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Research article

Quality Analysis and Testing of Undergarments

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Abstract

The quality of the undergarments is a combination of design and materials of the desirable products for intended use and the target market. No one will buy a product of poor quality or with any visual defects. The industry critically depends on the factories, the complex supply chain, and if the best procedures are maintained in their quality control systems. A good quality control system maximizes production according to specified requirements in the first attempt. To achieve an acceptable level of satisfaction, quality control is important for design quality, colours, suitability of products, stylistic approach and brand name impact on the market. The most common reason for fabric breakage on cheap undergarments is the fact that there are no set quality standards for most of the cheap products. The consumer checks the quality of undergarments in order to ensure product reliability and quality. While prices for items having higher quality, standards are higher than that of cheap fabrics, high quality tested garments are always a better choice. There are internationally recognized standards that follow a specific format of the inspection process to verify the product quality. This paper describes the most common testing standards required for undergarment production.

Keywords: Quality; Testing; Underwear; Undergarments; Innerwear; Brassiere; Lingerie; Slip; Fabrics

Introduction

Undergarments, underwear, innerwear, underclothes, undergarments, undies, smalls and sometimes underthings are a category of apparel that gets us down to the bare bones of ourselves. It relates to our body, comfort, sense of self, sex appeal and underpinning. Undergarments are worn next to the skin, underneath a person's outer clothing. It is the foundation for all our clothes helps to keep the outer garments clean by absorbing sweat and oils from skin. It helps to keep warm in the cold climates. While we spend years curating the perfect wardrobe, we often overlook its foundation - our underwear drawer. Right underwear, can change the way we feel in our clothes, giving us the confidence and the coverage, we need to wear everything from our everyday t-shirts to our evening dresses.

Women's undergarments are collectively known as 'lingerie'. The words underwear and lingerie are sometimes used interchangeably but tend to be reserved for women's wear. The French word lingerie means undergarments and applies for either sex, but in English-speaking countries, the term has come to be associated exclusively with more attractive or sensual lightweight underwear or nightclothes. The French word in its original form derives from the old French word 'linge', meaning linen. They may also be called 'intimate clothing' or simply 'intimates' made up of several product segments like bras, panties, shapewear, sleepwear, lightweight robes, and daywear, which means mostly slips and camisoles. The specific choice of the word often is motivated by an intention to imply the garments are alluring, fashionable or both [1].

Generally, regular underwear is more economical having a simple design. It is typically made from inexpensive cotton and can be purchased in packs. Lingerie, on the other hand, is typically a bit more expensive. It is often made from an expensive material, having intricacy of designs. One big difference between underwear and

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lingerie is the reason it is worn. Although lingerie is usually worn beneath the clothes as well, it is not usually chosen for practicality or comfort. Instead, lingerie is chosen because it is fashionable or enticing. Women often wear lingerie that they believe will be attractive. Informal usage suggests visually appealing or even erotic clothing. Although most lingerie is designed to be worn by women, some manufacturers now design lingerie for men [2]. Technically, all lingerie is underwear, but not all underwear is lingerie. Underwear is worn for practicality and comfort by both genders, while lingerie is typically worn by women because it is attractive. Regular underwear is usually less expensive than lingerie, and it has been around much longer.

Lingerie has been marketed for generations that reflect deep emotions and attitudes about themselves, their roles, and history as women. The underwear industry has been selling something that seemed sexy for years, even if it was not necessarily comfortable or functional. Many lingerie brands seem to design products form, in a voyeuristic perspective, it is for someone else's pleasure, not necessarily the wearers. The definition of what is sexy has changed steadily. It is now about women feeling comfortable in their own skins, as opposed to pleasing someone else. It is not about the shape - it is about the way one feels.

Origins of Underwear and Lingerie

The origins of underwear and lingerie are also quite different. Underwear is believed to have been around since ancient times. Historians believe that ancient Egyptians, Greeks, and Romans all wore undergarments. In fact, a loincloth is also considered a primitive type of underwear. The concept of lingerie being visually appealing was a development of the later 19th century. In the 19th century, undergarments were typically not spoken of in polite society, and it was bulky as well as unattractive. Lady Duff-Gordan, a prominent fashion designer, decided to change this. She began to design women's undergarments that were smaller, less restrictive, and more attractive. These alluring types of underwear eventually became known as lingerie. Up through the first half of the 20= century, women selected underwear for three major purposes: changing into a perfect shape, for preserving modesty and for hygiene reasons. Women's underwear before the invention of crinoline was very large and bulky [3]. As the 20th century, progressed underwear became smaller and more form fitting. In the 1960s, lingerie manufacturers begin to glamorize lingerie and the idea of lingerie having a sexual appeal slowly developed. The lingerie industry has expanded in the 21st century with designs that double as outerwear by categorizing lingerie as an accessory with details such as straps and lace trim that should be layered and shown as part of one's outerwear. Wearing underwear as outerwear is a fashion trend.

Underwear is gender-differentiated. Boxers, briefs, vest, banian for men; panties and bras for women. Our intimate connection with underwear clothing acts like a 'second skin'. Underwear especially fits this metaphor because it resides closest to the skin. This 'skin' functions as part of our boundary system even as it retains an independent reality. These aspects intersect and render possible deeply personal experiences of clothing. It is no exaggeration to regard underwear as the most personal kind of clothing having the most intimate association. There is more than one reason for this intimate connection. First, a basic utilitarian function of underwear is to protect our natural skin from our other clothes and simultaneously protect those clothes from soiling produced by our own bodies. As a 'second skin', the first boundary formed is between us and the other clothes we wear; a reality that creates not only physical distancing but some psychological distancing as well. No such distance intervenes with underwear, as a popular advertisement proclaimed about its apparel, nothing comes between us and our undergarments. Just as we take care of our natural skin through washing it, applying lotions, and so forth in order to be healthy and comfortable, so we do with our underwear. Over time the emphasis in making and marketing underwear has changed from utilitarian and health reasons to comfort and pleasure. In fact, as comfort increases through the pure sensuousness of fabric and fit, so does the intrinsic potential to eroticize the garment by the symbolic substitution for the body regions the apparel resides by.

Performance and luxury are the biggest drivers. The underwear industry operates the same way as the clothing industry. Moreover, much like the clothing industry, most underwear is made in Asia. In part, because it is cheaper and the technical skills and machinery needed to make underwear, in particular, lingerie does not exist at scale elsewhere. Lingerie and underwear brands must ensure a high degree of comfort and the right fit for different markets and body shapes. The brand must ensure that the product matches with customer expectations of fit, quality, size, comfort, functionality and safe for skin. A high level of cleanliness/hygiene is guaranteed in their production and they have the right suppliers, with the right expertise and technology, who are able to handle the production process and its quality. Product inspection for undergarments can be a complicated process. Many manufacturers are not sure what criteria to apply for inspection and tests to perform to ensure their items meet the customers' expectations.

Aesthetic and performance factors are, of course, inextricably linked with a price. The often-repeated statement that 'you get what you pay for' is generally associated with performance, but a customer's concept of what the level of performance should be will vary considerably. It is often influenced by aesthetic considerations. Thus, the concept of good quality is not a static issue operating at one level for all customers; it is influenced by aesthetics, performance, and price, and is specific to an individual customer. While poor product quality may not be the most common reason for a customer to return a product, it is a factor. Garment inspection is one of the best ways to verify the quality of a clothing item before it leaves the factory. Today's educated consumer is focused on finding apparel with the best balance of style, quality, and price, manufactured under the highest possible ethical standards. Increased consumer awareness is making apparel quality control more important than ever. The brand should have off-the-shelf customizable product-specific inspection checklists for quality control and assurance services at all stages of the supply chain-from source to shelf. It is vital for brands to focus on building trust in terms of quality, and an outstanding reputation for great customer service.

Objective

The main objective of this paper is to highlight the quality testing parameters that are essential for manufacturing of undergarments following the American Society for Testing Materials (ASTM) and American Association of Textile Chemists and Colorists (AATCC) standard norms known worldwide. These methods served as a basis and are equivalent to other national level standards. The study will serve as a knowledge base both for the manufacturers and the consumers.

Methodology

Methodology in writing of this paper is secondary and primary research both. As the secondary research, published articles/ papers, books related to textile and apparel quality, websites of the quality testing solution providers are studied and as the primary study, interviews of people working in the undergarment sector are taken into consideration. The primary study helps in finding out which quality systems that are prevalent in the manufacturing of undergarments and what exactly are being followed.

Literature Review

Quality of undergarments has been related to the longevity of products, functionality, and comfort. The physical characteristics and functionality of undergarments are very important for the consumer. In the study of Hume and Mills [4], brand recognition is highly significant for companies whose customers repurchase based on the comfort, functionality, and quality of garments. According to Suzianti et al. [5] client fashion e-commerce is related to product quality and warranty replacement and return of the garments. Therefore, the conditions exist to suggest that companies in the textile underwear, marketed by internet tend to have higher sales and long-term relationship with customers when considering the quality of both the product and the distribution channel.

The choosing or designing of undergarments that makes a suitable foundation for costume is a challenge to any girl's good taste. She may have attractive underwear if she is wise in the selection of materials and careful in making it or in choosing ready-made garments. It is not the amount of money that one spends so much as it is good judgment in the choice of styles, materials and trimmings. No matter how beautiful or appropriate a girl's outer garments may be, she is not well dressed unless she has used good judgment in making or selecting her underwear. Every girl likes to have attractive, well-fitting underwear. The right kind protects the body and acts as a foundation for outer garments, improving their appearance without calling attention to what is underneath. Usually we think of undergarments as including brassieres, girdles, foundation garments, panties and slips [6]. The utilitarian functions of intimate apparel are basic fit and support that are considered the key criteria for lingerie [7]. The products could be easily imitated by others in the fashion market. It is necessary to build an innovative strategy to ensure that businesses compete in an invincible position, based on meeting new needs of customers [8]. Material from which an undergarment is to be made should be soft and smooth, as fine a quality as one can afford, attractive in appearance, up to date in style, easy to launder, and reasonably durable considering the quality of the goods and the price paid [9].

The primary purpose of textile testing and analysis is to assess product performance and use the test results for predictions about its performance. Product performance is considered in conjunction with end use; hence, tests are performed with the ultimate end use in mind [10]. The esthetic factors provide the initial impulse of attraction and may be the only factors that influence the decision to buy clothing items. The exception is the requirement that the item should fit. But even fit may be a function of fashion and style. Such aesthetic factors as handle, drape, colours, and style all interact in a complex manner and are crudely and subtly influenced by social factors-a desire to be in fashion, a desire to present an image [11]. An item of clothing is a summation of materials, starting with fiber, through yarn, fabric, and trimmings which go to make it up. The complexities of balancing aesthetics, performance and cost factors, therefore, apply to the selection and use of these materials. Customers have perceptions of the aesthetic and performance values of all components of clothing items, although of course, their judgment may be faulty and subject to misunderstood technical factors as well as ingrained social habits [12].

Standardization in Garment Sector

Standardization is essential to maximize compatibility, interoperability, safety, repeatability, or quality. It started mainly in the beginning of the 19th century, with the need of practical interchangeability of screws and later with other machine parts [13]. There are different types of standards and are essential for the society. These can include standards for terms and definitions, specifications, management systems, test methods. Standards can be internal of an organization, but for trade, it is important that they are accepted for a large community. There are standards used in a private or local community or in a certain region. Standardization have many developments at national levels, under the supervision of national standardization bodies. But the need for the interchange of products and services at global level has led, especially since the second half of the 12th century, to a strong development of international standards. Standards are developed and published by many different groups and organizations using various degrees of consensus in their preparation and approval. Formal standards are approved or adopted by one of the National, Regional or International Standards bodies [14]. Few examples are mentioned below.

a) The Bureau of Indian Standards (BIS) is the National Standard Body of India working under the aegis of Ministry of Consumer Affairs, Food & Public Distribution, Government of India. It is established by the Bureau of Indian Standards Act, 1986 on 23 December 1986.

b) The South Asian Regional Standards Organization (SARSO), established in 2010 to achieve and enhance coordination and cooperation among South Asian Association for Regional Cooperation (SAARC) members in the areas of standardization and conformity assessment with the objective to develop harmonized standards for the region, to facilitate intra-regional trade, and to enhance access in the global market for the SAARC Region suppliers.

c) The International Organization for Standardization (ISO) is an International Standard setting body composed of representatives from various national standards organizations. It is headquartered in Geneva, Switzerland, and works in 162 countries. It was one of the first organizations granted general consultative status with the United Nations Economic and Social Council. Founded on 23 February 1947, the organization promotes worldwide proprietary, industrial and commercial standards. While, Informal Standards are published by another Standards Development Organizations (SDOs), many of which are very well known and highly respected, e.g.

d) ASTM publishes textile standard specifications and test methods for physical, mechanical, chemical properties of fibers, yarns, fabrics, and garments, used worldwide.

e) AATCC is known worldwide for developing and publishing test methods for textiles, especially related to dyeing and finishing. Many of these methods served as a basis and are equivalent to ISO standards.

f) The International Wool Textile Organization (IWTO) publishes specifications on test methods developed within the committees of IWTO for the measurement of wool fiber, yarn, and fabric properties.

Standard Performance Specification

The standard is issued under ASTM D7019 [15]. The performance specification covers fabrics used in underwear, brassieres, slips, and lingerie. Fabrics intended for the end-use should meet all the requirements listed in Table 1. The requirements apply to the length and width directions for those properties where each fabric direction is pertinent. It should be recognized that fabric can be produced utilizing an almost infinite number of combinations of construction variables (e.g., type of fibers, percentage of fibers, yarn twist, yarn number, warp and pick count, chemical, and mechanical finishes). Additionally, fashion or aesthetics dictate that the ultimate consumer may find acceptable articles made from fabrics that do not conform to all the requirements in Table 1. Hence, no single performance specification can possibly apply to all the various fabrics that could be utilized for the end-use. The uses and significance of properties and test methods are further discussed. There is more than one method that can be used to measure breaking strength, tearing strength, bursting strength and lightfastness. These methods cannot be used interchangeably since there may be no overall correlation between them.

Table 1: Specification Requirements.

Characteristic	Minimum Requirements	
	Sheer	Non-Sheer
Breaking strength (CRE)A	67 N (15lbf)	111 N (25lbf)
Tearing strength	4.4 N (1lbf)	6.7 N (1.5lbf)
Resistance to Yarn slippage 6mm (1/4 in.) separation,	45 N (10lbf)	67 N (15lbf) Brassieres - 133 N (30lbf)
Yarn distortion at 4.4 N (1lbf) load Satins	2.5mm (0.1 in.), max	
All other	1mm (0.05 in.), max	
Bursting strength	133 N (30lbf)	222 N (50lbf)
Dimensional Change		
Laundering (Woven)	3 %, max	
Drycleaning (Woven)	2 %, max	
Laundering (Knit)	5 % max	
Drycleaning (Knit)	5 % max	
Colourfastness:		
Laundering		
- Shade change	Grade 4	
- Staining	Grade 3	
Drycleaning		
- Shade change	Grade 4	
- Staining	Grade 3	
Bleaching (Shade change)		
- Sodium Hypochlorite	Grade 4	
- Non-Chlorine Bleach	Grade 4	
Burnt gas fumes - 2 cycles:		
- Shade change, original fabric	Grade 4	
- Shade change, after one cleaning	Grade 4	
Crocking:		
- Dry	Grade 4	
- Wet	Grade 3	
Perspiration:		
- Shade change	Grade 4	
- Staining	Grade 3	
Light (10 AFU) (xenon-arc)	Grade 4	
Fabric appearance	SA 3.5	
Flammability	Class I	

Discussions on Test methods

Breaking Strength (woven fabrics only)

ASTM Standards D 5034 Test Method for Breaking Strength and Elongation of Textile Fabrics covers the Grab Test procedures for determining the dry-breaking strength and elongation of most textile fabrics using a constant-rate-of-extension (CRE) tensile testing machine. It is not recommended for knitted fabrics and other textile fabrics which have a high amount of stretch (more than 11%). The method specifies a procedure to determine the maximum force and the elongation at maximum force of textile fabrics using a grab method. A grab test is a tensile test in which only the center part of the specimen (not the full width) is gripped in the jaw faces. Two sets of specimens are prepared, one in the warp (machine) direction and one in the filling (cross) direction. This test method provides the values in both inch-pound units and SI units. The test analyzes

a) Breaking force: The average force required to break (rupture) the sample and

b) Elongation: The average increase in the length of the sample at its break (rupture) point.

If preferred a Constant-Rate-of-Traverse (CRT) tensile testing machine may be used. There may be no overall correlation between the results obtained with the CRT and CRE machine. Consequently, these two testers cannot be used interchangeably. In case of controversy, the CRE method, shall prevail.

Tearing Resistance (woven fabrics only)

ASTM Standards D 1424 Test Method for Tearing Strength of woven fabrics by Falling-Pendulum (Elmendorf) apparatus covers the measurement of the tearing strength of textile fabrics by the tongue (single rip) procedure using a CRE-type tensile testing machine. This test measures peak force, tearing force, and tearing strength. Rectangular specimens are placed into the CRE tester. One side of the cut end is clamped into the upper jaw and the other is clamped into the lower jaw. The jaws move apart at a constant rate until the fabric begins to tear. Depending on the nature of the specimen, the tearing force will be shown as a peak or a series of peaks. The highest peaks appear to reflect the strength of the yarns, fiber bonds, or fiber interlocks needed to continue a tear. The CRE-type tensile testing machine has become the preferred test apparatus for determining tongue-tearing strength. It is recognized that some CRT type tensile testing machines continue to be used. Consequently, these test instruments may be used when agreed upon between the purchaser and the supplier. This test method applies to most fabrics including woven fabrics, napped fabrics, knit fabrics, layered fabrics, pile fabrics, and nonwovens. The fabrics may be untreated, heavily sized, coated, resin-treated, or otherwise treated. Instructions are provided for testing specimens with or without wetting.

Resistance to Yarn Slippage (woven fabrics only)

The test method ASTM Standards D 434 covers the determination of the resistance to slippage of weft yarns over warp yarns, or warp yarns over weft yarns, using a standard seam. The test involves a tensile testing machine, a pair of dividers, metal rule, metal clamp, and sewing machine. When doing the test, the load-elongation curve of the fabric is superimposed upon a load-elongation curve of the same fabric with a standard seam sewn parallel to the yarns being tested. Resistance to yarn slippage is reported as the load at which a pre-determined slippage is observed.

a) Seam Slippage Test: To evaluate the fabric condition when pulled apart at a sewn seam. A seam is sewn in a fabric, which is clamped at one end and pulled by weights at the other end. (Performed in both warp and weft directions.) The weight is increased until seam separates a specified distance. The number of pounds required to cause this separation determines the rating. 25lbs. minimum = upholstery 25lbs. minimum=panel and vertical surface fabrics.

Yarn Distortion (woven fabrics only)

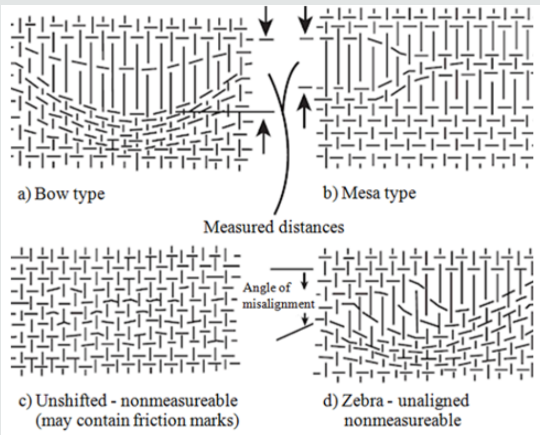

Figure 1: Measurable and nonmeasurable shift openings.

The test method ASTM Standards D 1336 covers the measurement of yarn distortion of one set of yarns over the other in woven cloth following the application of surface friction in a Fabric Shift Tester. The test method is applicable mainly to open-weave fabrics, like gauzes, nettings, marquisettes, chiffons, and heavier fabrics made from slippery surface yarns. A specimen is subjected to a specified shearing force acting in the plane of the fabric. The degree to which the force causes yarns to shift distorting the original symmetry of the weave is taken as a measure of ease of yarn distortion in the fabric. The degree of distortion is reported in terms of the widest opening, measured in hundredths of an inch. The specimen is allowed to relax for 15 minutes after being removed from the carriage. The widest opening of each shift mark, or distorted yarn group, is measured as shown in Figures 1a, 1b. Non-measurable openings, illustrated in Figure 1c, 1d, are described and reported. The average of the five measurements is calculated and reported.

Bursting Strength (knit fabrics only)

ASTM Standards D 3786 Test Method for Bursting Strength of Textiles-Diaphragm Bursting Strength Tester Method is used as a multidirectional tensile test to identify a failure in the direction of least resistance for evaluating the physical strength and fiber bond. Models are available to test a variety of materials. These models can also be fitted with a device to measure the deflection of the sample prior to burst. The textile burst tester is designed to meet international standards for tests on textiles. In textiles, the burst tester measures the fabric's strength along with immediate or eventual effects of dyes, chemicals, and processes. It also demonstrates the results of wear, age, and environment and evaluates the comparative strength of alternative fibers. The Textile Burst Tester is designed for measuring the bursting strength of fabric materials subjected to an increasing hydrostatic pressure. This pressure is applied to a circular region of the specimen via an elastic diaphragm. The specimen is firmly held around the edge of this circular region by a pneumatic clamping device. When the pressure is applied, the specimen deforms together with the diaphragm. The bursting strength corresponds to the maximum pressure supported by the specimen before failure.

Identical, in the principle to the multi-directional tensile test, Ball Burst Method for Fabrics, this measurement is independent of the cutting direction of the sample (machine or cross) since the failure naturally occurs in the least resistance direction. The rubber diaphragms with a specific thickness and shore hardness must have a bulge versus pressure pattern within the tolerance of the standards related to the type of material tested. If preferred, a Constant-Rate-of-Extension (CRE) tensile testing machine may be used. Since there is no overall correlation between the results obtained with CRE machine equipped with a bursting attachment (ASTM Test Method D 3787) and the Diaphragm Bursting Tester (ASTM Test Method D 3786), these two bursting testers cannot be used interchangeably. In case of controversy, the ASTM Test Method D 3786 shall prevail.

Dimensional Change

Dimensional change problems experienced in textile products are always been an important subject and a focus of attention. Dimensional stability is the ability of textile materials to maintain or return to its original geometric configuration. Consumer acceptance of garments depends mainly on the dimensional stability. They consider the dimensional change in a garment to be a critical performance characteristic. Dimensional property of a fabric is greatly influenced by laundering and dry cleaning.

a) Laundering: The dimensional changes of garments when subjected to home laundering procedures used by consumers are directed in the applicable procedure in AATCC Method 135. Four washing temperatures, three agitation cycles, two rinse temperatures, and four drying procedures cover the common home care options available to consumers using current laundering machines. The dimensional changes of garments subjected to home laundering care procedures are measured using benchmarks placed on designated areas of the garments. Measured dimensional changes may be affected by garment construction, tensions, sewing threads or trims in addition to fabric dimensional change. As an optional procedure, fabric dimensional changes may be determined by using benchmarks placed on the fabric in areas of the garment that contains no seams or sewing. This method may not be applicable for garments made of certain stretch fabrics (Table 2).

Table 2.

Washing Conditions	Drying Conditions
Normal/Cotton Sturdy cycle	Tumble dry, Cotton Sturdy
Hot water setting (actual=43.3°C)	High setting, 66±5°C (actual exhaust=60°C)
Water level=18±1 gal	Dry time=20min
Agitator speed=179±2 spm	Cool down time=10min
Washing time=12min	
Spin speed=645±15rpm	
Final spin time=6min	

b) Dry-cleaning: Determine the dimensional change after dry cleaning as directed in AATCC Method 158. This test method specifies a dry-cleaning procedure, using a commercial dry-cleaning machine, for the determination of the dimensional change of fabrics and garments after dry cleaning in perchloroethylene. It comprises processes for normal materials and sensitive materials. Very sensitive materials, which can be cleaned only when special precautions are taken, are excluded from the scope of this method. The test method is intended only for the assessment of dimensional changes undergone by a specimen subjected to a single dry cleaning and finishing operation. When it is desired to determine the amount of progressive dimensional change, the method may be repeated a specified number of times, normally not exceeding five cycles.

c) Dry-cleaning conditions

i. Commercial rotating cage type machine-(cleaning g-factor 0.5-0.8; extraction g-factor 35-120)

ii. Perchloroethylene solvent (30±3°C)

iii. Inlet dry temp = <80°C

iv. Outlet dry temp = <60°C

v. Finish treatment performed (pressing) until no wrinkles showed (g-factor is a unit to measure water extraction capacity of a washer. The more g-factor the better it is).

Colourfastness

Colourfastness is defined as 'the resistance of a material to change in any of its colour characteristics, to transfer its colorants(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.' In other words, it is a fabric's ability to retain its colour throughout its intended life cycle influenced by water, light, rubbing, washing, perspiration etc. to which they are normally exposed in textile manufacturing and in daily use. Colourfastness is one of the important factors in the case of buyers' demand. There are many types of colourfastness properties that must be considered to provide the consumer with an acceptable product. The outstandingly important property of a dyed material is the fastness of the shade of colour.

a) Laundering: The accelerated laundering tests evaluate the colourfastness to laundering of textiles, which are expected to withstand frequent laundering. Laundering refers to the washing of clothing and other textiles colourfastness to laundering are the common quality parameter, which is considered very important from the point of view of consumers. The test determines the degree of colour loss after repeated home launderings and staining of other items in a wash load. The test predicts the performance of any dyed or printed textile product to the common washing process using a detergent and additives. The test conditions are designed to simulate the behavior of the textile after five domestic or commercial launderings on 45 minutes test or according to the consumer's requirement. The colourfastness to laundering is performed as directed in the applicable procedure of AATCC Method 61.

The test evaluates the colourfastness to washing of textiles that expected to withstand repeated low-temperature machine laundering or hand laundering in the home or in the commercial laundry. The sample is paired with a multi-fiber strip and placed in a launder-o-meter and accelerated hand/machine laundering is performed with a detergent solution. Specimens subjected to the test show colour change like that produced by five machine launderings at 38±3°C (100±5°F) or by hand launderings at 40±3°C (105±5°F). However, the staining effect produced by five typical hand or home launderings cannot always be predicted by the 45min test. Staining is a function of the ratio of coloured to undyed fabrics, the fiber content of fabrics in the wash load and other end-use conditions, which are not always predictable.

b) Dry-cleaning: Dirt or contamination in textiles is often removed by either aqueous cleaning using detergents or chemical or dry cleaning using organic solvents. Dry cleaning is normally used in the case of textiles that cannot be washed for any reason or that cannot be washed by aqueous means, e.g. wool and silk garments. Due to dry cleaning, dyed or printed textiles may change their colour to some extent (fade) and another problem is that that may discolour the solvent used in dry cleaning. Different solvents can be used, but perchloroethylene is the most widely used solvent in the industry at this time. A colour that is not affected by perchloroethylene will not be affected by petroleum solvents, whereas the converse is not true. Pigment colours are more readily affected in perchloroethylene than in petroleum or fluorocarbon solvent dry cleaning. Similarly, Garment accessories like sequins; plastic beads etc. get affected by solvents. The colourfastness to dry- cleaning is determined as directed in AATCC Method 132.

The test method is intended for determining the colourfastness of textiles to all kinds to dry cleaning. The test method is neither suitable for the evaluation of the durability of textile finishes, nor is it intended for use in evaluating the resistance of colours to spot and stain removal procedures used by the dry cleaner. This test method only covers colourfastness to dry cleaning; it does not cover the effects of water spotting, solvent spotting and steam pressing which are normally involved in commercial dry-cleaning practice. The test method gives an indication of results to be obtained from three commercial dry cleaning. A specimen of the textile in contact with cotton fabric, multifiber swatch, and noncorrodible steel discs is agitated in perchloroethylene and then dried in air. Perchloroethylene is used because

a. it is the most used solvent in commercial dry cleaning and

b. it is slightly more severe in solvent action than petroleum.

A colour which is not affected by perchloroethylene will not be affected by petroleum solvents, whereas the converse is not always true. Any change in colour of specimen is assessed with the standard Gray Scale for colour Change and of staining by using Gray Scale for Staining or Chromatic Transference Scale. Launderable fabrics are expected normally to be dry-cleaned, except where all or part of fabric will not withstand dry cleaning. For example, the fabric could contain a functional finish soluble in the solvent, or the fiber could be degraded by the solvent, which would be the case with poly (vinyl chloride) fiber. If a fabric gets harmed by all methods of care except for dry cleaning, it should be considered dry clean only.

c) Bleaching: The test method is designed for home laundering devices. When testing with bleach is stated, test as directed in AATCC Method 172 for Colourfastness to powdered Non-Chlorine Bleach or AATCC Method 188 for Colourfastness to Sodium Hypochlorite Bleach in home laundering. The appropriate procedure for testing Colourfastness to chlorine bleach is AATCC Method 188. The procedure approximates Colourfastness results after five wash/dry cycles in presence of detergent and chlorine bleach. The procedure is very reliable, but is a time, labor and resource intensive. Colourfastness is not usually an issue with white fabric, but all white fabric known to have a chemical finish should be tested for potential yellowing by interaction with chlorine bleach. The bleach test can be used as a screening for white fabric. Fabrics that prove unacceptable for laundering in chlorine bleach must be tested for Colourfastness to non-chlorine bleach following the applicable protocol is AATCC Method 172. The care labeling rule is very specific. If a garment is safe in non-chlorine (colour-safe) bleach, but not in chlorine bleach the label must say 'Non-chlorine Bleach When Needed', or words to that effect. The only way to determine if non-chlorine bleach is safe is to test for Colourfastness. Grey Scales (Gray Scales) are used for assessing colour change and staining during Colourfastness testing. Both scales are used for visual assessment to enable you to specify a rating from 1 to 5, with 5 being 'good' and 1 being 'poor' (Table 3).

Table 3: Test method is designed for home laundering devices.

Test Type	Test Method	Comments on Requirements
AATCC Method 172	Colourfastness to powdered Non-Chlorine Bleach	Used to determine whether nonchlorine bleach will affect colours during washing. Labeling must be adjusted if colour affected.
AATCC Method 188	Colourfastness to Sodium Hypochlorite Bleach in home laundering	If the fabric is affected by chlorine bleach only, warning on the label to read: 'Only nonchlorine bleach if needed.' If sensitive to both bleach types, label to read: 'Do not bleach.'

d) Burnt Gas Fumes: The colourfastness to burnt gas fumes on the original fabric and after one laundering or one dry cleaning is determined as directed in AATCC Method 23. Washing or dry-cleaning conditions shall be as for dimensional change testing. This method is intended for determining the resistance of colour of textiles of all kinds and in all forms except loose fibres when exposed to atmospheric oxides of nitrogen as derived from the combustion of butane gas. This method may be used for rating colourfastness of dyes by applying the dye to textiles by a specified procedure and at a specified depth of colour and testing the dyed textiles. A specimen of the textile and the test-control fabric are exposed simultaneously to oxides of nitrogen from burnt gas fumes until the test control shows a change in colour corresponding to that of the standard of fading. The change in colour of the specimen is assessed with the grey scale. If no colour change is observed in the specimen after one exposure period or cycle, exposure may be continued for either a specified number of periods or for the number of periods required to produce a specified amount of colour change in the specimen.

e) Crocking: Colourfastness to dry and wet crocking is determined as per AATCC Method 8 for solid shades and AATCC Method 116 for prints or as agreed upon by the contractual parties. The process determines the amount of colour transferred from the surface of a coloured textile material to other surfaces by rubbing. The sample is placed on crock-meter. A standard white cotton fabric is rubbed across the sample 10 times in the wet and dry state. To test for wet crocking, the standard fabric is wet before rubbing against the test fabric. The AATCC Method 116 is a test specifically used for printed fabrics that do not lend themselves to the AATCC Method 8. The test fabric is held at the base of a Rotary Vertical Crockmeter and rubbed with a standard cotton white fabric either dry or wet. In both the test methods, after rubbing under controlled pressure for a specific number of times, the amount of colour transferred to the white test squares is compared to an AATCC Colour Chart and a rating is established. The cotton cloth is evaluated for staining. Grade 5 denotes 'no colour transfer' and Grade 1 denotes a 'high degree of colour transfer'.

f) Perspiration: Colourfastness to perspiration is determined as directed in AATCC Method 15. The test determines the fastness of coloured textiles to the effects of acid perspiration (sweat). A coloured textile specimen is wet out using a simulated acid perspiration solution. It is placed in contact with a multi-fiber strip, and then both subjected to a fixed mechanical pressure. The specimen is then evaluated for colour change using the AATCC Gray Scale for Staining, and the multi-fiber test strip is evaluated for colour transfer using the AATCC Chromatic Transference Scale.

g) Light: Colourfastness to light is the resistance of a material to a change in its colour characteristics as a result of exposure of the material to sunlight or an artificial light source. Colourfastness to light is determined following the AATCC Method 16. The test method provides general principles and procedures which are currently in use for determining the colourfastness to light of textile materials. The test options described are applicable to textile materials of all kinds and for colourants, finishes and treatments applied to textile materials. Test options are:

i. AATCC Test Method 16.1, Colourfastness to Light: Outdoor.

ii. AATCC Test Method 16.2, Colourfastness to Light: Carbon-Arc.

iii. AATCC Test Method 16.3, Colourfastness to Light: Xenon-Arc.

The use of these test options does not imply, expressly or otherwise, an accelerated test for a specific application. The relationship between any lightfastness test and the actual exposure in use must be determined and agreed upon by the contractual parties. Samples of the textile material to be tested and the agreed upon comparison standard(s) are exposed simultaneously to a light source under specified conditions. The colourfastness to light of the specimen is evaluated by comparison of the colour change of the exposed portion to the masked control portion of the test specimen or unexposed original material using the AATCC Gray Scale for Colour Change, or by instrumental colour measurement. Lightfastness classification is accomplished by evaluation versus a simultaneously exposed series of AATCC Blue Wool Lightfastness Standards (a pack of 8 graded dyed wool fabrics) used in determining the amount of light exposure of specimens during lightfastness testing. Duration of the test is defined by buyers, typically 10 AFU (accelerated fading units) is preferred for intimate apparels.

There are distinct differences in spectral distribution between various types of machines listed in AATCC Method 16, with no overall correlations between them. Consequently, the machines cannot be used interchangeably. In case of controversy, results obtained with water-cooled xenon-arc machine listed in AATCC Method 16E (Colourfastness to Light: Water-Cooled Xenon-Arc Lamp, Continuous Light) shall prevail. In 2003, AATCC Method 16 was revised to open certain parameters and adopted AATCC Method 16E for use at all levels. Retailers specified this option in their testing specifications for suppliers to follows. The change allowed the use of alternative lightfastness testers with different capabilities than the previously accepted instruments. The options within the revised method are numbered instead of lettered to distinguish it from the traditional version. The revised, broader xenon arc option is now Option 3. However, 16E has not been abandoned. Many retailers still call this method out in their own testing requirements because they do not want variation from all of the historical testing they have produced since 16E was adopted in 1964. The use of a different lightfastness tester may produce different results.

Fabric Appearance

Laundering and subsequent drying can affect the surface appearance of an item. The test method is intended to determine the Smoothness Appearance (SA) of flat fabric specimens as directed in AATCC Method 124 of fabrics after the applicable laundering or dry-cleaning procedure. SA in fabrics is the visual impression of planarity of a specimen quantified by comparison with a set of reference standards. Any washable fabric of any construction, such as woven, knit and nonwoven, may be evaluated for smoothness appearance using this method. Evaluation is performed using a standard lighting and viewing area by rating the appearance of specimens in comparison with appropriate reference standards. For fabrics not intended for use in durable press garments, determine the smoothness appearance after pressing as specified in AATCC Method 135 intended for the determination of dimensional changes of fabrics when subjected to home laundering procedures used by consumers. The dimensional changes in fabric specimens subjected to home laundering care are measured using pairs of benchmarks.

Flammability

The flammability test and requirements shall meet or exceed the Flammable Fabrics Act mandatory standards as specified in 16 CFR 1610. Flammability is the primary safety hazard associated with wearing apparel; therefore, all garments sold must meet government regulations in the United States. Exemptions are hats, gloves, footwear (excluding hosiery) and interlinings. All fabrics will burn; however, it is the ease, speed, and intensity of burning that determines whether a fabric is hazardous or not. Factors that directly affect burning characteristics are fibre content, weight, and fabric construction. Lightweight fabrics (those weighing 2.6 oz per sq. yd or less) made of natural fibers, cotton, rayon, silk, and brushed fabrics such as fleece or flannel, are particularly suspect for burning and must be tested to ensure compliance. This regulation is only a minimal standard and is relatively easy to pass. The test is designed to eliminate those fabrics that are highly flammable from the marketplace. Specimens are conditioned in a drying oven to remove all moisture prior to testing. The test is conducted in an enclosed chamber with the sample held at a 45-degree angle, while a one-inch ignition source impinges on the fabric for one second. A class determination is made on tested samples in original state and after one washing and dry-cleaning cycle.

i. Class 1-Normal flammability is considered commercially acceptable;

ii. Class 2-Intermediate flammability refers only to textiles with a napped or

iii. Class 3-Rapid and intense burning is considered dangerously flammable. Textile and apparel are banned from sale (Table 4).

Table 4: Summary of test criteria for specimen classification.

Class	Plain surface textile fabric	Raised surface textile fabric
1	Burn time is 3.5seconds or more ACCEPTABLE (3.5sec is a pass).	Burn time is greater than 7.0 seconds; or Burn time is 0-7 seconds with no base burns (SFBB). Exhibits rapid surface flash only. ACCEPTABLE.
2	Class 2 is not applicable to plain surface textile fabrics	Burn time is 4-7seconds (inclusive) with Surface Flash Base Burn (SFBB). ACCEPTABLE.
3	Burn time is less than 3.5seconds. NOT ACCEPTABLE.	Burn time is less than 4.0seconds with Surface Flash Base Burn (SFBB). NOT ACCEPTABLE.

General characteristics of flammable goods:

i. Low twist yarns ignite more readily than high twist;

ii. Loosely woven and lightweight fabrics burn more readily;

iii. Napped fabrics have an increased surface flammability;

iv. Some coated fabrics and plastic films burn rapidly;

v. Fiber content is the most influential factor in determining fabric flammability.

In most cases, only the exposed parts of finished garments are subject to this standard. The exceptions are items that can be reversible or worn inside out, such as sweatshirts. Lining materials that can be exposed when worn, such as the inside of a jacket, are also subject to this standard.

Conclusion

There are two things defining good quality underwear: comfort and style that represents our personality. Style is very individual, but comfort depends on the materials. The primary determinant of an undergarment quality depends on its fabric, construction and fit. The last thing that defines quality is the way the undergarment is sewn. The stitches should be even and straight with no irregularities in the thread. There should be no loose threads or puckered material under the stitching lines. All seams should be finished with no raw edges of fabric in sight. Like most things, it all comes down to use and preference. Every manufacturer should maintain a high-quality system of inspection policy, follow the test methods and specifications. A good quality system makes the companies more reliable and the customer is getting what they are paying for.

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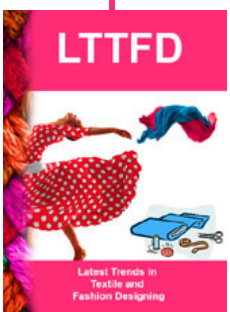

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