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## AN EVALUATION OF THE QUALITY OF MENS 100% COTTON JERSEY KNIT T-SHIRTS REPRESENTING THREE RETAIL CATEGORIES

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AN EVALUATION OF THE QUALITY OF MENS 100% COTTON  
JERSEY KNIT T-SHIRTS REPRESENTING THREE RETAIL CATEGORIES

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THESIS

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A thesis submitted in partial fulfillment of the  
requirements for the degree of Master of Science in  
Merchandising, Apparel, and Textiles  
in the College of Agriculture, Food and Environment  
at the University of Kentucky

by

Jeanne Oakes Badgett

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Lexington, Kentucky

2017

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## ABSTRACT OF THESIS

### AN EVALUATION OF THE QUALITY OF MENS 100% COTTON JERSEY KNIT T-SHIRTS REPRESENTING THREE RETAIL CATEGORIES

The purpose of this research was to evaluate the quality of design, materials, construction, appearance, and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. These retail categories were represented by brands Fruit of the Loom, H&M, and Brooks Brothers, respectively. A convenience sample was comprised of 78 t-shirts. 13 white and 13 navy t-shirts from each brand were used for testing according to ASTM and AATCC standards and specifications. Evaluations and measurements were conducted before washing, and after one, five, ten, and twenty laundry cycles. The t-shirts were evaluated for fabric weight, fabric count, color change, whiteness change, crocking, smoothness appearance, bursting strength, pilling, dimensional stability, and skewness. The navy t-shirts in the 'better' retail category met five out of the six requirements specified by the ASTM standard. However, the navy t-shirts in the 'fast fashion' category met four out of five met by the 'better' category. In conclusion, the decision to purchase a t-shirt from these retail categories may depend on consumer expectations.

KEYWORDS: Quality, T-Shirts, Mass Merchant, Fast Fashion, Better

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Jeanne Oakes Badgett

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July 24, 2017

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## Chapter One

According to a survey conducted by Cotton Incorporated, consumers have seen a “decline in the quality of apparel, including fading, pilling, losing shape, and shrinking” (Salfino, 2012a, p. 1). Regardless of consumers’ assumptions of a direct correlation between quality and price, consumers still expect clothing to remain as inexpensive as possible (Norum, 2003; Kaiser & Garner, 2012). This expectation prompts suppliers and retailers to feed consumers’ desires for discounts with mass produced clothing to be sold at very low price points (Amanda, 2012; Tan, 2016). Yet with low pricing, often comes low quality (O’Donnell & Kutz, 2008). “It’s virtually impossible to expect a \$6.99 cotton t-shirt [purchased today at Target] to last as long as [a t-shirt] purchased for \$6.99 twenty years ago” (Amanda, 2012, para. 3). Using an inflation calculator, a t-shirt that cost \$6.99 in 1995 should cost almost \$11.00 today (“US Inflation Calculator,” 2017), yet t-shirts priced less than \$6.99 are commonplace. Growing consumer dissatisfaction with poorly produced garments has been clearly voiced in countless product reviews and blogs, however, it is also documented that some consumers are willing to sacrifice apparel quality for a lower price (Adams, 2016; “Cotton Inc. taps into consumer ire,” 2013; Salfino, 2012a).

Increasing consumer disappointment in apparel quality has coincided with the proliferation and success of the fast fashion business model. Fast fashion apparel is described as “trendy, inexpensive versions of runway looks that shoppers wear for one season, or one occasion and often toss” (Holmes, 2014, para. 3). It is manufactured within a short lead time enabling new styles to be available in stores within a few weeks of conception, in order to satisfy consumer demand at its peak (Barnes & Lea-Greenwood, 2010). This is achieved by optimizing the supply and demand relationship through efficient design, production and distribution (“CIT Retail Outlook,” 2016). The low prices associated with these quickly constructed, stylish garments have created a desire for inexpensive fashion, of which the quality is sacrificed in order to maintain cost effective prices (Walters, 2010). To keep up with increased demand, fast fashion brands often resort to manufacturing in low wage countries, using cheap, synthetic materials and rudimentary manufacturing processes (Zarrolì, 2013).

The fast fashion trend has successfully carved a niche in consumers' wallets. Top fast fashion retailers have grown 9.7% since 2010, while traditional apparel retailers have grown only 6.8% in the same time period ("Fast fashion garners growth," 2015). The high volume, low priced fast fashion formula has squeezed the life out of the fashion industry, forcing independent department stores to consolidate, middle market manufacturers to shutter, and small retailers to either go high end or go home (Cline, 2012). These middle market brands are now being considered plodding and dowdy and must scramble to try to either up their fashionability, or lower their prices to try to compete (Siegle, 2012). As a result, traditional retailers are adapting to the polarization of the market by embracing the proverb, "if you can't beat 'em, join 'em" (Chen, 2015, para. 8). Hence, in order to stay in business, some apparel companies are adopting the fast fashion business model ("The impact of fast fashion," n.d.).

Consumers are value driven and expect more for what they are prepared to pay (DeKlerk & Lubbe, 2006). However, increased production costs, including the rise of cotton prices, joined with higher transportation costs and wages have resulted in clothing that is more expensive to manufacture (Smith, 2010; Magruder, 2011). Retailers and brands are faced with finding ways to minimize costs and save margins (Salfino, 2012a). Markups may help neutralize the increase in productions costs, however, retailers selling low cost *basic* apparel are not able to offset this hike in order to compete at a lower price point (Smith, 2010). Basic apparel is considered as any item with continued demand, which can be produced in large quantities, season after season, with few design changes (Johnson & Moore, 2001; Keiser & Garner, 2012). A significant price increase on a basic item, such as a t-shirt, might cause consumers to complain about the price tag. Therefore, with regard to rising manufacturing costs, shoppers of basic apparel should be on the lookout for a decline in quality (Kiplinger, 2010).

### **Problem**

The Dean of Fashion at Parsons New School for Design in New York, commented that some new apparel is, "like garbage...you're going to wear it Saturday to a party and then it's literally going to fall apart" (para.3). He implied that many fast fashion garments are so cheaply constructed they can be considered disposable (Zarroli, 2013). This notion is also supported in research by McAfee, Dessain, and Sjoeman

(2004), who concluded that some fast fashion retailers sell numerous garments that are expected to be used less than ten times. Unfortunately, this lack of longevity is now accepted by our throwaway society and is creating a market catered to consumers who want to pay less for their disposable apparel (Dunbar, 2016). According to sustainable consumption professor, Tim Cooper, this leads to clothing that is constructed with, “built in obsolescence, and because relentless novelty is the order of the day,...today’s fashion is tomorrow’s junk” (Walters, 2014, para. 5). The trend of disposable garments is problematic for apparel manufacturers as they now have to take into account the anticipated life span of a garment, literally and figuratively, during the design process.

Mass produced, affordable clothing has allowed fast fashion to take the apparel market by storm and enabled these retailers to realize up to 28% higher profits than traditional retailers (“Fast fashion garners growth,” 2015; Tan, 2016). The growth of fast fashion retailers coupled with their deliberately low pricing strategies has affected much of the fashion industry because cheap fashion aggressively chases and kills off anything priced near it (Cline, 2012). Fast fashion companies are outperforming American fashion mainstays...and forcing time honored brands to reevaluate their pricing and production strategies (Hallstein & Doyle, 2014). Traditional apparel companies feel pressured to compromise quality in order to remain competitive and relevant in the fashion industry. To save money and remain profitable, manufacturers have reduced production costs, which leads to giving up quality and diluting craftsmanship (Amanda, 2012; Gabrielli, Baghi, & Codeluppi, 2013).

The relationship between product pricing and positioning, branding, and perceived quality is complex. Apparel price is inherently defined by how a brand needs to position its product relative to where the competition is, but pricing is also heavily dependent on consumer expectations (Carroll, 2012). Chowdhary (2002) states, “quality products tend to meet or exceed the consumer expectation” (p. 128). Therefore, if pricing is dependent on consumer expectations, does that imply that a product with a high price will be of a high quality or that a low price product will be of a low quality? Not necessarily, due to the dynamic nature of pricing (Bhasin, 2016). But it is crucial that an apparel retailer finds the right balance between price and quality in order to remain profitable and satisfy the consumers’ desire for value. To this end, some apparel



companies have resorted to altering production methods to remain profitable (Hallstein & Doyle, 2014). Thus, under the vast umbrella of fast fashion retailers and traditional retailers, apparel quality and pricing can be so indiscriminate in nature, it is difficult for consumers to distinguish differences in order to ascertain its value.

### **Purpose**

The purpose of this research was to evaluate the quality of design, materials, construction, appearance, and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. ‘Mass merchant’ apparel includes a variety of national brands that appeal to many different market segments, all at low affordable prices. This includes clothing sold in retailers such as Wal-Mart or Target. ‘Better’ apparel has wide market appeal, and is often the highest price point available in department stores, such as Jones New York and Lauren by Ralph Lauren (Keiser & Garner, 2012).

### **Objectives**

Product specifications, including materials, construction, appearance, durability or serviceability, and performance characteristics, were measured and compared among each garment retail category. Methods of testing complied with industry standards and procedures developed by the American Society for Testing and Materials (ASTM) and the American Association of Textile Chemists and Colorists (AATCC).

Research objectives of this study were to:

1. Identify and compare the product specifications of mens 100% cotton jersey knit t-shirts at three retail categories.
2. Measure and compare the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories before and after home laundering.
3. Compare the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories to the ASTM Standard Specification requirements.

## **Research Questions**

In order to meet the thesis objectives, the following questions were presented:

1. Are there differences in the product specifications of mens 100% cotton jersey knit t-shirts at three retail categories?
  - a. Are there differences in the design specifications of mens 100% cotton jersey knit t-shirts at three retail categories?
  - b. Are there differences in the materials specifications of mens 100% cotton jersey knit t-shirts at three retail categories?
  - c. Are there differences in the construction specifications of mens 100% cotton jersey knit t-shirts at three retail categories?
2. Are there differences in the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories:
  - a. Before home laundering?
  - b. After home laundering?
3. Are there differences in the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories compared to the ASTM Standard Specification requirements?

## **Justification**

As a result of rapidly changing productions methods and quality being in eye of the beholder, gone are the days when the retailer and cost of apparel indicate quality (“A comparison of men’s t-shirts,” 2015; “The decline of quality clothes,” 2014). Consumers want price tags that are commensurate with quality, yet apparel retailers are not consistently delivering on that desire (“A comparison of men’s t-shirts,” 2015; Halzack, 2016). This means the expectations of a more expensive garment yielding better quality are not always met. For example, academic journalist, Guy Walters (2010), described “the decimation of not only the cheap clothes in [his] wardrobe, but of the more expensive clothes, too. After less than eight months of wear, the upmarket brands of [his] clothing looked just as distressed as those that had cost a third of the price. And new shirts, no matter how posh, didn’t seem to last as long” (para. 3). Therefore, product pricing and positioning do not always positively correlate with quality (Walters, 2010).

A decline in clothing quality has been recognized by consumers as documented in their critiques about apparel manufacturers' inclusion of "cheaper methods, crappier materials, thinner fabrics, and poor quality," ("Why is clothing getting crappier," 2010, para. 10). In addition, a Cotton Incorporated survey indicated that "73 per cent of respondents say clothing does not last as long as it used to; 60 per cent say fabrics have gotten thinner; and 41 per cent say the quality of clothing has decreased" (Salfino, 2012a, p. 1). These remarks substantiate and contribute to consumers' opinions and observations regarding the inferior quality and the limited life span of apparel.

It is important to understand the different features in products because consumers are bombarded with a plethora of brands of the same merchandise in varying degrees of quality (Chowdhary, 2002). Therefore, manufacturers, retailers, and marketers use quality as a way to differentiate their product from their competitors (Swinker & Hines, 2005). Consumers who flock to outlet stores to stock up on *basics*, such as t-shirts, may be further misled and confused about the value of these items because outlet specific merchandise is often of lower quality than goods sold at non-outlet retail locations (Hallstein & Doyle, 2014). As the t-shirt is a commodity product, its success can be driven and defined in terms of value by lowest price, but ultimately, the consumer may assign value based on the t-shirt's construction, appearance, and performance (D'Arienzo, 2016; Gross, 1987).

T-shirts have been a popular fashion staple since the 1950's and this classic style is available year round from almost every apparel manufacturer, representing different retail categories at various price points (Centeno, 2013; Glock & Kunz, 2005). This assessment of mens 100% cotton jersey knit t-shirts in three retail categories provided an objective comparison of similar merchandise. The selection of a homogenous sample of *basics* that was not as dependent on fashions and trends (Brown & Rice, 2001), supports this objectivity. Furthermore, the sample that is not limited by end use; a "dilapidated t-shirt can be as much a leisure choice for the wealthy, as a necessity for the poor" (Maynard, 2004, p. 97).

## **Assumptions**

For the purpose of this research, the sample was chosen based on the assumption of a positive relationship between price and quality and the extended connection between price and retail category (Glock & Kunz, 2005; Norum, 2003). A retail category or product class is one way to describe different classes of goods in the apparel industry. An overall pricing spectrum coincides with the generally accepted retail category labels that range from Discount to Haute Couture (Fasanella, 2009). Although one impetus for this research is derived from the view that the retail category is no longer indicative of quality, Fasanella (2009) states that, “quality levels typically increase or decrease accordingly” (para. 2).

The selection of three brands of mens t-shirts were considered to be representative of the product available in three retail categories: mass merchant, fast fashion, and better. It was assumed that codes assigned to the garments by the North American Industry Classification System were accurate.

## **Limitations**

The sample in this study would ideally include new, unwashed vintage t-shirts manufactured before the routine adoption of the fast fashion business model, as well as recently manufactured t-shirts from the same brands. Comparisons of the materials, construction and performance of the vintage t-shirts to recently manufactured t-shirts could be a reliable indicator of variations in apparel quality of t-shirts made before and during the fast fashion era. However, because all of the t-shirts evaluated in this laboratory test have been produced within the past two years, it would be difficult to determine if any differences in the quality of the t-shirts in this sample are caused by the mass popularity of fast fashion. For this reason, the evaluations and data provide only a comparison among t-shirts in three retail categories. From these comparisons, assessments of quality may be inferred. Finally, laboratory tests may not accurately simulate the t-shirt’s performance in response to environmental stressors, including wearer usage, soiling, and individual home laundering methods (Collier & Epps, 1999).

## **Chapter Two**

### **Literature Review**

The purpose of this research was to evaluate the quality of design, materials, construction, appearance, and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. The review of literature will provide an overview of the textile and apparel industry, including the supply chain and changes under which it has evolved are included to support this research. The concept of fast fashion is summarized as it relates to changes in the traditional supply chain and decreasing the time line for apparel production. Additionally, quality is defined in general terms and in relation to apparel, as well as how it is measured by the manufacturer and the consumer. Finally, a brief history of undershirt / t-shirt is included, followed by a review of the product positioning of the t-shirt in the apparel market.

#### **Textile and Apparel Industry**

The American apparel industry is over a century old. Prior to this, during the American Colonial period of the 1700s to the mid-1800s, family members made most clothing in the home using fabric made of natural fibers. Gradually, tailors and dressmakers began to provide these services for custom made clothing. As the presence of milliners' shops grew in the latter part of the eighteenth century, more raw materials and accessories were produced. Small quantities of low status, ready-to-wear clothing were available, but it was not until tailor shops began to import fine quality ready-to-wear apparel that this concept was accepted. Eventually, some manufacturers of goods focused production efforts on ready-to-wear apparel for men and boys. This evolved into clothing factories, the earliest of which dates to 1825 (Stamper, Sharp, & Donnell, 1991).

It was with the patent of the sewing machine in 1846 (Keiser & Garner, 2012) and the onset of the Civil War during the 1860s, that apparel production became mass-produced. The need to efficiently provide Confederate and Union uniforms resulted in the development of a standardized sizing system and simple production methods. Throughout the Industrial Revolution, weaving and knitting innovations supported the advancement of ready-to-wear apparel (Brown & Rice, 2001). The creation of man made fibers in the early 1900s expanded fabric options and influenced styles (Tortora, 2015).

The sewn products industry has grown from small sweatshop operations to a highly mechanized, predominately automated, and frequently unionized big business (Brown & Rice, 2001). With the variety of product categories and endless changes in materials and styling, however, some aspects of apparel manufacturing are labor-intensive and require manual production operations (Glock & Kunz, 2005). Regardless, the textile and apparel industry is a complex manufacturing and distribution network that has evolved to meet the demands of the current market and increased competition (Brown & Rice, 2001).

**Traditional supply chain.** The apparel supply chain as defined by Kadolph (2007), can be grouped into four parts: *raw materials* (includes fibers, yarns, dyes, finishing chemicals, plastics and metals that are processed into buttons and zippers); *processed materials* (materials that require no additional processing before use in the production of textile products); *sewn product manufacturers* (makers of apparel, furnishings and industrial products); and *retailers* (those who sell merchandise to consumers). These subdivisions are also known as the textile and apparel pipeline, which is simply sectioned into fiber and fabric producers, apparel manufacturers and wet processors, and retailers. The prosperity of these groups is dependent (Brown & Rice, 2001).

Dating back to the 1960s, the fashion industry operated under a series of fixed relationships. Consumers shopped at department stores and other retailers, which sourced apparel from domestic manufacturers (Zarroli, 2013). Consumers were selective in their buying habits, purchasing a few outfits for special occasions. They were also more prone to mend apparel when necessary as opposed to superfluously replacing it (Hardgrave, 2010).

New lines of clothing appeared on the runways months before it was expected to be sold in stores. Apparel *seasons* were grouped as spring/summer and fall/winter. It was not uncommon for a spring/summer forecasting show to be held in September of the previous year, and a fall/winter forecasting show to be held in February, as this would allow brands enough time to create their retail lines according to buyer interest (Gordon, 2015). Thus, the goal of the traditional supply chain was to produce materials and apparel to be sold in the intervals of four to six seasons (Keiser & Garner, 2012).

**Traditional lead time.** The time it takes between placing an order and delivering merchandise is known as *lead time*. This includes the time it takes to source materials and convert them into products (Glock & Kunz, 2005). Lead time traditionally took up to three years. Fiber development for yarn and fabric fairs occurred more than two years before a selling season (“Textile supply chain,” n.d.). And the availability of raw and processed materials combined with proximity of fabric mills and manufacturing facilities was a factor (Glock & Kunz, 2005). Color forecasting was performed 18 to 24 months in advance (Keiser & Garner, 2012, p. 120). Apparel orders were traditionally placed at least nine to twelve months before they were expected to be set on the shelves (Christopher, Lowson, & Peck, 2004). Also, the time of year or season in which a garment was sold was taken into consideration. Therefore, successfully forecasting consumer demand and fashion trends months ahead was crucial (“Technology in supply chain,” n.d.). If a trend emerged unexpectedly, it might take months to make the item available to the masses. As consumers were not always willing to wait, these lengthy lead times often resulted in revenue losses (Christopher et al., 2004).

**Changes in supply chain and lead time.** Success in the apparel industry had been based on the low cost, mass production of basic styles, but after the 1980s, consumers became more fashion conscious. Hence retailers, wanting to differentiate themselves from the competition while boosting margins and profits, began to manufacture their own brands. By cutting out the middleman, retailers could control the manufacturing and distribution themselves (Blessing, 2010; Zarroli, 2013). Retailers then focused on expanding their store branded and private labeled products with updated merchandise and faster responsiveness to the *newness* of fashion trends. The number of fashion seasons increased to allow for more frequent addition of variety. This coincided with global sourcing and the relocation of manufacturing to countries with low labor costs, thereby resulting in a substantial cost advantage. Although utilizing offshore resources was outwardly more cost efficient, geographical complications of varied processes and intricate import/export procedures resulted longer lead times (Bhardwaj & Fairhurst, 2010).

In the mid-1980s, companies sought to improve customer service by reducing the long lead times between product design and availability in retail stores, as well as

decrease the investment in inventory (Drake & Marley, 2010). The business strategy of *quick response* was developed as a reaction to this by preventing bottlenecks in the apparel pipeline (Christopher et al., 2004). The objective of quick response is to compress time lines in the manufacturing and distribution processes by optimizing the flow of goods in the apparel pipeline so that it is produced near the time of sale. The efficacy of quick response relies heavily on interindustry cooperation between suppliers, manufacturers, and retailers. This is fostered through constant communication, information technology, improved logistics operations, and advanced manufacturing techniques (Brown & Rice, 2001; Drake & Marley, 2010). The goal of each segment in the supply chain is to be profitable, and with the implementation of quick response programs the entire apparel supply chain can benefit from the added flexibility and responsiveness that comes with reducing the cumulative lead time (Drake & Marley, 2010; Frendenhall & Hill, 2001).

Large retailers that dominated the apparel industry during the evolution of quick response caused a shift from product driven to buyer driven supply chains in order to surpass the competition (Bhardwaj & Fairhurst, 2010). But as product development is now led by the retailer, conventional supply chains are driven by orders, which themselves are driven by forecasts and inventory replenishments (Christopher et al., 2004; Tyler, 2000). Fashions are impacted by popular culture, and these culture shifts can happen anytime, anywhere, creating consumer demand for a new styles or trends (Barnes & Lea-Greenwood, 2006). Celebrity inspired fashions and yearly trends make the apparel supply chain very time sensitive (Partridge, 2005). This makes forecasting difficult, therefore successfully responding to consumer demand is achieved through reduced lead times. Shorter lead times and the ability to stay on trend are achieved with tightly controlled manufacturing as well as sub-contracting, and have also led to a resurgence of sourcing locally (Christopher et al. 2004; Tyler, 2000).

Apparel companies rely heavily on information technology and supply chain logistics to meet the supply chain demands and to get items into a store while they are still popular. Supply chain manufacturers, importers, distributors, wholesalers, and retailers must have a good grasp on what sells, where it sells, and how to get it there at the right time. Technologies provide real-time information enabling apparel companies



to better track products along the supply chain providing the ability to make timely decisions and changes to styles, color, prices, and distribution patterns (Partridge, 2005). Quick response programs use data collected at the retail level during the point of sale by scanning bar codes or universal product codes (Drake & Marley, 2010). Larry Ravinett, a logistic and supply chain consultant, states that “because supply chain technology has added efficiency and value, the supply chain has now become a margin factor rather than a cost factor” (Partridge, 2005, para. 17).

Traditional lead times that ranged from 30 to 52 weeks are now as short as 3 to 6 weeks (“Fast fashion,” 2013). Christopher et al. (2004) divide lead time into three dynamic segments: time-to-market, time-to-serve, and time-to-react. Time-to-market is the length of time between the recognition of a sales opportunity and actual production; time-to-serve represents the time it takes to deliver a product once an order is actually placed; and time-to-react is the response time required to adjust to consumer demand. The reduction of time involved in these segments is necessary for successful competition in the fashion market (Christopher et al., 2004). Because over 50% of apparel sold in the United States today is made abroad, time and logistics are very important (Partridge, 2005). Consequently, due to operating in a global market, apparel products now represent a range of fibers, fabric structures, styles and fashions, construction methods, appearance standards, and performance levels (Kadolph, 2007).

### **Fast Fashion**

Apparel that is sold within weeks of first appearing on the runway is known as fast fashion. The trendy, inexpensive versions of new, coveted styles are usually worn for one season, or one occasion and often tossed (Holmes, 2014). This is because fast fashion apparel is produced with novelty in mind and lacks longevity (Josephson, 2015). Industry analyst, Marshal Cohen defines fast fashion as, “the process of putting merchandise in a store and being able to replicate it in an exceptionally expedient manner, sell it, react to it, sell it again, react to it again, and sell it again” (“Fast fashion,” 2013, para. 3). The product-driven concept of fast fashion is supported by emphasis on supply chain optimization and the utilization quick response programs. And the ability to decrease response times when reacting to trends equates to successful sales (Hayes & Jones, 2006).

Fast fashion clothing pioneer Hennes and Mauritz (H&M) was founded in 1947, but it wasn't until the early 2000s that the concept of high fashion at low prices began to take hold. H&M embraces quick response as their design, production, and distribution teams function seamlessly to deliver merchandise to the shelf within a few weeks. H&M operates two distinct supply chains; one focuses on established favorites and forecasted styles, while the other is dedicated to rapidly responding to unpredictable fashions and new trends. Strategically located distribution centers enable stores to be restocked daily to promote item turnover. Despite H&M's supply chain agility, it has a slightly longer lead time than its competitor, Zara. However, the ability of H&M to sell merchandise at prices averaging 40% less than Zara provide H&M a significant cost advantage (Drake & Marley, 2010; H&M, 2017).

Spain-based fast fashion retailer, Zara, opened its doors in 1975. Although the fast fashion phenomenon had not been fully realized at that time, Zara's creator Amano Ortega quickly understood the importance of producing products that synchronously fulfill fashion trends. He had been previously employed at a factory where production never seemed to match what people on the street wanted to wear (Buck, 2014). As a reaction to this, Zara, like H&M, embraces the fast changing tastes of customers (Petro, 2012).

The demand for retailers to meet consumers' desires for stylish fashion *fast* was the catalyst in creating the fast fashion business model. It is accepted that fast fashion is being driven by catwalk styles, celebrity looks and the desire for newness, particularly those trends identified in the media which create interest and drive high levels of consumer demand (Barnes & Lea-Greenwood, 2010).

Fast fashion aims to reduce the processes involved in the buying cycle and lead times for getting new fashion product into stores, in order to satisfy consumer demand at its peak (Barnes & Lea-Greenwood, 2010). Fast fashion can be sourced globally from whomever will provide the cheapest and often most compliant labor in the industry (Siegle, 2011). This production shift to low cost countries has contributed to the falling price of clothing (Fletcher, 2008).

With today's highly competitive fashion market and the constant need to refresh, there has been an increase in the number of fashion seasons, i.e. the frequency with which

merchandise is changed in stores or online (Bhardwaj & Fairhurst, 2010). The typical number of four to six seasons is now approaching 20 seasons in a year (Christopher et al., 2004; Keiser & Garner, 2012). Additionally, fast fashion retailers sell garments at very competitive price points (Birtwistle & Moore, 2007). This increased competition between traditional retailers and discounters has also contributed to a decrease in the average price of apparel over the past decade (Cline, 2012; Wilson, 2008).

Fast Fashion is a business model originally developed to make better, more fashionable clothes at affordable prices (Siegle, 2011). It has become the most well-recognized business model in the fashion industry due to its impressive performance in the global market during recent years (Kim, Choo, & Yoon, 2013). Retailers who carry fast fashion collect higher profits from the sale of their fast fashion merchandise because they are able to sell through it so rapidly that it skips the entire markdown process all together. Realizing the benefit in this, some traditional retailers are changing their business models to take part in fast fashion, and some consumers are breaking their loyalties to companies who don't carry fast fashion (Sydney, 2008).

**Fast fashion supply chain.** To attain more responsive replenishment systems, retailers have strived to reduce the number of suppliers with which they do business. There is a delicate balance between subcontracting in fast fashion and in house production facilities owned by the brand itself (Christopher et al., 2004). In house production allows for greater flexibility in the amount, frequency, and variety of new products (Lu, 2014). High levels of consumer responsiveness are achieved when fast fashion brands work closely with specialized subcontractors that perform labor intensive tasks (Christopher et al., 2004). To maintain maximum profit and responsiveness to consumer demand, fast fashion retailers manufacture basics at their lowest cost production facilities ("Fast fashion garners growth," 2015). Low cost manufacturing solutions are attained when company-owned factories utilize economies of scale, producing unfinished greige goods before they are sent to the smaller subcontractors for transformation to an on trend item (Christopher et al., 2004; Petro, 2012). Consequently, fast fashion garments are often dyed after they are constructed enabling the manufacturer to produce the best selling colors quickly (Mihm, 2010).

Agile supply chains are more likely to be information based. Virtual, real time connections among supply chain participants enable needs to be met. Fast fashion retailers are known to have fashion scouts that look for new ideas and trends in their markets. Customers' likes and dislikes are also identified and relayed back to designers in order to quickly make adjustments (Christopher et al., 2004). "It is the flow of information in this souped-up, highly responsive supply chains that enable fast fashion retailers to have trendy merchandise in stores within in weeks" (Halzack, 2015, para.10). And "newer technologies are making supply chain agility affordable and accessible, contributing to the crossover of the fast fashion business model to multiple categories and price points" ("Fast fashion," 2013, para. 5).

**Fast fashion lead time.** With the desire to fulfill consumer demand at its peak, fast fashion retailers have reduced the supply chain response time from 40 to 50 weeks, down to 8 to 10 weeks (Christopher et al. 2004). Through efficiencies of vertical integration, small and frequent shipments keep product inventories fresh. Short lead times and increased delivery speed enables apparel to go from concept to customer in a matter of weeks (Barnes & Lea-Greenwood, 2010; Siegle, 2011). Fast fashion retailer Zara delivers new products twice a week and has streamlined its design process so that a garment can be on the sales floor within 15 days of conception (Petro, 2012).

Recent years have seen fashion retailers compete with others by ensuring speed to market with their ability to provide the fashion trends revealed by fashion shows and runways (Bhardwaj & Fairhurst, 2010). Digital photograph technology allows designer runway fashions to be copied and knocked off by fast fashion retailers before the original style is available for purchase (Keiser & Garner, 2012). Additionally, the systematic method of production has enabled fast fashion retailers to rapidly react to runway shows and get products in the stores within two to three weeks, instead of four to six months (Sydney, 2008).

Shorter lead times are associated with a reduced forecasting horizon and a lower risk of error in satisfying consumers' wants. The ability to spot trends and quickly translate them in to products to sell in a short period of time has become necessary for success. The shorter lead times of fast fashion limit obsolescence, mark downs, and the cost of carrying inventory (Christopher et al., 2004).

**Fast fashion and the consumer.** Fashion theory is a concept in which consumers quickly become bored with whatever is widely accepted, leading them to constantly seek new and different variations in products (Glock & Kunz, 2005). As consumers' priorities rapidly change, long standing clothes buying skills, such as assessing for quality or looking at labels, have been lost in favor of buying new apparel, more frequently (Siegle, 2011). Fast Fashion consumers typically visit the clothing store four or five times more often than customers of more traditional apparel stores. With quickly changing inventory and clothing that may not last as long, recurrent trips to the store are warranted (Buck, 2014).

With the rise and frequent use of the Internet it became possible for the average consumer to gain access to photos and commentary of runway shows that had previously been conducted behind closed doors (Sydney, 2008). Consumers' interest in fashion and celebrities translates to more frequent shopping as demand is driven by weekly magazines and daily television shows, and consumers expect to see new looks and the latest pieces every time they shop (Barnes & Lea-Greenwood, 2010). And although fashion retailers are encouraging consumers to visit their stores more frequently with the idea that merchandise will not be around very long (Bhardwaj & Fairhurst, 2010), the demand for merchandise is now consumer driven (Gabrielli et al., 2013).

Today, consumers own about five times the amount of clothes compared to what was owned in the first half of the twentieth century, this can be attributed to the low cost production of clothing overseas (Dang, 2014). Fast fashion allows consumers to make numerous choices, even to make mistakes, as their purchases do not have a high cost and are reassuring because of the small economic and psychological investment they require (Gabrielli et al., 2013).

This apparel can be trendy, inexpensive versions of runway looks that shoppers wear for one season, or one occasion, and often toss (Holmes, 2014). A study conducted by Watson and Yan (2013) found that fast fashion consumers frequently throw their clothing away. This disposal habit is corroborated by Murphy's research (2005) that concluded some consumers purchase fast fashion with the intent of discarding the apparel prematurely in its life cycle.

Fast fashion allows customers shopping at all price points to adopt a fashion idea simultaneously (Keiser & Garner, 2012). This is because more people can afford to be fashionable due to lower price clothing (Wilson, 2008). Moreover, the fast fashion business model presents consumers with continually renewed proposals, such that they can make purchases when they want and as they require (Gabrielli et al., 2013). Rapidly changing style and novelty are sustainable because clothing is so cheap (Fletcher, 2008). Consumers now dictate the fashion lifecycle, and it is their desire for immediacy, fueled by technology and convenience, that has forced the fashion industry to evolve (“The Impact of Fast Fashion”, n.d.).

### **Quality in the Apparel Industry**

Quality is a broad term, and one that encompasses many different aspects of apparel (Stamper et al., 1991). Recently, participants in the 2013 American Society for Quality (ASQ) Global State of Quality Research survey were asked to define *quality* from their organization’s perspective. Relevant attributes were: “ensuring customers come back and products do not,” “delivering beyond what the customer wants,” and “anticipating what the customer will want when he or she knows the possibilities” (Kennedy, 2014, p. 18).

Quality as applied to apparel has a multiplicity of meanings (Glock & Kunz, 2005). It is a term often used by manufacturers of textiles and apparel to distinguish their product from the competition and to justify a higher price for similar items (Romeo, 2009). Quality includes understanding the way in which product development and production are integrated, so that products satisfy consumer expectations. It is represented by a set of precise and measurable characteristics or components of a finished product. Differences in product quality can be attributed to differences in components or characteristics. Additionally, the successful delivery of quality assurance requires coordination of wide ranging knowledge and skills in all areas of the textile industry complex (Kadolph, 2007).

Perceived quality is a composite of intrinsic and extrinsic cues. Intrinsic quality is created during product development and production and is dependent on styling, fit, materials and assembly methods. Because consumers are not well informed about properties of raw and processed materials, an objective analysis of the intrinsic quality or

performance by the consumer is not often possible. Price, brand name, reputation of retailers, visual merchandising techniques, and advertising are common extrinsic cues. Extrinsic cues are sometimes regarded as indicators of intrinsic qualities. Extrinsic cues seem to be less complex to interpret. Extrinsic cues are frequently used by manufacturers and retailers to influence perceptions of product quality, value and performance (Glock & Kunz, 2005). Quality may be inferred by consumers based upon specific extrinsic indicators, such as brand name or the store from which it was purchased, however, it has been shown that quality is not necessarily related to the price, brand name, or retailer (DeKlerk & Lubbe, 2008; Romeo, 2009).

Although profit can be the motivating force behind quality, the customers' demand for quality can also be a very powerful driving force to incorporate quality into a product (Mehta, 2004). The ultimate goal of the evaluation of the quality of apparel products is that the consumer will be satisfied with the item to that extent that it would lead to further purchases (DeKlerk & Lubbe, 2008).

**Dimensions of product quality.** Companies use quality assessments to promote their products. Unfortunately, producers and consumers do not always agree on the characteristics of quality and the ways in which quality should be assessed (Kadolph, 2007). Harvard Business School professor, David A. Garvin, identified eight dimensions of product quality to be used as a framework to define and understand the basic elements of quality (Kadolph, 2007). The dimensions are: performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality (Garvin, 1984).

***Performance.*** Performance refers to the primary operating characteristics of a product that can be measured and ranked, and the efficiency with which a product achieves its intended purpose. These measureable attributes may or may not be associated with higher levels of quality, depending on the view of the consumer (Garvin, 1984; Kadolph, 2007).

***Features.*** Features are secondary characteristics, sometimes referred to as 'bells and whistles,' that supplement a product's basic performance. A feature's impact on quality perception is may be influenced by a consumer's preference (Garvin, 1984; Kadolph, 2007)

**Reliability.** Reliability is the capacity for the product to perform consistently over its lifespan or the probability of a product's failing within a specified period of time. Reliability is more important with regard to durable goods as opposed to nondurable goods (Garvin, 1984; Kadolph, 2007).

**Conformance.** Conformance describes the degree to which a product's design and operating characteristics match pre-established standards. This includes materials, components and production processes (Garvin, 1984; Kadolph, 2007).

**Durability.** Durability is the amount of use a consumer will get before the product physically deteriorates, or the degree to which a product tolerates stress or trauma without failing (product lifecycle). Individual consumers may judge differently the point at which product is no longer suitable for end use (Garvin, 1984; Kadolph, 2007).

**Serviceability.** Serviceability refers to the speed and ease of repair. A garment that can be cleaned and restored to its new or near new condition is considered serviceable (Garvin, 1984; Kadolph, 2007).

**Aesthetics.** Aesthetics relate to the subjective ideas about how a product looks, feels, sounds, tastes or smells. Individual preferences can impact the importance of aesthetics (Garvin, 1984; Kadolph, 2007).

**Perceived quality.** Perceived quality refers to the customer's opinion regarding the money paid for a product in relation to the ability of the product to meet the customer's expectations. Because consumers do not always possess complete information about a product, they sometimes rely on nebulous factors, such as brand name or product packaging, to guide their purchasing decisions (Garvin, 1984; Kadolph, 2007).

**Apparel quality in manufacturing.** Manufacturers define quality as consistent conformance to specifications and standards (Kadolph, 2007). When a product meets a company's standards and specifications, it has achieved the desired quality level. This desired level may be high, low or at any point in between the extremes of continuum. By this definition, quality is achieved when products consistently fall within range of acceptable measures for all dimensions of quality. This measurement of quality addresses a company's ability to produce products that consistently meet predetermined criteria and can be sold in the market at full price. This is taken one step further, with



respect to retailers, who, on the other hand, are concerned that a product is suitable for their target market in terms of fashion, fit, price, performance, materials, etc. (Kadolph, 2007).

Successful manufacturers know that quality must be built into a product from its conception; it is inherent and should be incorporated into the product during product development, production, and marketing since it cannot be added at the end of the construction process (Kadolph, 2007; Keiser & Garner, 2012). Solinger (1988) concluded “the manufacturer perceives that *physical* features of a product involve what the product actually *is*; whereas *performance* features involve what the product actually *does*” (cited in Keiser & Garner, 2012, p. 412).

Manufacturers strive to convey that quality is not just about price. And although a brand name can be a telling sign of apparel quality, consumers should also examine the seams and fabric used in constructing the garment. Apparel construction, and materials used, goes a long way in determining how well clothing lasts. Price and brand name can help sort out some of the best from the rest, but consumers need to be a bit of a clothing detective, too (O'Donnell & Kutz, 2008). As cited in Romeo (2009), Marshall, Jackson, Stanley, Kefgen, and Touchie-Specht (2004), concluded that a discerning consumer will examine unseen elements of a garment such as interfacings, linings, and construction techniques as these will affect not only how the garment looks but also how it will retain its shape and how well it will wear.

Manufacturers realize that when the consumer examines sewn products at the retail level, only a few of the factors which ultimately influence quality can be easily discerned by careful inspection of the garment and its accompanying labels and tags. For example, a hem that is uneven in length is just as durable in most cases as one that is perfectly aligned, but the perception is that the uneven garment is of poorer quality (Stamper et al., 1991). Because shoppers are savvier and less loyal to brands and stores than previously, it is essential that the apparel offered at retail meets consumers' quality expectations (Salfino, 2012a).

**Measurement of the quality of apparel.** Clothing is made from textile fabrics that are produced for many different end uses. The physical and chemical properties of the materials affect how a fabric performs, and ultimately determine if it is suitable for

the desired use. Textile testing encompasses the procedures under which the characteristics and properties are assessed. Apparel analysis measures individual characteristics of the textile materials in order to determine how each contributes to the properties of the product (Collier & Epps, 1999). Through standards and specifications, consistency can be achieved and defined quality characteristics can be met (Glock & Kunz, 2005).

***ASTM standards.*** The American Society for Testing and Materials was founded in 1898 to develop standards on characteristics and performance of materials, products, systems and services (Bubonia, 2014; Collier & Epps, 1999). The organization is comprised of various committees, one of which oversees textiles. This committee annually publishes test methods and specifications, including any updates of procedures and measurements. ASTM standards usually relate to *physical* properties of materials, and adherence to the specifications is voluntary (Collier & Epps, 1999; Glock & Kunz, 2005).

***AATCC test methods.*** The American Association of Textile Chemists and Colorists was formed in 1921 to support knowledge of textile dyes and chemicals. As the name suggests, this organization specifically relates to textiles, with a focus on *chemical* properties. Committees develop test methods and corresponding rating scales by which the properties, performance, and appearance are judged (Bubonia, 2014; Collier & Epps, 1999). Assessment of the garment specifications through the use of AATCC test methods is voluntary (Keiser & Garner, 2012).

***Materials.*** Fabrics and other components such as threads, trims, and closures used to complete a garment are called materials. (Brown & Rice, 2001; Glock & Kunz, 2005). Materials selection has a significant impact on the quality and performance of a garment (Bubonia, 2014).

***Fabric weight.*** As an indicator of suitability to end use, fabric weight is a measurement recorded as mass per unit area (Glock & Kunz, 2005). It is usually reported as ounces or grams per square or linear yard or meter. Typical fabric weight ranges from 2 to 16 ounces per square yard and is classified as lightweight to heavyweight, with ranges in between (Keiser & Garner, 2012). Fabric weight must be appropriate for the

garment design, as it has implications in garment construction because of its impact on appearance and durability (Brown & Rice, 2001).

*Fibers and yarns.* The smallest unit within a fabric structure is a fiber. Fibers can be plant or animal based (e.g. cotton or wool), or they can be chemically based synthetics. The length and shape of fibers vary, and, in addition to the composition, can affect the performance properties of apparel. Fibers are twisted or spun into continuous strands called yarns. Yarns are then woven or interlocked (knitted) to create a fabric. Yarn strands can be single or ply. Ply yarns formed when two or more strands are twisted together. The amount of twist applied to a yarn can affect the performance and appearance of a fabric. Yarns with a higher twist are more durable and have an increased abrasion resistance because there are fewer loose fiber ends on the surface. Fabrics made with higher twist yarns appear smoother and more lustrous, however, they are typically costlier to make (Bubonia, 2014).

*Knits.* Fabrics formed when yarns are connected in a series of loops are called knits. The interloped structure enables knits to be stretched (Brown & Rice, 2001). According to the ASTM D3887 – 96 (2008): *Standard Specification for Tolerances for Knitted Fabrics*, yarns in the course direction of knitted fabric form a row of successive loops parallel to the width direction of a fabric. Yarns in the wale direction form a column of successive loops parallel to the length direction of the fabric. Knit density refers to the number of courses and wales in a measured area of fabric. The fineness or bulkiness of a knit fabric is dependent on the thickness of the yarn and the stitch type, tension and equipment used (Keiser & Garner, 2012).

***Construction.*** The methods used to sew and assemble the parts and materials of a garment are known as construction. This includes details about the stitch and seam requirements, as well as the order of operations in which components of a garment will be connected (Glock & Kunz, 2005; Kadolph, 2007; Lee & Steen, 2014).

*Stitches.* ASTM D123: *Standard Terminology Relating to Textiles* defines a stitch as a repeated unit formed by sewing thread. Because stitches are used to hold a garment together, the stitch properties are a critical component of overall apparel quality (Lee & Steen, 2014). Stitches help determine the functional and aesthetic performance of a garment. Stitch quality impacts seam strength and garment durability, just as uniform

stitches placed in a straight or smoothly curved line contribute to the attractiveness (Brown & Rice, 2001). The Federal Standard No. 751a, originally set forth to ensure standard construction for military uniforms, was converted to the ASTM D6193 – 97: *Standard Practice for Stitches and Seams*. In this Standard, stitches are grouped into six classes, 100 through 600, based on variations of the following criteria: numbers of needles and threads, requirement of thread interlooping vs. interlacing, stitched by hand vs. sewing machine, and requirement of threads to cover the raw edges of the material.

Stitch length is measured in terms of *stitches per inch* (SPI) and is an important determinate of the aesthetics and function of stitches (Brown & Rice, 2001). A jersey knit fabric, such as the t-shirts making up the sample, would have a standard stitch length of 10 to 12 SPI (Lee & Steen, 2014). Stitches too long or too short for a fabric type may lead to puckering, therefore, stitch length is an easy criterion to use when evaluating overall construction quality in a garment. Stitch length also directly relates to the amount of labor required to sew a garment. Garments with a lower SPI (longer stitch length) can be sewn in a shorter period of time, impacting the cost of manufacturing (Brown & Rice, 2001).

*Seams and hems.* According to the ASTM D6193–11: *Standard Practice for Stitches and Seams*, the characteristics of a properly constructed seam are strength, elasticity, durability, security, and appearance. The properties of the fabric to be joined must also be taken into account in order to form the optimum sewn seam (ASTM, 2011). Similar to stitches, seams are grouped into six classes based on the fabric ply arrangement, and how the seam is stitched, pressed, and finished (Brown & Rice, 2001). *Seam allowance* is the distance between the stitched line of the seam and the edge of the pattern. Seam allowance specifications impact ease of construction and its cost; there should be enough fabric to allow for a sturdy seam, but not too much extra to create bulk or fabric waste. Seam allowance can also effect consumers' perception of quality because a wider seam allowance in frequently altered garment locations such as the waist or hems allow for easier alterations (Shields, 2011).

Hems are an edge finish (EF) seam class and are a necessary edge treatment to prevent woven fabrics from unraveling and knit fabrics from curling (Keiser & Garner, 2012). The sequence for seam and hem construction can impact the quality of a final

product at a given price range. In the case of sleeve hemming, a cuff that is hemmed flat before the underarm sleeve seam is sewn closed would result in a visible underarm sleeve allowance that extends to the edge of the sleeve, possibly causing discomfort to the wearer. A desirable, yet more expensive way to construct a sleeve hem is to close the underarm seam first, then finish the garment edge (Lee & Steen, 2014).

*Assembly.* Garments can be assembled according to several systems. The make-through production system requires the most skill and produces the smallest volume in a given period of time. In this method, one operator assembles and sews the entire garment from start to finish. The modular production system encourages team work as a group of cross-trained operators collaborate on one garment at a time. The progressive bundle system functions in an assembly line format, where sewing operators complete the same task on each the portion of a garment in a bundle before passing it along. The unit production system offers greater efficiency and flow of goods by sending garment bundles to available cross trained operators (Brown & Rice, 2001; Bubonia, 2014; Keiser & Garner, 2012). T-shirt assembly may require as few as eight operations and can be sewn in as little as three minutes (Brown & Rice, 2001).

*Appearance.* “When an individual views and evaluates apparel from a conversational distance, he or she is judging the appearance of the garment. Appearance includes hanger appeal but does not include features that would be evaluated under close scrutiny” (Kadolph, 2007, p. 327). The aesthetic look and appeal of a garment during wear and after laundering is important to consumers and reflects on the quality of an item (Bubonia, 2014).

*Colorfastness.* The resistance of a material to change in any of its color characteristics is known as colorfastness. This includes transferring color to adjacent materials as a result of exposure to environmental factors during the processing, testing, storage, use or maintenance (AATCC, 2016). Color loss may occur after excess dye is removed during laundering or when residual dyes migrate out of the textile fibers (Kadolph, 2007). The retention of color is important to consumers and is sometimes used as a component in determining the serviceability of a textile item. Consumers may discard an otherwise satisfactory textile merely because the color has faded or changed (Collier & Epps, 1999).

*Crocking.* Crocking is the transfer of color from the surface of a colored fabric to another surface, principally by rubbing (AATCC, 2016). Crocking may occur when either adjacent surface is dry, however, it is more likely to occur and is more severe when one surface is wet (Kadolph, 2007).

*Smoothness.* With regard to fabrics, smoothness is a visual impression of the flatness or presence of creases and wrinkles (AATCC, 2016). A rating systems established by the AATCC utilizes standardized replicas to for comparison to the fabric. The ability of a fabric to resist wrinkling is impacted by the fiber composition, yarn structure and size, fabric construction (woven or knit), and the addition of finished applied to the surface (Collier & Epps, 1999). Knits are less likely to wrinkle during use, care, and storage. This is due to the loop structure enabling the yarns to move more freely within the knitted structure (Collier & Epps, 1999; Kadolph, 2010). Before purchasing, some consumers will consider the level of effort involved to maintain the wrinkle-free appearance of a garment (Azevedo, Pereira, Ferreira, & Miguel, 2009).

*Durability.* How long a textile product remains useable for its intended purpose, or its capability to withstand wear is known as durability (Collier & Epps, 1999). A garment that retains its usefulness is referred to as serviceable (Brown & Rice, 2001). Consumers' durability expectations may differ depending on whether an item is a high fashion or a basic product (Kadolph, 2007).

*Bursting strength.* The force or pressure required to rupture the yarns of a fabric via distention is known as bursting strength (AATCC, 2016). Force can be applied either pneumatically, hydraulically, or with a steel ball (Collier & Epps, 1999). Because the force is multidirectional, both the crosswise and lengthwise aspects of the fabric are tested (Kadolph, 2007). Bursting strength measurements help determine if a garment will hold up to its intended use (Keiser & Garner, 2012).

*Pilling.* When small balls of tangled fibers are held to a fabric's surface, they form pills (ASTM, 2016). As a garment is abraded during wear or laundering, loose fiber ends migrate to the surface and break and become entangled with other fibers on the surface. Fabrics that are tested as new and after laundering can perform differently. Finishes applied to new fabric may prevent surface yarns from becoming entangled. After laundering, the removal of finishes allows loose fiber ends on the surface to form

balls or ensnare lint. Fabrics made with a blend of yarns that possess different abrasion properties have a higher pilling propensity (Kadolph, 2007). Knits are more subject to pilling than woven fabrics because the knitted yarns are not held in place as rigidly (Brown & Rice, 2001)

*Dimensional stability.* When a fabric changes in either length or width after being subjected to specific conditions it undergoes dimensional change. The degree of change is usually expressed as a percentage of the initial fabric dimensions (AATCC, 2016). A fabric's ability to resist shrinkage or growth is known as dimensional stability. Exposure to moisture and heat during washing, drying, steaming, or pressing can impact the degree of dimensional change. The physical and chemical properties of the fibers and yarns cause the fabric determine how the fabric will react. Fibers may or may not absorb water, causing them to either swell or remain stable. Yarns under tension during the weaving or knitting process may begin to relax, causing the fabric to shrink (Collier & Epps, 1999).

Knits have a higher propensity for dimensional change than wovens. The ASTM specifies a tolerance of three percent change in knits and a three percent change in wovens (ASTM, 2016). During the knitting process, loops are pulled in the lengthwise direction, however once tension is removed and the yarns relax, the loops may broaden, essentially increasing the fabric width and shortening the length (Kadolph, 2010). As dimensional stability can affect the function of a garment in terms of appearance and fit, producing dimensionally stable fabrics has been a big challenge in the textile industry (Brown & Rice, 2001).

In most garments, shrinkage due to relaxation usually occurs during the first few wash/dry cycles, however some fabrics, including jersey knits may continue to shrink during subsequent wash/cycles, known as progressive shrinkage. Manufacturers take this into account by preshrinking fabrics using the compressive shrinkage process. Consumers expect a certain amount of fabric shrinkage after laundering, and therefore sometimes compensate for this by buying larger garments. However, the percentage of dimensional change is not always easy to predict, and larger amounts of shrinkage can contribute to consumer dissatisfaction (Brown & Rice, 2001; Kadolph, 2007).

*Garment twist.* As a result of laundering, skewness may occur when yarns in fabrics may become angularly displaced from a line perpendicular to the edge of the

fabric. Garments that are made of fabric that is skewed may appear to be twisted. The degree of twist in a garment is not only dependent on the fabric construction properties, but also on the manner of garment assembly (AATCC, 2016). The degree of skew is reported as a percentage and should be less than one percent to minimize garment distortion and consumer dissatisfaction (Kadolph, 2007).

Knit fabrics are more likely to experience skew or torque because of the knitting process, especially circular knits. This is because to form the tube of fabric, yarns are continuously carried in a spiral pattern, resulting in courses and wales that are not perpendicular. When tubular knits are finished, and pressed, creases will be off grain. Laundering causes rotation of the garment when the yarns relax and return to their original position. Excessive skew may distort garments so that they do not hang straight and become unwearable (Brown & Rice, 2001; Kadolph, 2010).

**Consumers' measure of apparel quality.** Consumers differ in the ways in which they evaluate the quality of apparel products. They define quality from many different perspectives; excellence in construction, good performance at a reasonable price, exquisite materials with good hand, high fashion, good fit and function, attractive or unique detailing, unusual trims, and recognized brand (DeKlerk & Lubbe, 2008; Kadolph, 2007). How a consumer measures quality will affect not only whether they make a purchase but also how much more they are willing to spend for the item (Romeo, 2009). Quality is a reflection of the consumer's opinion on the value they see in a product compared to that of a competitor's (Mehta, 1992).

Quality depends on the dimensions of a product or service that are of importance to the individual consumer. These dimensions will differ by product or service type. One challenge of examining quality from the consumer's perspective is understanding and incorporating the characteristics that the customer finds desirable at a price that is acceptable. A problem arises when a price conscious customer that desires superior performance for a certain characteristic may not be willing to pay a higher price for a product that exhibits that characteristic (Kadolph, 2007).

Olson and Jacoby (1972) note that consumers use both extrinsic and intrinsic product characteristics to form perceptions of apparel quality (cited in Hemmerick, 1985). Unfortunately, consumers are often uninformed about how the overall quality of



apparel items should be assessed and therefore lack the ability to objectively evaluate quality. Because clothing is cheaper than in the past, consumers have lower expectations. And as shoppers become conditioned to buying new clothes without inspecting the quality, elements such as the seams or the fabric are not evaluated (Dunbar, 2016).

Consumers' perception of quality has been shown to be affected by factors that may have no relationship to the actual quality of the item under consideration (DeKlerk & Lubbe, 2008; Romeo, 2009). Consumers tend to believe there is a positive relationship between price and quality, whereby high price may lend an aura of quality to a garment. When consumers cannot see a difference in two similar garments, they may rely on price in deciding which garment is of higher quality. However, price does not necessarily reflect quality. High quality goods can be found at low prices and low-quality goods can be found at high prices (Keiser & Garner, 2012). Consumers should be aware that cost does not always reflect aesthetic or durability benefits (Stamper et al., 1991).

Overall, consumers seek quality in their apparel purchases in order to gain satisfaction (Hemmerick, 1985) and they tend to be most satisfied when performance significantly exceed expectations (Kadolph, 2007). Abraham-Murali & Littrell (1995) found that consumers' conceptualization of apparel quality changes over time as it is purchased and used. In turn, quality is still regarded as one of the main reasons for a consumer's dissatisfaction with apparel products (DeKlerk & Lubbe, 2008). Ultimately, the consumer is the final judge of quality (Mehta, 1992).

**Fast fashion and quality.** Consumers of fast fashion are conditioned to expect a constant stream of new fashions. But to keep them buying, fast fashion has to be affordable. This sometimes requires the use cheap, synthetic materials in the apparel process. Although fast fashion has brought style to the masses, unfortunately much of it is poorly made (Zarrolì, 2013). When consumers put price above everything else, cheap fast fashion seems to make sense. Consumers like that they can keep up with multiple trends per season without emptying their wallets. But when many of these garments are quick to shrink, fade, or lose their shape, the bargain no longer seems worth it (Salfino, 2012b). A study by Watson and Yan (2013) revealed that although consumers were satisfied with the purchase of fast fashion garment, they were not always satisfied with the consumption wear and care of the garment.

Fast fashion products are generally only durable enough to last one or two seasons. Although fast fashion brands have attracted many mass market consumers via a variety of stylish products and spacious stores, problems and weaknesses have also arisen. Poor materials and construction quality, and overly trendy products mean that consumers are unable to use these products for more than one or two seasons. The short lives of these products mean that they end up as waste, which is harmful to the environment. Thus, many consumers are now criticizing fast fashion for producing large amounts of these low quality products that stimulate unnecessarily excessive consumption (Kim et al., 2013).

### **T-Shirts and Undershirts**

T-shirts are “mundane, quite unobtrusive...and amongst the commonest of mass-produced garments” (Maynard, 2004, p.96). Worn day or night, in both leisure and luxury contexts, t-shirts are considered “a basic, all purpose form of clothing which is universal in application” (Maynard, 2004, p. 99). And their omnipresent nature has enabled these garments to become a global phenomenon (Southerton, 2011). Some t-shirts have unisex sizing while others can reflect fashion trends through oversized or fitted styling, deep armholes, and varied lengths. The year round, seasonless appeal of t-shirts is achieved with simple changes in the color, fabric weight, or sleeve length (Glock & Kunz, 2005).

In the *Fairchild Dictionary of Fashion* (2003), Calasibetta and Tortora define the t-shirt as “originally a man’s undershirt with short sleeves and a high round neck, forming a T-shape, usually made in white cotton” (p.473). The authors’ definition of the undershirt is similarly stated as a “man’s knitted shirt...worn underneath an outer shirt or sweater” (p.473). They are basic, staple garments (Glock & Kunz, 2005) and “products for which there is a constant and continuing demand” (Calasibetta & Tortora, 2003, p. 25). Because the undershirt and t-shirt have separate definitions, they are technically not the same (Ingham, 2015), however there is documentation of the evolution of the t-shirt from the undershirt. The history of how the undershirt came into prominence is also significant.

**History of mens t-shirts and undershirts.** The function of clothing has been theorized to have many origins. Scholars attribute the adoption of clothing to meet our

needs for protection, modesty, immodesty, and adornment (Dunlap, 1928). Clothing worn as layers with a specific purpose dates back to BCE when Roman soldiers wore linen tunics under heavier cloth and armor (Centeno, 2013; Tortora & Marcketti, 2015). The utility and custom of undergarments evolved based on function, silhouette and eventually comfort (Cunnington & Cunnington, 1992). A reformative movement in the 1880's to impart comfort in the undergarment resulted in the knitted one-piece union suit (Calasibetta & Tortora, 2003). The union suit was then manufactured as a two-piece set, and the upper portion was sometimes worn alone in the nineteenth century by laborers.

At the turn of the twentieth century, the US Navy began to issue undershirts to be worn under service mens' uniforms, leading to the crew wearing just the undershirt to avoid soiling their uniforms while performing chores and dirty jobs. Undershirts soon became available to the public, and were quickly adopted by farmers and more laborers as the garments were inexpensive and easy to maintain. Young boys, who were not limited by a strict dress code, also began to wear undershirts as outerwear. World War II paved the way for greater acceptance of the undershirt. Upon returning after the War, veterans continued to wear undershirts alone as casual wear around the home, and civilians followed suit (Centeno, 2013; McKay & McKay, 2015). A 1940s Sears, Roebuck and Company catalogue advertised that "you needn't be a soldier to have your own personal t-shirt" (McKay & McKay, 2015, para. 7).

The undershirt as outerwear was further popularized in the 1950s when worn on-screen by the virile actors Marlon Brando and James Dean as they portrayed characters with defiant spirits in the movies *A Streetcar Named Desire* and *Rebel Without a Cause*. The adoption of this trend by young men, as form a rebellion and protest, gave birth to the modern t-shirt (Centeno, 2013; "A comparison of men's t-shirts," 2015; McKay & McKay, 2015). The continued expression of revolt and ideology was exhibited while young Hippies in the 1960s made fashionable tie-dyed t-shirts (Powe-Temperley, 2000). The t-shirt maintained popularity with teenagers through the 1970s and beyond (Tranquillo, 1984). It has materialized as a multifunctional garment that can be easily worn by anyone regardless of gender, age, race, fashion taste, social status, income, profession (Maynard, 2004; Glock & Kunz, 2005).

**Market of mens t-shirts and undershirts.** Comfortable, durable, and versatile, t-shirts have mass appeal because they may be worn as outerwear or underwear (Avizienis, 2015). Worn as a casual, base layer or a fashion statement embellished with logos, slogans, or pictures, t-shirts can be found everywhere in cities, suburbs and rural areas (Tranquillo, 1984; Maynard, 2004; “A comparison of mens t-shirts,” 2015).

T-shirts are the most commonly purchased mens clothing item (Smith, 2014). Worldwide approximately 3,800 t-shirts are sold every minute, creating a market worth over three billion dollars (Wallander, 2012; Avizienis, 2015; Dale, 2015). In 2014, the Mintel market research firm reported that 83% of 849 men surveyed had purchased a t-shirt within the previous twelve months (Smith, 2014, para. 13). Today consumers are purchasing more clothing than ever before and the average American owns fifteen t-shirts (Joung, 2014; Smith, 2014, para. 13).

Because a t-shirt can cost so little, it is a clothing option for consumers at all social and economic levels. For some, t-shirts may be perceived as a sign of a disadvantaged and impoverished existence, yet conversely, expensive versions of the garment are worn as status symbols for displaying upscale brand names (Southerton, 2011; Maynard, 2004). The adaptability of the t-shirt has made it the “everyday garment for so called under classes, but in other social contexts it can be a high fashion product with a chic designer logo for which an affluent consumer will pay an exorbitant price” (Maynard, 2004, p. 97). But even though “there are many different classes of t-shirts, but they can themselves be without absolute links to class” (Maynard, 2004, p. 97).

T-shirts were one of the first garments to communicate both verbal and nonverbal signals. Verbal signs on clothing, in the form of brand names, logos, and slogans have proliferated, in part, as a result of the ubiquity of the t-shirt. Printing on t-shirts began sporadically in the 1930s with University logos, then in the late 1940s political slogans migrated to the t-shirt. Advancements during the 1950’s and 1960’s in plastic inks and dye transfers gave rise to t-shirts plastered with commercial logos, designs, and phrases influenced by the cultural climate (Southerton, 2011).

When imprinted, t-shirts provide a unisex way for the wearer to communicate sentiment, views, and humor, or proclaim membership to a club. The wearer can also be associated with a trend by wearing a popular color, style or brand (Glock & Kunz, 2005;

Wells, 2007). Maynard (2004) states “t-shirts are most often associated with meaningful communication in terms of brands and localized messages as they are the material equivalent of something like a personal tattoo” (p. 96). T-shirts can convey both rebellion and conformity, depending on the context and the types of messages inscribed on the front or back (Maynard, 2004). Custom prints and licensed logos may increase the cost of t-shirts, but these designs provide consumer appeal well beyond the intrinsic value of the garment (Glock & Kunz, 2005). T-shirts can be a wordless form of communication based on style of wearing (i.e. cropped, fitted, or oversized) as opposed to what is actually on the t-shirt (Maynard, 2004).

Over the years, mens undershirts have functioned as t-shirts, especially the classic white crew neck t-shirt. But as the technical definitions of a t-shirt and undershirt are not the same (Calasibetta & Tortora, 2003), some manufacturers have confused things further by interchanging the terms t-shirt and undershirt in their promotion and packaging. They are both marketed and consumed to be worn alone or under another shirt (“A comparison of men’s t-shirts,” 2015; Ingham, 2015). Some purists would argue that an undershirt is not a t-shirt because they believe undershirts are meant to be worn solely as undergarments. Undershirts have a tendency to be made of thinner fabrics, and sometimes feature moisture wicking properties (“Why You Should Care About What’s Under There,” n.d.). The purpose of an undershirt is to absorb sweat and to provide a defensive layer between the wearer and his more expensive clothing. An undershirt can also provide insulation when needed, and some styles offer compression to the torso area to provide a slimmer appearance (Centeno, 2013). In these instances, the undershirt may be designed around function instead of form (“Why You Should Care About What’s Under There,” n.d.). Ingham’s (2015) viewpoint that “t-shirts are thicker than undershirts because they are designed to be worn on their own and not necessarily as a layer under something else” (para. 23) is limited because “textile technology has developed fabrics that look heavy without the weight” (Keiser & Garner, 2012, p. 181).

**Quality in mens t-shirts and undershirts.** T-shirts can be manufactured with varying degrees of quality and construction methods. And, the wide range of prices at which they are sold may not always be consistent with the quality level (Glock & Kunz, 2005; Southerton, 2011; Shelasky, 2012; Centeno, 2013; Smith, 2014; Ingham, 2015).

Glock & Kunz (2005) state that “undershirts have more consistency between price and quality; whereas outerwear t-shirts vary widely in quality in price and sometimes rely more on emotional appeal than intrinsic quality” (p. 592). But through this wide variety of t-shirts, the needs and expectations of consumers are to be met (Kadolph, 2010). T-shirts are a popular choice because they are “easy to wear, wash, and manage” (Wells, 2007, p.7). A survey of 6000 American men and women conducted by Cotton Incorporated revealed the participants expected their t-shirts to last four years (Smith, 2014).

T-shirt manufacturing is typically dominated by large companies that produce high volumes. Because the t-shirt is a basic apparel item, it can be continuously manufactured and remain relatively unchanged over multiple fashion cycles. This allows for high levels of automation and specialized equipment (Brown & Rice, 2001; Avizienis, n.d.). T-shirt fabrics are primarily 100% cotton or cotton and polyester blends; all cotton is generally used in making better quality t-shirts, but other factors such as yarn type, fabrication, design treatments, and fabric finishes can also affect quality. Styling variations that impact quality may be seen in the neckline, trims, the inclusion of pockets, or applied design (Glock & Kunz, 2005).

The quality properties of cotton fibers and fabrics make 100% cotton t-shirts more desirable for daily wear. A 2015 Cotton Incorporated survey of 500 consumers indicated that 79% agree that cotton fibers make better quality clothing (Cotton Incorporated Lifestyle Monitor, 2015). However, the influence of sportswear on everyday fashion has resulted in more t-shirts with blends of man made fibers that provide performance features (“A comparison of men’s t-shirts,” 2015). It is also as a result of escalating cotton prices that some brands and retailers began incorporating more man-made fibers into clothing. “Cotton dominant clothes (containing 51% cotton or greater) declined 11.8 percent in 2011 compared to 2010, while imports of predominantly man made apparel increased 8.3 percent” (Salfino, 2012a, p. 2). Rising cotton prices have put pressure on manufacturers to either raise t-shirt prices, use lower quality cotton, or incorporate a cotton blend (Smith, 2014). But ultimately, fabric quality is impacted by the combination and interaction of properties and characteristics of each component used to produce and finish the fabric (Kadolph, 2007).

Fabric weight is a factor that determines cost and quality, as well as its suitability for the intended use and comfort of the wearer (Stamper et al., 1991; Brown & Rice, 2001; Kadolph, 2007). However, “there isn’t necessarily a correlation between the thickness of a t-shirt’s fabric and its quality” (McKay & McKay, 2015, para. 28). Mens fashion blogger, Jamie Rice (2011) relates higher fabric weight to “cheap undershirts [made with] thicker cotton that have bulkier neck and arm seams” (Rice, 2011, para. 5). And although thicker, heavier weight t-shirts may not move as freely, they may be more durable, which is perceived as a quality attribute (Kadolph, 2007, 2010; Todd Shelton, 2016). Conversely, lightweight t-shirts may be luxuriously thin, produced with fine yarns using costly methods to attain a delicate fabric weight. But smaller, finer yarns tend to be weaker, and lightweight t-shirts may drape too limply over the body (Brown & Rice, 2001; Todd Shelton, 2016). Although fabric weight is a measureable way to compare t-shirts and “fabric itself provides a foundation for quality, a high quality fabric does not guarantee a high quality garment” (Brown & Rice, 2001, p. 173).

The characteristics for a perfect t-shirt depend on the desires of the consumer. Quality perceptions and preferences “guide the choices for t-shirts that are either fitted or relaxed, thick or thin, long or short, and crisp or worn” (Smith, 2014, para. 4). The pursuit of manufacturers to provide a perfect t-shirt has led to higher prices for some shirts. And according to Jeffrey Silberman, professor and chair of the Fashion Institute of Technology’s Textile and Development Marketing program, “you’re not going to get [high quality] properties with a shirt that sells for \$5.99” (Smith, 2014, para. 14). Yet cost does not always reflect aesthetic or durability benefits (Stamper et al., 1991) and quality is a multidimensional construct that cannot be measured by a single attribute (Abraham-Murali & Littrell, 1995).

## **Summary**

Clothing is a necessity that has evolved to meet our needs for protection and modesty, as well as our desires for immodesty and adornment (Dunlap, 1928). The time that previous generations spent spinning fibers into yarns, weaving yarns into fabrics, and constructing fabric into clothing are now spent viewing fashions online and clicking a button, followed by waiting as little as a day to receive new clothing. Advances in technology, communication and distribution have led to a global market in which

consumer demands require the marketplace to stay at least one step ahead in order to be successful.

The apparel industry is very complex in that it relies on the constant communication between all involved parties. From fiber growers and developers, material suppliers, designers, manufacturers, distributors, retailers, and even to consumers, the actions of one group can impact the other. The span in which fashions are introduced and adopted is shorter than it was, leading to changes in the industry. Fast fashion has emerged as a way to design, source, make, and distribute clothing *fast* so that the supply of on-trend apparel coincides with the consumers' demand. Some traditional retailers are adopting the fast fashion business model in order to remain competitive. Fast fashion apparel is associated with inferior materials and imperfect construction methods because under this concept, quality can be compromised in order to quickly produce garments (Joung, 2014). Quality, however, can be an abstract concept because it can be defined in many ways, and manufacturers and consumers perceive quality differently.

Product positioning describes how a garment relates to others like it in style, complexity of design, fabric, quality and price. Garments are positioned and priced with the customer and other products in mind (Bubonia, 2011, p. xxiii). According to the literature review, the classic t-shirt is good example of how a garment can be designed, constructed, and positioned with various levels of quality. To help the consumer ascertain the value of a t-shirt purchased at a particular price point within a retail category, it is important to identify and understand how quality is specified and measured. The literature provides support for this research.



## **Chapter Three**

### **Methodology**

The purpose of this research was to evaluate the quality of design, materials, construction, appearance, and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. Observations and measurements were collected from new t-shirts, and after the t-shirts were washed and dried one, five, ten, and twenty times. Fast fashion apparel is associated with inferior materials and imperfect construction methods (Joung, 2014). Despite this negative perspective, the formula of low-cost materials and inexpensive apparel has enabled fast fashion retailers to remain very successful (LaMonica, 2017). It is that success that has caused other retailers to adopt similar production methods in order to remain profitable (“The impact of fast fashion,” n.d.). The t-shirts evaluated in this study are easily differentiated by brand and price. The data was analyzed to ascertain differences and similarities and provide rankings according to the garment specifications. The research design, sample selection, and methods applied to achieve the research objectives are described in this chapter, followed by an overview of the data analysis.

### **Research Design**

A quantitative, quasi-experimental design was utilized to evaluate the t-shirts according to industry standards. The mens 100% cotton jersey knit t-shirts representing three retail categories served as the independent variables. The dependent variables were generated from the tests results; these included fabric weight, fabric count, colorfastness to laundry, colorfastness to crocking, smoothness appearance, bursting strength, pilling, dimensional stability and garment twist. Additionally, construction details, including the stitch and seam type, as well as packaging information were inspected.

### **Samples**

Significant in-store and on-line research was conducted to determine which brands and types of t-shirts would best constitute the sample. The selection was based on the criteria of belonging to one of the three retail categories included in this study, as well as possessing the identical fiber content and fabric construction. T-shirts were purchased in-store, on-line, and over the telephone.

The sample was comprised of mens 100% cotton jersey knit t-shirts from three retail categories, and two colors: white and navy (see Table 3.1). In all, there were 78 t-shirts: 13 white Fruit of the Loom, 13 navy Fruit of the Loom, 13 white H&M, 13 navy H&M, 13 white Brooks Brothers, and 13 navy Brooks Brothers. The retail categories of mass merchant, fast fashion, and better were represented by brands Fruit of the Loom, H&M, and Brooks Brothers, respectively. Fruit of the Loom, known as one of the world's largest manufacturers of underwear, was founded in 1851. This vertically integrated company, headquartered in Bowling Green, Kentucky, offers basic, value-priced clothing (Fruit of the Loom, 2017; "Fruit of the Loom," 2017). H&M (Hennes & Mauritz), a Swedish retail company founded in 1947, entered the U.S. market in 2000. H&M's fast fashion business model, including strategically outsourced production, has enabled it to become the second largest global retailer ("Profile of H&M," 2007; Tan, 2016; H&M, 2017). Brooks Brothers is a privately owned traditional clothier founded in 1818 in Manhattan. With a rich, iconic history of dressing Presidents and celebrities, Brooks Brothers sells clothing world-wide, some of which is still manufactured in the United States (Brooks Brothers, 2017; "Brooks Brothers," 2017).

Table 3.1

*Summary of Sample*

Retail Categories	Brand	T-Shirt Color	Price as Sold	Cost Per T-Shirt
Mass Merchant	Fruit of the Loom	White	\$8.26 / 3 pack	\$2.75
		Navy	\$4.88	\$4.88
Fast Fashion	H&M	White	\$12.99 / 2 pack	\$6.50
		Navy	\$17.99	\$17.99
Better	Brooks Brothers	White	\$39.50 / 3 pack	\$13.17
		Navy	\$49.50	\$49.50

All samples were a short-sleeved crewneck style without pockets or other adornments. The white t-shirts were sold in a pack of multiples and the navy t-shirts were sold individually. By including both white t-shirts and navy t-shirts in the sample,

different aspects of the change in appearance after laundering were measured. The t-shirts were marketed to be worn alone or as an underlayer.

Thirteen t-shirts of each type were included; one served as a control, two were used to measure dimensional stability and skewness, two shirts were evaluated before laundering, and ten shirts were evaluated (as pairs) at the post-laundering intervals of one, five, ten, and twenty. Samples were numbered 1 through 13. The experimental design is presented in Table 3.2.

Table 3.2

*Design of Experiments*

T-Shirt Number 1 served as a control.		T-Shirt Sample Identification Numbers					
		2 & 3	4 & 5	6 & 7	8 & 9	10 & 11	12 & 13
Criteria		Testing Intervals*					
Materials	Garment Weight	<i>All</i>					
	Fabric Weight		<i>0</i>	<i>1</i>	<i>5</i>	<i>10</i>	<i>20</i>
	Fabric Count		<i>0</i>				<i>20</i>
Construction	Stitch Type		<i>0</i>				
	Seam Type		<i>0</i>				
	Assembly		<i>0</i>				
Appearance	Colorfastness & Whiteness	<i>All</i>					
	Crocking	<i>All</i>					
	Appearance	<i>All</i>					
	Smoothness	<i>All</i>					
Performance	Bursting Strength		<i>0</i>	<i>1</i>	<i>5</i>	<i>10</i>	<i>20</i>
	Pilling		<i>0</i>	<i>1</i>	<i>5</i>	<i>10</i>	<i>20</i>
	Dimensional Stability	<i>All</i>					
	Skewness	<i>All</i>					

\*Intervals: *0* = “Initial” (before washing); *All* = Tested at Intervals 0, 1, 5, 10, 20

## **Instruments and Measurements**

Key variables of the experimental segment included the recommended test methods designated in the ASTM D6321/D6321M-14: *Standard Practice for the Evaluation of Machine Washable T-Shirts*. Instruments used for direct testing of the apparel were the specified textile testing equipment located in the University of Kentucky Textile Testing Laboratory. Measurements and ratings for these laboratory tests were based on the standard test method procedures set forth by the American Society for Testing and Materials (ASTM) and the American Association of Textile Chemists and Colorists (AATCC). Testing and evaluations were performed: initially, and after laundry cycles one, five, ten, and twenty.

## **Procedures**

The samples and specimens of each t-shirt type were prepared under the same parameters and subjected to identical textile tests and evaluations. When required, samples and specimens were conditioned for a minimum of four hours in an atmospheric chamber, registering  $70^{\circ} \pm 2^{\circ}$  Fahrenheit and with a relative humidity of  $65\% \pm 5\%$ , prior to testing and evaluation as set forth by the ASTM D1776 *Standard Practice for Conditioning and Testing Textiles* (ASTM, 2016). Criteria for identification, inspection, testing and evaluation are outlined in the sections following the description of the laundering methods.

**Laundering methods.** The care labels of the types of t-shirts were reviewed in order to establish washer and dryer cycles that would closely mimic a consumer's laundry habits. T-shirts were laundered, face-side out, in residential washers and dryers for 20 cycles. Two top-load, center-agitator washers, and two electric tumble dryers were used to launder the t-shirts. The navy t-shirts were laundered separately from the white t-shirts, essentially forming a 'navy t-shirt load' and a 'white t-shirt load.' Both loads were washed in 'large level' of 'warm' water ( $40^{\circ}\text{C}$  /  $104^{\circ}\text{F}$ ), on the 'Colors/Regular' cycle, using 40 grams of a national brand of liquid detergent. The water supply was from a municipal source with an average hardness of 12 grains per gallon. The wash cycle duration was approximately 35 minutes. Both t-shirt loads were dried with medium heat on the 'timed dry' cycle for 60 minutes. The navy and white loads were alternated between the two sets of washers and dryers at each laundering interval.

**Design specifications.** A basic style and materials overview of each type t-shirt was documented. Recorded details were the fabric and color information, style number, sample size and size range. Purchase price, purchase location, merchandising description, as well as hangtag and packaging details were noted. Additionally, the country of origin and care label instructions were reported. Sizing and fit of the t-shirts was compared using technical measurement specifications and tolerances for men's size large t-shirts, sourced from *The Apparel Design and Production Hand Book* (The Fashionindex, 2001), Sample measurements each t-shirt were recorded initially, averaged and reported in table format for comparison.

**Materials specifications.** Fabrics and other components such as threads, trims, and closures used to complete a garment are called materials. (Brown & Rice, 2001; Glock & Kunz, 2005). Materials selection has a significant impact on the quality and performance of a garment (Bubonia, 2014).

**Fiber content and finish.** The fiber content of the t-shirts was verified through a chemical fiber analysis. And fabric finishes were documented.

**Fabric weight.** For each t-shirt type, the ounces per square yard were calculated according to the ASTM D3776/D3776M – 09a (2013): *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*. Specimens were collected initially, and from t-shirts laundered one, five, ten, and twenty times. From each sample, three 5.94 in. circular specimens were cut from disparate locations using a J.A. King® Universal Sample Cutter (model SASD-688) and were weighed on an analytical balance. The weight was initially reported in grams to the thousandths place and then converted to ounces per square yard using the formula:

$$\text{oz./yd}^2 = 45.72 \times \text{weight in grams} / 5.94$$

**Fabric count.** The wale and course yarns in three 1 in. x 1 in. locations were counted and averaged according to the ASTM D8007-15: *Standard Test Method for Wale and Course Count of Weft Knitted Fabrics*. Knit fabric count was reported as 'wale x course,' where the total count was the addition of the two values. Fabric count was performed initially and on t-shirts laundered twenty times.

**Construction specifications.** Apparel construction specifications provide detailed information about how each part of a garment is sewn and assembled (Lee & Steen, 2014). Construction is a physical feature of a garment and can impact the overall quality based on the execution of specified methods (Brown & Rice, 2001). The construction of the t-shirts was evaluated by determining the stitch types, stitches per inch, and stitch locations. Seam types, seam locations, and hems were also identified. The results are illustrated in table format in Appendix B. The order of operations in which each t-shirt was assembled was identified and described.

**Appearance specifications.** The aesthetic appeal of a garment during wear and after laundering is important to consumers and reflects on the quality of an item (Bubonia, 2014). Appearance was evaluated by measuring changes in the color or whiteness of the t-shirts, as well as the transfer of color, and the degree to which fabric components of the t-shirts performed compared to AATCC reference standards.

***Colorfastness to laundry.*** A subjective visual evaluation and an objective instrumental measurement was performed throughout the study to record any change in color of the navy t-shirts. Subjective color assays were performed after washes one, five, ten, and twenty; instrumental color assays included initial measurements. Some fading usually occurs during the laundering process, especially when cotton is the dominant fiber. Fading usually occurs gradually, but becomes more apparent if two matching garments are laundered a different amount of times (Stamper et al., 1991).

***Subjective color change.*** Utilizing the AATCC Evaluation Procedure 1–2012: *Gray Scale for Color Change*, a subjective, visual evaluation was performed to compare the color of washed t-shirts to an unwashed control. After the designated testing intervals, the specified washed t-shirt and the corresponding control were placed side-by-side, oriented in the same direction (face-side out), on a small viewing board set at a  $45^{\circ} \pm 5^{\circ}$  angle in a SpectraLight QC light booth. A D65 illuminant was used to simulate mid-day light. Observation occurred at  $90^{\circ} \pm 5^{\circ}$  to the plane of the samples. An AATCC Gray Scale for Color Change card was used as the standard for measuring color change. The Gray Scale consists of pairs of standard gray chips that represent progressive differences in color or contrast that correspond to numerical colorfastness grades. The grading scale ranges from 1 to 5, with half ratings in between. A colorfastness grade of 1

represents *very severe* color change, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color change. Based on this scale, the perceived difference in color or contrast between the original samples and the washed t-shirts were recorded.

**Instrumental color change.** The color difference (*Delta E*) of the navy t-shirts before and after washing was measured according to the AATCC Evaluation Procedure 7-2015: *Instrumental Assessment of the Change in Color of Test Specimen*. A HunterLab LabScan XE spectrophotometer with a 2 inch port, set to 0° illumination, with a 45° viewing angle was used to calculate the L\*a\*b\* color coordinates of the specified t-shirts. Each t-shirt served as its own control. To capture a measurement, the t-shirt was arranged face-side out and folded to the thickness of four layers. Locations of the t-shirt that were free of seams and wrinkles were randomly selected and placed over the spectrophotometer viewing port. After a measurement was taken, the sample was rotated 90° in order to have a second measurement taken in the same location. The color coordinates of three locations per t-shirt were measured, averaged and recorded. The Delta E after washes one, five, ten, and twenty was calculated using EasyMatch QC™ software.

**Whiteness of textiles.** A subjective visual evaluation and an objective instrumental measurement was performed throughout the study to record any change in the whiteness of t-shirts. Subjective whiteness was performed after washes one, five, ten, and twenty.

**Subjective whiteness change.** As instructed in the AATCC Evaluation Procedure 1–2012: *Gray Scale for Color Change*, a subjective, visual evaluation was performed to compare the whiteness of washed t-shirts to an unwashed control. After the designated testing intervals, the specified washed t-shirt and the corresponding control were placed side-by-side, oriented in the same direction (face-side out), on a small viewing board set at a 45° ± 5° angle in a SpectraLight QC light booth. A D65 illuminant was used to simulate mid-day light. Observation occurred at 90° ± 5° to the plane of the samples. An AATCC Gray Scale for Staining card was used as the standard to measure color change. The use of this scale is a modification to the Evaluation Procedure to compare white objects that have and have not been laundered. The Gray Scale for Staining consists of pairs of standard gray and white reference chips that represent progressive

differences in color or contrast that correspond to numerical staining grades. The grading scale ranges from 1 to 5, with half ratings in between. A grade of 1 represents *very severe* whiteness change, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no whiteness change. Based on this scale, the perceived difference in whiteness or contrast between the original sample and the washed t-shirt were recorded.

*Instrumental whiteness change.* The ‘whiteness’ of the white t-shirts, before and after washing, was measured according to the AATCC Test Method 110 – 2015:

*Whiteness of Textiles.* A HunterLab LabScan XE spectrophotometer with a 2 inch port, set to 0° illumination, with a 45° viewing angle was used to calculate the *whiteness index* and the L\*a\*b\* color coordinates of the specified t-shirts. Each t-shirt served as its own control. To capture a measurement, the t-shirt was arranged face-side out and folded to the thickness of four layers. Locations of the t-shirt that were free of seams and wrinkles were randomly selected and placed over the spectrophotometer viewing port. After a measurement was taken, the sample was rotated 90° in order to have a second measurement taken in the same location. The whiteness coordinates at three locations per t-shirt were measured, averaged and recorded. The whiteness indices before washing, and after washes one, five, ten, and twenty were calculated using Universal™ software.

*Colorfastness to crocking.* The crocking propensity of the navy t-shirts was evaluated according to the AATCC Test Method 8 – 2013: *Colorfastness to Crocking: Crockmeter Method*. This test was performed on the navy t-shirts, initially and after washes one, five, ten, and twenty.

‘Wet’ and ‘dry’ crocking tests were performed. In each method, a 5 cm x 5 cm Crockmeter Test Cloth, meeting specifications designated in section 14.5 of the test method noted above, was rubbed against the t-shirt. Dry crocking was performed when the test cloth was dry; wet crocking was performed when the test cloth was moistened with deionized water. For methods, random locations of each navy t-shirt were placed (in the wale direction) on an Atlas CM-5 AATCC Electronic Crockmeter apparatus and exposed to ten rubbing cycles against the 5 cm x 5 cm test cloth.

Transfer of the t-shirt color onto the test cloths was evaluated after the test cloths were conditioned in an atmospheric chamber. The test cloth crocking specimens were backed with an additional layer of a white test cloth and then mounted on a white piece of



paper. Crocking specimens were placed on a viewing board set at a  $45^{\circ} \pm 5^{\circ}$  angle in a SpectraLight QC light booth. A D65 illuminant was used to simulate mid-day light and observation occurred at  $90^{\circ} \pm 5^{\circ}$  to the plane of the specimens. An AATCC Gray Scale for Staining card was placed at the edge of the color transfer and white portion of the test cloth. The Gray Scale consists of pairs of standard gray and white reference chips that represent progressive differences in color or contrast that correspond to numerical color transfer grades. The grading scale ranges from 1 to 5, with half ratings in between. A grade of 1 represents *very severe* color transfer, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color transfer. Based on this scale, the perceived degree of color transfer was recorded.

***Appearance of stitches/seams/hems/neckline after laundering.*** A visual inspection of all stitches, seams, hems, and necklines initially and after laundry cycles one, five, ten, and twenty was conducted. These observations provided information about each shirt's ability to maintain its original appearance.

***Smoothness appearance.*** The ability for the t-shirts to release wrinkles after home laundering was evaluated according to the procedures outlined in the AATCC Test Method 124 – 201: *Smoothness Appearance of Fabrics after Repeated Home Launderings*. Smoothness evaluations were performed initially, and after laundry cycles one, five, ten, and twenty. For each evaluation, the samples were hung on a clothes hanger after the appropriate wash/dry interval and placed in an atmospheric chamber for a minimum of four hours before assigning smoothness ratings. Upon evaluation, samples were hung, one at a time, on an AATCC viewing board according to Fig. 1 noted in the AATCC Test Method 124. Samples were viewed at a distance of  $1.2 \pm 0.3$  m. Ratings were assigned based on comparisons to the AATCC 3-D Smoothness Appearance Replicas. There are six grading increments between 1 and 5, where 'SA-1' represents a *crumpled, creased and severely wrinkled appearance* and 'SA-5' represents a *very smooth, pressed, finished appearance*. Smoothness grades 2, 3, 3.5, and 4 represent appearances progressing from *rumpled* to *smooth*, accordingly.

***Durability/Serviceability specifications.*** Durability is the amount of use a consumer will get before the product physically deteriorates, or the degree to which a product tolerates stress or trauma without failing. Individual consumers may judge

differently the point at which product is no longer suitable for end use (Garvin, 1984; Kadolph, 2007). Serviceability refers to the speed and ease of repair. A garment that can be cleaned and restored to its new or near new condition is considered serviceable (Garvin, 1984; Kadolph, 2007).

***Fabric bursting strength.*** The t-shirt knit fabrics were subjected to pneumatic pressure to the point of rupture as outlined in the ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method*. T-shirts were tested initially and after laundry cycles one, five, ten, and twenty. Five 5 in.<sup>2</sup> specimens were cut from random locations of the selected samples and conditioned in an atmospheric chamber for a minimum of four hours. To measure the pounds per square inch (psi) required to burst the t-shirt yarns, each specimen was placed face-side up on a James Heal TruBurst Bursting Tester, model 600. The diaphragm inflation rate was adjusted as necessary to achieve bursting at  $20 \pm 5$  seconds. Results for the five specimens from each sample were averaged and reported in psi.

***Pilling and fuzzing.*** The ability of the t-shirt fabric to resist abrasion was evaluated according to the ASTM D4970/D4970M – 10: *Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Martindale Tester*. T-shirts were tested initially and after laundry cycles one, five, ten, and twenty. Three specimen sets, consisting of circles with diameters of 1.5 in. and 5.5 in., were cut at random locations from each designated t-shirt. After being conditioned in an atmospheric chamber for a minimum of four hours, specimen sets were placed on a James Heal Nu-Martindale Abrasion and Pilling Tester, model 864, with face-sides touching. A 9 kPa pressure spindle was used and each specimen set was exposed to 1600 rubbing cycles. Upon completion, the 1.5 in. diameter pilling specimens were placed on a viewing board set at a  $45^\circ \pm 5^\circ$  angle in a SpectraLight QC light booth. A D65 illuminant was used to simulate mid-day light and observation occurred at  $90^\circ \pm 5^\circ$  to the plane of the specimens. The surface wear was evaluated by comparison to an ASTM photographic standard. Ratings of 1 through 5, with half steps in between were assigned based on the degree of surface change. Ratings are classified to be 1 as *very severe pilling*, 2 as *severe pilling*, 3 as *moderate pilling*, 4 as *slight pilling*, and 5 as *no pilling*.

**Dimensional stability.** Changes in the t-shirt length and width were measured according to the AATCC Test Method 150 – 2012: *Dimensional Changes of Garments after Home Laundering*. Benchmarks were designated in section 7.2.3 of ASTM D6321/D6321M–14: *Standard Practice for the Evaluation of Machine Washable T-Shirts*. T-shirts were evaluated initially and after washes one, five, ten, and twenty. Prior to measuring the benchmarks, the t-shirts were conditioned in an atmospheric chamber for a minimum of four hours and then laid flat, free of tension, with wrinkles smoothed. Measurements obtained after washes one, five, ten, and twenty were compared to the initial measurements before washing. The dimensional change was calculated using the following formula:

$$\%DC = 100 (B - A) / A$$

**Garment twist.** Distortion of the t-shirt fabrics after laundering was evaluated according to the AATCC Test Method 179 – 201: *Skewness Change in Fabric and Garment Twist Resulting from Automatic Home Laundering*. ‘Marking Method 2’ was followed as indicated in section 7.2.4 of the ASTM D6321/D6321M–14: *Standard Practice for the Evaluation of Machine Washable T-Shirts*. Benchmarks were drawn before laundering, and the t-shirts were laid flat, free of tension, with wrinkles smoothed for all intervals of marking and measuring. Measurements were performed initially, and after washes one, five, ten, and twenty. The percent change in skewness was calculated to the nearest 0.1% according to the following formula:

$$\%Skewness\ Change = 100 (AA' / AB)$$

## **Data Analysis**

Numerical data was entered into Excel software to calculate descriptive statistics. Procedural results from instrumental measurements, ratings, and evaluations were presented in either figure or table format. For data analysis, Excel data was imported to Minitab statistical software to complete a one-way analysis of variance (ANOVA). A 95% confidence interval with a significance level ( $\alpha$ ) of 0.05 was used to determine the statistical significance. Results were followed by a discussion of differences among the t-shirts from three retail categories.

## **Chapter Four**

### **Results and Discussion**

The purpose of this research was to evaluate the quality of design, materials, construction, appearance, and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. The sample was comprised of 78 t-shirts: 13 white Fruit of the Loom, 13 navy Fruit of the Loom, 13 white H&M, 13 navy H&M, 13 white Brooks Brothers, and 13 navy Brooks Brothers. Observations and measurements were collected from new t-shirts, and after the t-shirts were washed and dried one, five, ten, and twenty times.

To interpret results, data was grouped by testing interval, t-shirt color and brand. Summaries are presented via figures and tables with descriptive statistics. Statistical analysis was performed using Minitab software to conduct a one-way ANOVA. A 95% confidence interval with a significance level ( $\alpha$ ) of 0.05 was used to determine the statistical significance of the data. Tables in Appendix B present the details of the data for all wash cycles. When applicable, results are discussed in comparison to the ASTM D4154–14: *Standard Performance Specification for Men's and Boy's Knitted and Woven Beachwear and Sports Shirt Fabrics*.

Due to the large sample size, the focus of the discussion will be the data collected after washes five and twenty. A product tested after five washes should reflect how it will function after residual and/or temporary finishes are removed. Data collected after twenty washes is an indication of the expected serviceability of a garment throughout its wear (Brown & Rice, 2001; Glock & Kunz, 2005).

#### **Design Specifications**

An overview of the style and materials of the t-shirts are presented in Tables 4.1 and 4.2. This includes the fabric and color information, style number, sample size, and size range.

Table 4.1

*Style and Materials Summary, White T-Shirts*

Retail Category	Fruit of the Loom	H&M	Brooks Brothers
Item Category	Men's crewneck t-shirt	Men's crewneck t-shirt	Men's crewneck t-shirt
Fabric Category	Single Jersey Weft Knit	Single Jersey Weft Knit	Single Jersey Weft Knit
Fiber Content	100 % Cotton	100 % Cotton	100 % Supima® Cotton
Color	White	White	White
Finish	Routine	Routine	"Ultra-Fresh"
Neckband	1 x 1 Rib	1 x 1 Rib	1 x 1 Rib
Tape at Neck and Shoulder	Knit Self-Fabric	Knit Self-Fabric	Knit Self-Fabric
Body Construction	Tube	Side Seams	Tube
Sample Size	Large	Large	Large
Size Range	S, M, L, XL	XS, S, M, L, XL, XXL	S, M, L, XL, XXL
Style No.	2828	38420	3861
FTC Label at Neck	Tagless / Heat Transfer	Tagless / Heat Transfer	Tagless / Heat Transfer
Country of Origin	Made in El Salvador	Made in Bangladesh	Made in Thailand
Registration Number (RN)	13765	101255	93986

As a group of white t-shirts, there was a difference in body construction and size range. The body of the Fruit of the Loom and Brooks Brothers t-shirts was constructed of a seamless tube of knit fabric. The body of the H&M t-shirts was constructed with side seams. The range of sizes differed as follows: Fruit of the Loom was S to XL; H&M was XS to XXL; and Brooks Brothers was S to XXL.

Table 4.2

*Style and Materials Summary, Navy T-Shirts*

Retail Category	Fruit of the Loom	H&M	Brooks Brothers
Item Category	Men's crewneck t-shirt	Men's crewneck t-shirt	Men's crewneck t-shirt
Fabric Category	Single Jersey Weft Knit	Single Jersey Weft Knit	Single Jersey Weft Knit
Fiber Content	100 % Cotton	100 % Cotton	100 % Supima® Cotton
Color	Navy	Dark Blue	Navy
Finish	N/A	N/A	"Washed in a secret wash to give it an ultra soft hand feel."
Neckband	1 x 1 Rib	1 x 1 Rib	1 x 1 Rib
Tape at Neck and Shoulder	Knit Self-Fabric	Knit Self-Fabric	Woven Contrast Fabric
Body Construction	Tube	Side Seams	Side Seams
Sample Size	Large	Large	Large
Size Range	S, M, L, XL-6XL	XS, S, M, L, XL, XXL	S, M, L, XL, XXL
FTC Label at Neck	Tagless / Heat Transfer	Tagless / Heat Transfer	Tagless / Heat Transfer
Style No.	3930	50236	51718
Country of Origin	Made in El Salvador	Made in Cambodia	Made in China
Registration Number (RN)	13765	101255	93986

As a group of navy t-shirts, there were differences in body construction and size range. The Fruit of the Loom body was a seamless tube of knit fabric. The body of the H&M t-shirts and the Brooks Brothers t-shirts was constructed with side seams. The range of sizes differed as follows: Fruit of the Loom was S to 6XL; H&M was XS to XXL; and Brooks Brothers was S to XXL. The Brooks Brothers t-shirts had three additional design details. The tape material used as facing inside the neck and shoulder seams was a woven tape instead of knit self-fabric. These t-shirts also included a self-colored embroidered logo on the front left chest area. Also, there were side vents at each side of the bottom hem. Photographs of these additions are included in Appendix B.

The retail price and promotion description are presented in Tables 4.3 and 4.4. Packaging details and merchandising format are also included.

Table 4.3

*Price, Promotion, and Packaging Details, White T-Shirts*

Retail Category	Fruit of the Loom	H&M	Brooks Brothers
Retail Price	\$8.26 / 3-pack	\$12.99 / 2-pack	\$39.50 / 3-pack
Online Description	Men's White Crews 3 pack	2-pack T-shirts	Supima® Cotton Crewneck Undershirt – 3 pack
Retail Channel	In store or online: Wal-Mart Website www.walmart.com	Online only: H&M Website www.hm.com	In store or online: Brooks Brothers Website www.brooksbrothers.com
Online Promotion	New Reinvented Fruit of the Loom Men's White Crews, 3-Pack. This tee has been completely reinvented to eliminate ride-up and stay tucked so you can go about your busy day with confidence.	CONSCIOUS. Round-neck T-shirts in jersey made from an organic cotton blend.	Soft Supima® cotton. Finished with Ultra-Fresh for protection against odors.
Care Instructions as Noted on Package or Online	On Package: Machine wash warm; gentle cycle; colors separately; only non-chlorine bleach when needed; tumble dry low; cool iron	Online: Machine wash warm	Online: Machine wash
Packaging and Presentation	As packaged in store: Folded in polybag; product details printed on polybag; 3 t-shirts stacked and wrapped together around one piece of lightweight paperboard	As packaged online: Folded in polybag as a pair; no product details printed on polybag; 1 t-shirt of the pair had a hang-tag attached	In store and online: Folded in polybag; product details printed on paperboard inserted in polybag; 3 t-shirts folded individually and around own heavyweight paperboard
In Store Merchandise Format	Polybags are set vertically on shelves in the men's underwear department	N/A	Polybags are set vertically on shelves in the accessory location of the store

As a group of white t-shirts, there were differences in price and packaging units. The Fruit of the Loom t-shirts were available in packs of three, six or nine. H&M t-shirts were sold in a two pack, and Brooks Brothers t-shirts were sold in a three pack. The lowest price point was the Fruit of the Loom t-shirts at \$8.26 per pack, and the highest price point was the Brooks Brothers t-shirts at \$39.50 per pack. The Fruit of the Loom and Brooks Brothers t-shirts were available for purchase in store and online, however, the H&M t-shirts were available online only. Packaging for the Brooks Brothers t-shirts included the most materials in that each t-shirt was folded with a shape retaining paperboard, a thicker polybag was used, and a heavy paper insert was used to promote product details.



Table 4.4

*Price, Promotion, and Packaging Details, Navy T-Shirts*

Retail Category	Fruit of the Loom	H&M	Brooks Brothers
Retail Price	\$4.88 each	\$17.99 each	\$49.50 each
Online Description	Men's Lightweight Short Sleeve T-Shirt	Premium Cotton T-Shirt	Supima® Cotton Tee Shirt
Retail Channel	In store or online: Wal-Mart Website www.walmart.com	In store or online: H&M Website www.hm.com	In store or online: Brooks Brothers Website www.brooksbrothers.com
Online Promotion	"This fit won't quit, wear after wear, wash after wash"; A great men's crew neck t-shirt is a like a buddy you love to hang out with; 100% cotton preshrunk jersey	PREMIUM QUALITY. Crew-neck t-shirt in jersey made from premium cotton.	Put this on and you'll never want to take it off. Our classic pure Supima® cotton tee shirt. Washed in a secret wash to give it an ultra soft hand feel.
Care Instructions	N/A	Online: Machine wash warm	Online: Machine wash
Packaging and Presentation	In store and online: No polybag; Adhesive label on chest indicates size and price	As packaged online: Folded in polybag without tissue or paperboard	As packaged online: Folded in polybag with tissue between the folds and plastic clips to maintain folds; no paperboard
In Store Merchandise Format	Folded and stacked on shelves	On hanger	No polybag; Folded on table with tissue paper between the folds

As a group of navy t-shirts, there were differences in price and merchandising format. The lowest price point was Fruit of the Loom t-shirts at \$4.88 each, and the highest price point was the Brooks Brothers t-shirts at \$49.50 each. Fruit of Loom t-shirts were folded and displayed on shelves, with adhesive labels on the chest which included sizing and product information. H&M t-shirts were merchandised on hangers placed on a garment rack, with a hang tag inserted in the neck seam. Brooks Brothers t-shirts were folded and included tissue paper within the fold. They were merchandised on tables with a hang tag inserted in the neck seam.

The recommended care instructions provided by the manufacturer are presented in Tables 4.5 and 4.6. The location of the care label is also included.

Table 4.5

*Care Instructions, White T-Shirts*

Retail Category	Fruit of the Loom	H&M	Brooks Brothers
Location of Care Label	At neck; tagless	Sewn into side seam	Sewn into bottom hem
Care Label Material	N/A	Woven Tafetta / Satin	Woven Tafetta / Satin
Care Instructions on Label	(Symbols only) Machine wash warm, non-chlorine bleach, Tumble dry low heat, iron medium heat	(Symbols only) Machine wash warm, do not bleach, do not tumble dry, iron medium heat, do not dry clean	Machine wash warm with like colors, only non-chlorine bleach, tumble dry low, cool iron if needed, dry clean any solvent except trichloroethylene

As a group of white t-shirts, the Fruit of the Loom t-shirts included a tagless heat transfer care label, while the care labels for both H&M and Brooks Brothers were printed on labels sewn into the t-shirts. The care labels for the H&M t-shirts were sewn into the left side seam, 4” above the bottom hem. The care labels for the Brooks Brothers t-shirt were sewn into the bottom hem. The Brooks Brothers care labels had a tendency to hang down below the bottom hem of the t-shirt, therefore it would be visible if the t-shirt was worn untucked. All three brands of t-shirts had care instructions that recommended a warm water wash and a dry cycle with low heat. The instructions for the Fruit of the Loom and Brooks Brothers t-shirts indicated that non-chlorine bleach could be used, however, the H&M t-shirts recommended no bleach. Dry cleaning was listed as a cleaning option for the Brooks Brothers t-shirts.

Table 4.6

*Care Instructions, Navy T-Shirts*

Retail Category	Fruit of the Loom	H&M	Brooks Brothers
Location of Care Label	At neck; tagless	Sewn into side seam	Sewn into side seam
Care Label Material	N/A	Woven Taffeta / Satin	Woven Taffeta / Satin
Care Instructions on Label	(Symbols only) Machine wash cold, non-chlorine bleach, Tumble dry low heat, iron medium heat	(Symbols only) Machine wash warm, do not bleach, do not tumble dry, iron medium heat, dry clean any solvent except trichloroethylene	Machine wash warm with like colors, do not bleach, tumble dry low, cool iron if needed, dry clean any solvent except trichloroethylene

As a group of navy t-shirts, the care labels for both the H&M and Brooks Brothers t-shirts were printed on labels that were sewn into left side seams of the t-shirts, 4” above the bottom hems. The Fruit of the Loom t-shirts included a tagless heat transfer care label. The care instructions differed as Fruit of the Loom t-shirts recommended a cold water wash, while the H&M and Brooks Brothers t-shirts recommended a warm water wash. Tumble dry, low heat was recommended for the Fruit of the Loom and Brooks Brothers t-shirts, however the H&M care label recommended do not tumble dry. Fruit of the Loom recommended a non-chlorine bleach when needed, however do not bleach was the recommendation of H&M and Brooks Brothers t-shirts. The care instructions for both H&M and Brooks Brothers t-shirts included dry clean.

**Size and fit.** Technical specifications and garment measurements for men’s size large t-shirts are presented in Tables 4.7 and 4.8. Measurements of the sample are included for comparison. Details for measurement locations are in Appendix B.

Table 4.7

*Comparison of Technical Specifications and Measurements of the White T-Shirts*

Measurement Location	Specification Size Large	Specification Tolerance + or -	Fruit of the Loom		H&M		Brooks Brothers	
			White T-Shirts		White T-Shirts		White T-Shirts	
			Avg.	+ or - <sup>a</sup>	Avg.	+ or - <sup>a</sup>	Avg.	+ or - <sup>a</sup>
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Body Length	30	3/4	31 6/16	1 6/16 <sup>b</sup>	29 5/16	- 11/16	30 14/16	14/16 <sup>b</sup>
Chest Width	48	1/2	44 13/16	-3 3/16 <sup>b</sup>	44 2/16	- 3 14/16 <sup>b</sup>	45 4/16	-2 12/16 <sup>b</sup>
Bottom Width	48	N/A	45 2/16	-2 14/16	44 4/16	- 3 12/16	47	-1
Cross Shoulder	21	3/8	19 11/16	-1 5/16 <sup>b</sup>	17 15/16	- 3 1/16 <sup>b</sup>	18 14/16	-2 2/16 <sup>b</sup>
Cross Front	20 1/4	3/8	18 6/16	-1 15/16 <sup>b</sup>	15 12/16	- 4 8/16 <sup>b</sup>	18 8/16	-1 13/16 <sup>b</sup>
Cross Back	20 1/2	3/8	18 13/16	- 1 11/16 <sup>b</sup>	16 11/16	- 3 14/16 <sup>b</sup>	18 6/16	-2 3/16 <sup>b</sup>
Armhole	21 1/2	1/2	18 3/16	-3 5/16 <sup>b</sup>	19 14/16	- 1 10/16 <sup>b</sup>	21 12/16	4/16
Sleeve Length	10	3/8	7 4/16	-2 2/16 <sup>b</sup>	8 13/16	-1 3/16 <sup>b</sup>	8 10/16	-1 6/16 <sup>b</sup>
Sleeve Opening	15 1/2	1/2	14 10/16	-14/16 <sup>b</sup>	14 1/16	-1 7/16 <sup>b</sup>	15 3/16	-5/16
Side Length	N/A	N/A	18 14/16	n/a	19 7/16	n/a	18 12/16	n/a
Neckline Circumference	20 1/2	3/8	21 11/16	1 3/16 <sup>b</sup>	21 14/16	1 6/16 <sup>b</sup>	19 5/16	-1 3/16 <sup>b</sup>
Back Neck Width	8 1/4	N/A	7 13/16	-7/16	8	- 5/16	6 1/16	-2 4/16
Front Neck Drop	3 1/4	3/8	4 13/16	1 9/16 <sup>b</sup>	4 3/16	15/16 <sup>b</sup>	5 2/16	1 14/16 <sup>b</sup>
Back Neck Drop	1 1/4	3/8	1 10/16	6/16	1 2/16	- 2/16	12/16	- 9/16 <sup>b</sup>
Neck Trim Height	7/8	1/4	12/16	-3/16	8/16	- 6/16 <sup>b</sup>	12/16	- 2/16
Bottom Hem Width	1	1/4	11/16	-6/16 <sup>b</sup>	1	0	12/16	- 4/16

*Note.* Specifications adapted from *The Apparel Design and Production Handbook: A Technical Reference*, pp. 4•127, 7•10 (2001).

<sup>a</sup>Difference between technical specification and average sample measurement.

<sup>b</sup>Measurement is outside of tolerance range.

Table 4.8

*Comparison of Technical Specifications and Measurements of the Navy T-Shirts*

Measurement Location	Specification Size Large	Specification Tolerance + or -	Fruit of the Loom		H&M		Brooks Brothers	
			Navy T-Shirts		Navy T-Shirts		Navy T-Shirts	
			Avg.	+ or - <sup>a</sup>	Avg.	+ or - <sup>a</sup>	Avg.	+ or - <sup>a</sup>
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Body Length	30	3/4	30 4/16	4/16	28 4/16	- 1 13/16 <sup>b</sup>	28 14/16	-1 3/16 <sup>b</sup>
Chest Width	48	1/2	45 7/16	- 2 9/16 <sup>b</sup>	43 7/16	- 4 9/16 <sup>b</sup>	45 6/16	-2 10/16 <sup>b</sup>
Bottom Width	48	N/A	45 8/16	- 2 8/16	42 14/16	- 5 2/16	45 12/16	-2 4/16
Cross Shoulder	21	3/8	21 6/16	6/16	17 11/16	- 3 6/16 <sup>b</sup>	19 12/16	-1 4/16 <sup>b</sup>
Cross Front	20 1/4	3/8	20 5/16	1/16	15 12/16	-4 8/16 <sup>b</sup>	18 5/16	-1 15/16 <sup>b</sup>
Cross Back	20 1/2	3/8	20 6/16	- 3/16	16 7/16	-4 1/16 <sup>b</sup>	18 8/16	-2 1/16 <sup>b</sup>
Armhole	21 1/2	1/2	22 1/16	9/16 <sup>b</sup>	19 11/16	-1 13/16 <sup>b</sup>	21 14/16	6/16
Sleeve Length	10	3/8	7 8/16	- 2 8/16 <sup>b</sup>	8 10/16	-1 6/16 <sup>b</sup>	10 2/16	2/16
Sleeve Opening	15 1/2	1/2	15 4/16	- 4/16	13 6/16	-2 2/16 <sup>b</sup>	14 1/16	-1 7/16 <sup>b</sup>
Side Length	N/A	N/A	17 13/16	17 13/16	15 9/16	15 9/16	17 4/16	17 4/16
Neckline Circumference	20 1/2	3/8	21 10/16	1 2/16 <sup>b</sup>	19 7/16	-1 1/16 <sup>b</sup>	20 4/16	- 5/16
Back Neck Width	8 1/4	N/A	7 6/16	- 14/16	7 5/16	- 1	7 4/16	- 1
Front Neck Drop	3 1/4	3/8	4 3/16	15/16 <sup>b</sup>	3 13/16	9/16 <sup>b</sup>	4 11/16	1 7/16 <sup>b</sup>
Back Neck Drop	1 1/4	3/8	1 6/16	2/16	1	- 5/16	1 1/16	- 3/16
Neck Trim Height	7/8	1/4	12/16	- 2/16	10/16	- 4/16	12/16	- 2/16
Bottom Hem Width	1	1/4	11/16	- 6/16 <sup>b</sup>	13/16	- 3/16	1	0

*Note.* Specifications adapted from *The Apparel Design and Production Handbook: A Technical Reference*, pp. 4•127, 7•10 (2001).

<sup>a</sup>Difference between technical specification and average sample measurement.

<sup>b</sup>Measurement is outside of tolerance range.

All t-shirts exhibited a wide range of measurements, with many of them outside the specified tolerances. Three essential measurements that impact fit are: body length, chest width, and neckline circumference. For a men's size large t-shirt, the technical specification of the body length is 30" with a tolerance of  $\pm 3/4$ ". The navy Fruit of the Loom and white H&M t-shirts were within that tolerance. The white Fruit of the Loom and Brooks Brothers t-shirts were longer than 30 3/4" tolerance. The navy H&M and Brooks Brothers t-shirts were shorter than 29 1/4" tolerance. The technical specification of the chest width is 48" with a tolerance of  $\pm 1/2$ ". All brands of t-shirts had chest widths smaller than 48  $\pm 1/2$ " tolerance. The technical specification of neckline circumference is 20 1/2" with a tolerance of  $\pm 3/8$ ". The navy Brooks Brothers t-shirts were within the tolerance range. Fruit of Loom and H&M white t-shirts were greater than 20 1/2  $\pm 3/8$ " tolerance. The navy H&M and white Brooks Brothers t-shirts were smaller than 20 1/2  $\pm 3/8$ ".

Adherence to the technical specification is voluntary. Measurements are provided by the industry as a sizing guide. Designers may specify measurements of a garment style to include *design ease* to create a distinct look or in order to conform to current trends of wearing slim fitting or over-sized garments (Keiser & Garner, 2012). Consumers have varied expectations about how a t-shirt will fit, and a "good fit is crucial to customer satisfaction" (Brown & Rice, 2001, p. 153).

### **Materials Specifications**

Materials are a physical feature of a garment such as the fabric. T-shirt fabric details including fiber content and finishes were identified. Other characteristics of the knit fabric were quantified with a fabric weight and a fabric count.

**Fiber content and finish.** All of the t-shirts were labeled as having a "100% cotton" fiber content. This was verified with a chemical fiber analysis. However, both Brooks Brothers t-shirts identified the variety of cotton used in their t-shirts as Supima®. Supima® cotton is considered to be of higher quality because its long, staple fibers produce softer, smoother, and stronger fabrics (Kadolph, 2010). The white Brooks Brothers t-shirts were described as being treated with an "ultra-fresh" finish to protect against odors. And the navy Brooks Brothers t-shirts were described as being finished with a "secret wash to give [them] an ultra soft hand feel."

**Fabric weight.** The fabric weight was measured according to the ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric*. Measurements were performed initially, and after one, five, ten, and twenty laundry cycles. Data are presented in Figure 4.1.

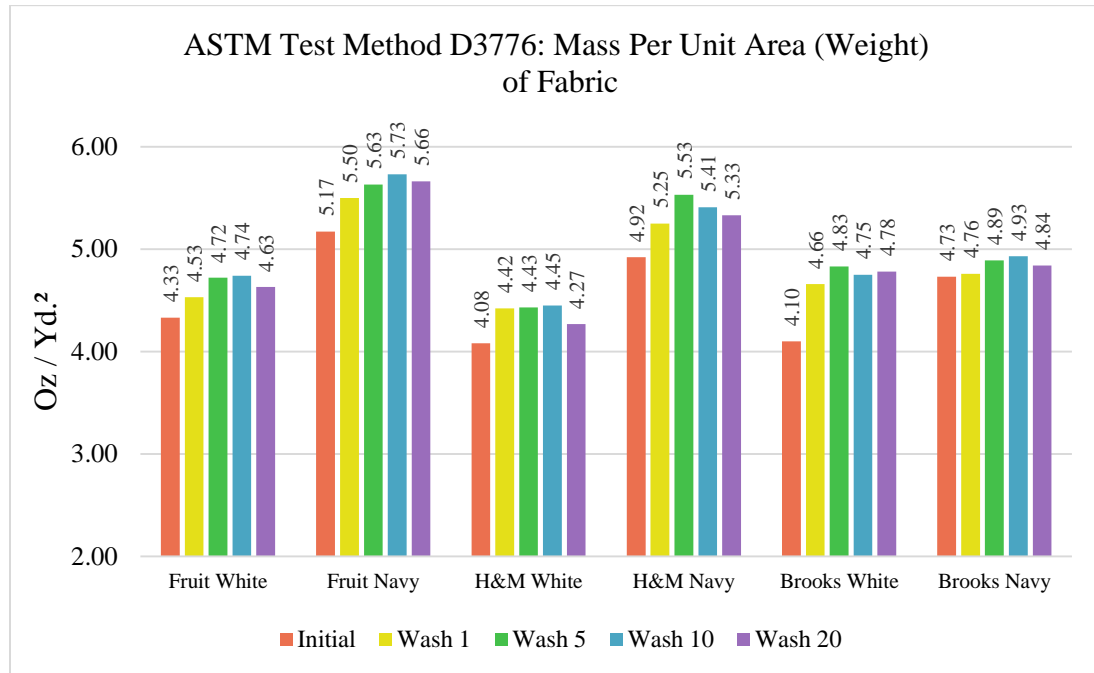


Figure 4.1. Fabric Weight, ASTM Test Method D3776: Mass Per Unit Area of Fabric

Fabric weight for a “light top weight t-shirt” is between 4 to 6 oz/yd<sup>2</sup> (Bubonia, 2014, p. 257). All of the t-shirt fabric weights were within that range. The t-shirts with the lightest fabric weight after five and twenty washes were the white H&M at 4.43 oz/yd<sup>2</sup> and 4.27 oz/yd<sup>2</sup> respectively. The t-shirts with the heaviest fabric weight after five and twenty washes were the navy Fruit of the Loom at 5.63 oz/yd<sup>2</sup> and 5.66 oz/yd<sup>2</sup> respectively.

The fabric weights of all t-shirts increased after washing and drying. Although all t-shirts exhibited a decrease in fabric weight between washes five and twenty, the final fabric weights were higher than the initial weights. The increase in weight was a result of shrinkage.

**Fabric count.** The fabric count was measured initially and after twenty laundry cycles according to the ASTM D8007 – 15: *Standard Test Method for Wale and Course Count of Weft Knitted Fabrics*. Results are presented in Figure 4.2.

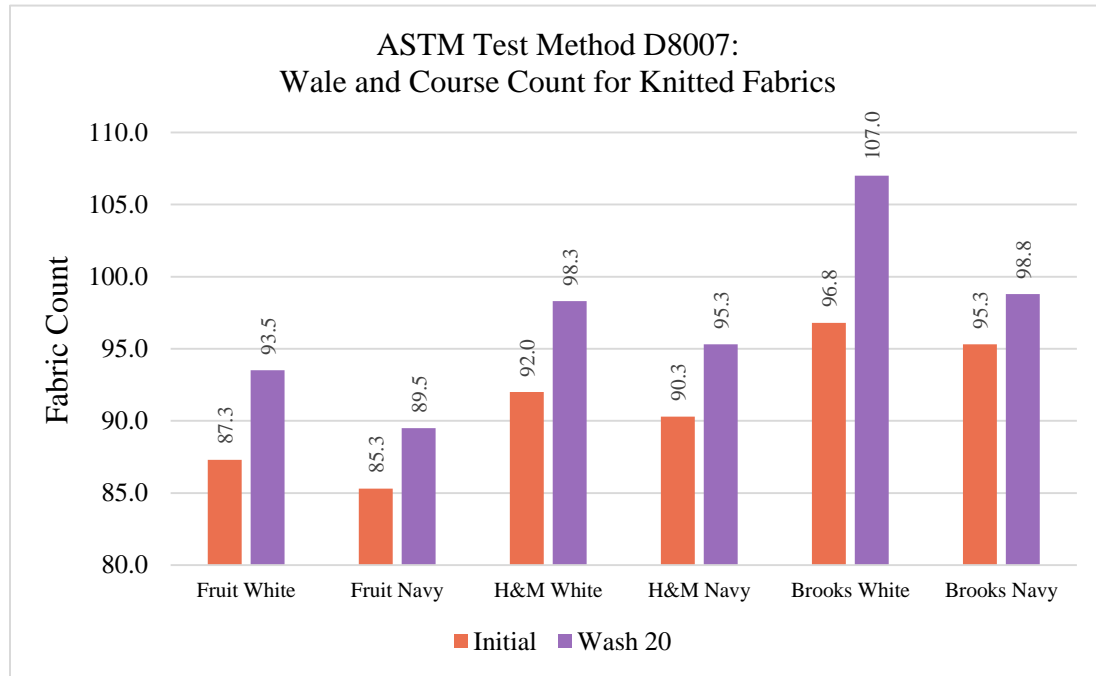
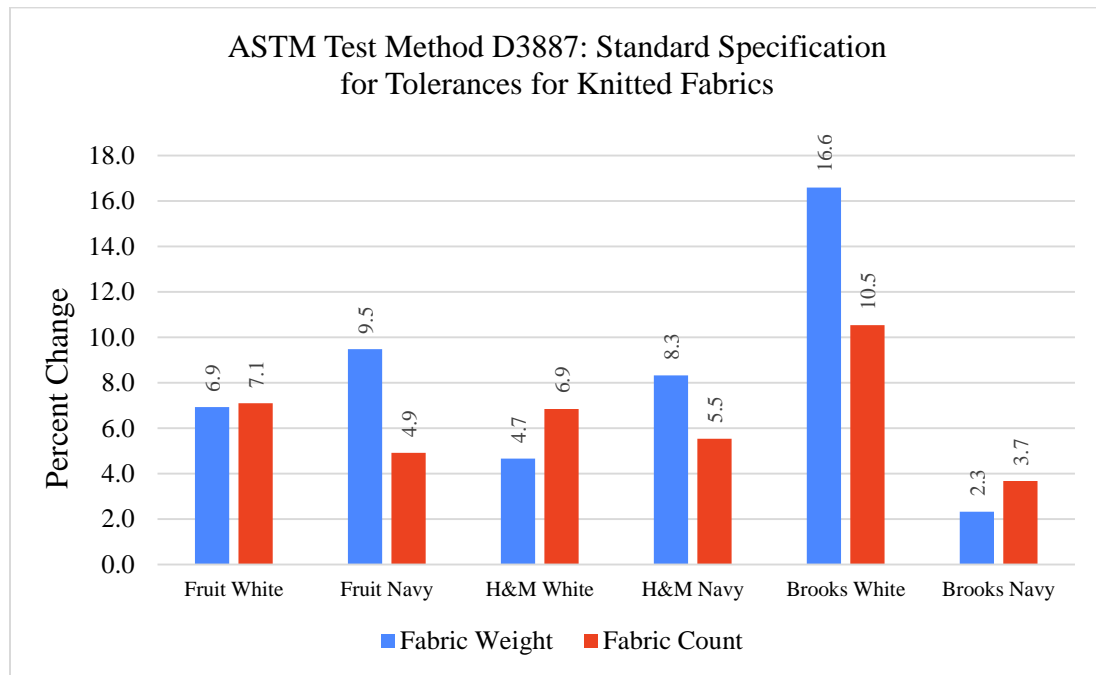


Figure 4.2. Fabric Count, ASTM Test Method D8007: Wale and Course Count for Knitted Fabrics

For all t-shirts, the initial fabric counts were within 12% of each other with a range from 85.3 to 96.8. After twenty washes, the fabric counts were within 16% of each other with a range of 89.5 to 107.0. Similar to fabric weight, the increase in fabric count was due to shrinkage. As a group, Fruit of the Loom t-shirts had the lowest fabric counts, followed by H&M t-shirts with the second lowest counts, and Brooks Brothers t-shirts had the highest fabric counts.



**Correlation between fabric weight and fabric count.** A comparison of the percent change in fabric weight and fabric count is presented in Figure 4.3.



*Figure 4.3.* Percent Change in Fabric Weight and Fabric Count

The fabric weight increased more than the fabric count in the navy Fruit of the Loom and H&M, and the white Brooks Brothers t-shirts. Conversely, the white H&M and navy Brooks Brothers t-shirts exhibited a greater change in the fabric count as opposed to the fabric weight. The increase in fabric weight and fabric count in the white Fruit of the Loom t-shirts was practically the same.

### **Construction Specifications**

Apparel construction specifications provide detailed information about how each part of a garment is sewn and assembled (Lee & Steen, 2014). Construction is a physical feature of a garment and can impact the overall quality and performance. (Brown & Rice, 2001).

**Stitch types.** T-shirt stitch types, stitches per inch, and stitch locations are summarized in Table 4.9. Stitch illustrations are located in Appendix B, Tables B1 – B7.

Table 4.9

*Summary of Stitch Type and Stitches per Inch, White and Navy T-Shirts*

Location	Fruit of the Loom		H&M		Brooks Brothers	
	White	Navy	White	Navy	White	Navy
	Type (SPI)	Type (SPI)	Type (SPI)	Type (SPI)	Type (SPI)	Type (SPI)
Sleeve Hem	406 (9)	406 (9)	406 (10)	406 (14)	406 (15)	406 (13)
Underarm Seam	504 (9)	504 (12)	514 (12)	514 (14)	504 (15)	514 (13)
Armscye	504 (10)	504 (11)	514 (12)	514 (15)	514 (13)	514 (13)
Shoulder Seam	504 (11)	504 (13)	504 (10)	514 (13)	504 (13)	504 (12)
Shoulder and Neck Tape	101 (13)	101 (12)	101 (12)	101 (12)	101 (15)	101 (13)
Attach Neckband	504 (11)	504 (10)	504 (12)	504 (15)	504 (14)	504 (13)
Neckband Topstitching	406 (10)	406 (10)	N/A	101 (15)	N/A	406 (13)
Body Side-Seam	N/A	N/A	514 (12)	514 (14)	N/A	514 (13)
Bottom Opening Hem	406 (9)	406 (11)	406 (11)	406 (13)	406 (13)	406 (14)

A jersey knit fabric, such as that used in the sample, would have a stitch length of 10 to 12 SPI (Lee & Steen, 2014). White and navy Fruit of the Loom t-shirts included stitching that ranged from 9 to 13 SPI. In contrast, navy H&M and white Brooks Brothers t-shirts included stitching that ranged from 12 to 15 SPI. Stitch length directly relates to the amount of labor required to sew a garment. Garments with a lower SPI can be sewn in a shorter period of time, impacting the cost of manufacturing. A higher SPI is associated with higher quality apparel (Brown & Rice, 2001).

There were four classifications of stitches used in the construction of the t-shirts: 101 (chainstitch), 406 (coverstitch), 504 (3 thread overedge), and 514 (4 thread overedge). The underarm seam was closed using a class 504 stitch for white and navy

Fruit of the Loom and white Brooks Brothers t-shirts. However, white and navy H&M and navy Brooks Brothers t-shirts used a class 514 stitch to close the underarm seam. A class 504 stitch was used to insert the sleeves (armscye) in all Fruit of Loom t-shirts, while a class 514 stitch was used to insert the sleeves in all H&M and all Brooks Brothers t-shirts. A class 504 stitch was used to close the shoulder seams on all t-shirts except navy H&M, which was closed with a class 514 stitch. The tapes inside the neck and shoulder seams were attached using a class 101 stitch, and the all neckbands were attached using a class 504 stitch. The neckband topstitching, which was visible across the neckband front, utilized a class 406 stitch on all Fruit of the Loom and navy Brooks Brothers t-shirts. The navy H&M t-shirts used a class 101 stitch for neckband topstitching. Neither the white H&M t-shirts nor the white Brooks Brothers t-shirts included neckband topstitching. Side seams of all H&M and the navy Brooks Brothers t-shirts were closed with a class 514 stitch. The bottom hem on all t-shirt brands was finished with a class 406 stitch. The navy Brooks Brothers t-shirts included a side vent finished with contrasting tape using a class 301 stitch (see Appendix B, Figure B1). A bartack class 101 stitch was used to reinforce the mitered tape. The navy Brooks Brothers t-shirts were the only t-shirts that included an embroidered logo at the left chest (see Appendix B, Figure B3). This was constructed using a class 304 stitch.

**Seam and hem types.** Seam types, locations, and hems are summarized in Table 4.10. Seam illustrations are presented in Appendix B, Tables B8 – B13.

Table 4.10

*Summary of Seam and Hem Types, White and Navy T-Shirts*

Location	Fruit of the Loom		H&M		Brooks Brothers	
	White	Navy	White	Navy	White	Navy
	Notation	Notation	Notation	Notation	Notation	Notation
Sleeve Hem	EFa Inv.	EFa Inv.	EFa Inv.	EFa Inv.	EFa Inv.	EFa Inv.
Underarm Seam	SSa	SSa	SSa	SSa	SSa	SSa
Armhole	SSa	SSa	SSa	SSa	SSa	SSa
Shoulder Seam	SSa	SSa	SSa	SSa	SSa	SSa
Shoulder and Neck Tape	SSag	SSag	SSag	SSag	SSag	SSag
Attach Neckband	SSab	SSab	SSab	SSab	SSab	SSab
Body Side-Seam	NA	NA	SSa	SSa	NA	SSa
Bottom Opening Hem	EFa Inv.	EFa Inv.	EFa Inv.	EFa Inv.	EFa Inv.	EFa Inv.

The seam classifications were of the same type for all t-shirts. Of the three t-shirts that were constructed with side seams, all utilized a superimposed seam for the closure. The placket creating the side vent on the navy Brooks Brothers t-shirts included an edge finish and a lapped seam. All t-shirts were constructed with the same edge finish on the sleeve and bottom hems, however, the width of the hems varied. Hem widths are presented in Table 4.11.

Table 4.11

*Hem Depth Comparison, White and Navy T-Shirts*

Location	Criteria	Fruit of the Loom		H&M		Brooks Brothers	
		White	Navy	White	Navy	White	Navy
Sleeve Hem	Depth in Inches	11/16	11/16	15/16	12/16	11/16	1
Bottom Hem	Depth in Inches	11/16	11/16	1	13/16	12/16	1

The narrowest sleeve and bottom hems of 11/16 inches were located on all Fruit of the Loom and white Brooks Brothers t-shirts. The widest sleeve and bottom hems of 1 inch were located on the navy Brooks Brothers t-shirts.

**Assembly.** The construction of a t-shirt may require as few as eight operations and can be sewn in as little as three minutes (Brown & Rice, 2001). The order in which the t-shirts were assembled differed in two operations. The first was the order in which the underarm seams and sleeve hems were constructed. All Fruit of the Loom t-shirts had the sleeve hem constructed first, followed by the closure of the underarm seam. Contrarily, the t-shirts from H&M and Brooks Brothers closed the underarm seam first, then finished the sleeve hem. Second, the t-shirts that included side seams (white and navy H&M; navy Brooks Brothers) had sleeves inserted first, followed by the closure of the side seam.

### **Appearance Specifications**

The aesthetic appeal of a garment during wear and after laundering is important to consumers and reflects on the quality of an item (Bubonia, 2014). Appearance was evaluated by measuring changes in the color or whiteness of the t-shirts, as well as the transfer of color, and the degree to which fabric components of the t-shirts performed compared to AATCC reference standards.

**Colorfastness to laundry.** A subjective visual evaluation and an objective instrumental measurement was performed to record any change in color of the navy t-shirts. Subjective color measurements were performed after washes one, five, ten, and twenty; instrumental color measurements were also performed initially.

**Subjective color change.** Utilizing the AATCC Evaluation Procedure 1–2012: *Gray Scale for Color Change*, a subjective, visual evaluation was performed to compare

the color of washed t-shirts to an unwashed control. The AATCC Gray Scale grading ranges from 1 to 5, with half ratings in between. A colorfastness grade of 1 represents *very severe* color change, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color change. The perceived difference in color or contrast between the original samples and the washed t-shirts are presented in Figure 4.4 and Table 4.12.

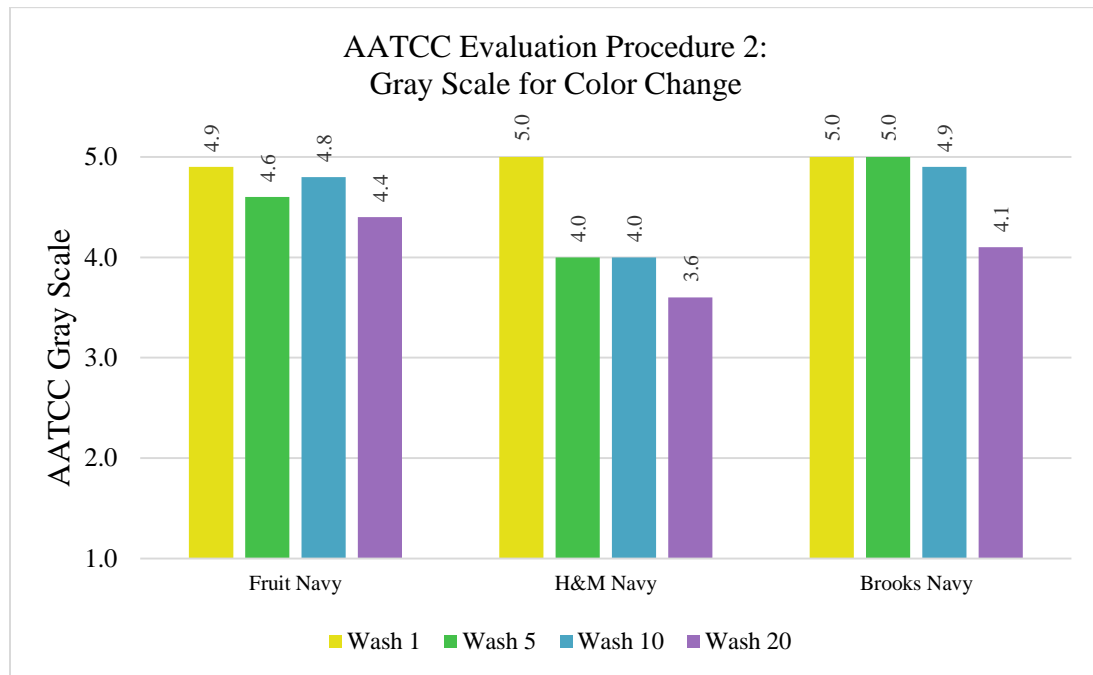


Figure 4.4. Subjective Color Change, Navy T-Shirts

Table 4.12

Subjective Color Change, Navy T-Shirts

Testing Interval	T-Shirt Color	Retail Category	Mean Rating	(SD)	Grouping	P-Value	N
Wash 5	Navy	Fruit of the Loom	4.6	(0.3)	B	0.000*	4
		H&M	4.0	(0.0)	C		4
		Brooks Brothers	5.0	(0.0)	A		4
Wash 20	Navy	Fruit of the Loom	4.4	(0.3)	A	0.006*	4
		H&M	3.6	(0.3)	B		4
		Brooks Brothers	4.1	(0.3)	A		4

\*p < 0.05 = statistically significant.

After both five and twenty washes, color change in the navy t-shirts was greatest for the H&M t-shirts (4.0). A one-way ANOVA indicated there was a significant difference ( $p=0.000$ ) between the color change ratings after the fifth wash for all three t-shirts. A one-way ANOVA indicated there was no significant difference between the ratings after the twentieth for the Fruit of the Loom and the Brooks Brothers t-shirts. However, the rating for H&M was significantly different ( $p=0.006$ ). The greatest perception of color change occurred between wash one and wash five for the H&M t-shirts, as the rating after wash one was a 5.0, and then decreased to a 3.6 after the fifth wash.

**Instrumental color change.** The color difference (*Delta E*) of the navy t-shirts before and after washing was measured according to the AATCC Evaluation Procedure 7-2015: *Instrumental Assessment of the Change in Color of Test Specimen*. The Delta E after washes one, five, ten, and twenty was calculated using EasyMatch QC™ software and are presented in Figure 4.5 and Table 4.13.

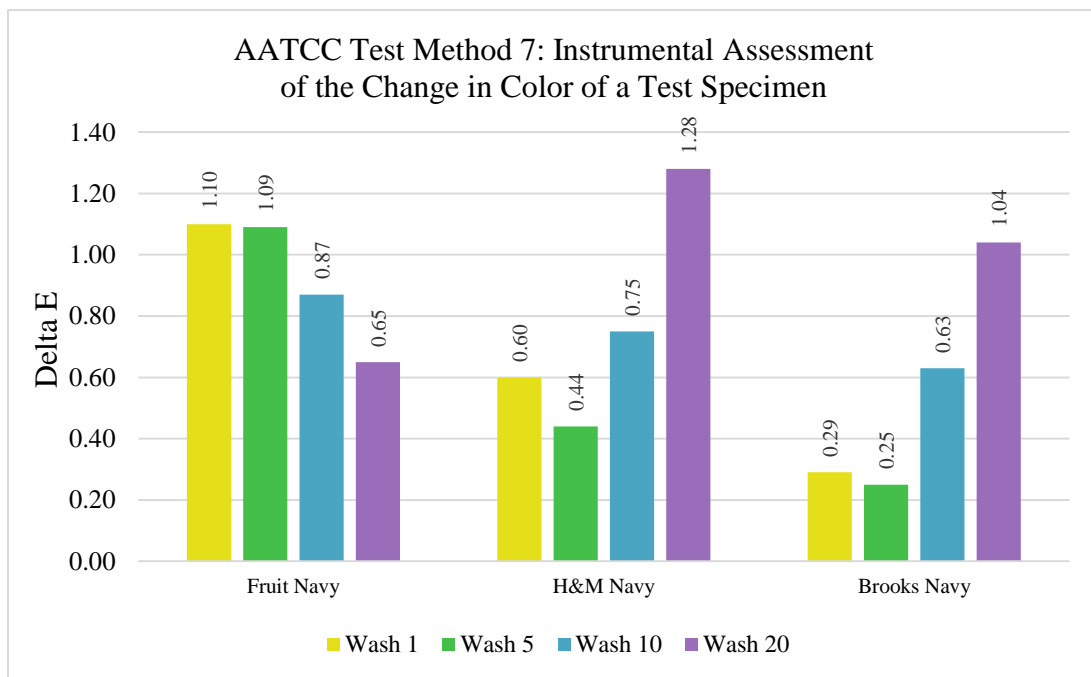


Figure 4.5. Degree of Instrumental Color Change (Delta E), Navy T-Shirts

Table 4.13

*Degree of Instrumental Color Change (Delta E), Navy T-Shirts*

Testing Interval	T-Shirt Color	Retail Category	Mean Delta E	(SD)	Grouping	P-Value	N
Wash 5	Navy	Fruit of the Loom	1.09	(0.12)	A	0.006*	2
		H&M	0.44	(0.08)	B		2
		Brooks Brothers	0.25	(0.07)	B		2
Wash 20	Navy	Fruit of the Loom	0.65	(0.13)	B	0.022*	2
		H&M	1.28	(0.11)	A		2
		Brooks Brothers	1.04	(0.06)	A B		2

\* $p < 0.05$  = statistically significant.

After five washes the highest degree of color change occurred in navy Fruit of the Loom t-shirts (1.09). A one-way ANOVA confirmed that this was significantly different ( $p=0.006$ ) than the color change of H&M and Brooks Brothers t-shirts. After twenty washes, the highest degree of color change occurred in H&M (1.28). A one-way ANOVA confirmed that the color change was significant ( $p=0.022$ ). However, only the Fruit of the Loom and H&M t-shirts were significantly different. There was no significant difference in the color change between Brooks Brothers and Fruit of the Loom, nor Brooks Brothers and H&M.

**Whiteness of textiles.** A subjective visual evaluation and an objective instrumental measurement were performed to record the change in whiteness of the white t-shirts from each brand. Subjective whiteness was performed after washes one, five, ten, and twenty.

**Subjective whiteness change.** As instructed in the AATCC Evaluation Procedure 1–2012: *Gray Scale for Color Change*, a subjective, visual evaluation was performed to compare the whiteness of washed t-shirts to an unwashed control. An AATCC Gray Scale for Staining card was used to assign ratings. The grading scale ranges from 1 to 5, with half ratings in between. A grade of 1 represents *very severe* whiteness change, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no whiteness change. The perceived difference in whiteness or contrast between the original sample and the washed t-shirt are presented in Figure 4.6 and Table 4.14.



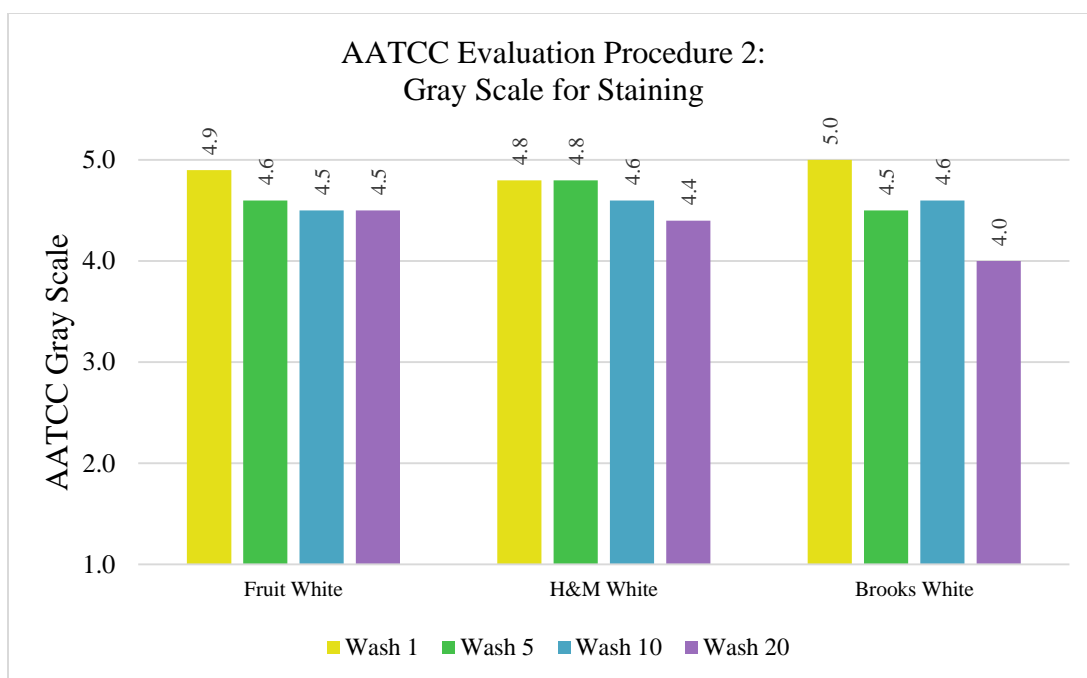


Figure 4.6. Subjective Whiteness Change, White T-Shirts

Table 4.14

Subjective Change in Whiteness, White T-Shirts

Testing Interval	T-Shirt Color	Retail Category	Mean Rating	(SD)	Grouping	P-Value	N
Wash 5	White	Fruit of the Loom	4.6	(0.3)	A	0.323	4
		H&M	4.8	(0.3)	A		4
		Brooks Brothers	4.5	(0.0)	A		4
Wash 20	White	Fruit of the Loom	4.5	(0.0)	A	0.002*	4
		H&M	4.4	(0.3)	A		4
		Brooks Brothers	4.0	(0.0)	B		4

\* $p < 0.05$  = statistically significant.

After five washes, there was no significant difference ( $p=0.323$ ) in the perceived change in whiteness of all white t-shirts. After twenty washes, however, a one-way ANOVA confirmed the whiteness rating of the Brooks Brothers t-shirts was significantly different ( $p=0.002$ ) from the whiteness ratings of Fruit of the Loom and H&M. After twenty washes, the whiteness ratings for Brooks Brothers decreased the most.

**Instrumental whiteness change.** The whiteness index of the white t-shirts, before and after washing, was measured according to the AATCC Test Method 110-2015:

*Whiteness of Textiles* The whiteness indices before washing, and after washes one, five, ten, and twenty were calculated using Universal™ software. Results are presented in Figure 4.7 and Table 4.15.

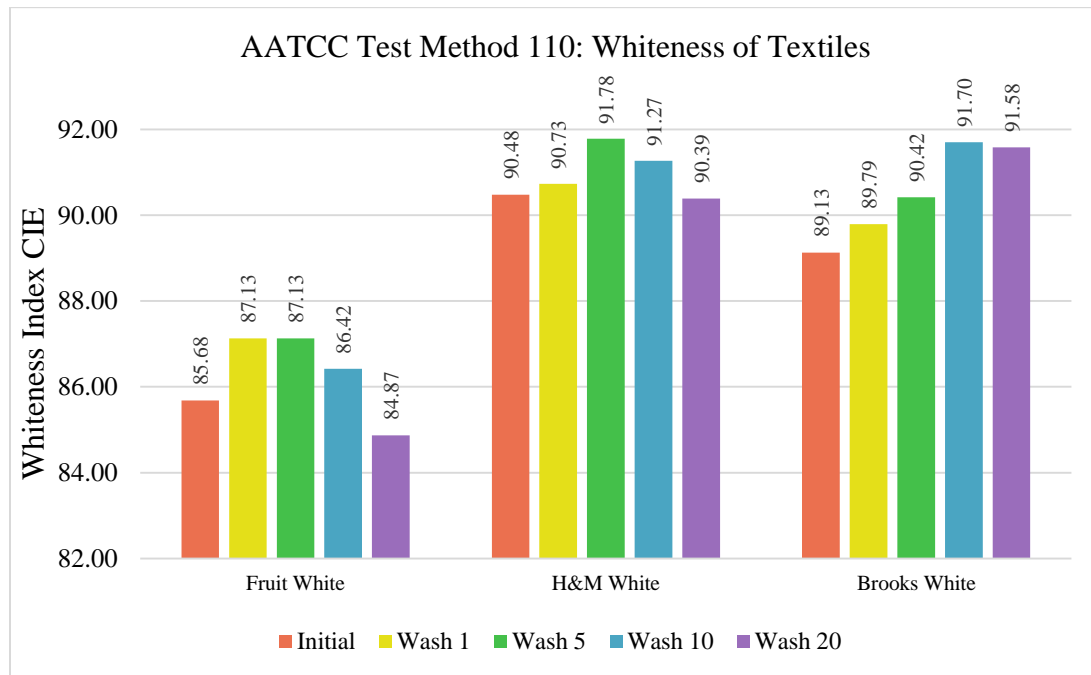


Figure 4.7. Whiteness Index, White T-Shirts

Table 4.15

*Instrumental Whiteness Index, White T-Shirts*

Testing Interval	T-Shirt Color	Retail Category	Mean WICIE	(SD)	Grouping	P-Value	N
Wash 5	White	Fruit of the Loom	87.13	(1.12)	B	0.027*	2
		H&M	91.78	(0.67)	A		2
		Brooks Brothers	90.42	(0.75)	A B		2
Wash 20	White	Fruit of the Loom	84.87	(1.37)	B	0.019*	2
		H&M	90.39	(0.66)	A		2
		Brooks Brothers	91.58	(1.25)	A		2

\*p < 0.05 = statistically significant.

After five washes, the white t-shirts with the highest whiteness index were the H&M t-shirts (91.78). A one-way ANOVA determined the whiteness of the H&M t-shirts and the Fruit of the Loom were significantly different ( $p=0.027$ ), however there was no significant difference between Brooks Brothers t-shirts (90.42) and the Fruit of the Loom t-shirts (87.13) or between the Brooks Brothers (90.42) t-shirts and the H&M t-shirts (91.78). After twenty washes, the t-shirts with the highest whiteness index were the Brooks Brothers (91.58). Although the one-way ANOVA determined there was a significant difference ( $p=0.019$ ) in the whiteness index of the Fruit of the Loom t-shirts (84.87) compared to the H&M t-shirts (90.39) and the Brooks Brothers t-shirts (91.58), there was no significant difference in the whiteness index between the H&M t-shirts (90.39) and the Brooks Brothers t-shirts (91.58).

**Colorfastness to crocking.** The crocking propensities of the navy t-shirts were evaluated as outlined in the AATCC Test Method 8-2013: *Colorfastness to Crocking: Crockmeter Method*. Crocking was tested initially and after washes one, five, ten, and twenty. Both ‘wet’ and ‘dry’ crocking tests were performed. Upon completion, an AATCC Gray Scale for Staining card was used to assign the grades of color transfer to the test cloths. The grading scale ranges from 1 to 5, with half ratings in between. A grade of 1 represents *very severe* color transfer, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color transfer. The results for dry crocking are presented in Figure 4.8 and Table 4.16. The results for wet crocking are presented in Figure 4.9 and Table 4.17.

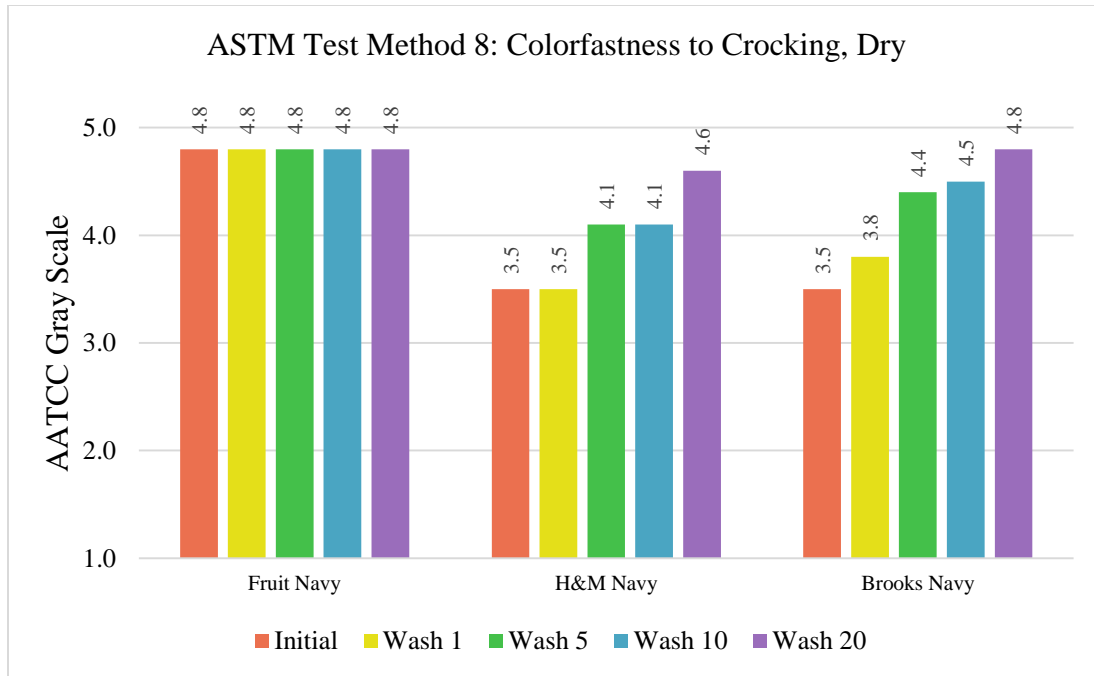


Figure 4.8. Colorfastness to Dry Crocking, Navy T-Shirts

Table 4.16

Colorfastness to Dry Crocking, Navy T-Shirts

Testing Interval	T-Shirt Color	Retail Category	Mean Rating	(SD)	Grouping	P-Value	N
Wash 5	Navy	Fruit of the Loom	4.8	(0.3)	A	0.025*	4
		H&M	4.1	(0.3)	B		4
		Brooks Brothers	4.4	(0.3)	A B		4
Wash 20	Navy	Fruit of the Loom	4.8	(0.6)	A	0.767	4
		H&M	4.6	(0.3)	A		4
		Brooks Brothers	4.8	(0.3)	A		4

\* $p < 0.05$  = statistically significant.

After five and twenty washes, the Fruit of the Loom shirts exhibited the least degree of color transfer. A one-way ANOVA determined that although the color transfer exhibited by the H&M t-shirts and the Brooks Brothers t-shirts were not significantly different from each other, their color transfer ratings were significantly different ( $p=0.025$ ) from the Fruit of the Loom t-shirts. After twenty washes, the degree of color transfer decreased overall, resulting in no significant difference ( $p=0.767$ ) in the crocking ratings for all three t-shirts.

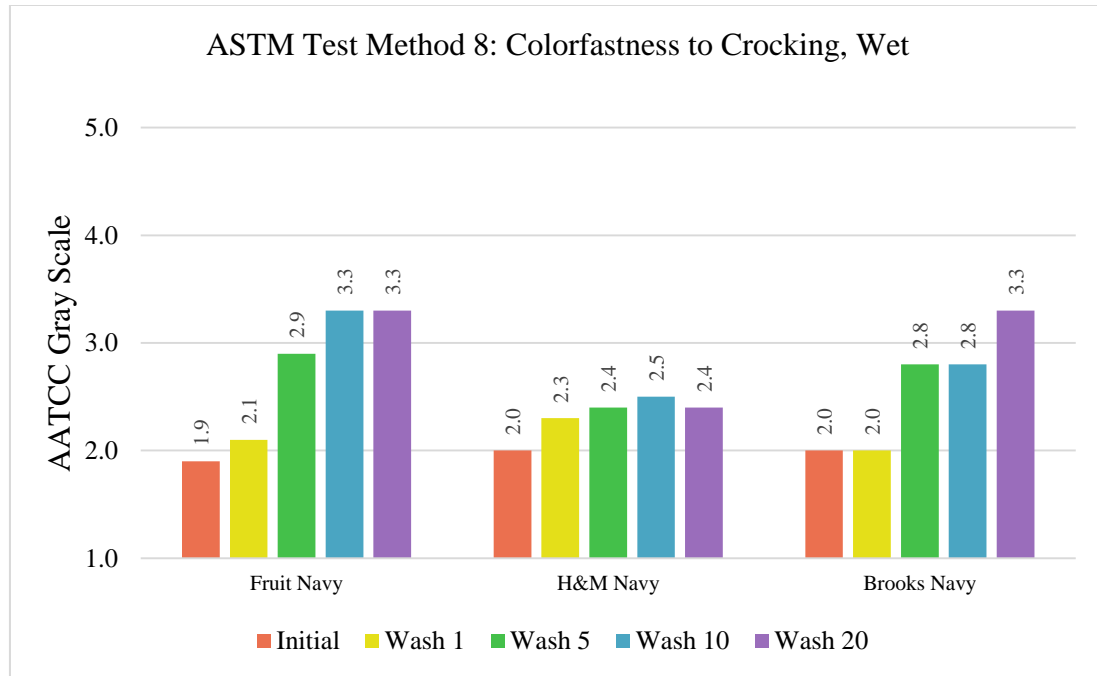


Figure 4.9. Colorfastness to Wet Crocking, Navy T-Shirts

Table 4.17

*Colorfastness to Wet Crocking, Navy T-Shirts*

Testing Interval	T-Shirt Color	Retail Category	Mean Rating	(SD)	Grouping	P-Value	N
Wash 5	Navy	Fruit of the Loom	2.9	(0.8)	A	0.360	4
		H&M	2.4	(0.3)	A		4
		Brooks Brothers	2.8	(0.3)	A		4
Wash 20	Navy	Fruit of the Loom	3.3	(0.6)	A	0.028*	4
		H&M	2.4	(0.3)	B		4
		Brooks Brothers	3.3	(0.3)	A		4

\* $p < 0.05$  = statistically significant.

After five washes there was no significant difference ( $p=0.360$ ) in the wet crocking ratings of all brands of t-shirts. After twenty washes, the crocking ratings improved for Fruit of the Loom and Brooks Brothers t-shirts and there was a significant different ( $p=0.028$ ) compared to the crocking rating for the H&M t-shirts.

**Appearance of stitches/seams/hems/neckline after laundering.** After washing, there was puckering and roping in the armseye seams on the all of the t-shirts. The neckband of white H&M T-shirts had a narrow width and lacked topstitching, which caused it to roll. Also, The narrow hem depths on both Fruit of the Loom and the white Brooks Brothers t-shirts contributed to hem rolling after laundering, detracting from the appearance.

**Smoothness appearance.** Smoothness evaluations were performed according to the procedures outlined in the AATCC Test Method 124-201: *Smoothness Appearance of Fabrics after Repeated Home Launderings*. Ratings were assigned initially, and after laundry cycles one, five, ten, and twenty, based on comparisons to the AATCC 3-D Smoothness Appearance Replicas. There are six grading increments between 1 and 5, where ‘SA-1’ represents a *crumpled, creased and severely wrinkled appearance* and ‘SA-5’ represents a *very smooth, pressed, finished appearance*. Smoothness grades 2, 3, 3.5, and 4 represent appearances progressing from *rumpled* to *smooth*, accordingly. Smoothness ratings are presented in Figure 4.10.

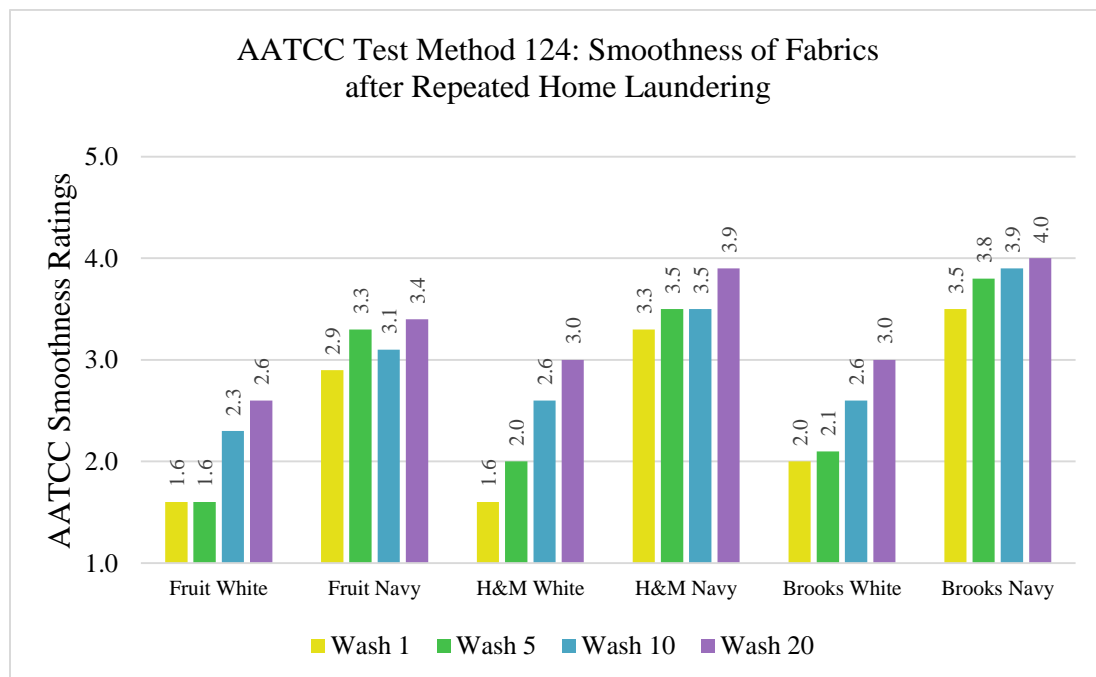


Figure 4.10. Smoothness Appearance, White and Navy T-Shirts

After five washes, the white Fruit of the Loom t-shirts had the lowest rating (1.6) and the navy Brooks Brothers t-shirts had the highest rating (3.8). After twenty washes, the white Fruit of the Loom t-shirts continued to have the lowest rating (2.6) and the navy Brooks Brothers t-shirts continued to have the highest rating (4.0). Smoothness appearance improved for all t-shirts and this can be attributed to the relaxation of the fabric yarns and the removal of any sizing finishes during laundering.

### Durability/Serviceability Specifications

The length of time a product remains useable for its intended purpose, or its capability to withstand wear is known as durability (Collier & Epps, 1999). A garment that retains its usefulness is referred to as serviceable (Brown & Rice, 2001). These criteria were evaluated by measuring the fabric bursting strength, pilling propensity, dimensional stability and skewness change.

**Fabric bursting strength.** The t-shirt knit fabrics were subjected to pneumatic pressure to the point of rupture as outlined in the ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method*. T-shirts were tested initially and after laundry cycles one, five, ten, and twenty. Results are presented in Figure 4.11 and Table 4.18.

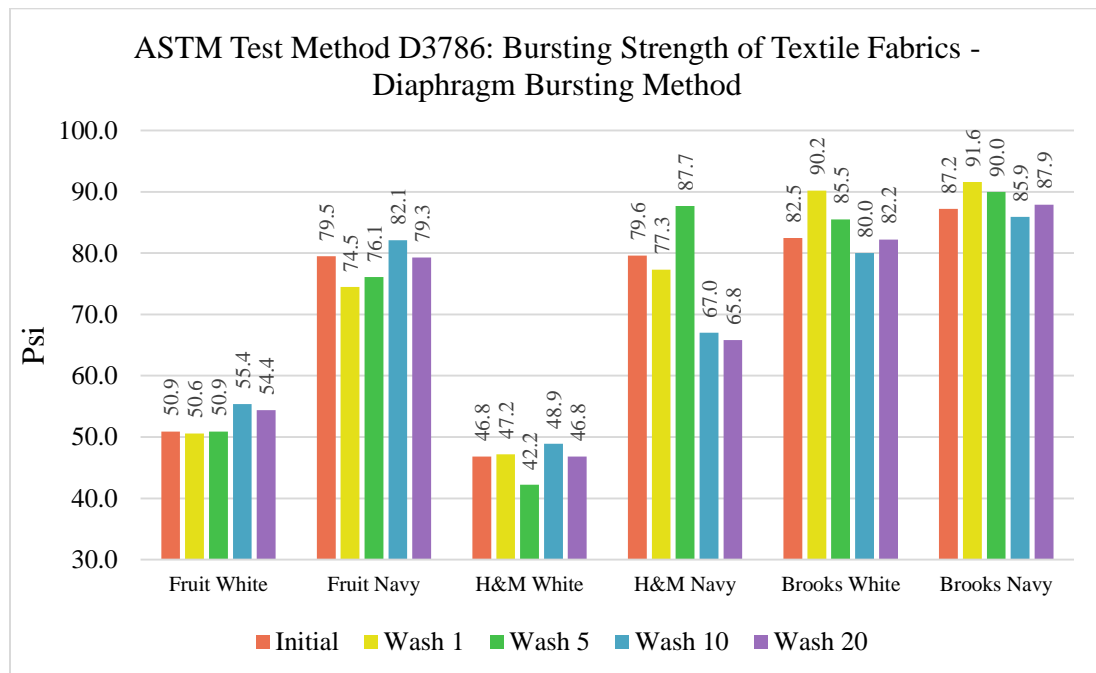


Figure 4.11. Bursting Strength, White and Navy T-Shirts

Table 4.18

*Bursting Strength, White and Navy T-Shirts*

Testing Interval	T-Shirt Color	Retail Category	Mean Psi	(SD)	Grouping	P-Value	N
Wash 5	White	Fruit of the Loom	50.9	(3.08)	B	0.000*	10
		H&M	42.2	(5.07)	C		10
		Brooks Brothers	85.5	(3.58)	A		10
	Navy	Fruit of the Loom	76.1	(4.93)	B	0.000*	10
		H&M	87.7	(2.45)	A		10
		Brooks Brothers	90.0	(5.56)	A		10
Wash 20	White	Fruit of the Loom	54.4	(4.26)	B	0.000*	10
		H&M	46.8	(4.94)	C		10
		Brooks Brothers	82.2	(5.61)	A		10
	Navy	Fruit of the Loom	79.3	(5.68)	A	0.000*	10
		H&M	65.8	(12.03)	B		10
		Brooks Brothers	87.9	(7.44)	A		10

\* $p < 0.05$  = statistically significant.

After five washes, the white H&M t-shirts had the lowest bursting strength (42.2 psi) and the navy Brooks Brothers t-shirts had the highest bursting strength (90.0 psi). A one-way ANOVA determined there was significant difference ( $p=0.000$ ) in bursting strength among all three white t-shirts after five washes. However, among the navy t-shirts after five washes, only the bursting strength of the Fruit of the Loom t-shirts (76.1 psi) was significantly different ( $p=0.000$ ).

After twenty washes, white H&M t-shirts continued to have the lowest bursting strength (46.8 psi), and navy Brooks Brothers t-shirts continued to have the highest bursting strength (87.9 psi). A one-way ANOVA determined there was significant difference ( $p=0.000$ ) in bursting strength among all white t-shirts after twenty washes. However, the only navy t-shirts with a bursting strength that was significant ( $p=0.000$ ) after twenty washes were H&M (65.8 psi).



**Pilling and fuzzing.** The ability of the t-shirt fabric to resist abrasion was evaluated according to the ASTM D4970/D4970M–10: *Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Martindale Tester*. T-shirts were tested initially and after laundry cycles one, five, ten, and twenty. The surface wear was evaluated by comparison to an ASTM photographic standard. Ratings of 1 through 5, with half steps in between were assigned based on the degree of surface change. Ratings are classified to be 1 as *very severe pilling*, 2 as *severe pilling*, 3 as *moderate pilling*, 4 as *slight pilling*, and 5 as *no pilling*. Results are presented in Figure 4.12 and Table 4.19.

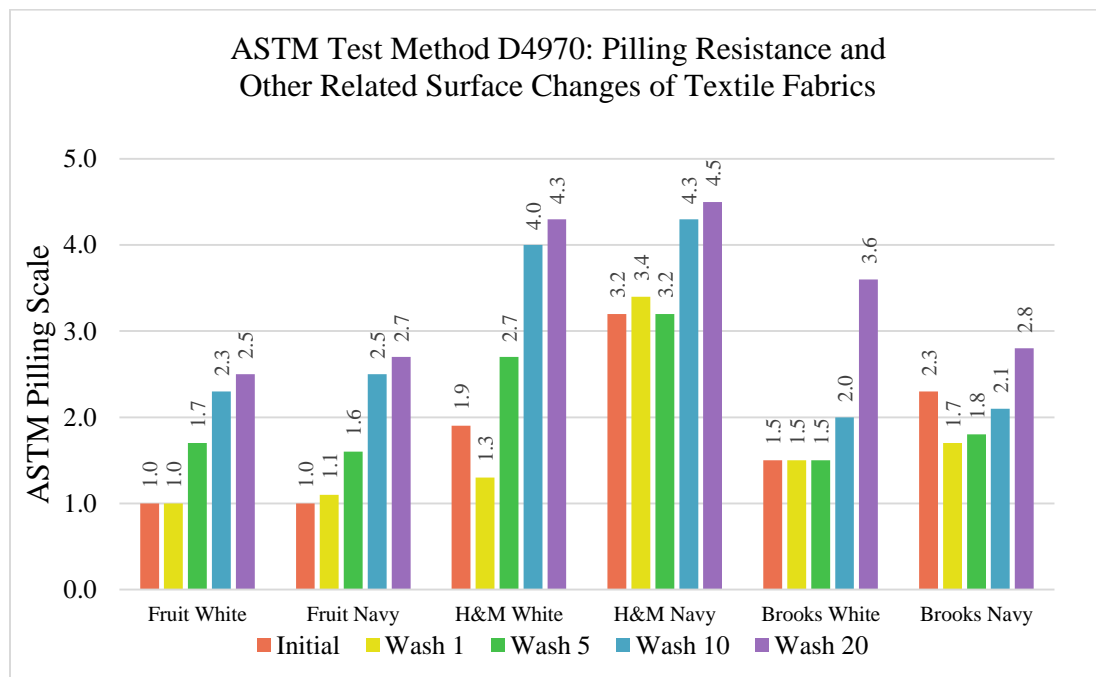


Figure 4.12. Pilling Resistance, White and Navy T-Shirts

Table 4.19

*Pilling Resistance, White and Navy T-Shirts*

Testing Interval	T-Shirt Color	Retail Category	Mean Rating	(SD)	Grouping	P-Value	N
Wash 5	White	Fruit of the Loom	1.7	(0.5)	B	0.000*	12
		H&M	2.7	(0.5)	A		12
		Brooks Brothers	1.5	(0.5)	B		12
	Navy	Fruit of the Loom	1.6	(0.5)	B	0.000*	12
		H&M	3.2	(0.6)	A		12
		Brooks Brothers	1.8	(0.5)	B		12
Wash 20	White	Fruit of the Loom	2.5	(0.5)	C	0.000*	12
		H&M	4.3	(0.5)	A		12
		Brooks Brothers	3.6	(1.0)	B		12
	Navy	Fruit of the Loom	2.7	(0.5)	B	0.000*	12
		H&M	4.5	(0.5)	A		12
		Brooks Brothers	2.8	(0.6)	B		12

\* $p < 0.05$  = statistically significant.

After five washes, the white Brooks Brothers t-shirts had the worst pilling rating (1.5) and the navy H&M t-shirt had the best pilling rating (3.2). A one-way ANOVA determined that, for the group of white t-shirts after wash five, only the pilling rating for the H&M t-shirt (2.7) was significantly different ( $p=0.000$ ). Although the Brooks Brothers t-shirts exhibited the worst pilling rating (1.5), the results were not significantly different from pilling rating of the Fruit of the Loom t-shirts (1.6). Among the navy t-shirts after wash five, a one-way ANOVA determined that the pilling rating for the H&M t-shirts (3.2) was significantly different ( $p=0.000$ ) than the pilling ratings for the Fruit of the Loom t-shirts (1.6) and the navy Brooks Brothers t-shirts (1.8).

After twenty washes, the white Fruit of the Loom t-shirts had the worst pilling rating (2.5) and the navy H&M t-shirt continued to have the best pilling rating (4.5). A one-way ANOVA determined that, for the white t-shirts after wash twenty, the pilling ratings for all three white t-shirts were significantly different ( $p=0.000$ ) from each other. Among the navy t-shirts after wash twenty, a one-way ANOVA determined that the pilling rating for the H&M t-shirt (4.5) was significantly different ( $p=0.000$ ) than the pilling ratings for the Fruit of the Loom t-shirts (2.7) and the Brooks Brothers t-shirts

(2.8). The pilling ratings for each t-shirt improved overall due to removal of short fiber ends on the fabric surface.

**Dimensional stability.** Changes in the t-shirt length and width were measured according to the AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering*. Measurements obtained after washes one, five, ten, and twenty were compared to the initial measurements. The dimensional change percentages of the length measurements only are presented in Figure 4.13. The dimensional change percentages of the width measurements only are presented in Figure 4.14. The dimensional change in the length and width measurements are combined and presented as the overall dimensional change in Figure 4.15.

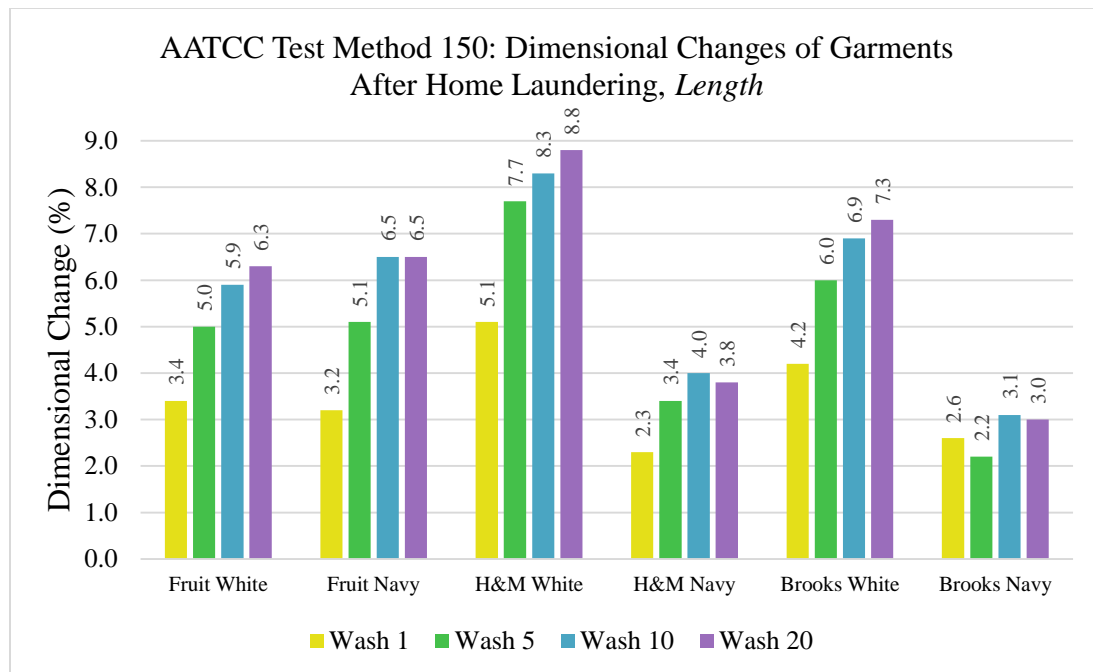
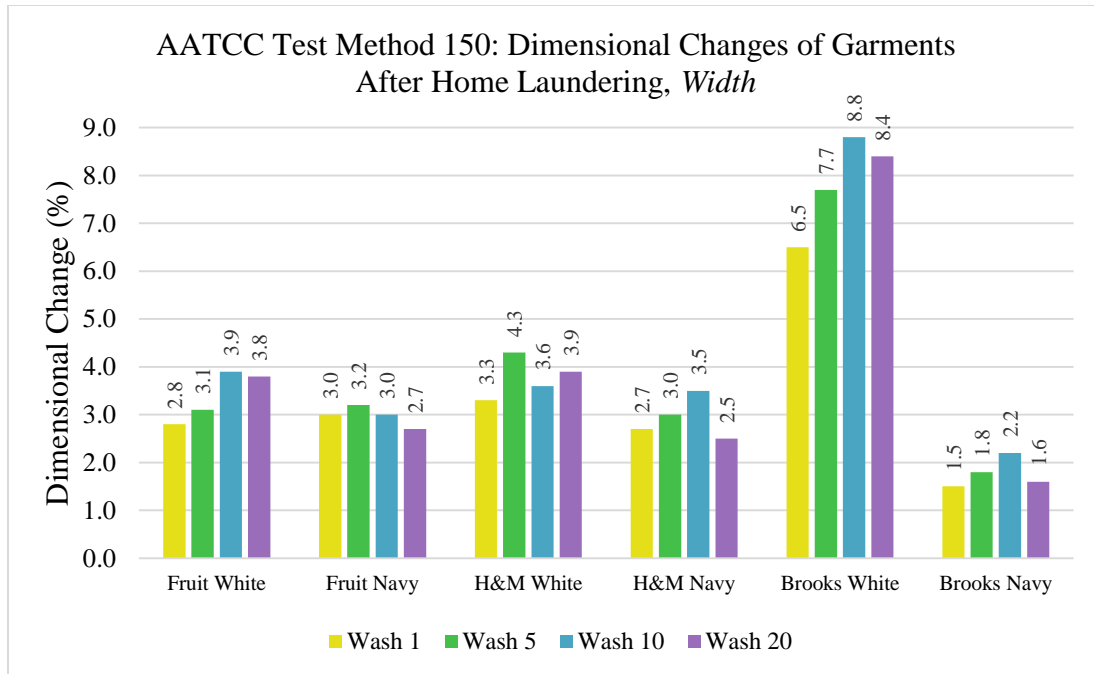


Figure 4.13. Dimensional Change in Length, White and Navy T-Shirts

All t-shirts exhibited shrinkage in the length dimension after washing. After five washes, white H&M exhibited the highest percent change (7.7%) and the navy Brooks Brothers shirts exhibited the least percent change (2.2%). After twenty washes, the white H&M t-shirts continued to exhibit the highest percent of change (8.8%) and the navy Brooks Brothers continued to exhibit the least percent of change in length (3.0%). Shrinkage in the lengthwise dimension steadily increased over the course of laundry cycles.



*Figure 4.14.* Dimensional Change in Width, White and Navy T-Shirts

After washing, all t-shirts exhibited shrinkage in the width dimension. After five washes, the width dimension of the white Brooks Brothers t-shirts exhibited the highest change (7.7%). The navy Brooks Brothers t-shirts exhibited the least change in width (1.8%). After twenty washes, the navy Brooks Brothers t-shirts exhibited the least percent change in width (1.6%), which is actually less than exhibited after wash five (1.8%). The white Brooks Brothers t-shirts exhibited the greatest percentage of shrinkage in the width direction (8.4%) after twenty washes.

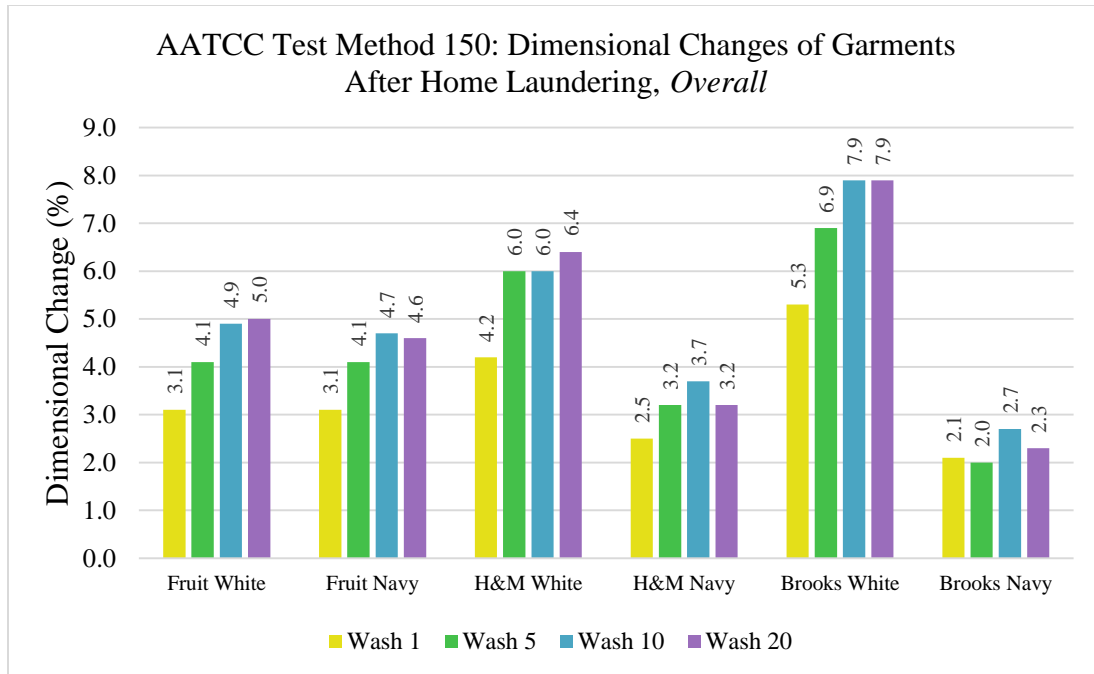


Figure 4.15. Dimensional Change Overall, White and Navy T-Shirts

The average of the length and width measurements was used to calculate the overall dimensional change. All t-shirts experienced shrinkage. After five washes, the white Brooks Brothers t-shirts exhibited the highest dimensional change (6.9%). The navy Brooks Brothers t-shirt exhibited the least percent of dimensional change (2.0%). After twenty washes, the white Brooks Brothers t-shirt continued to exhibit the highest dimensional change (7.9%). And the navy Brooks Brothers t-shirts continued to exhibit the least percent change (2.3%).

**Garment twist.** Distortion of the t-shirt fabrics after laundering was evaluated according to the AATCC Test Method 179-201: *Skewness Change in Fabric and Garment Twist Resulting from Automatic Home Laundering*. Measurements were performed initially, and after washes one, five, ten, and twenty. The percent change in skewness are presented in Figure 4.16 and Table 4.20.

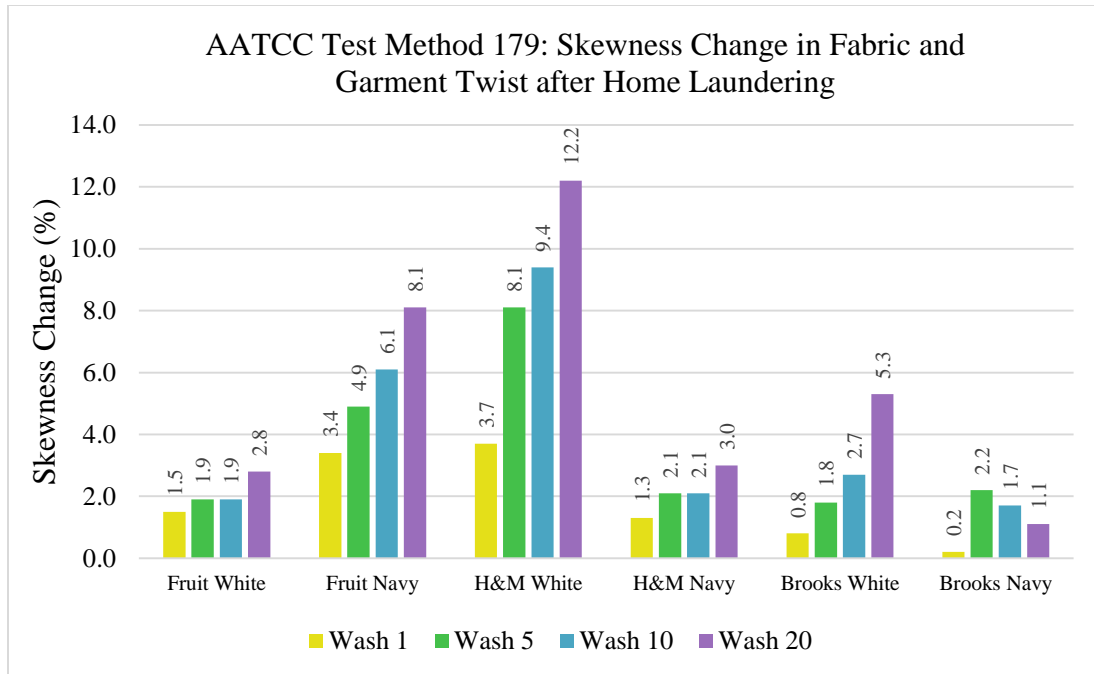


Figure 4.16. Skewness Change, White and Navy T-Shirts

Table 4.20

*Skewness Change in Fabric and Garment Twist after Home Laundering*

Testing Interval	T-Shirt Color	Retail Category	Mean Skew %	(SD)	Grouping	P-Value	N
Wash 5	White	Fruit of the Loom	1.9	(1.1)	A	0.340	2
		H&M	8.1	(7.0)	A		2
		Brooks Brothers	1.8	(0.3)	A		2
	Navy	Fruit of the Loom	4.9	(2.7)	A	0.396	2
		H&M	2.1	(0.1)	A		2
		Brooks Brothers	2.2	(2.1)	A		2
Wash 20	White	Fruit of the Loom	2.8	(2.3)	A	0.245	2
		H&M	12.2	(7.1)	A		2
		Brooks Brothers	5.3	(2.5)	A		2
	Navy	Fruit of the Loom	8.1	(0.6)	A	0.010*	2
		H&M	3.0	(0.5)	B		2
		Brooks Brothers	1.1	(1.1)	B		2

\* $p < 0.05$  = statistically significant.

*Skewness* is a fabric defect that occurs when yarns in the wale and courses direction of the fabric are angularly displaced from a line perpendicular to the edge or side of the fabric due to uneven distribution of tension. In a finished garment, such as a t-shirt, skewness change results in garment twist.

After five washes, white H&M exhibited the greatest percentage of twist (8.1%). The navy Brooks Brothers t-shirts exhibited the least percentage of twist (1.8%). After twenty washes, the white H&M t-shirts continued to exhibit the greatest percent twist (12.2%). And the navy Brooks Brothers t-shirts continued to exhibit the least percent twist (1.1%). The only data of any statistical significance was among the group of navy t-shirts after wash twenty. The percent skewness of navy Fruit of the Loom (8.1%) was statistically significant ( $p=0.010$ ) from the percent skewness of navy H&M (3.0%) and navy Brooks Brothers (1.1%).

### **Research Questions**

**Research question #1.** Are there differences in the product specifications of mens 100% cotton jersey knit t-shirts at three retail categories?

**Research question #1a.** *Are there differences in the design specifications of mens 100% cotton jersey knit t-shirts at three retail categories?* The design specifications were described based on observations and measurements on the t-shirts before laundering.

**Style.** The group of white t-shirts differed in the construction of the body. Fruit of the Loom and Brooks Brothers t-shirts were constructed using a tube of knit fabric, while H&M t-shirts were constructed with side seams. The group of navy t-shirts also differed in body construction of the body. The body of the Fruit of the Loom t-shirts was constructed using a tube of knit fabric, while the bodies of the H&M t-shirts and the Brooks Brothers t-shirts were constructed with side seams. The navy Brooks Brothers t-shirts also had three design elements not included on any other t-shirts. They included an embroidered logo, side vents at the bottom hem, and a contrasting fabric used to tape the neck and shoulder seams. Photos of these unique details are in Appendix B.

**Size and fit.** Fit implies the conformance of a garment to the shape and size of the individual that wears it. It is important to understand that sizing is based on body measurements, whereas fit is based on garment measurements (Keiser & Garner, 2012).

Compared to sizing guidelines set forth by the apparel industry, the sample t-shirts had variations at all measurement points. Adherence by designers and manufacturers to sizing specifications is voluntary. As a result, many retailers include body measurement charts in their catalogues and on their websites so that customers can make informed purchase decisions (Keiser & Garner, 2012).

**Research question #1b.** *Are there differences in the materials specifications of mens 100% cotton jersey knit t-shirts at three retail categories?*

The fiber content of all Brooks Brothers t-shirts was Supima® variety cotton. The white Brooks Brothers was treated with an “ultra-fresh” finish to protect against odors. The navy Brooks Brothers t-shirts was finished with a “secret wash to give [them] an ultra soft hand feel.” The additional design elements on the navy Brooks Brothers included a contrasting woven tape on the side vents at the bottom hem, and as tape on the neck and shoulder seams. A photograph of this material is included in Appendix B.

All of the fabric weight specimens were within a typical “light top weight t-shirt” range of 4 to 6 oz/yd<sup>2</sup> (Bubonia, 2014, p. 257). There was no difference in the fabric weights of the t-shirts because they all increased from the initial weight, over the course of washing and drying, and ultimately measured heavier after wash twenty.

The initial fabric counts were within 12% of each other with a range from 85.3 to 96.8. There was a significant difference ( $p=0.001$ ) in the initial fabric count of the navy Fruit of the Loom t-shirts (85.3) and the white Brooks Brothers t-shirts (96.8). After twenty washes, the fabric counts were within 16% of each other with a range of 89.5 to 107.0. There was a significant difference ( $p=0.000$ ) in the initial fabric count of the navy Fruit of the Loom t-shirts (89.5) and the white Brooks Brothers t-shirts (107.0). The increase in fabric count was due to shrinkage of the t-shirts.

The fabric weight increased more than the fabric count in the navy t-shirts from Fruit of the Loom and H&M, and in the white Brooks Brothers t-shirts. Conversely, the white H&M t-shirts and the navy Brooks Brothers t-shirts exhibited a greater change in the fabric count as opposed to the fabric weight. Finally, the increase in fabric weight and fabric count in the white Fruit of the Loom t-shirts was practically the same.

**Research question #1c.** *Are there differences in the construction specifications of mens 100% cotton jersey knit t-shirts at three retail categories?* The construction



specifications were evaluated on the t-shirts before laundering. Differences in stitch types, seam and hem types, and the order of garment assembly were compared.

***Stitch types.*** The underarm seams were closed using a class 504 stitch for all Fruit of the Loom t-shirts and the white Brooks Brothers t-shirts. However, all H&M t-shirts and the navy Brooks Brothers t-shirts used a class 514 stitch to close the underarm seams. A class 514 stitch uses more thread and therefore requires more materials and labor to produce. A class 504 stitch was used to insert the sleeves (armscye) in all Fruit of Loom t-shirts, while a more costly class 514 stitch was used to insert the sleeves in all H&M t-shirts and all Brooks Brothers t-shirts. A class 504 stitch was used to close the shoulder seams on all of the t-shirts except the navy H&M t-shirts, which were closed with a class 514 stitch. The neckband topstitching, which was visible across the neckband front, was executed using a double needle class 406 stitch on all Fruit of the Loom t-shirts and the navy Brooks Brothers t-shirts. The navy H&M t-shirts used a more refined, single needle, class 101 stitch for neckband topstitching. Neither the white H&M t-shirts nor the white Brooks Brothers t-shirt included neckband topstitching. The omission of topstitching saves time, materials, and labor. Additional stitch classes were used on the navy Brooks Brothers t-shirts. These t-shirts included a side vent finished with tape using a class 301 stitch (see Appendix B, Figure B1). A bartack class 101 stitch was used to reinforce the mitered tape. The navy Brooks Brothers t-shirts were the only t-shirts to include an embroidered logo at the left chest area (see Appendix B, Figure B3). This was executed with a class 304 stitch. The use of the additional stitching in the navy Brooks Brothers t-shirts requires more materials, time, and labor.

The stitch count for all of t-shirts ranged from 9 to 15 SPI. All Fruit of the Loom t-shirts included some stitching with 9 SPI, while the navy H&M t-shirts and the white Brooks Brothers t-shirts included some stitching with 15 SPI. Stitches that are too long (low SPI) or too short (high SPI) for a specific fabric type can lead to puckering, therefore, stitch length is an important criterion to use when evaluating overall construction quality in a garment. Stitch length also directly relates to the cost of materials and time required to sew a garment. Garments with a lower SPI (longer stitch length) utilize less thread and can be sewn in a shorter period of time, impacting the cost of manufacturing (Brown & Rice, 2001).

***Seam and hem types.*** All Fruit of the Loom t-shirts and the white Brooks Brothers t-shirts did not have side seams. The hem depths were also different. The narrowest hem depths were on all Fruit of the Loom t-shirts (11/16”) and the widest hem depths were on the white H&M t-shirts (15/16”, 1”) and the navy Brooks Brothers t-shirts (1”). From a quality perspective, hems should be wide enough to avoid rolling when the fabric is stretched (Glock & Kunz, 2005). And, in general, wider hems tend to hang more smoothly. Therefore, higher quality garments tend to have wider hems than those on lower quality garments. Because wider hems require more fabric, they can be more costly (Keiser & Garner, 2012).

***Assembly.*** The main difference in assembly operations is the order in which the underarm seams and sleeve hems are finished. The Fruit of the Loom t-shirts finish the sleeve hem first, then close the underarm seam. This sequence for hem and seam construction can impact the quality of a final product at a given price range. A sleeve that is hemmed flat before the underarm sleeve seam is sewn closed results in a visible underarm seam that extends to the edge of the sleeve, possibly causing discomfort to the wearer. A desirable, yet more expensive way to construct a sleeve hem is to close the underarm seam first, then finish the garment edge (Lee & Steen, 2014). The t-shirts from H&M and Brooks Brothers were assembled in this order.

**Research question #2a.** *Are there differences in the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories before home laundering?* Whiteness, crocking, and bursting strength, were evaluated before the t-shirts were laundered.

***Instrumental whiteness.*** Before laundering, the whiteness index for the white t-shirts were as follows: Fruit of the Loom, 85.68; H&M 90.48; Brooks Brothers, 89.13. “The average consumer’s perception of whiteness is based on a clear, bright, almost bluish white” (Kadolph, 2007, p. 261). As the values for the H&M and Brooks Brothers t-shirts were closer to 100, this is indication of a brighter appearance.

***Colorfastness to dry and wet crocking.*** Crocking ratings correspond to the AATCC Gray Scale for Staining card. The grading scale ranges from 1 to 5, with half ratings in between. A grade of 1 represents *very severe* color transfer, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color transfer. Initial crocking ratings can help

predict how a garment will perform during use and care. When dry crocking was performed on the navy t-shirts before laundering, the ratings were: Fruit of the Loom, 4.8; H&M, 3.5; and Brooks Brothers, 3.5. The H&M and Brooks Brothers t-shirts experienced more color transfer. Wet crocking ratings for the Fruit of the Loom, H&M, and Brooks Brothers t-shirts were 1.9, 2.0, and 2.0 respectively. These ratings were not significantly different, yet they did indicate that all of the navy t-shirts have a high propensity for color transfer when wet.

***Fabric bursting strength.*** The initial bursting strengths for the t-shirts, from lowest to highest, were as follows: white H&M, 46.8; white Fruit of the Loom, 50.9; navy Fruit of the Loom, 79.5; navy H&M, 79.5; white Brooks Brothers, 82.5; and navy Brooks Brothers, 87.2. Although data analysis was not performed on this set, the results for the white Fruit of the Loom and the white H&M t-shirts were much lower than the other t-shirts.

**Research question #2b.** *Are there differences in the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories after home laundering?* Data for color change, whiteness, crocking, smoothness, bursting strength, and pilling, dimensional stability and garment twist from washes five and twenty were analyzed in Minitab. Significant findings are included below.

***Subjective color change.*** The AATCC Gray Scale colorfastness grade of 1 represents *very severe* color change, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color change. After five washes, there was slight color change in the navy t-shirts, however the differences between their ratings were significant ( $p=0.000$ ). Fruit of the Loom was given a rating of 4.6, H&M was given a rating of 4.0, and Brooks Brothers was given a rating of 5.0. After twenty washes, the H&M t-shirts were perceived to have experienced the most color change (3.6) and this was significantly different ( $p=0.006$ ) than the color change for the Fruit of the Loom t-shirts (4.4) and the Brooks Brothers t-shirts (4.1).

***Instrumental color change.*** After five washes, the navy Fruit of the Loom t-shirts had a significantly higher ( $p=0.006$ ) degree of color change (1.19) compared to the H&M (0.44) and Brooks Brothers (0.25) t-shirts. However, the degree to which color of

the Fruit of the Loom t-shirts changed decreased after wash twenty (0.65). This can be an indication that the color is actually getting darker. This also correlates to the subjective color change data. After wash twenty, there was a significant difference ( $p=0.022$ ) in the color change among the H&M (1.28) and Fruit of the Loom (0.65) t-shirts.

**Subjective whiteness change.** After five washes there was no significant difference ( $p=0.323$ ) in the whiteness ratings for the group of white t-shirts, which ranged from 4.5 to 4.8. After twenty washes, only the slight whiteness change rating (4.0) for the Brooks Brothers t-shirts was significantly different ( $p=0.002$ ) from the Fruit of the Loom (4.5) and H&M t-shirts (4.4). As fabrics age or are laundered, discoloration may appear and this can affect whiteness perception (Kadolph, 2007).

**Instrumental whiteness.** As a group of white t-shirts after five washes, there was a statistically significant difference ( $p=0.027$ ) in the whiteness indices of the Fruit of the Loom (87.13) and H&M t-shirts (91.78). After wash twenty, the difference in whiteness indices continued to be statistically significant ( $p=0.019$ ). The whiteness indices decreased for the Fruit of the Loom (84.87) and H&M t-shirts (90.39), but increased for the Brooks Brother t-shirts (91.58). And it was the greater decrease in the Fruit of the Loom t-shirts that resulted in its whiteness index being statistically different from the other t-shirts.

**Colorfastness to crocking.** Crocking ratings correspond to the AATCC Gray Scale for Staining card. The grading scale ranges from 1 to 5, with half ratings in between. A grade of 1 represents *very severe* color transfer, 2 is *severe*, 3 is *moderate*, 4 is *slight*, and 5 is *none* or no color transfer. As a group of navy t-shirts after five washes, the dry crocking ratings for the Fruit of the Loom t-shirts (4.8) were significantly different ( $p=0.025$ ) from the H&M t-shirts (4.1). After twenty washes, there was less color transfer from all t-shirts, as ratings ranged from 4.6 to 4.8, and there was no significant difference ( $p=0.767$ ). Ratings for wet crocking after five washes were more severe than the dry ratings, ranging from 1.9 to 2.0, but they were not statistically different ( $p=0.360$ ). After wash twenty, however, the difference in wet crocking ratings was statistically significant ( $p=0.028$ ) between the H&M t-shirts (2.4) and the Fruit of the Loom and Brooks Brothers t-shirts, as both were rated 3.3. Wet crocking became less severe as color transfer decreased. By wash twenty, residual dyes have been removed.

**Smoothness appearance.** Smoothness ratings were not statistically analyzed, however interpretations can be made based on the smoothness appearance data in Figure 4.10. Ratings are based on comparisons to the AATCC 3-D Smoothness Appearance Replicas. The grading increments ranged between 1 and 5, where ‘SA-1’ represented a *crumpled, creased and severely wrinkled appearance* and ‘SA-5’ represented a *very smooth, pressed, finished appearance*. Smoothness grades 2, 3, 3.5, and 4 represented appearances that progressed from *rumpled* to *smooth*, accordingly. After wash five, the white t-shirts had lower smoothness ratings than the navy t-shirts. The white t-shirts ranged from 1.6 to 2.1, while the navy t-shirts ranged from 3.3 to 3.8. After wash twenty, the smoothness appearance improved for all t-shirts, however, as a group the white t-shirts had lower ratings (2.6 to 3.0) compared to the navy t-shirts (3.4 to 4.0).

**Fabric bursting strength.** Among the group of white t-shirts after five washes, the Brooks Brothers had the highest bursting strength (85.5 psi). This was significantly different ( $p=0.000$ ) than the Fruit of the Loom (50.9 psi) or the H&M t-shirts (42.2 psi). There was also a significant difference ( $p=0.000$ ) in the white t-shirt bursting strength after twenty washes. The Brooks Brothers t-shirts continued to have the highest bursting strength (82.2 psi). While the bursting strengths of the Fruit of the Loom (50.9 psi) and H&M t-shirts (42.2 psi) were significantly lower. Regarding the navy t-shirts, the bursting strength for Fruit of the Loom (76.1 psi) was significantly lower ( $p=0.000$ ) than both the H&M (87.7 psi) and Brooks Brothers t-shirts (90.0 psi). After twenty washes, the navy H&M t-shirts exhibited the lowest bursting strength (65.8 psi), which was significantly different ( $p=0.000$ ) than the Fruit of the Loom (79.3 psi) and Brooks Brothers t-shirts (87.9 psi).

**Pilling and fuzzing.** The surface wear was evaluated by comparison to an ASTM photographic standard. Ratings of 1 through 5, with half steps in between were assigned based on the degree of surface change. Ratings are classified to be 1 as *very severe pilling*, 2 as *severe pilling*, 3 as *moderate pilling*, 4 as *slight pilling*, and 5 as *no pilling*. T-shirts were grouped by color for statistical analysis. As a group of white t-shirts after five washes, there was a significant difference ( $p=0.000$ ) in the pilling ratings. The H&M t-shirt had a significantly better rating (2.7) than the Fruit of the Loom (1.7) or Brooks Brothers t-shirts (1.5). After twenty washes, the differences between all three white t-

shirts were statistically significant ( $p=0.000$ ). Ratings were: Fruit of the Loom, 2.5; H&M, 4.3; and Brooks Brothers, 3.6. The navy t-shirts also had pilling ratings that were statistically significant ( $p=0.000$ ) after five washes. The H&M t-shirts had a better pilling rating (3.2) than the Fruit of the Loom (1.6) and Brooks Brothers t-shirts (1.8). And after wash twenty, the ratings for the navy t-shirts improved proportionately, resulting in a statistically significant difference ( $p=0.000$ ) between the H&M t-shirts (4.5) and the Fruit of the Loom (2.7) and Brooks Brothers t-shirts (2.8).

***Dimensional stability.*** The t-shirt measurements were not statistically analyzed, therefore the dimensional stability figures (4.13-4.15) were used to summarize the findings. After five and twenty washes, the white H&M t-shirts exhibited the highest change (shrinkage) in length (7.7% and 8.8%), while the navy Brooks Brothers shirts exhibited the least percent shrinkage (2.2% and 3.0%). Regarding changes in t-shirt width, as a group after five and twenty washes, the white Brooks Brothers t-shirts exhibited the highest change in width (7.7% and 8.4%), while the navy Brooks Brothers shirts exhibited the least percent change in width (1.8% and 1.6%). The results for dimensional change overall, show that, after five and twenty washes, the white Brooks Brothers t-shirts exhibited the highest shrinkage (6.9% and 7.9%), while the navy Brooks Brothers shirts exhibited the least percent shrinkage (2.0% and 2.3%).

***Garment twist.*** In the group of white t-shirts after wash five, skewness change was more severe in the H&M t-shirts (8.1%) compared to the Fruit of the Loom (1.9%) and Brooks Brothers t-shirts (1.8%). However because N was 2 and the SD for the H&M t-shirts was 7.0, these percentages were not statistically significant ( $p=0.340$ ). After twenty washes, the skewness change increased, but the difference in percentages (2.8%, 12.2%, and 5.3%) were not statistically significant for the same reasons. In the group of navy t-shirts after five washes, there was no statistically significant difference ( $p=0.245$ ) in the skewness change between the Fruit of the Loom (4.9%), H&M (2.1%), and Brooks Brothers t-shirts (2.2%). However, there was a statistically significant difference ( $p=0.010$ ) in the skewness changes between the Fruit of the Loom t-shirts (8.1%) compared to the H&M (3.0%) and Brooks Brothers t-shirts (1.1%).

**Research question #3.** *Are there differences in the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories*

compared to the ASTM Standard Specification requirements? The appearance and performance ratings and measurements for color change, crocking, smoothness, fabric bursting strength, and dimensional stability were compared to the specifications designated in the ASTM D4154–14: Standard Performance Specification for Men’s and Boy’s Knitted and Woven Beachwear and Sports Shirt Fabrics. A summary of results is presented in Table 4.21. Pilling and skewness results were discussed in the narrative, as compared to published *H&M Quality Standards & Requirements* only (H&M, 2010).

Table 4.21

*ASTM D4154 Specification Requirements Compared to T-Shirt Data, After 5 Washes*

Characteristic	Requirement	Fruit of the Loom		H&M		Brooks Brothers	
		White	Navy	White	Navy	White	Navy
Color Change	4.0 min	N/A	4.6	N/A	4.0	N/A	5.0
Dry Crocking	4.0 min	N/A	4.8	N/A	4.1	N/A	4.4
Wet Crocking	3.0 min	N/A		N/A		N/A	
Smoothness Appearance	3.5 min				3.5		3.8
Bursting Strength	50 psi	50.9	76.1		87.7	85.5	90.0
Dimensional Change	3% max						2.0

***Subjective color change.*** A minimum grade 4 shade change was required to meet the ASTM D4154 specification. All of the navy t-shirts met this requirement at all intervals, except for the H&M t-shirts after was twenty. It was perceived to have a grade 3.6 shade change.

***Colorfastness to crocking.*** A minimum rating of 4.0 was required to meet dry crocking specifications. After washes five and twenty, all navy t-shirts were assigned ratings that exceeded this. Wet crocking ratings specify a minimum of 3.0. This was met by the Fruit of the Loom t-shirts after washes ten and twenty, and the Brooks Brothers t-shirts after wash twenty.

***Smoothness appearance.*** A minimum smoothness rating of 3.5 is specified by the ASTM standard. Only the navy H&M t-shirts and the navy Brooks Brothers t-shirts met this rating after five, ten, and twenty washes. The smoothness ratings for the H&M t-shirts ranged from 3.5 to 3.9 and the Brooks Brothers ranged from 3.8 to 4.0.

***Fabric bursting strength.*** The ASTM specifies a minimum 50 psi rating. All t-shirts at all intervals met this minimum except for the white H&M t-shirt. The bursting strength for this t-shirt ranged from 46.8 psi to 48.9 psi.

***Pilling and fuzzing.*** Although the ASTM D4154 standard does not specify a minimum pilling rating, published guidelines set forth by H&M for knit tops require minimum pilling ratings of 3.0. Using these ratings as a model, only the navy H&M would pass these requirements at all intervals with a range of 3.2 to 4.5. The white H&M had pilling ratings at intervals ten and twenty of 4.0 and 4.3 respectively. The white Brooks Brothers only met the pilling guidelines after wash twenty (3.6).

***Dimensional stability.*** A 3% change in either shrinkage or growth is the ASTM maximum for dimensional change. Only the navy Brooks Brothers t-shirts were within that range for both length and width. Although the change in length after wash ten was 3.1%, the final change after wash twenty was 3%. In general, there was greater shrinkage in t-shirt lengths as opposed to t-shirt widths. The t-shirts with the highest shrinkage in length after twenty washes were the white H&M (8.8%). The t-shirts with the highest shrinkage in width after twenty washes were the white Brooks Brothers (8.4%). Overall, the t-shirts that exhibited most shrinkage were the white Brooks Brothers (7.9%). And the t-shirts that exhibited the least shrinkage overall were the navy Brooks Brothers (2.3%).

***Garment twist.*** Maximum skewness change is not specified by the ASTM, however H&M has published guidelines that recommend skewness change to be less than 5%. Using these suggestions as a guide, the navy Fruit of the Loom t-shirts exceeded the maximum rating after washes ten and twenty (6.1%, 8.1%). The white H&M t-shirts exceed the maximum percentage after washes five, ten, and twenty (8.1%, 9.4%, and 12.2%). And the white Brooks Brothers t-shirts exceed the maximum percentage after wash twenty (5.3%).



## Chapter Five

### Conclusion

The purpose of this research was to evaluate the quality of design, materials, construction, appearance, and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. The retail categories of mass merchant, fast fashion, and better were represented by the brands Fruit of the Loom, H&M, and Brooks Brothers, respectively, in the colors of white and navy. In all, the sample was comprised of 78 t-shirts: 13 white Fruit of the Loom, 13 navy Fruit of the Loom, 13 white H&M, 13 navy H&M, 13 white Brooks Brothers, and 13 navy Brooks Brothers. All of the t-shirts were a short-sleeved crewneck style without pockets or other adornments. The white t-shirts were sold in a pack of multiples, while the navy t-shirts of each brand were sold individually. By including both white and navy in the sample, different aspects of the change in appearance after laundering were able to be measured. Observations and measurements were collected from new t-shirts, and after the t-shirts were washed and dried one, five, ten, and twenty times.

The t-shirts evaluated in this study were easily differentiated by brand and price. But as a result of this research the t-shirts were able to be differentiated by design, materials, construction, appearance, and performance. The data was analyzed after washes five and twenty to ascertain differences and similarities and provide rankings according to the garment specifications. Key variables of the experimental segment included the recommended test methods designated in the ASTM D6321/D6321M-14: *Standard Practice for the Evaluation of Machine Washable T-Shirts*. And results from select tests were compared to the ASTM D4154-14: *Standard Performance Specification for Men's and Boy's Knitted and Woven Beachwear and Sports Shirt Fabrics*. Measurements and ratings for these laboratory tests were based on the standard test method procedures set forth by the American Society for Testing and Materials (ASTM) and the American Association of Textile Chemists and Colorists (AATCC).

Research objectives of this study were to:

1. *Identify and compare the product specifications of mens 100% cotton jersey knit t-shirts at three retail categories.*

T-shirts are a multi-functional clothing option for consumers at all social and economic levels because they are available in a wide range of prices and quality levels. When product specifications for a garment are developed, designers must take into account how the design, materials, and construction methods relate in order to produce a garment that will satisfy the consumer (Lee & Steen, 2014). The t-shirts this research varied in design, materials, construction and these aspects have been compared.

All of the t-shirts included the same basic T design. The H&M t-shirts were constructed with side seams. The navy Brooks Brothers t-shirts were also constructed with side seams that included side vents. The side vents add detail to the design of the t-shirts and upgrade the appearance of the basic t-shirt. An embroidered logo was also present on the navy Brooks Brothers t-shirts. These additional design details add to the production costs, but are a way to communicate brand image and may lead to the consumer to associate the t-shirts with a higher quality garment (Kadolph, 2007; Kendall, 2009). The t-shirts in the ‘better’ retail category (Brooks Brothers) had extra design details not incorporated into the other retail categories.

The t-shirts were all 100% cotton. The Brooks Brothers t-shirts, however, were made with Supima® variety cotton that is known to produce longer fibers that are spun into smoother yarns. The white Brooks Brothers t-shirts included an “ultra fresh” fabric finish to reduce odors, the navy Brooks Brothers t-shirts were treated with a “secret wash” to yield a softer fabric hand or touch. With the differences in cotton variety and fabric finishes, the Brooks Brothers fabric could be perceived by the consumer to be of higher quality. The navy H&M t-shirt included a woven jacquard main label sewn into the neck seam to form a loop. A secondary woven label was attached as a loop in the same location, but was imprinted. The navy Brooks Brothers t-shirts included two woven jacquard woven labels sewn into the neck seam; the label used mitered technique, the secondary label was sewn as a loop. The labels in navy H&M and Brooks Brothers t-shirts could add to the production costs, however, the label in the navy Brooks Brothers t-shirts included a higher cost fabric for label. The contrasting tape on the neck and

shoulder seams of the navy Brooks Brothers t-shirts and the facing of the side vents also contributes to a higher production cost. Overall, the design details and materials used in the ‘better’ retail category (Brooks Brothers) would be associated with a higher production cost.

As a basic garment, the production of a t-shirt requires relatively few stitch and seam types and assembly operations. A higher production cost and more durable stitch type was used in all H&M and the navy Brooks Brothers t-shirts. In this research the ‘fast fashion’ category t-shirts were constructed with the same type of stitches as the ‘better’ t-shirt category. The stitches per inch (SPI) were the highest in the navy H&M t-shirt. Stitch length directly relates to the amount of thread required to sew a garment and is associated with higher quality garments (Brown & Rice, 2001). The SPI in the ‘fast fashion’ category navy t-shirts were higher than ‘better’ t-shirt category. Topstitching was used on all Fruit of the Loom t-shirts and the H&M and Brooks Brother’s navy t-shirts. This is also an indicator of better quality garments (Glock & Kunz, 2005). Although all of the t-shirts in the ‘mass merchant’ category (Fruit of the Loom) had topstitching on the neckband, a lower SPI was used in this location. The t-shirt assembly was also the same in all except for the order in which the sleeve hems were finished on the Fruit of the Loom t-shirt. By finishing the hem before closing the underarm seam, Fruit of the Loom used a lower cost production method (Lee & Steen, 2014). Overall the construction of the ‘fast fashion’ t-shirts (H&M) was similar to that of the t-shirts in the ‘better’ category (Brooks Brothers).

*2. Measure and compare the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories before and after home laundering.*

The appearance of the t-shirts before laundering was similar. From a colorfastness stand-point, however, some transfer of color from the dry navy H&M and dry navy Brooks Brothers onto another dry surface might occur if rubbed against the t-shirt fabric. This could also occur with all of the navy t-shirts if either the t-shirts or adjacent fabric were wet. With regard to performance, a consumer is unlikely to perceive any difference if the t-shirts were worn before laundering. This research tested bursting

strength on t-shirts initially, and although white H&M and white Fruit of the Loom had the lowest bursting strength, this should not affect the initial performance.

After five wash cycles, the appearance and performance of the t-shirts was a reflection of the removal of residual and/or temporary finishes. After twenty washes, the results of this study were an indication of the expected serviceability of the t-shirts.

After washing, there was puckering and roping of the armcye seams on all of the t-shirts. The neckband width of the white H&M t-shirts was narrow and lacked topstitching, which caused it to roll. Also, the narrow hem depths on white and navy Fruit of the Loom and white Brooks Brothers contributed to hem rolling after laundering, detracting from the appearance. With regard to stitching, seaming and hemming, a consumer might be most satisfied with the navy 'fast fashion' (H&M) and navy 'better' (Brooks Brothers) t-shirts.

As a group of navy t-shirts, a change in color was perceived in H&M after five washes. After twenty washes, all navy t-shirts showed a color loss but it was most apparent in H&M. The instrumental measurement of color change supported the visual color change observation. The appearance of the Fruit of the Loom t-shirts could be viewed as having the lowest satisfactory appearance. This is because the Fruit of the Loom t-shirts had a lower pilling rating, which means there were more fiber pills on the surface of the Fruit of the Loom t-shirts, negatively impacting its appearance. After twenty washes, H&M exhibited the least degree of pilling. With regard to color change and pilling, a consumer might be most satisfied with the appearance of the navy 'fast fashion' (H&M) t-shirts. Fuzzing and pilling contribute to a perceived loss of color, therefore, the consumer may perceive that the color is brighter due to a lack of fuzz and pilling.

As a group of white t-shirts, the change in the whiteness after laundering was not apparent. Instrumental values reported that, after twenty washes, Brooks Brothers t-shirts were the 'whitest' (91.58), however, a difference in whiteness perceived only when the white t-shirts from each brand were placed next to each other. If a consumer were to compare the appearance of pilling on the surface of the t-shirts, they would probably be most satisfied with the t-shirts in 'fast fashion' (H&M) t-shirts.

Due to the fiber content and jersey knit construction of the fabric, a change in dimensions of a 100% cotton t-shirt is expected. However, if the change is great enough to affect the size of a garment, consumer satisfaction may decrease. A change of 5% or more may impact the fit of the t-shirt and this would be apparent to the consumer. The t-shirts in this research did experience a change in dimensions (shrinkage) that would impact the size or fit of the t-shirt. The decrease in length of white H&M would potentially impact the fit. A decrease in length (shrinkage) also occurred in white and navy Fruit of the Loom and white Brooks Brothers, but it was not as severe as in the white H&M t-shirts. The decrease in width measurements of the t-shirts was highest in white Brooks Brothers. Based on the combination of the decrease in t-shirt length and width, overall size of white Brooks Brothers would be affected. This correlates to the fabric weight results that indicated the highest increase in fabric weight as a percentage, was in white Brooks Brothers. The least percent change in the overall size was exhibited in navy Brooks Brothers. This correlates to the fabric weight results that indicated navy Brooks Brothers had the lowest increase in fabric weight.

The white Fruit, navy Fruit, and white Brooks t-shirts were constructed as tubular knit fabrics. The white H&M, navy H&M, and navy Brooks were constructed with seamed pieces in the body. Research results showed that the seamed navy H&M and navy Brooks Brothers had less skew, however, the seamed white H&M had the highest skew. This can occur when pattern pieces are placed off-grain when cutting. The percent skewness in the white H&M would lead to consumer dissatisfaction with the fit of this garment after just five washes. The navy Brooks Brothers experienced the least percent skewness, followed by navy H&M. Therefore, with regard to skew, a consumer is likely to be equally satisfied with the fit and appearance of navy 'fast fashion' (H&M) t-shirts and the 'better' (Brooks Brothers).

3. *Compare the appearance and performance characteristics of mens 100% cotton jersey knit t-shirts at three retail categories to the ASTM Standard Specification requirements.*

The physical and chemical properties of the materials in a t-shirt fabric will affect how it performs, and ultimately determine if it is suitable for the desired use. The textile testing in this thesis research encompassed the procedures under which the t-shirt

characteristics and properties were assessed. The results after five washes for subjective color change, colorfastness to crocking, smoothness appearance, fabric bursting strength, and dimensional stability were compared to the specification requirements set forth in the ASTM D4154–14: *Standard Performance Specification for Men's and Boy's Knitted and Woven Beachwear and Sports Shirt Fabrics*. From a production standpoint, it is through standards and specifications that consistency can be achieved, and defined quality characteristics can be met (Glock & Kunz, 2005).

The white Fruit of the Loom t-shirts met the requirement for bursting strength only. The navy Fruit of the Loom t-shirts met the requirements for subjective color change, colorfastness to dry crocking, and bursting strength. The white H&M t-shirts did not meet any of the requirements specified by ASTM D4154. The navy H&M t-shirts met the requirements for subjective color change, colorfastness to dry crocking, smoothness appearance, and bursting strength. The white Brooks Brothers t-shirts met the requirement for bursting strength only. The navy Brooks Brothers t-shirts met the requirements for subjective color change, colorfastness to dry crocking, smoothness appearance, bursting strength, and dimensional change. In all, none of the navy t-shirts met the minimum requirement for wet crocking. The navy Brooks Brothers t-shirts met five out of the six applicable requirements specified by ASTM D4154. From a production stand point, the navy t-shirts in the 'better' retail category (Brooks Brothers) would be considered a higher quality 100% cotton mens jersey knit t-shirt. In conclusion, the decision to purchase a t-shirt from these retail categories may depend on consumer expectations.

### **Limitations**

This research was limited by the use of a non-randomized, convenience sample. There was a limited population of t-shirts and no control over in which manufacturers' production lot the t-shirts were produced. Also, to simplify the experimental design and to replicate the laundry habits of a typical consumer, all of the t-shirts were laundered using the same wash and dry parameters. A 40° C, "warm water" wash was used, followed by a drying cycle on high heat. However, the care label of the navy H&M t-shirts recommended washing in cold water and avoiding the dryer. Had the navy H&M t-shirts been laundered according to these care instructions, results may have differed.

Also, the suitability of the t-shirts' designs, materials, construction, appearance, and performance were evaluated after before and laundering, but the t-shirts were never worn. Speculation about consumer satisfaction can only be made based on measurements and evaluations performed in a laboratory setting. The t-shirts might perform differently exposed to other environmental stressors, including wearer usage, soiling, and individual home laundering methods. In the realm of apparel testing, it is not always known how a textile fabric will be used by consumers, and because of the variability of consumer behavior, even when end use is known, the actual performance expectations may not be well understood (Collier & Epps, 1999).

### **Recommendations for Future Research**

The purpose this research was to evaluate the quality of specifications, materials, appearance and performance of mens 100% cotton jersey knit t-shirts from three retail categories: mass merchant, fast fashion, and better. Recommendations for future research are to include a wear study and to obtain samples that are produced in different lots. A wear study would improve results for test methods that are limited by a laboratory setting. For example, pilling propensity is impacted by abrasion experienced during wear. Also, exposure to body oils and environmental soils during wear may impact the color or whiteness of the t-shirt fabrics. The addition of a soil ballast to the wash cycle would help simulate this. The ability to obtain samples from different production lots would aid in the randomization of the experimental design. Also, for this thesis research, there were two t-shirts from each color and retail category that were evaluated. Accuracy could be improved if more samples were included at each testing interval. Other recommendations are to introduce variables in the laundering conditions. Finally, with the increasing popularity of the *slow fashion* movement, which focuses on quality-based instead of time-based fashions (Watson & Yan, 2013), a study comparing t-shirts from this production method to the sample could be informative.

## Appendix A

### *Definition of Terms*

Better: products with wide market appeal, often the highest price point available in department stores (Keiser & Garner, 2012).

Bursting Strength: the force or pressure required to rupture a textile by distending it with a force, applied at right angles to the plane of the fabric, under specified conditions (AATCC, 2016).

Colorfastness: the resistance of a material to change in any of its color characteristics, to transfer its colorant(s) to adjacent materials or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material (AATCC, 2016).

Crocking: the transfer of colorant from the surface of a colored yarn or fabric to another surface or to an adjacent area of the same fabric, principally by rubbing (AATCC, 2016).

Delta E: *in color difference evaluation*, a single number defining the total color difference in color measurement units from a trial to a standard (AATCC, 2016).

Design Ease: measurements added to a garment to produce the look intended by the designer (Keiser & Garner, 2012, p. 382)

Dimensional Change: a generic term for variation in length or width of a garment or fabric specimen subjected to specified conditions. The change is usually expressed as a percentage of the initial dimension of the specimen (AATCC, 2016).

Fabric Count: the number (counted units) of wale and courses per 1 inch (ASTM, 2016).

Fabric Hand: the tactile sensations or impressions that occur when fabrics are touched, squeezed, rubbed or otherwise manipulated (AATCC, 2016).

Fabric Weight: describes fabric mass or how much a fabric weighs for a given area or length of fabric; it is described as oz/yd<sup>2</sup> or g/m<sup>2</sup> (Kadolph, 2010).

Fast Fashion: a relatively new category that offers fast fashion at a moderate to better price point (Keiser & Garner, 2012).

Fit Ease: dimensions amount added to body measurements to compensate for body movement (Keiser & Garner).



Mass Merchant: a variety of brands that appeal to many different market segments, all at low affordable prices (Keiser & Garner, 2012).

Pilling: occurs when balls of tangled fibers are held to the surface of a fabric by one of more fibers (ASTM, 2016).

Production Lot: a part of one manufacturer's production made from the same nominal raw material under essentially the same conditions and designed to meet the same specifications (ASTM, 2016).

Quick Response: comprehensive business strategy consisting of computer linkages and interindustry partnerships based on trust and cooperation that substantially speed up the production and delivery of goods while at the same time enhancing quality (Brown & Rice, 2001).

Registration Number: (RN) assigned by the Federal Trade Commission for the purpose of identifying the manufacturer, importer, or distributor of apparel products; requirement for disclosure of information on a garment label (Bubonia, 2014).

Skewness: a fabric condition resulting when filling yarns or knitted courses are angularly displaced from a line perpendicular to the edge of side of the fabric (AATCC, 2016).

Smoothness Appearance: *in fabrics*, the visual impression of planarity of a specimen quantified by comparison with a set of reference standards (AATCC, 2016).

Slow Fashion: clothing produced using an approach that focuses on quality-based instead of time-based fashions (Watson & Yan, 2013)

T-Shirt: originally a man's undershirt with short sleeves and high round neck, forming a T shape, usually made of white cotton knit (Calasibetta & Tortora, 2003).

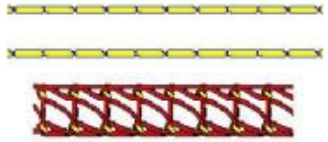
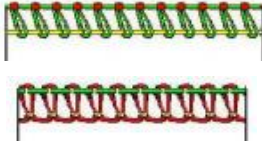
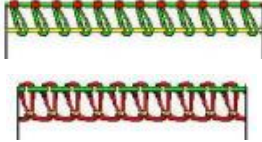
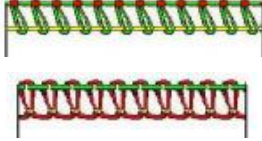

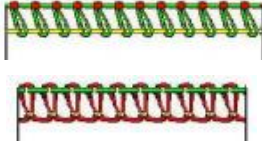
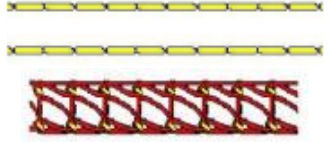
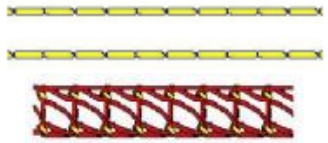
Undershirt: man's knitted shirt, usually white cotton with a U neckline into built-up straps, or with short sleeves and crew neck or V neck (Calasibetta & Tortora, 2003).

Whiteness: the attribute by which an object color is judge to approach a preferred white (AATCC, 2016).

## Appendix B

Table B1

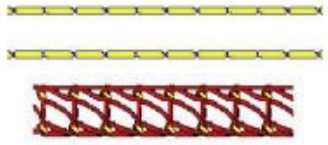
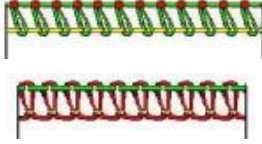
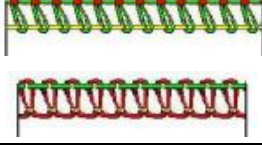
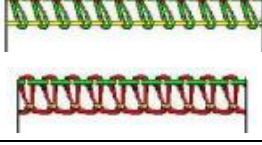

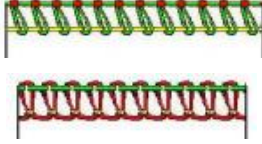
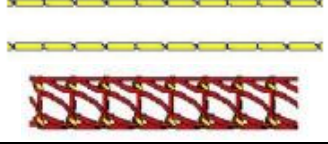
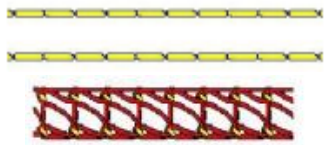
*Stitch Types, White Fruit of the Loom T-Shirts*

Location	Classification	Name	SPI	Illustration <sup>a</sup>
Sleeve Hem	406	Coverstitch	9	
Underarm Seam	504	3 Thread Overedge	9	
Armscye	504	3 Thread Overedge	10	
Shoulder Seam	504	3 Thread Overedge	11	
Shoulder and Neck Tape	101	Chainstitch	13	
Attach Neckband	504	3 Thread Overedge	11	
Neckband Topstitching Front	406	Coverstitch	10	
Body Side-Seam	N/A			
Bottom Opening Hem	406	Coverstitch	9	

<sup>a</sup>Illustration of Top View and Bottom View of stitch.

Table B2

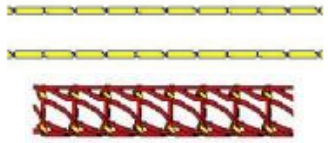
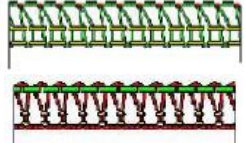
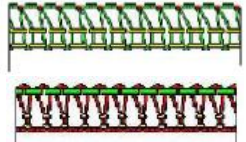
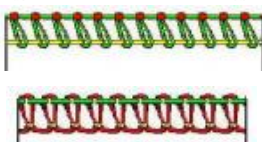

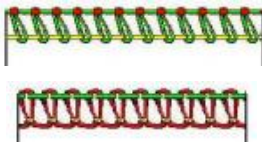
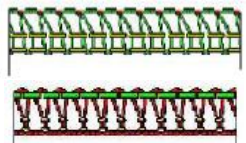
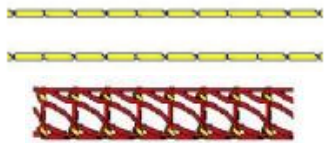
*Stitch Types, Navy Fruit of the Loom T-Shirts*

Location	Classification	Name	SPI	Illustration <sup>a</sup>
Sleeve Hem	406	Coverstitch	9	
Underarm Seam	504	3 Thread Overedge	12	
Armscye	504	3 Thread Overedge	11	
Shoulder Seam	504	3 Thread Overedge	13	
Shoulder and Neck Tape	101	Chainstitch	12	
Attach Neckband	504	3 Thread Overedge	10	
Neckband Topstitching Front	406	Coverstitch	10	
Body Side-Seam	N/A			
Bottom Opening Hem	406	Coverstitch	11	

<sup>a</sup>Illustration of Top View and Bottom View of stitch.

Table B3

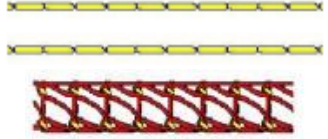
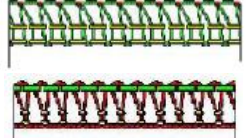
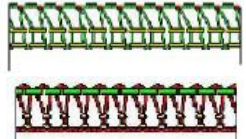
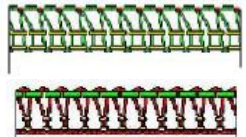

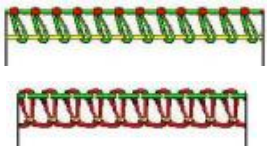

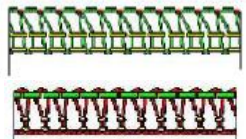
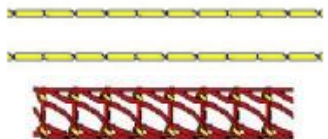
*Stitch Types, White H&M T-Shirts*

Location	Classification	Name	SPI	Illustration <sup>a</sup>
Sleeve Hem	406	Coverstitch	10	
Underarm Seam	514	4 Thread Overedge	12	
Armhole	514	4 Thread Overedge	12	
Shoulder Seam	504	3 Thread Overedge	10	
Shoulder and Neck Tape	101	Chainstitch	12	
Attach Neckband	504	3 Thread Overedge	12	
Neckband Topstitching Front	N/A			
Body Side-Seam	514	4 Thread Overedge	12	
Bottom Opening Hem	406	Coverstitch	11	

<sup>a</sup>Illustration of Top View and Bottom View of stitch.

Table B4

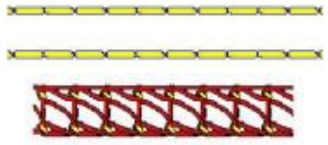
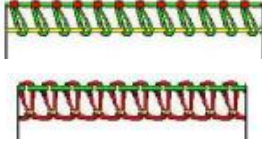
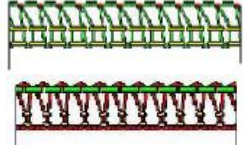
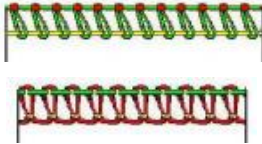
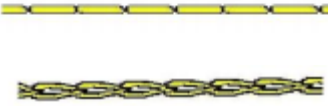
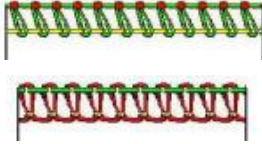
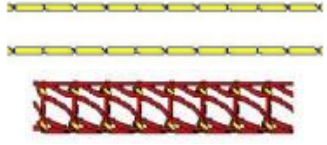
*Stitch Types, Navy H&M T-Shirts*

Location	Classification	Name	SPI	Illustration <sup>a</sup>
Sleeve Hem	406	Coverstitch	14	
Underarm Seam	514	4 Thread Overedge	14	
Armscye	514	4 Thread Overedge	15	
Shoulder Seam	514	4 Thread Overedge	13	
Shoulder and Neck Tape	101	Chainstitch	12	
Attach Neckband	504	3 Thread Overedge	15	
Neckband Topstitching Front	101	Chainstitch	15	
Body Side-Seam	514	4 Thread Overedge	14	
Bottom Opening Hem	406	Coverstitch	13	

<sup>a</sup>Illustration of Top View and Bottom View of stitch.

Table B5

*Stitch Types, White Brooks Brothers T-Shirts*

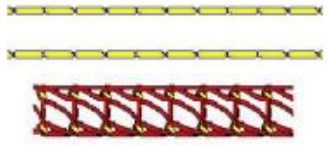
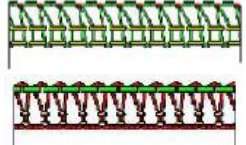
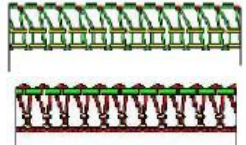
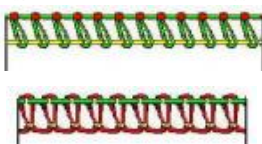

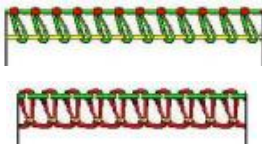
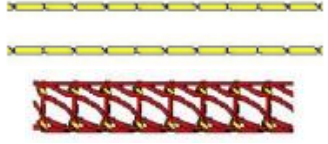

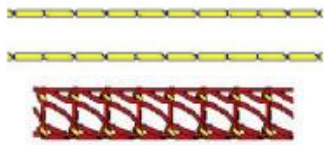
Location	Classification	Name	SPI	Illustration <sup>a</sup>
Sleeve Hem	406	Coverstitch	15	
Underarm Seam	504	3 Thread Overedge	15	
Armscye	514	4 Thread Overedge	13	
Shoulder Seam	504	3 Thread Overedge	13	
Shoulder and Neck Tape	101	Chainstitch	15	
Attach Neckband	504	3 Thread Overedge	14	
Neckband Topstitching Front	N/A			
Body Side-Seam	N/A			
Bottom Opening Hem	406	Coverstitch	13	

<sup>a</sup>Illustration of Top View and Bottom View of stitch.



Table B6


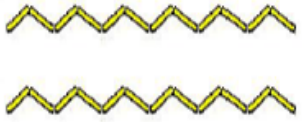


*Stitch Types, Navy Brooks Brothers T-Shirts*

Location	Classification	Name	SPI	Illustration <sup>a</sup>
Sleeve Hem	406	Coverstitch	13	
Underarm Seam	514	4 Thread Overedge	13	
Armscye	514	4 Thread Overedge	13	
Shoulder Seam	504	3 Thread Overedge	12	
Shoulder and Neck Tape	101	Chainstitch	13	
Attach Neckband	504	3 Thread Overedge	13	
Neckband Topstitching Front	406	Coverstitch	13	
Body Side-Seam	514	4 Thread Overedge	13	
Bottom Opening Hem	406	Coverstitch	14	

<sup>a</sup>Illustration of Top View and Bottom View of stitch.

Table B7

*Stitch Types, Navy Brooks Brothers T-Shirts, Side Vent and Logo*

Location	Classification	Name	SPI	Illustration <sup>a</sup>
Side Vent Tape	301	Lockstitch	14	
Side Vent Bartack	304	Lockstitch	N/A	
Logo Embroidery	304	Lockstitch	N/A	
				

<sup>a</sup>Illustration of Top View and Bottom View of stitch.



Table B8

*Seam and Hem Types, White Fruit of the Loom T-Shirts*




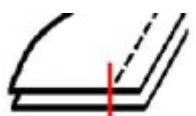
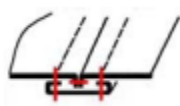


Location	Classification	Notation	Illustration
Sleeve Hem	Edge Finish	EFa Inv.	
Underarm Seam	Superimposed Seam	SSa	
Armscye	Superimposed Seam	SSa	
Shoulder Seam	Superimposed Seam	SSa	
Shoulder and Neck Tape	Superimposed Seam	SSag	
Neckband Attachment	Superimposed Seam	SSab	
Body Side-Seam	N/A		
Bottom Opening Hem	Edge Finish	EFa Inv.	

Table B9

*Seam and Hem Types, Navy Fruit of the Loom T-Shirts*




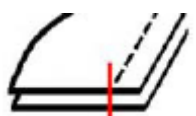
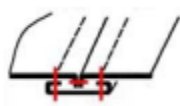


Location	Classification	Notation	Illustration
Sleeve Hem	Edge Finish	EFa Inv.	
Underarm Seam	Superimposed Seam	SSa	
Armscye	Superimposed Seam	SSa	
Shoulder Seam	Superimposed Seam	SSa	
Shoulder and Neck Tape	Superimposed Seam	SSag	
Neckband Attachment	Superimposed Seam	SSab	
Body Side-Seam	N/A		
Bottom Opening Hem	Edge Finish	EFa Inv.	

Table B10

*Seam and Hem Types, White H&M T-Shirts*




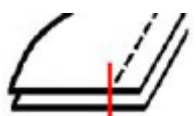
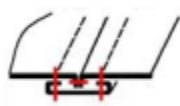



Location	Classification	Notation	Illustration
Sleeve Hem	Edge Finish	EFa Inv.	
Underarm Seam	Superimposed Seam	SSa	
Armscye	Superimposed Seam	SSa	
Shoulder Seam	Superimposed Seam	SSa	
Shoulder and Neck Tape	Superimposed Seam	SSag	
Neckband Attachment	Superimposed Seam	SSab	
Body Side-Seam	Superimposed Seam	SSa	
Bottom Opening Hem	Edge Finish	EFa Inv.	

Table B11

*Seam and Hem Types, Navy H&M T-Shirts*




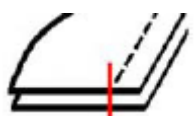
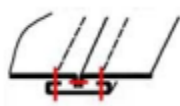



Location	Classification	Notation	Illustration
Sleeve Hem	Edge Finish	EFa Inv.	
Underarm Seam	Superimposed Seam	SSa	
Armscye	Superimposed Seam	SSa	
Shoulder Seam	Superimposed Seam	SSa	
Shoulder and Neck Tape	Superimposed Seam	SSag	
Neckband Attachment	Superimposed Seam	SSab	
Body Side-Seam	Superimposed Seam	SSa	
Bottom Opening Hem	Edge Finish	EFa Inv.	

Table B12

*Seam and Hem Types, White Brooks Brothers T-Shirts*




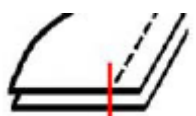
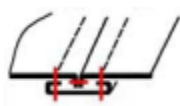




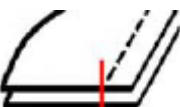
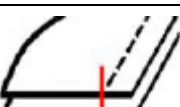


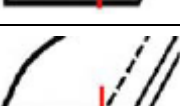

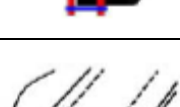
Location	Classification	Notation	Illustration
Sleeve Hem	Edge Finish	EFa Inv.	
Underarm Seam	Superimposed Seam	SSa	
Armscye	Superimposed Seam	SSa	
Shoulder Seam	Superimposed Seam	SSa	
Shoulder and Neck Tape	Superimposed Seam	SSag	
Neckband Attachment	Superimposed Seam	SSab	
Body Side-Seam	N/A		
Bottom Opening Hem	Edge Finish	EFa Inv.	

Table B13

*Seam and Hem Types, Navy Brooks Brothers T-Shirts*

Location	Classification	Notation	Illustration
Sleeve Hem	Edge Finish	EFa Inv.	
Underarm Seam	Superimposed Seam	SSa	
Armhole	Superimposed Seam	SSa	
Shoulder Seam	Superimposed Seam	SSa	
Shoulder and Neck Tape	Superimposed Seam	SSag	
Neckband Attachment	Superimposed Seam	SSab	
Body Side-Seam	Superimposed Seam	SSa	
Bottom Opening Hem	Edge Finish	EFa Inv.	
Side Vent Tape	Lapped Seam	LSm	



*Figure B1.*  
Side Vent Placket, Navy  
Brooks Brothers T-Shirts



*Figure B2.*  
Tape at Neck and Shoulder  
Seam, Navy Brooks Brothers  
T-Shirts



*Figure B3.*  
Embroidery Logo, Navy Brooks  
Brothers T-Shirts

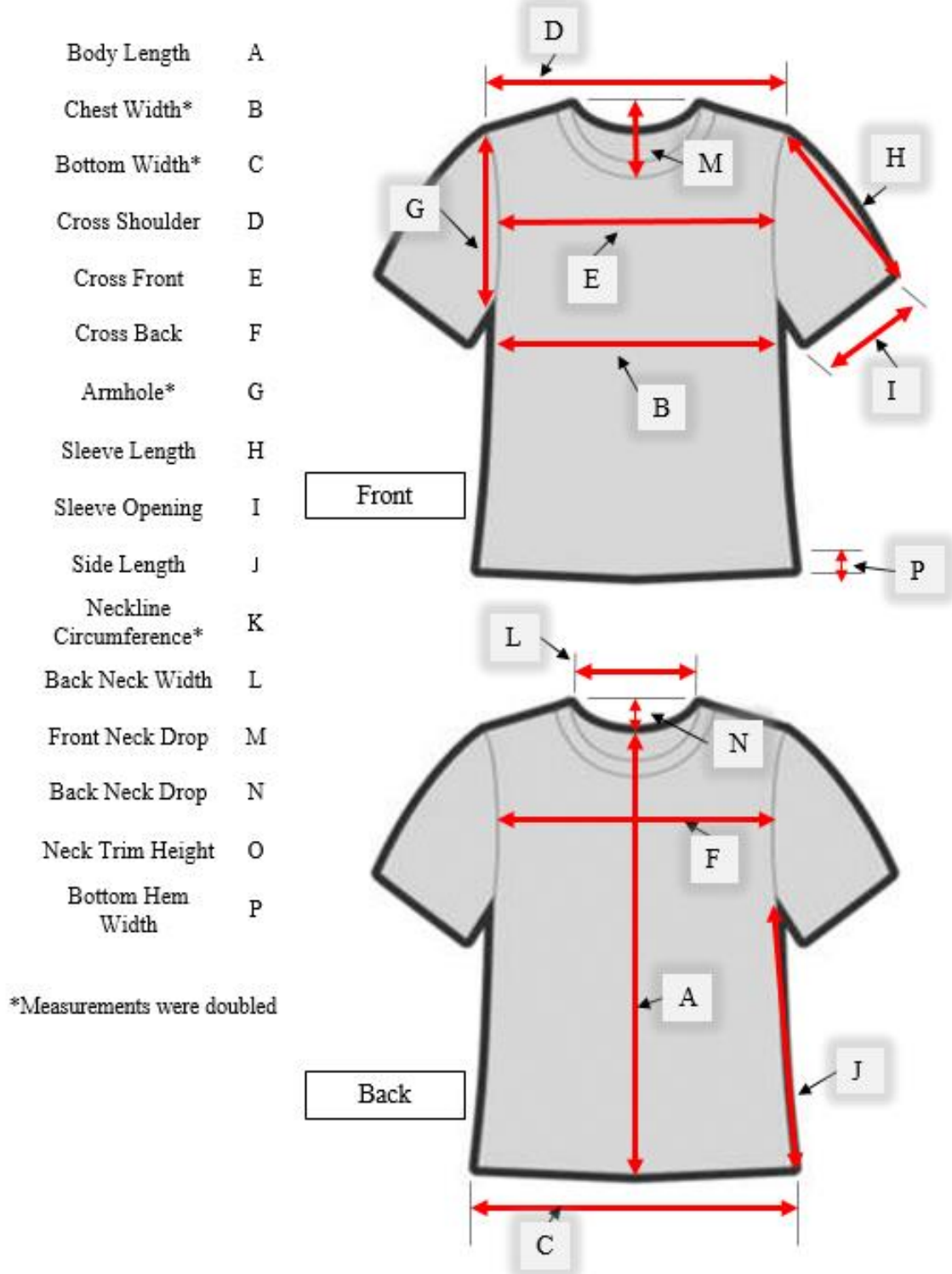


Figure B4 Garment Measurement Locations



Table B14

ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric, White Fruit of the Loom T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Fabric Weight (g)	Fabric Weight (oz/yd <sup>2</sup> )	T-Shirt Average (oz/yd <sup>2</sup> )	T-Shirt <i>SD</i>	Interval Average	Interval <i>SD</i>
Initial	4	1	0.560	4.310	4.37	0.07	4.33	0.06
		2	0.577	4.441				
		3	0.565	4.349				
	5	1	0.557	4.287	4.28	0.00		
		2	0.557	4.287				
		3	0.556	4.28				
Wash 1	6	1	0.595	4.58	4.55	0.07	4.53	0.06
		2	0.599	4.61				
		3	0.581	4.47				
	7	1	0.587	4.52	4.50	0.02		
		2	0.584	4.50				
		3	0.583	4.49				
Wash 5	8	1	0.613	4.72	4.71	0.02	4.72	0.02
		2	0.609	4.69				
		3	0.613	4.72				
	9	1	0.615	4.73	4.73	0.01		
		2	0.613	4.72				
		3	0.615	4.73				
Wash 10	10	1	0.628	4.83	4.77	0.06	4.74	0.05
		2	0.613	4.72				
		3	0.617	4.75				
	11	1	0.610	4.70	4.72	0.02		
		2	0.613	4.72				
		3	0.616	4.74				
Wash 20	12	1	0.611	4.70	4.73	0.03	4.63	0.11
		2	0.618	4.76				
		3	0.613	4.72				
	13	1	0.597	4.60	4.54	0.05		
		2	0.586	4.51				
		3	0.588	4.53				

Table B15

ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric, Navy Fruit of the Loom T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Fabric Weight (g)	Fabric Weight (oz/yd <sup>2</sup> )	T-Shirt Average (oz/yd <sup>2</sup> )	T-Shirt <i>SD</i>	Interval Average	Interval <i>SD</i>
Initial	4	1	0.671	5.16	5.17	0.08	5.17	0.05
		2	0.661	5.09				
		3	0.682	5.25				
	5	1	0.669	5.15	5.18	0.03		
		2	0.676	5.20				
		3	0.674	5.19				
Wash 1	6	1	0.720	5.54	5.53	0.04	5.50	0.04
		2	0.722	5.56				
		3	0.713	5.49				
	7	1	0.717	5.52	5.48	0.04		
		2	0.708	5.45				
		3	0.709	5.46				
Wash 5	8	1	0.740	5.70	5.63	0.08	5.63	0.06
		2	0.720	5.54				
		3	0.733	5.64				
	9	1	0.741	5.70	5.63	0.07		
		2	0.724	5.57				
		3	0.731	5.63				
Wash 10	10	1	0.753	5.80	5.76	0.03	5.73	0.05
		2	0.746	5.74				
		3	0.747	5.75				
	11	1	0.734	5.65	5.70	0.05		
		2	0.743	5.72				
		3	0.746	5.74				
Wash 20	12	1	0.741	5.70	5.66	0.12	5.66	0.09
		2	0.718	5.53				
		3	0.748	5.76				
	13	1	0.745	5.73	5.67	0.07		
		2	0.727	5.60				
		3	0.737	5.67				

Table B16

ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric, White H&M T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Fabric Weight (g)	Fabric Weight (oz/yd <sup>2</sup> )	T-Shirt Average (oz/yd <sup>2</sup> )	T-Shirt <i>SD</i>	Interval Average	Interval <i>SD</i>
Initial	4	1	0.519	3.99	4.08	0.12	4.08	0.08
		2	0.523	4.03				
		3	0.547	4.21				
	5	1	0.530	4.08	4.08	0.02		
		2	0.533	4.10				
		3	0.527	4.06				
Wash 1	6	1	0.580	4.46	4.48	0.01	4.42	0.08
		2	0.583	4.49				
		3	0.582	4.48				
	7	1	0.574	4.42	4.37	0.08		
		2	0.573	4.41				
		3	0.556	4.28				
Wash 5	8	1	0.574	4.42	4.42	0.02	4.43	0.04
		2	0.572	4.40				
		3	0.576	4.43				
	9	1	0.585	4.50	4.44	0.07		
		2	0.577	4.44				
		3	0.568	4.37				
Wash 10	10	1	0.582	4.48	4.52	0.03	4.45	0.08
		2	0.590	4.54				
		3	0.589	4.53				
	11	1	0.568	4.37	4.38	0.02		
		2	0.573	4.41				
		3	0.568	4.37				
Wash 20	12	1	0.552	4.25	4.29	0.06	4.27	0.07
		2	0.567	4.36				
		3	0.554	4.26				
	13	1	0.562	4.33	4.25	0.07		
		2	0.549	4.23				
		3	0.544	4.19				

Table B17

ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric, Navy H&M T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Fabric Weight (g)	Fabric Weight (oz/yd <sup>2</sup> )	T-Shirt Average (oz/yd <sup>2</sup> )	T-Shirt <i>SD</i>	Interval Average	Interval <i>SD</i>
Initial	4	1	0.619	4.76	4.78	0.04	4.92	0.18
		2	0.627	4.83				
		3	0.617	4.75				
	5	1	0.675	5.20	5.07	0.12		
		2	0.646	4.97				
		3	0.654	5.03				
Wash 1	6	1	0.707	5.44	5.42	0.05	5.25	0.20
		2	0.698	5.37				
		3	0.709	5.46				
	7	1	0.655	5.04	5.07	0.04		
		2	0.665	5.12				
		3	0.656	5.05				
Wash 5	8	1	0.716	5.51	5.53	0.06	5.53	0.05
		2	0.728	5.60				
		3	0.712	5.48				
	9	1	0.718	5.53	5.53	0.04		
		2	0.715	5.50				
		3	0.724	5.57				
Wash 10	10	1	0.740	5.70	5.62	0.07	5.41	0.23
		2	0.722	5.56				
		3	0.728	5.60				
	11	1	0.677	5.21	5.21	0.02		
		2	0.679	5.23				
		3	0.675	5.20				
Wash 20	12	1	0.719	5.53	5.56	0.08	5.33	0.25
		2	0.734	5.65				
		3	0.713	5.49				
	13	1	0.671	5.16	5.11	0.05		
		2	0.662	5.10				
		3	0.659	5.07				

Table B18

ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric, White Brooks Brothers T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Fabric Weight (g)	Fabric Weight (oz/yd <sup>2</sup> )	T-Shirt Average (oz/yd <sup>2</sup> )	T-Shirt <i>SD</i>	Interval Average	Interval <i>SD</i>
Initial	4	1	0.542	4.17	4.14	0.04	4.10	0.06
		2	0.532	4.09				
		3	0.540	4.16				
	5	1	0.527	4.06	4.05	0.02		
		2	0.529	4.07				
		3	0.524	4.03				
Wash 1	6	1	0.599	4.61	4.60	0.06	4.66	0.07
		2	0.590	4.54				
		3	0.605	4.66				
	7	1	0.612	4.71	4.71	0.03		
		2	0.608	4.68				
		3	0.616	4.74				
Wash 5	8	1	0.625	4.81	4.85	0.04	4.83	0.03
		2	0.635	4.89				
		3	0.629	4.84				
	9	1	0.628	4.83	4.82	0.02		
		2	0.624	4.80				
		3	0.626	4.82				
Wash 10	10	1	0.621	4.78	4.77	0.02	4.75	0.03
		2	0.623	4.80				
		3	0.617	4.75				
	11	1	0.613	4.72	4.73	0.02		
		2	0.617	4.75				
		3	0.613	4.72				
Wash 20	12	1	0.626	4.82	4.79	0.10	4.78	0.08
		2	0.608	4.68				
		3	0.634	4.88				
	13	1	0.631	4.86	4.78	0.07		
		2	0.619	4.76				
		3	0.612	4.71				

Table B19

ASTM D3776/D3776M – 09a (2013) *Standard Test Methods for Mass Per Unit Area (Weight) of Fabric, Navy Brooks Brothers T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Fabric Weight (g)	Fabric Weight (oz/yd <sup>2</sup> )	T-Shirt Average (oz/yd <sup>2</sup> )	T-Shirt <i>SD</i>	Interval Average	Interval <i>SD</i>
Initial	4	1	0.619	4.76	4.76	0.02	4.73	0.07
		2	0.615	4.73				
		3	0.621	4.78				
	5	1	0.597	4.60	4.71	0.10		
		2	0.621	4.78				
		3	0.617	4.75				
Wash 1	6	1	0.608	4.68	4.69	0.07	4.76	0.10
		2	0.619	4.76				
		3	0.600	4.62				
	7	1	0.637	4.90	4.84	0.06		
		2	0.622	4.79				
		3	0.626	4.82				
Wash 5	8	1	0.631	4.86	4.91	0.05	4.89	0.04
		2	0.642	4.94				
		3	0.642	4.94				
	9	1	0.633	4.87	4.86	0.02		
		2	0.628	4.83				
		3	0.634	4.88				
Wash 10	10	1	0.647	4.98	4.96	0.02	4.93	0.04
		2	0.646	4.97				
		3	0.642	4.94				
	11	1	0.634	4.88	4.89	0.02		
		2	0.634	4.88				
		3	0.639	4.92				
Wash 20	12	1	0.620	4.77	4.83	0.06	4.84	0.04
		2	0.634	4.88				
		3	0.630	4.85				
	13	1	0.635	4.89	4.84	0.04		
		2	0.627	4.83				
		3	0.626	4.82				

Table B20

ASTM D8007-15: *Standard Test Method for Wale and Course Count of Weft Knitted Fabrics, White T-Shirts*

		Fruit of the Loom				H&M				Brooks Brothers			
Test Interval	T-Shirt	White		White		White		White		White		White	
	ID #	4		5		4		5		4		5	
Initial	Location	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses
	Count 1	36.0	52.0	36.0	51.0	39.0	53.0	39.0	51.0	42.0	55.0	41.0	56.0
	Count 2	36.0	51.0	36.0	51.0	41.0	54.0	40.0	51.0	42.0	55.0	41.0	55.0
	Average	36.0	51.5	36.0	51.0	40.0	53.5	39.5	51.0	42.0	55.0	41.0	55.5
	Knit Count	87.5		87.0		93.5		90.5		97.0		96.5	
	Average	87.3				92.0				96.8			
	SD	0.4				2.1				0.4			
Wash 20	T-Shirt	White		White		White		White		White		White	
		12		13		12		13		12		13	
	Location	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses
	Count 1	38.0	56.0	37.0	58.0	42.0	56.0	41.0	56.0	44.0	64.0	43.0	63.0
	Count 2	38.0	55.0	37.0	55.0	42.0	57.0	42.0	57.0	44.0	64.0	44.0	62.0
	Average	38.0	55.5	37.0	56.5	42.0	56.5	41.5	56.5	44.0	64.0	43.5	62.5
	Knit Count	93.5		93.5		98.5		98.0		108.0		106.0	
	Average	93.5				98.3				107.0			
	SD	0.0				0.4				1.4			

Table B21

ASTM D8007-15: *Standard Test Method for Wale and Course Count of Weft Knitted Fabrics, Navy T-Shirts*

		Fruit of the Loom				H&M				Brooks Brothers			
Test Interval	T-Shirt	Navy		Navy		Navy		Navy		Navy		Navy	
	ID #	4		5		4		5		4		5	
Initial	Location	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses
	Count 1	35.0	50.0	35.0	50.0	40.0	50.0	42.0	50.0	40.0	54.0	40.0	54.0
	Count 2	36.0	50.0	35.0	50.0	39.0	48.0	41.0	51.0	41.0	56.0	41.0	55.0
	Average	35.5	50.0	35.0	50.0	39.5	49.0	41.5	50.5	40.5	55.0	40.5	54.5
	Knit Count	85.5		85.0		88.5		92.0		95.5		95.0	
	Average	85.3				90.3				95.3			
	SD	0.4				2.5				0.4			
Wash 20	T-Shirt	Navy		Navy		Navy		Navy		Navy		Navy	
		12		13		12		13		12		13	
	Location	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses	Wales	Courses
	Count 1	37.0	52.0	37.0	52.0	42.0	54.0	40.0	54.0	42.0	57.0	41.0	57.0
	Count 2	37.0	51.0	38.0	54.0	42.0	54.0	42.0	53.0	42.0	57.0	41.0	58.0
	Average	37.0	51.5	37.5	53.0	42.0	54.0	41.0	53.5	42.0	57.0	41.0	57.5
	Knit Count	88.5		90.5		96.0		94.5		99.0		98.5	
	Average	89.5				95.3				98.8			
	SD	1.4				1.1				0.4			



Table B22

AATCC Evaluation Procedure 1–2012: *Gray Scale for Color Change, White and Navy T-Shirts,*

		Fruit of the Loom				H&M				Brooks Brothers			
Test Interval	T-Shirt	White		Navy		White		Navy		White		Navy	
	ID #	2	3	2	3	2	3	2	3	2	3	2	3
Wash 1	Rating 1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
	Rating 2	5.0	4.5	5.0	4.5	4.5	4.5	5.0	5.0	5.0	5.0	5.0	5.0
	Average	5.0	4.8	5.0	4.8	4.8	4.8	5.0	5.0	5.0	5.0	5.0	5.0
	Interval Average	4.9		4.9		4.8		5.0		5.0		5.0	
	SD	0.3		0.3		0.3		0.0		0.0		0.0	
Wash 5	Rating 1	5.0	4.5	5.0	4.5	5.0	5.0	4.0	4.0	4.5	4.5	5.0	5.0
	Rating 2	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.5	4.5	5.0	5.0
	Average	4.8	4.5	4.8	4.5	4.8	4.8	4.0	4.0	4.5	4.5	5.0	5.0
	Interval Average	4.6		4.6		4.8		4.0		4.5		5.0	
	SD	0.3		0.3		0.3		0.0		0.0		0.0	
Wash 10	Rating 1	4.5	4.5	5.0	5.0	5.0	4.5	4.0	4.0	4.5	5.0	5.0	5.0
	Rating 2	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.5	4.5	4.5	5.0
	Average	4.5	4.5	4.8	4.8	4.8	4.5	4.0	4.0	4.5	4.8	4.8	5.0
	Interval Average	4.5		4.8		4.6		4.0		4.6		4.9	
	SD	0.0		0.3		0.3		0.0		0.3		0.3	
Wash 20	Rating 1	4.5	4.5	4.5	4.5	4.5	4.5	4.0	3.5	4.0	4.0	4.0	4.5
	Rating 2	4.5	4.5	4.5	4.0	4.5	4.0	3.5	3.5	4.0	4.0	4.0	4.0
	Average	4.5	4.5	4.5	4.3	4.5	4.3	3.8	3.5	4.0	4.0	4.0	4.3
	Interval Average	4.5		4.4		4.4		3.6		4.0		4.1	
	SD	0.0		0.3		0.3		0.3		0.0		0.3	

Table B23

AATCC Evaluation Procedure 7-2015: *Instrumental Assessment of the Change in Color of Test Specimen, Navy T-Shirts*

Fruit of the Loom	Navy Fruit of the Loom T-Shirt ID # 2					Navy Fruit of the Loom T-Shirt ID # 3					Fruit of the Loom	
	Interval	L	a	b	dE	Interval	L	a	b	dE	Avg dE	SD
	Initial	16.77	1.42	-10.71	—	Initial	16.93	1.35	-10.64	—	—	—
	Wash 1	15.75	1.63	-10.86	1.04	Wash 1	15.81	1.51	-10.81	1.15	1.10	0.08
	Wash 5	15.85	1.46	-11.12	1.00	Wash 5	15.86	1.38	-11.12	1.17	1.09	0.12
	Wash 10	16.22	1.28	-11.19	0.74	Wash 10	16.11	1.19	-11.17	0.99	0.87	0.18
	Wash 20	16.67	1.20	-11.21	0.55	Wash 20	16.72	1.07	-11.30	0.74	0.65	0.13
H&M	Navy H&M T-Shirt ID # 2					Navy H&M T-Shirt ID # 3					H&M	
	Interval	L	a	b	dE	Interval	L	a	b	dE	Avg dE	SD
	Initial	15.44	1.11	-3.00	—	Initial	15.26	1.13	-2.95	—	—	—
	Wash 1	14.78	1.17	-3.09	0.66	Wash 1	14.75	1.15	-3.08	0.53	0.60	0.09
	Wash 5	15.29	0.97	-3.32	0.38	Wash 5	15.43	0.94	-3.38	0.50	0.44	0.08
	Wash 10	15.67	0.87	-3.55	0.65	Wash 10	15.75	0.86	-3.59	0.84	0.75	0.13
	Wash 20	16.34	0.86	-3.74	1.20	Wash 20	16.33	0.84	-3.75	1.36	1.28	0.11
Brooks Brothers	Navy Brooks Brothers T-Shirt ID # 2					Navy Brooks Brothers T-Shirt ID # 3					Brooks Brothers	
	Interval	L	a	b	dE	Interval	L	a	b	dE	Avg dE	SD
	Initial	18.39	0.28	-7.57	—	Initial	18.27	0.29	-7.57	—	—	—
	Wash 1	18.13	0.32	-7.69	0.29	Wash 1	18.04	0.34	-7.73	0.28	0.29	0.01
	Wash 5	18.44	0.12	-7.68	0.20	Wash 5	18.45	0.19	-7.79	0.30	0.25	0.07
	Wash 10	18.91	0.06	-7.78	0.60	Wash 10	18.82	0.12	-7.91	0.66	0.63	0.04
	Wash 20	19.33	0.03	-7.77	0.99	Wash 20	19.30	0.09	-7.82	1.08	1.04	0.06

Table B24

AATCC Test Method 110-2015: *Whiteness of Textiles, White Fruit of the Loom T-Shirts*

Interval	White Fruit of the Loom											
Initial	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Initial	
	1	95.92	-0.81	0.95	85.52	1	95.71	-0.44	0.90	85.24	T-Shirt	
	2	96.09	-0.76	0.79	86.66	2	95.74	-0.39	0.90	85.34	Average	
	3	95.94	-0.80	0.95	85.58	3	95.83	-0.38	0.85	85.76	WICIE	SD
	Average	95.98	-0.79	0.90	85.92	Average	95.76	-0.40	0.88	85.45	85.68	0.33
Wash 1	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 1	
	1	96.11	-0.77	0.59	87.58	1	95.46	-0.84	0.27	87.48	T-Shirt	
	2	96.24	-0.80	0.67	87.55	2	95.62	-0.82	0.26	87.91	Average	
	3	96.05	-0.83	0.60	87.42	3	95.37	-0.61	0.80	84.85	WICIE	SD
	Average	96.13	-0.80	0.62	87.52	Average	95.48	-0.76	0.44	86.75	87.13	0.54
Wash 5	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 5	
	1	95.86	-0.71	0.37	88.00	1	95.31	-0.45	0.52	85.98	T-Shirt	
	2	95.66	-0.72	0.40	87.40	2	95.69	-0.54	0.52	86.89	Average	
	3	95.85	-0.73	0.28	88.38	3	95.29	-0.51	0.47	86.14	WICIE	SD
	Average	95.79	-0.72	0.35	87.93	Average	95.43	-0.50	0.50	86.34	87.13	1.12
Wash 10	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 10	
	1	95.39	-0.91	0.31	87.11	1	95.23	-0.71	0.65	85.18	T-Shirt	
	2	95.62	-0.95	0.50	86.83	2	95.45	-0.62	0.62	85.88	Average	
	3	95.74	-0.95	0.50	87.11	3	95.71	-0.70	0.65	86.39	WICIE	SD
	Average	95.58	-0.94	0.44	87.02	Average	95.46	-0.68	0.64	85.82	86.42	0.85
Wash 20	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 20	
	1	95.80	-1.37	0.88	85.53	1	95.85	-1.26	1.11	84.61	T-Shirt	
	2	96.19	-1.32	0.86	86.57	2	95.59	-1.28	1.25	83.34	Average	
	3	95.61	-1.32	0.80	85.42	3	95.45	-1.24	1.08	83.76	WICIE	SD
	Average	95.87	-1.34	0.85	85.84	Average	95.63	-1.26	1.15	83.90	84.87	1.37

Table B25

AATCC Test Method 110-2015: *Whiteness of Textiles, White H&M T-Shirts*

Interval	White H&M											
Initial	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Initial	
	1	95.47	-0.38	-0.11	89.24	1	95.50	-0.45	-0.58	91.43	T-Shirt	
	2	95.51	-0.38	-0.14	89.47	2	95.40	-0.47	-0.55	91.06	Average	
	3	95.62	-0.41	-0.13	89.66	3	95.62	-0.43	-0.65	92.02	WICIE	SD
	Average	95.53	-0.39	-0.13	89.46	Average	95.51	-0.45	-0.59	91.50	90.48	1.45
Wash 1	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 1	
	1	95.54	-0.41	-0.46	90.96	1	95.32	-0.53	-0.18	89.19	T-Shirt	
	2	95.76	-0.42	-0.45	91.43	2	95.84	-0.44	-0.16	90.33	Average	
	3	95.84	-0.44	-0.44	91.59	3	95.90	-0.37	-0.24	90.85	WICIE	SD
	Average	95.71	-0.42	-0.45	91.33	Average	95.69	-0.45	-0.19	90.12	90.73	0.85
Wash 5	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 5	
	1	95.75	-0.62	-0.47	91.51	1	95.94	-0.55	-0.25	90.98	T-Shirt	
	2	96.41	-0.58	-0.46	93.03	2	96.10	-0.47	-0.28	91.49	Average	
	3	96.04	-0.56	-0.47	92.20	3	96.11	-0.57	-0.26	91.44	WICIE	SD
	Average	96.07	-0.59	-0.47	92.25	Average	96.05	-0.53	-0.26	91.30	91.78	0.67
Wash 10	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 10	
	1	96.02	-0.84	-0.27	91.27	1	96.09	-0.95	-0.02	90.29	T-Shirt	
	2	96.46	-0.85	-0.26	92.24	2	96.20	-0.89	-0.12	91.00	Average	
	3	96.09	-0.80	-0.27	91.43	3	96.43	-0.87	-0.08	91.40	WICIE	SD
	Average	96.19	-0.83	-0.27	91.65	Average	96.24	-0.90	-0.07	90.90	91.27	0.53
Wash 20	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 20	
	1	96.61	-1.20	0.10	91.02	1	96.49	-1.26	0.25	90.03	T-Shirt	
	2	96.39	-1.21	0.08	90.56	2	96.44	-1.28	0.30	89.70	Average	
	3	96.64	-1.25	0.12	90.98	3	96.56	-1.25	0.29	90.02	WICIE	SD
	Average	96.55	-1.22	0.10	90.85	Average	96.50	-1.26	0.28	89.92	90.39	0.66

Table B26

AATCC Test Method 110-2015: *Whiteness of Textiles, White Brooks Brothers T-Shirts*

Interval	White Brooks Brothers											
Initial	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Initial	
	1	97.18	-0.94	0.87	88.97	1	97.37	-0.90	0.77	89.89	T-Shirt	
	2	97.10	-0.93	1.01	88.14	2	97.59	-0.94	0.88	89.95	Average	
	3	96.94	-0.92	1.01	87.75	3	97.37	-0.89	0.73	90.08	WICIE	SD
	Average	97.07	-0.93	0.96	88.29	Average	97.44	-0.91	0.79	89.97	89.13	1.19
Wash 1	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 1	
	1	96.95	-0.90	0.83	88.60	1	97.40	-0.76	0.54	91.02	T-Shirt	
	2	96.79	-0.92	0.82	88.26	2	97.39	-0.67	0.50	91.15	Average	
	3	96.75	-0.82	0.65	88.92	3	97.34	-0.73	0.55	90.81	WICIE	SD
	Average	96.83	-0.88	0.77	88.59	Average	97.38	-0.72	0.53	90.99	89.79	1.70
Wash 5	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 5	
	1	96.37	-0.7	0.21	89.91	1	96.79	-0.63	0.12	91.36	T-Shirt	
	2	96.61	-0.71	0.32	90.03	2	97.04	-0.61	0.11	92.02	Average	
	3	96.46	-0.65	0.31	89.72	3	95.99	-0.61	0.11	89.47	WICIE	SD
	Average	96.48	-0.69	0.28	89.89	Average	96.61	-0.62	0.11	90.95	90.42	0.75
Wash 10	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 10	
	1	97.14	-1.06	0.37	91.11	1	97.27	-0.85	0.11	92.58	T-Shirt	
	2	97.09	-1.06	0.38	90.94	2	97.09	-0.88	0.03	92.53	Average	
	3	96.58	-0.96	0.26	90.22	3	97.16	-0.83	0.00	92.83	WICIE	SD
	Average	96.94	-1.03	0.34	90.76	Average	97.17	-0.85	0.05	92.65	91.70	1.34
Wash 20	T-Shirt ID #2					T-Shirt ID #3						
	Location	L	a	b	WICIE	Location	L	a	b	WICIE	Wash 20	
	1	97.21	-1.34	0.55	90.48	1	97.56	-1.30	0.32	92.38	T-Shirt	
	2	97.31	-1.32	0.53	90.80	2	97.54	-1.31	0.27	92.55	Average	
	3	97.34	-1.34	0.55	90.80	3	97.56	-1.28	0.30	92.47	WICIE	SD
	Average	97.29	-1.33	0.54	90.69	Average	97.55	-1.30	0.30	92.47	91.58	1.25

Table B27

AATCC Test Method 8-2013: *Colorfastness to Crocking: Crockmeter Method,*  
*Dry Crocking, Navy T-Shirts*

Test Intervals	T-Shirt	Fruit of the Loom		H&M		Brooks Brothers	
	ID #	2	3	2	3	2	3
Initial	Rating 1	5.0	5.0	3.5	3.5	3.5	3.5
	Rating 2	4.5	4.5	3.5	3.5	3.5	3.5
	Average	4.8	4.8	3.5	3.5	3.5	3.5
	Interval Average	4.8		3.5		3.5	
	SD	0.3		0.0		0.0	
Wash 1	Rating 1	5.0	5.0	3.5	3.5	3.5	3.5
	Rating 2	4.5	4.5	3.5	3.5	4.0	4.0
	Average	4.8	4.8	3.5	3.5	3.8	3.8
	Interval Average	4.8		3.5		3.8	
	SD	0.3		0.0		0.3	
Wash 5	Rating 1	5.0	5.0	4.5	4.0	4.5	4.5
	Rating 2	4.5	4.5	4.0	4.0	4.0	4.5
	Average	4.8	4.8	4.3	4.0	4.3	4.5
	Interval Average	4.8		4.1		4.4	
	SD	0.3		0.3		0.3	
Wash 10	Rating 1	5.0	5.0	4.0	4.5	4.5	4.5
	Rating 2	4.5	4.5	4.0	4.0	4.5	4.5
	Average	4.8	4.8	4.0	4.3	4.5	4.5
	Interval Average	4.8		4.1		4.5	
	SD	0.3		0.3		0.0	
Wash 20	Rating 1	5.0	5.0	4.5	5.0	5.0	5.0
	Rating 2	4.5	4.5	4.5	4.5	4.5	4.5
	Average	4.8	4.8	4.5	4.8	4.8	4.8
	Interval Average	4.8		4.6		4.8	
	SD	0.3		0.3		0.3	

Table B28

AATCC Test Method 8-2013: *Colorfastness to Crocking: Crockmeter Method, Wet Crocking, Navy T-Shirts*

Test Intervals	T-Shirt	Fruit of the Loom		H&M		Brooks Brothers	
	ID #	2	3	2	3	2	3
Initial	Rating 1	1.5	2.5	2.0	2.0	2.0	2.0
	Rating 2	1.5	2.0	2.0	2.0	2.0	2.0
	Average	1.5	2.3	2.0	2.0	2.0	2.0
	Interval Average	1.9		2.0		2.0	
	SD	0.5		0.0		0.0	
Wash 1	Rating 1	2.5	2.0	2.0	2.5	2.0	2.0
	Rating 2	2.0	2.0	2.0	2.5	2.0	2.0
	Average	2.3	2.0	2.0	2.5	2.0	2.0
	Interval Average	2.1		2.3		2.0	
	SD	0.3		0.3		0.0	
Wash 5	Rating 1	3.5	2.5	2.5	2.5	3.0	3.0
	Rating 2	3.5	2.0	2.0	2.5	2.5	2.5
	Average	3.5	2.3	2.5	2.5	2.8	2.8
	Interval Average	2.9		2.4		2.8	
	SD	0.8		0.3		0.3	
Wash 10	Rating 1	4.0	3.0	2.5	3.0	3.0	3.0
	Rating 2	3.5	2.5	2.0	2.5	2.5	2.5
	Average	3.8	2.8	2.3	2.8	2.8	2.8
	Interval Average	3.3		2.5		2.8	
	SD	0.6		0.4		0.3	
Wash 20	Rating 1	3.5	3.0	2.5	2.5	3.5	3.5
	Rating 2	4.0	2.5	2.0	2.5	3.0	3.0
	Average	3.8	2.8	2.3	2.5	3.3	3.3
	Interval Average	3.3		2.4		3.3	
	SD	0.6		0.3		0.3	

Table B29

AATCC Test Method 124-201: *Smoothness Appearance of Fabrics after Repeated Home Launderings, White and Navy T-Shirts*

		Fruit of the Loom				H&M				Brooks Brothers			
Test Interval	T-Shirt	White		Navy		White		Navy		White		Navy	
	ID #	2	3	2	3	2	3	2	3	2	3	2	3
Wash 1	Rating 1	2.0	2.0	3.0	3.0	1.5	2.0	3.5	3.0	2.0	2.0	3.5	3.5
	Rating 2	1.5	1.0	2.5	3.0	1.0	2.0	3.5	3.0	2.0	2.0	3.5	3.5
	Average	1.8	1.5	2.8	3.0	1.3	2.0	3.5	3.0	2.0	2.0	3.5	3.5
	Interval Average	1.6		2.9		1.6		3.3		2.0		3.5	
	SD	0.5		0.3		0.5		0.3		0.0		0.0	
Wash 5	Rating 1	1.5	2.0	3.5	3.5	2.0	2.0	3.5	3.5	2.0	2.5	4.0	4.0
	Rating 2	1.5	1.5	3.0	3.0	2.0	2.0	3.5	3.5	2.0	2.0	3.5	3.5
	Average	1.5	1.8	3.3	3.3	2.0	2.0	3.5	3.5	2.0	2.3	3.8	3.8
	Interval Average	1.6		3.3		2.0		3.5		2.1		3.8	
	SD	0.3		0.3		0.0		0.0		0.3		0.3	
Wash 10	Rating 1	2.5	2.5	3.0	3.5	2.5	3.0	3.5	3.5	3.0	2.5	4.0	4.0
	Rating 2	2.0	2.0	3.0	3.0	2.5	2.5	3.5	3.5	2.5	2.5	3.5	4.0
	Average	2.3	2.3	3.0	3.3	2.5	2.8	3.5	3.5	2.8	2.5	3.8	4.0
	Interval Average	2.3		3.1		2.6		3.5		2.6		3.9	
	SD	0.3		0.3		0.3		0.0		0.3		0.3	
Wash 20	Rating 1	3.0	2.5	3.5	3.5	3.0	3.0	3.5	4.0	3.0	3.0	4.0	4.0
	Rating 2	2.5	2.5	3.0	3.5	3.0	3.0	4.0	4.0	3.0	3.0	4.0	4.0
	Average	2.8	2.5	3.3	3.5	3.0	3.0	3.8	4.0	3.0	3.0	4.0	4.0
	Interval Average	2.6		3.4		3.0		3.9		3.0		4.0	
	SD	0.3		0.3		0.0		0.3		0.0		0.0	



Table B30

ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method, White Fruit of the Loom T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Psi	Psi Average	T-Shirt <i>SD</i>	Interval Psi Average	Interval <i>SD</i>	Seconds to Burst
Initial	4	1	52.6	46.5	3.84	50.9	5.74	19
		2	45.2					17
		3	43.0					18
		4	47.8					19
		5	44.0					18
	5	1	53.0	55.2	3.50			19
		2	57.1					20
		3	52.6					19
		4	60.5					21
		5	52.8					19
Wash 1	6	1	56.5	49.6	5.63	50.6	5.02	18
		2	43.9					15
		3	43.7					15
		4	52.2					17
		5	51.9					17
	7	1	56.7	51.6	4.75			18
		2	48.2					16
		3	45.6					16
		4	51.6					18
		5	55.7					19
Wash 5	8	1	51.6	51.6	2.69	50.9	3.08	18
		2	48.0					17
		3	51.3					18
		4	55.6					19
		5	51.7					18
	9	1	52.0	50.1	3.55			19
		2	43.8					16
		3	51.8					18
		4	51.4					18
		5	51.7					19
Wash 10	10	1	52.5	52.1	5.19	55.4	5.65	19
		2	57.1					20
		3	45.0					17
		4	56.9					20
		5	49.1					18
	11	1	53.1	58.6	4.28			19
		2	58.1					20
		3	60.3					21
		4	64.7					22
		5	57.0					20
Wash 20	12	1	56.0	52.0	2.98	54.4	4.26	20
		2	53.0					19
		3	49.0					18
		4	49.1					18
		5	53.1					19
	13	1	53.1	56.8	4.19			19
		2	61.4					21
		3	56.5					20
		4	52.4					19
		5	60.8					22

Table B31

ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method, Navy Fruit of the Loom T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Psi	Psi Average	T-ShirtSD	Interval Psi Average	IntervalSD	Seconds to Burst
Initial	4	1	85.6	82.7	2.65	79.5	5.75	22
		2	85.6					22
		3	80.7					21
		4	80.4					21
		5	81.3					21
	5	1	73.5	76.2	6.40			24
		2	85.2					25
		3	71.1					19
		4	80.6					21
		5	70.7					19
Wash 1	6	1	75.8	75.4	3.33	74.5	3.87	20
		2	80.1					21
		3	75.5					20
		4	70.7					19
		5	75.1					20
	7	1	70.7	73.5	4.50			19
		2	80.7					21
		3	70.4					20
		4	75.2					20
		5	70.5					19
Wash 5	8	1	75.8	73.6	5.52	76.1	4.93	21
		2	80					21
		3	75.8					20
		4	70.6					19
		5	65.7					18
	9	1	75.2	78.6	2.86			20
		2	81					21
		3	80.7					21
		4	75.8					21
		5	80.4					21
Wash 10	10	1	82.6	84.4	2.71	82.1	5.91	26
		2	87.4					23
		3	80.7					21
		4	85.6					22
		5	85.8					22
	11	1	75.9	79.8	7.60			20
		2	91.1					23
		3	70.5					19
		4	80.9					21
		5	80.6					21
Wash 20	12	1	85.4	81.9	6.20	79.3	5.68	22
		2	71.4					19
		3	85.8					22
		4	85.8					22
		5	80.9					21
	13	1	70.6	76.7	4.21			19
		2	80.4					21
		3	81					22
		4	75.7					20
		5	76					20

Table B32

ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method, White H&M T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Psi	Psi Average	T-ShirtSD	Interval Psi Average	IntervalSD	Seconds to Burst
Initial	4	1	46.9	46.9	5.03	46.8	4.70	18
		2	42.9					17
		3	43.5					17
		4	55.4					21
		5	45.8					19
	5	1	43.4	46.7	4.94			17
		2	41.5					17
		3	54.4					20
		4	47.3					18
		5	46.9					18
Wash 1	6	1	54.6	52.4	5.76	47.2	7.16	20
		2	58.4					21
		3	51					19
		4	43.2					18
		5	54.7					20
	7	1	47.1	42.1	3.97			18
		2	39.4					16
		3	43.3					17
		4	36.9					16
		5	43.6					18
Wash 5	8	1	36.6	38.4	4.37	42.2	5.07	16
		2	44.4					18
		3	37.1					16
		4	33					15
		5	40.9					17
	9	1	45.2	46.0	1.57			19
		2	45.7					19
		3	45.3					19
		4	45.1					19
		5	48.8					20
Wash 10	10	1	56.3	54.8	4.16	48.9	7.24	22
		2	60.1					23
		3	53					22
		4	48.9					20
		5	55.7					22
	11	1	44.6	43.0	3.76			18
		2	36.9					16
		3	42.1					18
		4	46.1					19
		5	45.5					19
Wash 20	12	1	54.2	50.8	3.23	46.8	4.94	22
		2	50.3					21
		3	53.4					22
		4	46.1					20
		5	49.8					21
	13	1	39.5	42.9	2.45			18
		2	42.6					19
		3	46.4					20
		4	43					19
		5	43.1					19

Table B33

ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method, Navy H&M T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Psi	Psi Average	T-ShirtSD	Interval Psi Average	IntervalSD	Seconds to Burst
Initial	4	1	69.7	63.7	4.63	79.6	17.29	16
		2	67					16
		3	63.1					16
		4	60.5					16
		5	58.4					16
	5	1	87.7	95.4	5.01			19
		2	98.9					24
		3	98.8					21
		4	98.7					21
		5	92.9					20
Wash 1	6	1	87.4	89.4	2.98	77.3	13.15	20
		2	87.3					19
		3	92.8					20
		4	87.1					19
		5	92.6					20
	7	1	63.7	65.1	3.31			15
		2	69.6					16
		3	65.9					18
		4	60.6					17
		5	65.9					18
Wash 5	8	1	86.2	86.8	2.08	87.7	2.45	22
		2	90.5					23
		3	85.5					22
		4	86.1					22
		5	85.8					22
	9	1	85.6	88.6	2.70			22
		2	90.4					23
		3	85.6					22
		4	90.7					23
		5	90.5					23
Wash 10	10	1	73.6	77.7	2.32	67.0	11.70	19
		2	79					21
		3	78.3					20
		4	78.8					20
		5	78.9					21
	11	1	58.2	56.3	4.00			16
		2	56.1					16
		3	53.7					16
		4	51.6					16
		5	61.9					19
Wash 20	12	1	75.3	76.5	3.89	65.8	12.03	22
		2	75.7					22
		3	71.0					21
		4	80.3					23
		5	80.2					23
	13	1	59.5	55.1	4.99			19
		2	46.5					17
		3	56.4					19
		4	56.7					19
		5	56.5					19

Table B34

ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method, White Brooks Brothers T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Psi	Psi Average	T-ShirtSD	Interval Psi Average	IntervalSD	Seconds to Burst
Initial	4	1	76.4	79.5	7.03	82.5	7.48	19
		2	71.1					18
		3	86.9					21
		4	76.4					19
		5	86.8					21
	5	1	96	85.5	7.34			24
		2	86.8					21
		3	81.8					20
		4	86.8					21
		5	76.1					19
Wash 1	6	1	86.7	85.8	4.19	90.2	5.69	21
		2	81.7					20
		3	91.8					22
		4	87					21
		5	81.9					20
	7	1	93	94.5	2.87			22
		2	92					22
		3	97.1					23
		4	98.1					23
		5	92.3					22
Wash 5	8	1	87.1	84.0	4.85	85.5	3.58	21
		2	81.9					20
		3	87.4					21
		4	87.3					22
		5	76.4					19
	9	1	87.3	86.9	0.35			21
		2	87.1					22
		3	86.7					21
		4	87					21
		5	86.4					21
Wash 10	10	1	76.4	80.5	2.32	80.0	2.56	19
		2	81.6					20
		3	81.8					20
		4	81.5					20
		5	81.4					20
	11	1	81.8	79.5	2.94			20
		2	81.6					20
		3	76.1					19
		4	81.6					20
		5	76.5					19
Wash 20	12	1	86.9	82.7	6.72	82.2	5.61	21
		2	86.6					21
		3	82.1					20
		4	86.6					21
		5	71.2					18
	13	1	76.6	81.6	5.00			19
		2	86.4					21
		3	76.6					19
		4	86.8					21
		5	81.7					20

Table B35

ASTM D3786/D3786M – 13: *Bursting Strength of Textile Fabrics: Diaphragm Bursting Strength Tester Method, Navy Brooks Brothers T-Shirts*

Test Interval	T-Shirt ID #	Specimen	Psi	Psi Average	T-ShirtSD	Interval Psi Average	IntervalSD	Seconds to Burst
Initial	4	1	81.6	86.7	6.49	87.2	5.26	20
		2	81.2					20
		3	86.5					21
		4	97.3					23
		5	86.8					21
	5	1	92.3	87.8	4.40			23
		2	81.5					20
		3	86.9					21
		4	91.7					22
		5	86.6					21
Wash 1	6	1	92.1	89.9	4.64	91.6	3.90	22
		2	92					22
		3	91.7					22
		4	81.6					20
		5	92.1					22
	7	1	92.1	93.2	2.41			22
		2	92.1					22
		3	97.5					23
		4	92.4					22
		5	91.9					22
Wash 5	8	1	92.2	91.1	6.78	90.0	5.56	22
		2	97.6					23
		3	97					23
		4	81.6					20
		5	87.2					21
	9	1	91.8	88.8	4.52			22
		2	86					21
		3	82.2					20
		4	92.4					22
		5	91.7					22
Wash 10	10	1	81.6	85.8	2.40	85.9	3.31	20
		2	87.6					21
		3	86.6					21
		4	86.6					21
		5	86.7					21
	11	1	86.8	85.9	4.34			21
		2	92.3					22
		3	86.6					21
		4	82.3					21
		5	81.4					20
Wash 20	12	1	97.3	92.2	3.75	87.9	7.44	23
		2	92					22
		3	86.7					21
		4	92.4					23
		5	92.4					22
	13	1	86.86	83.7	8.08			21
		2	92.3					22
		3	81.6					20
		4	86.7					21
		5	70.9					18

Table B36

ASTM D4970/D4970M–10: *Pilling Resistance and Related Surface Changes of Textile Fabrics: Martindale Tester, White T-Shirts*

Test Interval	T-Shirt	Fruit of the Loom						H&M						Brooks Brothers					
Initial	ID #	4			5			4			5			4			5		
	Rating 1	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	
	Average	1.0			1.0			1.8			2.0			1.5			1.5		
	Interval Avg	1.0						1.9						1.5					
	SD	0.0						0.3						0.5					
Wash 1	ID #	6			7			6			7			6			7		
	Rating 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	
	Average	1.0			1.0			1.0			1.7			1.5			1.5		
	Interval Avg	1.0						1.3						1.5					
	SD	0.0						0.5						0.5					
Wash 5	ID #	8			9			8			9			8			9		
	Rating 1	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	2.0	1.0	2.0	1.0	1.0	1.0	3.0	3.0	3.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	
	Average	1.8			1.5			3.0			2.3			1.5			1.5		
	Interval Avg	1.7						2.7						1.5					
	SD	0.5						0.5						0.5					
Wash 10	ID #	10			11			10			11			10			11		
	Rating 1	2.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	4.0	5.0	5.0	5.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	1.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	4.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
	Average	2.2			2.5			3.5			4.5			2.0			2.0		
	Interval Avg	2.3						4.0						2.0					
	SD	0.7						0.7						0.0					
Wash 20	ID #	12			13			12			13			12			13		
	Rating 1	3.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	3.0	4.0	
	Rating 2	2.0	2.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.0	2.0	3.0	
	Average	2.5			2.5			4.2			4.5			3.8			3.3		
	Interval Avg	2.5						4.3						3.6					
	SD	0.5						0.5						1.0					

Table B37

ASTM D4970/D4970M–10: *Pilling Resistance and Related Surface Changes of Textile Fabrics: Martindale Tester, Navy T-Shirts*

Test Interval	T-Shirt	Fruit of the Loom						H&M						Brooks Brothers					
Initial	ID #	4			5			4			5			4			5		
	Rating 1	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	
	Average	1.0			1.0			1.8			2.0			1.5			1.5		
	Interval Avg	1.0						1.9						1.5					
	SD	0.0						0.3						0.5					
Wash 1	ID #	6			7			6			7			6			7		
	Rating 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	
	Average	1.0			1.0			1.0			1.7			1.5			1.5		
	Interval Avg	1.0						1.3						1.5					
	SD	0.0						0.5						0.5					
Wash 5	ID #	8			9			8			9			8			9		
	Rating 1	2.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	2.0	1.0	2.0	1.0	1.0	1.0	3.0	3.0	3.0	2.0	2.0	2.0	1.0	1.0	1.0	1.0	1.0	
	Average	1.8			1.5			3.0			2.3			1.5			1.5		
	Interval Avg	1.7						2.7						1.5					
	SD	0.5						0.5						0.5					
Wash 10	ID #	10			11			10			11			10			11		
	Rating 1	2.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	4.0	5.0	5.0	5.0	2.0	2.0	2.0	2.0	2.0	
	Rating 2	1.0	2.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	4.0	4.0	4.0	2.0	2.0	2.0	2.0	2.0	
	Average	2.2			2.5			3.5			4.5			2.0			2.0		
	Interval Avg	2.3						4.0						2.0					
	SD	0.7						0.7						0.0					
Wash 20	ID #	12			13			12			13			12			13		
	Rating 1	3.0	3.0	3.0	3.0	3.0	3.0	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	3.0	4.0	
	Rating 2	2.0	2.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.0	2.0	3.0	
	Average	2.5			2.5			4.2			4.5			3.8			3.3		
	Interval Avg	2.5						4.3						3.6					
	SD	0.5						0.5						1.0					



Table B38

AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering, White Fruit of the Loom T-Shirts*

Test Interval	Benchmark Location	T-Shirt ID# 2				T-Shirt ID# 3				Interval Average						
		Initial	After	Shrinkage by Dimension		Initial	After	Shrinkage by Dimension		T-Shirt Average	SD	Dimension		SD	Overall Average	SD
		(inches)	(inches)			Average	SD					Average	SD			
Wash 1	Chest Width	20 13/16	20 3/16	-3.0%	-2.4%	21 9/16	20 9/16	-4.6%	-3.2%	-3.8%	1.2%	Width	-2.8%	1.4%	-3.1%	1.3%
	Sleeve Opening	14 6/16	14 2/16	-1.7%		15	14 12/16	-1.7%		-1.7%	0.1%					
	Front Length	24 12/16	23 9/16	-4.8%	-4.2%	23 13/16	23 6/16	-1.8%	-2.6%	-3.3%	2.1%	Length	-3.4%	1.2%		
	Sleeve Length	6 15/16	6 11/16	-3.6%		7 5/16	7 1/16	-3.4%		-3.5%	0.1%					
Wash 5	Chest Width	20 13/16	20 4/16	-2.7%	-2.7%	21 9/16	20 6/16	-5.5%	-3.6%	-4.1%	2.0%	Width	-3.1%	1.7%	-4.1%	1.9%
	Sleeve Opening	14 6/16	14	-2.6%		15	14 12/16	-1.7%		-2.1%	0.7%					
	Front Length	24 12/16	23 1/16	-6.8%	-5.7%	23 13/16	23 2/16	-2.9%	-4.4%	-4.9%	2.8%	Length	-5.0%	1.7%		
	Sleeve Length	6 15/16	6 10/16	-4.5%		7 5/16	6 14/16	-6.0%		-5.2%	1.0%					
Wash 10	Chest Width	20 13/16	20 2/16	-3.3%	-3.8%	21 9/16	20 6/16	-5.5%	-4.0%	-4.4%	1.6%	Width	-3.9%	1.3%	-4.9%	1.6%
	Sleeve Opening	14 6/16	13 12/16	-4.3%		15	14 10/16	-2.5%		-3.4%	1.3%					
	Front Length	24 12/16	23	-7.1%	-6.7%	23 13/16	22 13/16	-4.2%	-5.1%	-5.6%	2.0%	Length	-5.9%	1.2%		
	Sleeve Length	6 15/16	6 8/16	-6.3%		7 5/16	6 14/16	-6.0%		-6.1%	0.2%					
Wash 20	Chest Width	20 13/16	20 4/16	-2.7%	-3.5%	21 9/16	20 9/16	-4.6%	-4.0%	-3.7%	1.4%	Width	-3.8%	0.9%	-5.0%	2.0%
	Sleeve Opening	14 6/16	13 12/16	-4.3%		15	14 8/16	-3.3%		-3.8%	0.7%					
	Front Length	24 12/16	22 10/16	-8.6%	-6.5%	23 13/16	22 12/16	-4.5%	-6.1%	-6.5%	2.9%	Length	-6.3%	2.1%		
	Sleeve Length	6 15/16	6 10/16	-4.5%		7 5/16	6 12/16	-7.7%		-6.1%	2.3%					

Table B39

AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering, Navy Fruit of the Loom T-Shirts*

Test Interval	Benchmark Location	T-Shirt ID# 2				T-Shirt ID# 3				Interval Average						
		Initial	After	Shrinkage by Dimension		Initial	After	Shrinkage by Dimension		T-Shirt Average	SD	Dimension Average		SD	Overall Average	SD
		(inches)	(inches)			(inches)	(inches)									
Wash 1	Chest Width	22	21 5/16	-3.1%	-2.8%	21 9/16	21 3/16	-1.7%	-3.3%	-2.4%	1.0%	Width	-3.0%	1.3%	-3.1%	1.6%
	Sleeve Opening	15 4/16	14 14/16	-2.5%		15 12/16	15	-4.8%		-3.6%	1.6%					
	Front Length	22 15/16	22 7/16	-2.2%	-1.9%	22 9/16	21 2/16	-6.4%	-4.4%	-4.3%	3.0%	Length	-3.2%	2.2%		
	Sleeve Length	7 8/16	7 6/16	-1.7%		7 9/16	7 6/16	-2.5%		-2.1%	0.6%					
Wash 5	Chest Width	22	21 2/16	-4.0%	-3.2%	21 9/16	21 1/16	-2.3%	-3.1%	-3.1%	1.2%	Width	-3.2%	0.9%	-4.1%	1.9%
	Sleeve Opening	15 4/16	14 14/16	-2.5%		15 12/16	15 2/16	-4.0%		-3.2%	1.1%					
	Front Length	22 15/16	22 2/16	-3.5%	-3.9%	22 9/16	20 10/16	-8.6%	-6.4%	-6.1%	3.6%	Length	-5.1%	2.3%		
	Sleeve Length	7 8/16	7 3/16	-4.2%		7 9/16	7 4/16	-4.1%		-4.1%	0.0%					
Wash 10	Chest Width	22	21 3/16	-3.7%	-3.1%	21 9/16	21	-2.6%	-2.9%	-3.2%	0.8%	Width	-3.0%	0.6%	-4.7%	2.4%
	Sleeve Opening	15 4/16	14 14/16	-2.5%		15 12/16	15 4/16	-3.2%		-2.8%	0.5%					
	Front Length	22 15/16	21 3/16	-7.6%	-5.9%	22 9/16	20 8/16	-9.1%	-7.0%	-8.4%	1.1%	Length	-6.5%	2.3%		
	Sleeve Length	7 8/16	7 3/16	-4.2%		7 9/16	7 3/16	-5.0%		-4.6%	0.6%					
Wash 20	Chest Width	22	21 6/16	-2.8%	-2.6%	21 9/16	21 4/16	-1.4%	-2.7%	-2.1%	1.0%	Width	-2.7%	1.0%	-4.6%	2.6%
	Sleeve Opening	15 4/16	14 14/16	-2.5%		15 12/16	15 2/16	-4.0%		-3.2%	1.1%					
	Front Length	22 15/16	21 14/16	-4.6%	-4.8%	22 9/16	20 6/16	-9.7%	-8.2%	-7.2%	3.6%	Length	-6.5%	2.3%		
	Sleeve Length	7 8/16	7 2/16	-5.0%		7 9/16	7 1/16	-6.6%		-5.8%	1.1%					

Table B40

AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering, White H&M T-Shirts*

Test Interval	Benchmark Location	T-Shirt ID# 2				T-Shirt ID# 3				Interval Average						
		Initial	After	Shrinkage by Dimension		Initial	After	Shrinkage by Dimension		T-Shirt Average	SD	Dimension Average		SD	Overall Average	SD
		(inches)	(inches)			(inches)	(inches)									
Wash 1	Chest Width	21	20 4/16	-3.6%	-4.0%	21	20 8/16	-2.4%	-2.5%	-3.0%	0.8%	Width	-3.3%	0.9%	-4.2%	1.3%
	Sleeve Opening	14 2/16	13 8/16	-4.4%		14	13 10/16	-2.7%		-3.6%	1.2%					
	Front Length	21 11/16	20 8/16	-5.5%	-5.8%	21 8/16	20 8/16	-4.7%	-4.4%	-5.1%	0.6%	Length	-5.1%	0.9%		
	Sleeve Length	9 2/16	8 9/16	-6.2%		8 15/16	8 9/16	-4.2%		-5.2%	1.4%					
Wash 5	Chest Width	21	20 3/16	-3.9%	-4.6%	21	20 1/16	-4.5%	-4.0%	-4.2%	0.4%	Width	-4.3%	0.8%	-6.0%	1.9%
	Sleeve Opening	14 2/16	13 6/16	-5.3%		14	13 8/16	-3.6%		-4.4%	1.2%					
	Front Length	21 11/16	19 15/16	-8.1%	-7.5%	21 8/16	19 12/16	-8.1%	-7.9%	-8.1%	0.0%	Length	-7.7%	0.6%		
	Sleeve Length	9 2/16	8 8/16	-6.8%		8 15/16	8 4/16	-7.7%		-7.3%	0.6%					
Wash 10	Chest Width	21	20 3/16	-3.9%	-3.7%	21	20 1/16	-4.5%	-3.6%	-4.2%	0.4%	Width	-3.6%	0.7%	-6.0%	2.5%
	Sleeve Opening	14 2/16	13 10/16	-3.5%		14	13 10/16	-2.7%		-3.1%	0.6%					
	Front Length	21 11/16	19 15/16	-8.1%	-8.1%	21 8/16	19 11/16	-8.4%	-8.4%	-8.2%	0.3%	Length	-8.3%	0.2%		
	Sleeve Length	9 2/16	8 6/16	-8.2%		8 15/16	8 3/16	-8.4%		-8.3%	0.1%					
Wash 20	Chest Width	21	20 2/16	-4.2%	-3.9%	21	20 1/16	-4.5%	-4.0%	-4.3%	0.2%	Width	-3.9%	0.5%	-6.4%	2.7%
	Sleeve Opening	14 2/16	13 10/16	-3.5%		14	13 8/16	-3.6%		-3.6%	0.0%					
	Front Length	21 11/16	19 14/16	-8.4%	-8.3%	21 8/16	19 7/16	-9.6%	-9.3%	-9.0%	0.9%	Length	-8.8%	0.6%		
	Sleeve Length	9 2/16	8 6/16	-8.2%		8 15/16	8 2/16	-9.1%		-8.7%	0.6%					

Table B41

AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering, Navy H&M T-Shirts*

Test Interval	Benchmark Location	T-Shirt ID# 2				T-Shirt ID# 3				Interval Average						
		Initial	After	Shrinkage by Dimension		Initial	After	Shrinkage by Dimension		T-Shirt Average	SD	Dimension Average	SD	Overall Average	SD	
		(inches)	(inches)			(inches)	(inches)									
Wash 1	Chest Width	20 9/16	20 3/16	-1.8%	-2.3%	20 7/16	19 14/16	-2.8%	-3.2%	-2.3%	0.7%	Width	-2.7%	0.7%	-2.5%	0.7%
	Sleeve Opening	13 12/16	13 6/16	-2.7%		13 14/16	13 6/16	-3.6%		-3.2%	0.6%					
	Front Length	20 14/16	20 5/16	-2.7%	-2.1%	20 14/16	20 7/16	-2.1%	-2.5%	-2.4%	0.4%	Length	-2.3%	0.6%		
	Sleeve Length	8 12/16	8 10/16	-1.4%		8 12/16	8 8/16	-2.9%		-2.1%	1.0%					
Wash 5	Chest Width	20 9/16	20	-2.7%	-2.7%	20 7/16	19 14/16	-2.8%	-3.2%	-2.7%	0.0%	Width	-3.0%	0.4%	-3.2%	0.4%
	Sleeve Opening	13 12/16	13 6/16	-2.7%		13 14/16	13 6/16	-3.6%		-3.2%	0.6%					
	Front Length	20 14/16	20 2/16	-3.6%	-3.6%	20 14/16	20 4/16	-3.0%	-3.3%	-3.3%	0.4%	Length	-3.4%	0.3%		
	Sleeve Length	8 12/16	8 7/16	-3.6%		8 12/16	8 7/16	-3.6%		-3.6%	0.0%					
Wash 10	Chest Width	20 9/16	20	-2.7%	-3.2%	20 7/16	19 13/16	-3.1%	-3.8%	-2.9%	0.2%	Width	-3.5%	0.8%	-3.7%	0.8%
	Sleeve Opening	13 12/16	13 4/16	-3.6%		13 14/16	13 4/16	-4.5%		-4.1%	0.6%					
	Front Length	20 14/16	20	-4.2%	-3.9%	20 14/16	20 3/16	-3.3%	-4.1%	-3.7%	0.6%	Length	-4.0%	0.8%		
	Sleeve Length	8 12/16	8 7/16	-3.6%		8 12/16	8 5/16	-5.0%		-4.3%	1.0%					
Wash 20	Chest Width	20 9/16	20 2/16	-2.1%	-2.4%	20 7/16	20 2/16	-1.5%	-2.6%	-1.8%	0.4%	Width	-2.5%	0.9%	-3.2%	0.9%
	Sleeve Opening	13 12/16	13 6/16	-2.7%		13 14/16	13 6/16	-3.6%		-3.2%	0.6%					
	Front Length	20 14/16	20 1/16	-3.9%	-3.7%	20 14/16	20 2/16	-3.6%	-3.9%	-3.7%	0.2%	Length	-3.8%	0.3%		
	Sleeve Length	8 12/16	8 7/16	-3.6%		8 12/16	8 6/16	-4.3%		-3.9%	0.5%					

Table B42

AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering, White Brooks Brothers T-Shirts*

Test Interval	Benchmark Location	T-Shirt ID# 2				T-Shirt ID# 3				Interval Average						
		Initial	After	Shrinkage by Dimension		Initial	After	Shrinkage by Dimension		T-Shirt Average	SD	Dimension Average		SD	Overall Average	SD
		(inches)	(inches)			(inches)	(inches)									
Wash 1	Chest Width	21 11/16	20 6/16	-6.1%	-6.7%	21 15/16	20 11/16	-5.7%	-6.2%	-5.9%	0.3%	Width	-6.5%	0.8%	-5.3%	1.4%
	Sleeve Opening	15 2/16	14	-7.4%		15	14	-6.7%		-7.1%	0.5%					
	Front Length	22 15/16	21 13/16	-4.9%	-4.3%	22 8/16	21 8/16	-4.4%	-4.1%	-4.7%	0.3%	Length	-4.2%	0.6%		
	Sleeve Length	8 10/16	8 5/16	-3.6%		8 8/16	8 3/16	-3.7%		-3.6%	0.0%					
Wash 5	Chest Width	21 11/16	20 2/16	-7.2%	-7.7%	21 15/16	20 4/16	-7.7%	-7.6%	-7.4%	0.3%	Width	-7.7%	0.4%	-6.9%	1.0%
	Sleeve Opening	15 2/16	13 14/16	-8.3%		15	13 14/16	-7.5%		-7.9%	0.5%					
	Front Length	22 15/16	21 8/16	-6.3%	-5.7%	22 8/16	20 15/16	-6.9%	-6.4%	-6.6%	0.5%	Length	-6.0%	0.8%		
	Sleeve Length	8 10/16	8 3/16	-5.1%		8 8/16	8	-5.9%		-5.5%	0.6%					
Wash 10	Chest Width	21 11/16	20 1/16	-7.5%	-8.7%	21 15/16	20 3/16	-8.0%	-9.0%	-7.7%	0.3%	Width	-8.8%	1.3%	-7.9%	1.5%
	Sleeve Opening	15 2/16	13 10/16	-9.9%		15	13 8/16	-10.0%		-10.0%	0.1%					
	Front Length	22 15/16	21 3/16	-7.6%	-7.1%	22 8/16	20 13/16	-7.5%	-6.7%	-7.6%	0.1%	Length	-6.9%	0.8%		
	Sleeve Length	8 10/16	8 1/16	-6.5%		8 8/16	8	-5.9%		-6.2%	0.5%					
Wash 20	Chest Width	21 11/16	19 14/16	-8.4%	-9.1%	21 15/16	20 6/16	-7.1%	-7.7%	-7.7%	0.9%	Width	-8.4%	1.1%	-7.9%	1.1%
	Sleeve Opening	15 2/16	13 10/16	-9.9%		15	13 12/16	-8.3%		-9.1%	1.1%					
	Front Length	22 15/16	21 2/16	-7.9%	-7.2%	22 8/16	20 10/16	-8.3%	-7.5%	-8.1%	0.3%	Length	-7.3%	0.9%		
	Sleeve Length	8 10/16	8 1/16	-6.5%		8 8/16	7 15/16	-6.6%		-6.6%	0.1%					

Table B43

AATCC Test Method 150–2012: *Dimensional Changes of Garments after Home Laundering, Navy Brooks Brothers T-Shirts*

Test Interval	Benchmark Location	T-Shirt ID# 2				T-Shirt ID# 3				Interval Average						
		Initial	After	Shrinkage by Dimension		Initial	After	Shrinkage by Dimension		T-Shirt Average	SD	Dimension Average		SD	Overall Average	SD
		(inches)	(inches)			(inches)	(inches)									
Wash 1	Chest Width	21 7/16	21 1/16	-1.7%	-1.8%	21	20 10/16	-1.8%	-1.3%	-1.8%	0.0%	Width	-1.5%	0.5%	-2.1%	1.8%
	Sleeve Opening	14	13 12/16	-1.8%		14 6/16	14 4/16	-0.9%		-1.3%	0.6%					
	Front Length	21	20 13/16	-0.9%	-1.1%	21 4/16	19 14/16	-6.5%	-4.2%	-3.7%	3.9%	Length	-2.6%	2.6%		
	Sleeve Length	10 3/16	10 1/16	-1.2%		10 1/16	9 14/16	-1.9%		-1.5%	0.4%					
Wash 5	Chest Width	21 7/16	21	-2.0%	-1.9%	21	20 7/16	-2.7%	-1.8%	-2.4%	0.5%	Width	-1.8%	0.8%	-2.0%	0.8%
	Sleeve Opening	14	13 12/16	-1.8%		14 6/16	14 4/16	-0.9%		-1.3%	0.6%					
	Front Length	21	20 10/16	-1.8%	-1.5%	21 4/16	20 11/16	-2.6%	-2.9%	-2.2%	0.6%	Length	-2.2%	0.8%		
	Sleeve Length	10 3/16	10 1/16	-1.2%		10 1/16	9 12/16	-3.1%		-2.2%	1.3%					
Wash 10	Chest Width	21 7/16	21	-2.0%	-2.4%	21	20 8/16	-2.4%	-2.1%	-2.2%	0.2%	Width	-2.2%	0.4%	-2.7%	0.7%
	Sleeve Opening	14	13 10/16	-2.7%		14 6/16	14 2/16	-1.7%		-2.2%	0.7%					
	Front Length	21	20 9/16	-2.1%	-2.9%	21 4/16	20 8/16	-3.5%	-3.3%	-2.8%	1.0%	Length	-3.1%	0.7%		
	Sleeve Length	10 3/16	9 13/16	-3.7%		10 1/16	9 12/16	-3.1%		-3.4%	0.4%					
Wash 20	Chest Width	21 7/16	21 2/16	-1.5%	-1.6%	21	20 8/16	-2.4%	-1.6%	-1.9%	0.7%	Width	-1.6%	0.6%	-2.3%	1.1%
	Sleeve Opening	14	13 12/16	-1.8%		14 6/16	14 4/16	-0.9%		-1.3%	0.6%					
	Front Length	21	20 10/16	-1.8%	-3.0%	21 4/16	20 10/16	-2.9%	-3.0%	-2.4%	0.8%	Length	-3.0%	1.0%		
	Sleeve Length	10 3/16	9 12/16	-4.3%		10 1/16	9 12/16	-3.1%		-3.7%	0.8%					







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## VITA

Jeanne Oakes Badgett was born in New York City and raised in New Jersey, Louisiana, and Maryland. She graduated from Seneca Valley High School in Germantown, Maryland in 1990. She worked at The Container Store in Atlanta, Georgia and Tyson's Corner, Virginia before moving to Lexington in 1995 to attend the University of Kentucky. She earned a Bachelor of Science in Merchandising, Textiles and Apparel and graduated Summa Cum Laude in 2000. As an undergraduate she was recognized as an Outstanding Undergraduate Researcher in Merchandising, Apparel, and Textiles and was awarded as Outstanding Student in both her major and her college. After graduation, she worked in administration for St. Joseph Children's Home in Louisville, Kentucky before leaving the workforce in 2004 to raise her three daughters. In 2014, she returned to school to pursue a graduate degree at the University of Kentucky. She earned her Master of Science in Retailing and Tourism Management with a focus in textiles in 2017 (expected). During her undergraduate and graduate education, Jeanne worked as a lab technician in the University's Textile Testing Lab. She was granted a graduate research assistantship in 2014, 2015, and 2016. She also received academic funding from Lion Apparel.

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