), 563–570. https://doi.org/10.1016/j.ajic.2020.10.013

Mehrotra P., Malani P., & Yadav P. (2020) Personal protective equipment shortages during COVID-19—supply chain–related causes and mitigation strategies. *JAMA Health Forum*. 1(5):e200553. doi:10.1001/jamahealthforum.2020.0553

Mitchell, A. H. (2014, October 11). A retrospect: PPE use then and now. Retrieved from https://www.infectioncontroltoday.com/view/retrospect-ppe-use-then-and-now

Monmaturapoj, N., Sri-On, A., Klinsukhon, W., Boonnak, K., & Prahsarn, C. (2018). Antiviral activity of multifunctional composite based on TiO2-modified hydroxyapatite. *Materials science & engineering*. C, Materials for biological applications, 92, 96–102. https://doi.org/10.1016/j.msec.2018.06.045

Periolatto, M., Ferrero, F., Vineis, C., Varesano, A., & Gozzelino, G. (2017). Novel antimicrobial agents and processes for textile applications. In *Antibacterial agents*. InTech. https://doi.org/10.5772/intechopen.68423

Rutala, W. A., & Weber, D. J. (2001). A review of single-use and reusable gowns and drapes in health care. *Infection control and hospital epidemiology*, 22(4), 248–257. https://doi.org/10.1086/501895

Smith, J. W., & Nichols, R. L. (1991). Barrier efficiency of surgical gowns. Are we really protected from our patients' pathogens?. *Archives of surgery* (Chicago, Ill. : 1960), 126(6), 756–763. https://doi.org/10.1001/archsurg.1991.01410300102016

Overcash, M. (2012). A Comparison of Reusable and Disposable Perioperative Textiles. *Anesthesia & Analgesia*, 114(5), 1055–1066. https://doi.org/10.1213/ane.0b013e31824d9cc3

United States Consumer Product Safety Commission. (2008). Standard for the flammability of

clothing textiles. *Federal Register* (Vol. 73, No. 58). Retrieved from https://www.cpsc.gov/s3fs-public/pdfs/blk_pdf_textflamm.pdf

United States Department of Labor. (2019). Bloodborne pathogens. *Occupational Safety and Health Administration* (1910.1030). Retrieved from https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1030

Vozzola, E., Overcash, M., & Griffing, E. (2018). Environmental considerations in the selection of isolation gowns: A life cycle assessment of reusable and disposable alternatives. *American journal of infection control*, 46(8), 881–886. https://doi.org/10.1016/j.ajic.2018.02.002

VITA

Susan Ishaq Dabbain was born in Lexington, Kentucky. She attended West Jessamine High School and graduated in 2015. At the University of Kentucky, she received a Bachelor of Science in Merchandising, Apparel, and Textiles, a Bachelor of Business Administration in Marketing, and a Master of Science in Retailing and Tourism Management (expected). As an undergraduate, Susan was accepted and completed a professional internship at the University of Kentucky's Textile Testing Laboratory and an E-commerce and Digital Marketing internship at MODD haus, a media agency. As a graduate, Susan worked as the Laboratory Supervisor in the University of Kentucky's Textile Testing Laboratory. She also earned her Lean Six Sigma Green Belt. Susan was granted graduate research assistantship in 2019, 2020, and 2021, and teaching assistantship in 2020 and 2021. She also received the Alice P. Killpatrick Fellowship and the John I. and Patricia J. Buster Fellowship.

Susan Ishaq Dabbain