TECHNICAL BULLETIN

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BASICS OF COLOR FOR COTTON TEXTILE PRODUCTS

This report is sponsored by the Importer Support Program and written to address the technical needs of product sourcers.

INTRODUCTION

The perception of color, the use of colored materials or color-producing products, and the communication of color are circumstances that are unique to human beings. One only has to look at the colorful products and art that our ancient ancestors produced, such as artifacts from the early Egyptian civilizations, to realize the importance of color to humans. This use of color for human expression transcends the centuries. Further, the use of color has accelerated in modern times. Compare black and white photographs with color photographs, a monochrome computer monitor with a high resolution color monitor, or black and white movies with Technicolor® movies. This is a color-filled world, where humans use and enjoy color. The textile and retail businesses worldwide use color to segregate and market materials, products, and product lines. Color variety and new color or shade development are major driving forces in the production and marketing of textiles as well as numerous other products. The importance of color to the textile and retail businesses of today cannot be overstated. However, for such an important aspect of industry, commerce, and everyday life, the concept of color, the production of color, and the control of color, especially on textile products, are poorly understood by textile producers, merchants, and consumers.

WHAT IS COLOR?

The question, “What is color?” must be addressed before discussing any other aspects of color production or color control. Color or the perception of color may be thought of as “psycho-physical” phenomena. The “psycho” part of the nomenclature comes from psychology, which is the study of human behavior. It may be true that some animals can perceive color, but these animals cannot communicate any information about their perception of color. Humans communicate with color terms. Common everyday phrases such as: “I was so angry I saw red,” “They were green with envy,” “It was a blue Monday,” or “Today is a gray day” are all expressions of emotions or feelings experienced by humans. People of nearly all cultures throughout history have used color to describe their emotions. The study of color as a part of psychology is well documented. However, these discussions mainly involve the “physical” aspect of color, especially as it relates to textile products.

Visible Light

The first and foremost part of the physical aspect of color is visible light. Visible light is one form of electromagnetic radiation, which exists naturally. The original source of this energy is the sun, but this radiation is also produced by all the stars in the universe. The spectrum of electromagnetic radiation includes cosmic rays, gamma rays, x-rays, ultraviolet radiation (UV), infrared radiation (IR), microwaves, TV waves, and FM and AM radio waves. Visible light is a small fraction of this total radiation spectrum. All this energy moves through space at the same speed, the speed of light, and in the form of waves. What separates visible light, which can be seen from the other forms of this radiation, is the aspect known as wavelength. Wavelength is the distance, normally measured in meters, from the top of one wave to the top of the next wave. Normally, energy that has very short wavelengths is dangerous or even lethal to living organisms including humans. This is true of cosmic rays, gamma rays, and x-rays. Even ultraviolet radiation, which causes skin to sunburn, can lead to skin diseases and damage to nerves in the eyes, especially in cases of very high exposure. Other forms of longer wavelength energy are less harmful as far as is known. Visible light, which is of moderate wavelength, is not harmful to humans. For visible light, the wavelengths have been measured at 1/1,000,000,000 (one billionth) of a meter, which is known as a nanometer (nm). Most humans see light from 380-780 nm. Radiant energy with wavelengths longer or shorter cannot be seen.

Color in Textile Materials

Now since visible light has been defined, where does color originate and how is color produced in textile materials? The first truth of color is that without light there is no color. This can be easily proven by taking different color garments of similar constructions into a room or closet and eliminate all of the light, then attempt to sort the garments by color. Color cannot be sensed except by vision and without light no color can be seen. In fact, as light intensity fades, the color of objects appears to change. Notice the color of objects as dusk approaches to verify this. Next, take white light from sources such as sunshine or light bulbs, then project this light through a raindrop or a prism. This projected light is bent to reveal a rainbow or color spectrum. Wavelength bands have been assigned to the specific colors seen in the color spectrum. These are as follows:

Wavelength (NM) Color	
Less than 380	UV (not seen)
380-435	violet
435-480	blue
480-490	turquoise
490-500	bluish-green
500-560	green
560-580	yellowish-green
580-595	yellow
595-650	orange
650-780	red
Greater than 780	IR (not seen)

Textile materials as well as all other objects, except colored lights, exhibit color because they interact with the light to produce the color that is observed. In the case of textiles, there are three specific ways in which these materials can interact with light.

Textile materials can *reflect*, *absorb*, and/or *transmit* light. For example, if a green textile fabric is placed under a white light, the light can be reflected by the fabric, but the fabric is not a perfect reflector. A mirror would be an example of a nearly perfect reflector. The light can be absorbed by the fabric, but the fabric is not a perfect absorber. The best example of a perfect light absorber is a black hole in outer space; however, because it absorbs all light, a black hole is invisible, and their exact nature is the subject of much scientific debate. The light can also be transmitted through the fabric, but if the material is folded several times, the possibility of light transmission is lessened or even eliminated. Preventing light from passing through a sample is a major consideration in any shade matching operation and must be taken into account in order to achieve accurate and consistent evaluations.

If the folded fabric is seen as green, it is because as the white light illuminates it, the dyes in the fabric absorb all wavelengths of light except those that produce the green color; those wavelengths are reflected by the dyes. Textile dyes and pigments are known as colorants, because they have the ability to selectively absorb certain wavelengths of light and reflect others. The color name of the dye is given due to the color produced by the reflected wavelengths. The specifications of color of textile materials are therefore determined by three independent factors. The first factor is the *illuminant* or *light source*. The second factor is the *observer*. Normally, the observer is a person; however, with current technical advances color computer systems are observers and can measure color. The third factor is the *textile material* itself. Each of these factors will be analyzed in detail.

Light Source

As was mentioned previously, color is due to the various wavelengths of visible light interacting with the dyes or pigments on the textile material. However, there are a number of potential light sources available for the judgment of the color of a textile product. Traditionally, everyone used natural sunlight as the “standard” light source, particularly “north sky” white light. Today, however, the textile industry is an international business existing in every part of the globe. Sunlight is variable in different regions, at different times of the day, during various seasons and is greatly affected by cloud cover and/or pollution gases in the atmosphere. Actually, natural sunlight is a poor choice to use for color judgment. In the 20th century, manufactured electric light sources were developed. Most light boxes used for shade judgment employ three light sources: synthetic daylight D-65, tungsten bulb (standard residential light), and cool white fluorescent (standard office or retail store light). Each one of the light sources has its own independent spectral power distribution across the visible spectrum of wavelengths. For example, the tungsten bulb generates much more spectral power output in the orange-red region than it does in the violet-blue region. Therefore, tungsten light generally makes fabrics appear redder. In contrast, synthetic daylight D-65 has much more spectral power in the violet-blue region than tungsten light, but much less power in the orange-red region. Synthetic daylight D-65 is preferred as a shade matching standard light source for textile materials, because it has nearly equal spectral power output in all color regions. Nevertheless, any textile fabric or garment will appear to be somewhat different in color under each different light source. This variation in color constancy can lead to color confusion when purchasing textile materials under one light source and using them under different lighting conditions. The first factor to specify for color control is the light. *It is very important for the supplier and customer to use the same standard light source for evaluating the color of textile materials.*

Observer

The second factor to consider in color specification of textiles is the observer. Human color vision has been a primary topic of scientific study since the time of Sir Isaac Newton. However, even today, color vision is not entirely understood. Briefly, the following facts are known about the human eye and its response to visible light. The eye is a receiving sphere for light, which enters through the small opening in the front. The tough outer coating of the eye is crystal clear living tissue known as the cornea. The cornea is responsible for approximately two-thirds of the focus of images. The iris of the eye surrounds the pupil, which is the opening where light enters.

The iris is responsible for the color of the eye and is attached to the cilliary muscle. Behind the pupil is the lens, which is responsible for the other one-third of the focus of images. The lens is also crystal clear living tissue. As light enters the eye, the lens is stretched or thickened by the cilliary muscle to focus the image on the nerve endings at the back of the eye known as the retina. The retina is an extension of the optic nerve, which sends visual information from the eye to be interpreted by the brain. The focal length distances required for the eye to work are maintained, because the area between the cornea and the lens is filled with a clear liquid known as the aqueous humor. Also, the area between the lens and the retina is filled with a clear jelly type substance known as the vitreous humor. If either of these substances leak out of the eye, clear vision is not possible. Additionally, the internal surface of the eye is covered with a velvet like coating called the chorid, which traps scattered light and allows for the observation of sharp images. The retina contains nerves, which sense color and light intensity. The nerves that sense color are known as cones. Those that sense light intensity are known as rods. These are interconnected in the retina along with numerous other cells, which help amplify the color and light intensity information. The color sensing cones are concentrated at the fovea, the central focus point of light on the retina. All of this information is sent to the brain in a very complex method, which is human sight and color vision. Humans have two eyes that allow for three-dimensional sight. In summary, the human eye is extremely complicated, and there are many complexities to color vision that are still not understood.

Color vision has been studied in detail by scientists for many centuries. There are currently two generally accepted theories describing how color vision operates. Both of these proposals originated in the 1870s. Each idea was developed independently. The proposal known as Young-Helmholtz suggests that the cones are composed of three receptor types: red, blue, and green. Each receptor nerve is described by an independent response. Also, each nerve has some response to both luminance (light intensity) as well as color. Equal excitation of all three receptor types yields a white sensation. Various color sensations occur due to mixing of response to red, blue, and green. This system accounts for the currently known forms of color blindness. The alternate proposal known as Hering-Jameson suggests that the receptor nerves have opponent color response corresponding to blue-yellow, red-green, and black-white (light intensity). In this proposal, color perception is due to the build-up or breakdown of chemicals in the cones. This system accounts for color fatigue and after image colors. Human color vision has a number of variables that do not fit these proposals. According to some recently published literature, “color normal humans” can sense over 22 million different colors. Color normal for human observers means that an individual can recognize differences between colors. However, the only way to truly determine whether any individual can see color is through using scientifically accepted color vision tests. Through many years of testing and compiling statistics, scientists have determined that approximately 91.5% of the general population are color normal. However, this implies that 8.5% of the population has some degree of color deficiency or confusion, which is normally referred to as color blindness. People who are color blind typically see color, but they confuse certain colors so that they cannot be classified as being color normal. Of the 8.5% of the general population who have some degree of color blindness, the 8.0 part of this percentage are male and 0.5 are female. This means that for every one female who is found to be color blind, 16 males will be colorblind. However, this does not mean that females are superior in color perception or color judgment ability to males. Color judgment ability is related to individual capability or talent and does not follow any other type of classification. Both males and females can develop into excellent judges of color or color quality.

Color normal people are referred to as trichromats in the technical literature. Individuals with color blindness are referred to as dichromats. Unfortunately, there are a number of variations and degrees of severity of color blindness identified throughout the population. The most common form of color blindness is red-green color confusion. Individuals with this condition see green and red as being the same color. This condition takes two different forms. Some individuals can see green but also see red as being green. These people are considered to be red blind and have the technical name of protans. Other red-green confusers can see red, but also see green as being red. These individuals are considered green blind and referred to by the technical name of deutans. A much more rare form of color deficiency occurs when individuals confuse blue and yellow. This blue-yellow color blindness is not subdivided like red-green color deficiency. Individuals with this condition are referred to as tritans. In general discussions, most people associate the term color blindness with individuals who cannot see color at all. People with this condition see only black, gray, and white. Their vision yields images very similar to the images normal individuals would see in a black and white movie. These individuals are known as monochromats. This is an extremely rare form of color deficiency. Many of these monochromats also have a hypersensitivity to light intensity and often do not like to participate in activities in bright sunlight. Color blindness is normally associated with heredity and is passed from one generation to the next. However, like other forms of blindness, color vision deficiency can be developed due to eye injuries or diseases. In order to ascertain the color capability of any individual, proper color vision testing is required. The Psuedo Isochromatic and Ishihara color tests examine and classify the color normalcy of the individual. These tests consist of various colored dots arranged into numbers or letters with various background colors. The individual is asked to recognize the colored dot letters or numbers. These tests are very effective in determining red-green color deficiency. The lighting and viewing conditions for the tests are strictly specified to guarantee the accuracy of the tests. Anyone involved in color judgment or shade matching should have their color vision checked with this type of test to insure that their vision is color normal. However, these are only color ability tests.

In addition, it is highly recommended that color professionals also take the Farnsworth-Munsell 100 hue test. This test allows for direct measurement of the color or hue discrimination of an individual. The test consists of a series of black small medical bottle caps with the center of each cap colored. There are 100 different hues in these caps arranged in four groups, which are contained in four slender wooden boxes. Each wooden box contains two fixed caps with divergent hues such as a yellow-green on one end and a bluish-pink on the other end. The bottle cap hues are arranged in a series of barely noticeable color changes from the yellow-green to the bluish-pink. The tested individual is asked to arrange the 25 colored bottle caps precisely in order from one fixed hue to the other fixed. This is repeated over four different hue ranges. The test can then be accurately graded for correct color order because the colored caps are numbered. Therefore individuals taking this test can be classified into groups of “superior,” “average,” or “poor” ability to distinguish barely noticeable differences in shade over four different hue or color ranges. This is a color skill test and an individual’s score can improve with practice in color judging.

Finally, the Glen Colorule, which has been offered by the American Association of Textile Chemists (AATCC), is a test that allows two individuals, buyer and seller for example, to judge how much difference there is in the way each sees color. This test consists of a double slide rule that is fixed with a series of small colored woven fabric swatches. On the top slide, each swatch is numbered, and on the bottom slide, each swatch is lettered. The tested individual is asked to make the best shade match possible between the top and the bottom slide. Because there is no "perfect match," the color judgment as well as the color experience of the individual is tested. In addition, this best shade match can be obtained under different light sources or at different shade matching booths or rooms within a single building or at multiple locations. Where properly used, this test reveals differences between shade matching areas as well as differences between individuals. Color vision of anyone can change due to their health, eye disease, or even their age. Individuals should be routinely tested for color normalcy and color discrimination if they are practicing color professionals.

Textile Material

The third factor in color specification is the textile material itself. There are a number of variables that influence the apparent color of the final textile product. These include fiber variability, yarn and fabric constructions, and/or fabric wet processing techniques. For instance, in the case of fibers, the fiber cross-section, fiber fineness, surface roughness or luster, and ability of the fiber to uptake or resist dye can all influence the apparent color of the final textile product. In many instances, color problems due to fiber variability may not be recognized until the fiber is in fabric or garment form. Cotton fibers, because they are grown from the cotton plant, have inherent variability in various fiber properties including fiber size, fiber length uniformity, fiber convolution count, and surface roughness.

It is well known that improper or poor blending of cotton during the yarn manufacturing process can lead to poor dyeing uniformity in the yarn or fabric form. Micronaire is a measurement of fiber fineness by maturity. Cotton Incorporated has conducted research that has shown that micronaire differences can lead to noticeable color differences in dyed fabric. Textured synthetic fibers reflect light differently than smooth synthetic fibers of the same fiber type. This leads to apparent color differences in the final dyed textile product. Yarn construction differences also can impact final product color. For cotton, this staple fiber can be spun into yarn by employing a number of different technologies. Two of the most popular technologies today are open-end (rotor) spinning and ring spinning.

Once manufactured these yarns have different properties even if they are made from the same original fiber. For example, if knitted side by side, they will look different in color from each other after dyeing because they reflect light differently. Mixing yarns of the same fiber spun from different technologies can be a major cause of knit fabric barré. Fibers of both synthetic and natural origin can age, and when older yarns (generally yarns over one year old) are woven or knitted with new yarns, then the old and new yarns will not dye the same, causing differential dyeing. A good rule of thumb is if dyeing streaks or unevenness is in straight lines, then the cause of the problem is fiber or yarn related. Additionally, issues such as differential yarn tension, yarn abrasion, mixed high twist and low twist yarns, and yarns of different lusters used in weaving or knitting lead to dyeing defects observed in straight lines. These dyeing problems are actually fabric construction issues.

The condition of color directionality is exhibited in both high and low pile fabrics. The classic example of this is shown by corduroy. Brush the corduroy in one direction, and it appears to be a given color. Brush the pile in the opposite direction and the color appears to change. This effect can be minimal to very large depending on the type of pile, yarn constructions, and hue of the fabric. In addition, chemical and mechanical processes that might change the fabric dye uptake, fabric surface smoothness, or add a chemical film or coating have the potential to affect the final fabric color. One of the most dramatic changes in color is seen when cotton fabric is mercerized. Mercerization causes the cotton to have a rounder cross-section, to deconvolute the cotton fibers, to increase dye uptake, and to increase overall fabric smoothness and luster. Mercerized cotton fabric appears to dye deeper and is brighter than untreated fabric. Fabric construction issues such as knits or wovens, twills or plain weaves, jersey or rib knits are all variables that can influence the apparent fabric color.

COLOR MIXING SYSTEMS

Additive Color Matching System

In textile dyeing, single dyes are rarely used to obtain the final fabric shade. Color mixing is an important issue in color control of textile materials. There are two distinct color-mixing systems. The first mixing system deals with colored light such as is shown in the use of a computer color monitor or television. Different colors are obtained by mixing just three primary colors: red, green, and blue. There is no perfect red, green, or blue that will reproduce all the colors perceived by color normal humans, but modern high resolution computer monitors reproduce approximately 16 million different colors. This mixing of light is known as the additive color mixing system. Mixing of red and blue yields magenta, mixing of blue and green yields cyan, and mixing of red and green yields yellow. The mixed colors magenta, cyan, and yellow are all brighter than each primary, because they have greater final radiant energy. White is a mixture of all three primaries, and true black is the absence of any light.

Subtractive Color Mixing System

The second mixing system deals with colorants such as dyes and pigments used for textiles. In this system the primary colors are magenta, cyan, and yellow. However, in practical terms, dye houses use workhorse red, blue, and yellow dyes. Because of the way dyes absorb and reflect color wavelengths of light, this system is known as the subtractive color mixing system. Mixing of red and blue yields purple, mixing of red and yellow yields orange, and mixing of blue and yellow yields green. White is obtained by destroying inherent color in textiles (bleaching) while black is produced by mixing red, blue, and yellow. Black is considered a “recovery” color for textile products. Off quality dyeings of any hue can be recovered into first quality black shades.

VISUAL COLOR SENSATION VARIABLES

In the textile industry, retail stores, business offices, and homes throughout the world, visual assessment of color is the primary method of determining color accuracy and control. Several visual color sensation variables are important and must be considered.

Metamerism

Historically, one of the most difficult of these variables for textile producers and buyers to deal with is known as "metamerism." Metamerism occurs when two objects (textile materials) match under one set of viewing conditions (light and observer), but do not match when the viewing conditions are changed. Metamerism has benefits and challenges for the textile producer and buyer. For instance, as a benefit, the color of a dyed standard fabric can be matched even if the dyes used for the standard are unknown. However, a major problem can be that when a different light source is used, the standard fabric and trial color match flare in widely different directions. The minimization of negative metamerism effects on a wide range of shades of textile materials is an indication of a highly skilled textile producer.

Color Fatigue

Another problematic color sensation variable is color fatigue. When an individual views a potential color match, because of the process of color vision, the nerve light receptors in the eye begin to fatigue. The result is that color matches begin to appear closer over time, usually after 15-20 seconds of viewing. Also viewing bright colors just before viewing deep colors can affect color judgment without enough time allowed for visual rest and recovery. Many have suggested that at least 1-2 minutes are required for color vision to recover between viewing divergent colors. As mentioned earlier, color monitors only have three primary color stimuli. The condition known as a color fusion allows for perception of smooth solid colors rather than specky or uneven color on monitors, color photos, color paper printing, and certain textile materials. Another color sensation variable, which often creates problems for textile producers and buyers, is the influence of the surround or background on the color being judged. To minimize this effect, shade booths normally have standard gray interior color. However, this variable (simultaneous contrast) is a definite factor when judging individual colors within pattern fabrics such as textile prints or yarn dyes.

Visual Assessment of Color Difference of Textiles

Because of the importance and widespread use of visual assessment of color and the fact that numerous variables exist in this process, AATCC has published an evaluation procedure entitled "Visual Assessment of Color Difference of Textiles." The procedure provides information and a systematic method for standardized visual color evaluation. It also describes important color matching variables such as illumination type, illumination level, viewing environment, viewing geometry, and reporting procedures. This method is highly recommended as a guide for textile materials. It does not give definite pass/fail tolerances for shade matching, but does indicate some important considerations.

INSTRUMENTS

Because of the variation between human observers, scientists, and textile producers, buyers have wanted an accurate, consistent method to judge color by employing instruments. However, the complexity of human color vision and textile materials has presented enormous obstacles to the practical use of instrumental color measurement. Although not a replacement for human observers, the development of high-speed computers, sensitive instruments such as spectrophotometers and colorimeters, and refined color software now allow for the use of color instruments that serve as practical tools for color professionals. Both desktop and handheld models deliver accurate and consistent color information. These instruments offer the user options such as illuminant choice and measuring geometry. Operators of the equipment must be properly trained and also understand textile materials.

All of these instruments measure textile color by reflectance and then use complex mathematical equations to plot these measurements in color spaces. Color spaces used by instruments are mathematical organization systems such as CIE L*a*b*. For example, in the CIE L*a*b* system, the L* represents lightness-darkness, the a* represents redness-greenness, and the b* represents blueness-yellowness. The use of this system yields a three-dimensional color space where color measurement data can be evaluated. There are visual systems such as Munsell. Munsell uses hue (the color name), value (lightness-darkness), and chroma (purity of the color) to develop a visual three-dimensional color organization system. Munsell is often converted to a mathematical system for use by instruments. Software allows for the use of these instruments to yield dye formulations, dye add predictions, color difference measurements, and development of consistent pass/fail color tolerance systems. Remember, instruments measure color while humans see color, and this can lead to various problems over wide ranges of shade and textile constructions. For example, AATCC has published an evaluation procedure entitled "Instrumental Color Measurement," which describes principles and standard methods for the practical use of color instruments with textile materials. Additionally, AATCC test method 173-1998 "CMC: Calculation of Small Color Differences for Acceptability" defines Delta E cmc, which is proposed as a universal measure of color difference of acceptability between color standard and trial. This is based on the CIE L*a*b* system and works well over a variety of fabric constructions. However, it has shown to not work well with certain fabric construction extremes such as tight, highly lustrous woven or certain pile fabrics. Great care should be used in following the method exactly.

As a final word of caution when using color instruments, it is important to remember that these machines measure only one color at a time. They may have severe limitations when measuring patterned fabrics such as plaids, prints, or surface finished or highly textured fabrics, which result in the fabric surface having pronounced three-dimensional appearance. It is strongly recommended that instrumental color measurement and visual color assessment be conducted jointly for the best overall color judgment.

SHADE SORTING

Once textile materials have been dyed or printed, several other issues concerning shade quality and evaluation should be considered. Shade sorting is a color quality control system, which works well when high volumes of the same shade on the same fabric constructions are sold to numerous fabric buyers. Once shade tolerances are set, then fabrics that fall within those tolerance limits, yet are somewhat dissimilar from each other due to cast or shade depth, are sorted and grouped in the finished goods warehouse, so each fabric buyer receives as consistent a fabric shade as possible. For example, each roll of cotton twill khaki fabric will be color evaluated, then color grouped such as slightly red, slightly yellow, slightly blue, slightly deep, and slightly light. Once grouped, the slightly green khaki is shipped to buyer #1, the slightly red khaki is shipped to buyer #2, and so forth. However, this system does not work so well for low volumes of wide shade ranges to multiple buyers. There are a number of these types of color control systems available, but any system used should be adapted to the specific needs of the supplier and buyer.

Not only is the initial acceptable shade important for textile product quality, but also the retention of shade by the textile after exposure to various end use conditions. AATCC has published three visual color evaluation procedures employing scales to help standardize the judgment of shade quality of textiles. These procedures are the “Gray Scale for Color Change,” the “Gray Scale for Staining,” and the “AATCC 9-Step Chromatic Transference Scale.” All three scales require consideration of key issues such as illuminant choice, viewing conditions, and the color normalcy and skill of the observer. Each scale is designed for specific circumstances.

Gray Scale for Color Change

The Gray Scale for Color Change is used for visual evaluation of changes in color of the textiles resulting from colorfastness tests such as washing in home or commercial laundries, dry cleaning, and exposure to light, or exposure to chlorinated pool water. The scale allows for a rating of 1-5 with half-step grades intermediate between each whole step pair. Grade 5 is the highest grade and is considered as no noticeable color change after testing between the original and tested fabric samples.

Gray Scale for Staining

The Gray Scale for Staining is the scale used in visual evaluation of staining (color transfer) from dyed to unstained textiles resulting from colorfastness tests, such as crocking or accelerated washing. Here crock squares or multifiber strips are evaluated for staining acquired during the specific tests. The scale allows for a rating of 1-5 with half-step grades intermediate between each whole step pair. Grade 5 is the highest grade and considered no transfer of color or staining from the original fabric during the testing. As can be seen, although similar, these two gray scales are intended for different purposes and are very different from each other.

Chromatic Transference Scale

The AATCC 9-Step Chromatic Transference Scale is used in the evaluation of staining of undyed textiles in colorfastness tests, especially crockfastness. The purpose of this scale is similar to that of the Gray Scale for Staining. It differs in that it consists of 60 color chips in five hues: red, yellow, green, blue, purple, and neutral gray, corresponding to the Gray Scale for Staining. Many manufacturers have found these chromatic scales somewhat easier to use than the gray scale. However, for critical evaluations or in the case of legal arbitration or litigation, the Gray Scale for Staining should be used.

SUMMARY

In summary, although the perception of color is as normal to human beings as sight itself, the complexities of color make color perception difficult at best. These complications of color vision include different light sources, differences of fibers, yarns, and fabrics as well as complications caused by color sensation variations and communication. The color professional should always take steps to control as many variables as possible when judging the color and color quality of textile products. Consideration of factors such as illuminants, textile product content, and constructions and observer issues are all important to the accurate and consistent evaluation of the color of textiles.

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Importer Support Program

The Cotton Board and Cotton Incorporated are funded by U.S. upland cotton growers and importers of cotton and cotton products (this includes raw cotton, piece goods, and finished apparel). A percentage of the importer funds are devoted for importer specific programs organized under the Importer Support Program. Examples of projects funded from this fund include training schools, educational programs, focus groups, economic meetings, and research initiatives.

Selected technical issues have been identified by importer members as relevant to their business. This report is a condensed, less technical report of those issues intended to provide the reader with basic, yet useful information on the topic.

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