TECHNICAL BULLETIN

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TRI 3018

COLORFASTNESS FOR WOVEN FABRICS

SUMMARY

Dye selection as well as dye penetration are key aspects in the production of woven fabrics with good colorfastness to home laundering. Dye penetration achieved during wet processing is a critical aspect of the dyeing application in the prevention of crease edge abrasion or 'frosting' that occurs during home laundering. Improved color retention may be achieved by using reactive dyes in continuous applications and batch methods such as pad/batch, jig, or jet dyeing. Reactive dyes are a key component in the production of woven cotton fabrics to achieve good to excellent colorfastness performance on dark colors, particularly black and navy shades. Reactive dyes applied to woven twill fabric by continuous methods show improvement, or reduction, in crease edge abrasion and greater durability to home laundering when compared to other dye classes used in continuous dyeing of bottom weight woven fabrics. Exhaust dyeing application of reactive dyes tends to produce further improvement and resistance to crease edge abrasion and color wash-down that is aggravated in home laundering cycles.

Degree of mercerization (barium number) can impact dye penetration and consequently reduce crease edge abrasion and improve color retention. Additionally, preparing yarn from mercerized fiber and subsequently weaving this yarn into fabric increases dye penetration and can improve color retention and reduce crease edge abrasion.

Finishing applications are an important element in resolving color change and wash-down issues as well as in alleviation or minimization of the crease edge abrasion problem. Specific softener selection in resin treatments can affect color retention and promote resistance to crease-edge abrasion. Proper preparation and mercerization, critical dye selection, optimum process conditions in dyeing, and selected finish applications are all key components in the production of dyed woven fabric with acceptable performance levels for colorfastness to home laundering and minimal or no crease edge abrasion.

INTRODUCTION

The introduction of the wrinkle-resistant finishing process for cotton products created a new product category for cotton garments. Casual Friday has stimulated this product category, particularly in the area of wrinkle-resistant slacks. Product lines produced by the major apparel manufacturers and retailers have been popular because of styling options, easy care, comfort, functionality, and durability. Variables considered important to and having an influence on crease edge abrasion and color fastness might include short fiber content of the cotton, twist multiple, fabric construction, spinning system used in yarn manufacture, yarn hairiness, degree of mercerization, dye selection, dye penetration, and resin/softener systems. Fabric design and wet processing applications play a role in fabric performance characteristics for the consumer. Typical testing protocol normally attempts to predict color fastness performance to five home laundering cycles. Consumer expectations, which have driven apparel manufacturers and retailers recently, demand acceptable performance levels for twenty, and in some cases, thirty home laundering cycles. This Technical Bulletin addresses some aspects of wet processing that can impact color retention and the crease edge phenomenon experienced with woven cotton fabrics after multiple home laundering/tumble drying cycles.

DYE APPLICATION METHODS

Woven fabrics are typically dyed by continuous methods to achieve production efficiency and economy of scale for high volume colors. Dye selection has historically included naphthol, reactive, sulfur, and vat dye classes in continuous dyeing. Woven fabrics may be processed by pad/batch and jigger applications, with limited applications in soft flow jets for lower weight fabrics.

Evaluations conducted on production dyed woven fabrics sourced from various mills and finished with a resin formulation using a post-cure procedure indicated a varying degree of color retention after ten and twenty home laundering cycles with results shown in Table I [1]. All fabrics exhibited noticeable crease edge abrasion. This edge abrasion may be attributed to surface or ring dyeing with minimal dye penetration into the yarn bundle. Color loss was between five and twenty percent after ten home laundering cycles.

Table I - Production Dyed Fabrics

		Color Strength	
Sample	Dye Class	HLTD 10X	HLTD 20X
Royal Blue	Vat (C)	90.5	89.5
Lt. Green	Vat (C)	94.5	93.4
Black	Vat (C)	87.9	87.3
Orange	Vat (C)	84.7	87.1
Red	Naphthol (C)	93.0	97.3
Burgundy	Naphthol (C)	80.9	88.5
Navy	Naphthol (C)	95.9	91.1
Dk. Green	Sulfur (C)	91.0	87.2
Navy	Sulfur (C)	82.6	85.4
Black	Sulfur (C)	83.4	----
Turquoise	Reactive (C)	76.5	81.6
Orange	Reactive (C)	95.1	96.5
Gray	Reactive (P/B)	90.6	90.1
Green	Reactive (P/B)	95.3	88.8

(C) Continuous
(P/B) Pad/Batch

Dye Penetration

An example of poor or insufficient dye penetration is shown in Figure 1. Desirable dye penetration is demonstrated in Figure 2. A yarn cross-section from a woven twill fabric made from fiber mercerized before the yarn manufacturing process is shown in Figure 3.

Figure 1. Nominal Dye Penetration

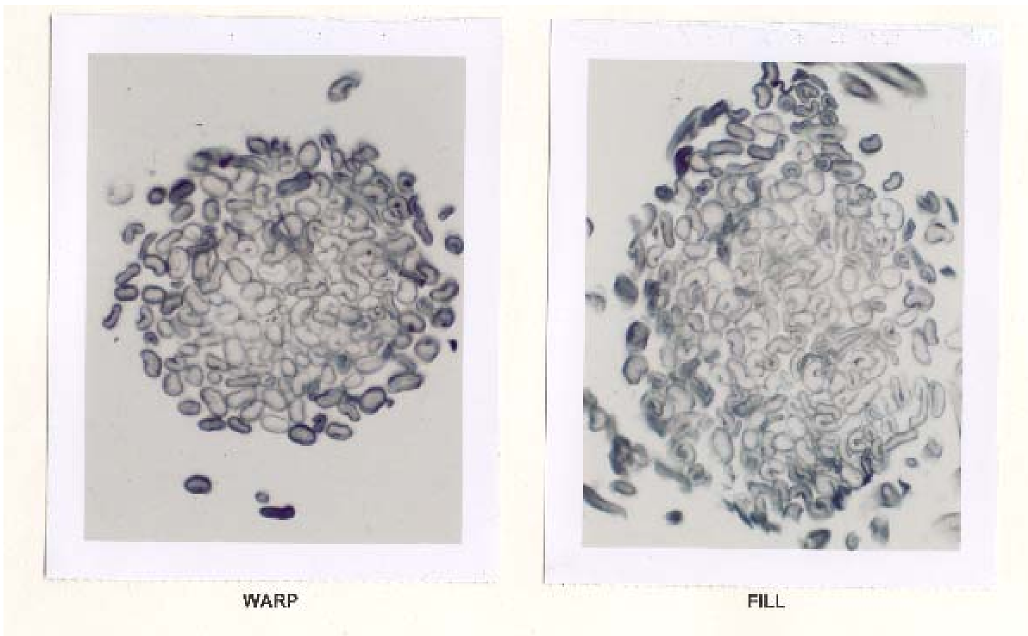


Figure 2. Good Dye Penetration

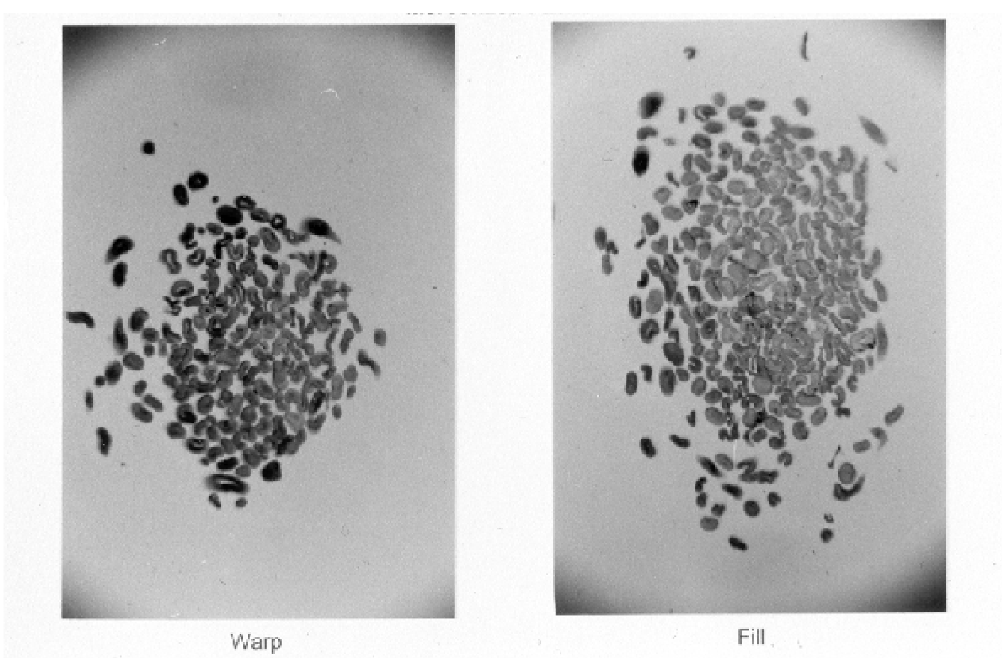
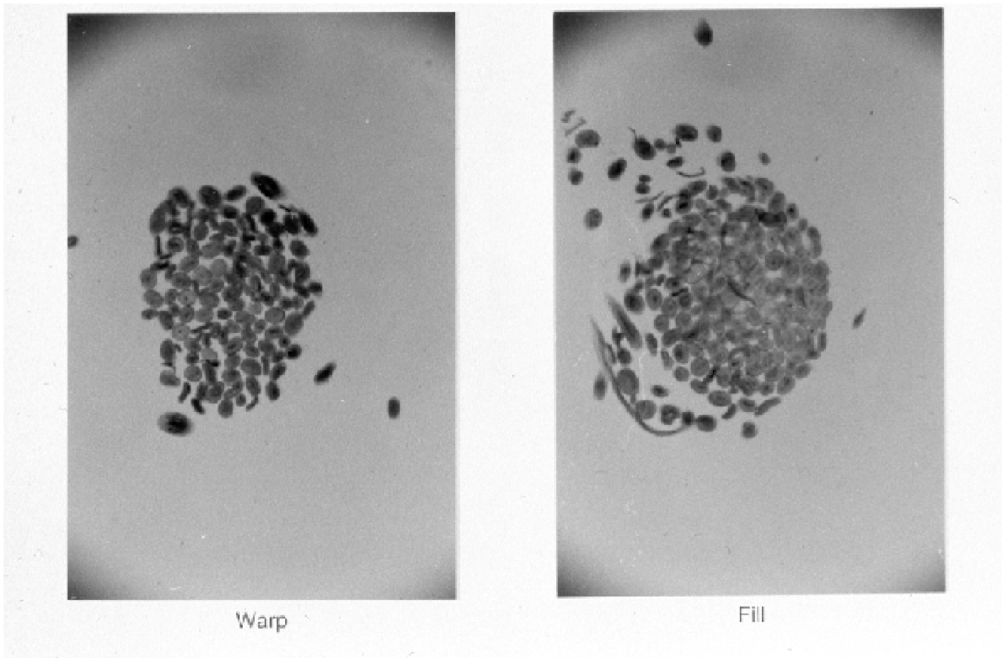


Figure 3. Dye Penetration with Mercerized Fiber



Dye Selection

Reactive dyes are expected to improve color retention based on the formation of a covalent chemical bond with cotton and reduce the crease edge abrasion (frosting) problem in dark colors such as black and navy when the dyestuffs are applied in a continuous method on woven fabrics. The use of reactive dyes, when appropriately applied, can yield improved dye penetration thereby improve color retention[2,3].

Exhaust dyeing by jet, jigger, or pad/batch methods on woven fabrics will provide an enhanced ability to improve dye penetration and yield better resistance to color fading with proper dyestuff selection. The time element offered by exhaust dyeing methods is advantageous over continuous applications due to the added exposure time to the dye liquor. Color retention levels of well above ninety percent after 20 home launderings (HLTD) are achievable with reactive dyes for navy shades[4].

Several reactive dye types are available in the dyeing of woven fabrics[5]. Reactive dyes may be mono-functional, bi-functional, or multi-functional. Bi-functional and multi-functional reactive dyes will tend to give colors that provide improved wash fastness and greater resilience to laundering. Light fastness properties can be improved with some multi-functional reactive dyes.

COLOR RETENTION

Evaluation of a number of different types of reactive dyes demonstrated the effectiveness of this dye class for achieving good to excellent color strength retention and is shown in Figure 4 for a black shade, Figure 5 for a green shade, and Figure 6 for a navy shade.

Figure 4. The effects of dyeing system and dyeing process on the color strength of the black shades finished with a conventional resin formula after 20 home laundry/tumble dry cycles.

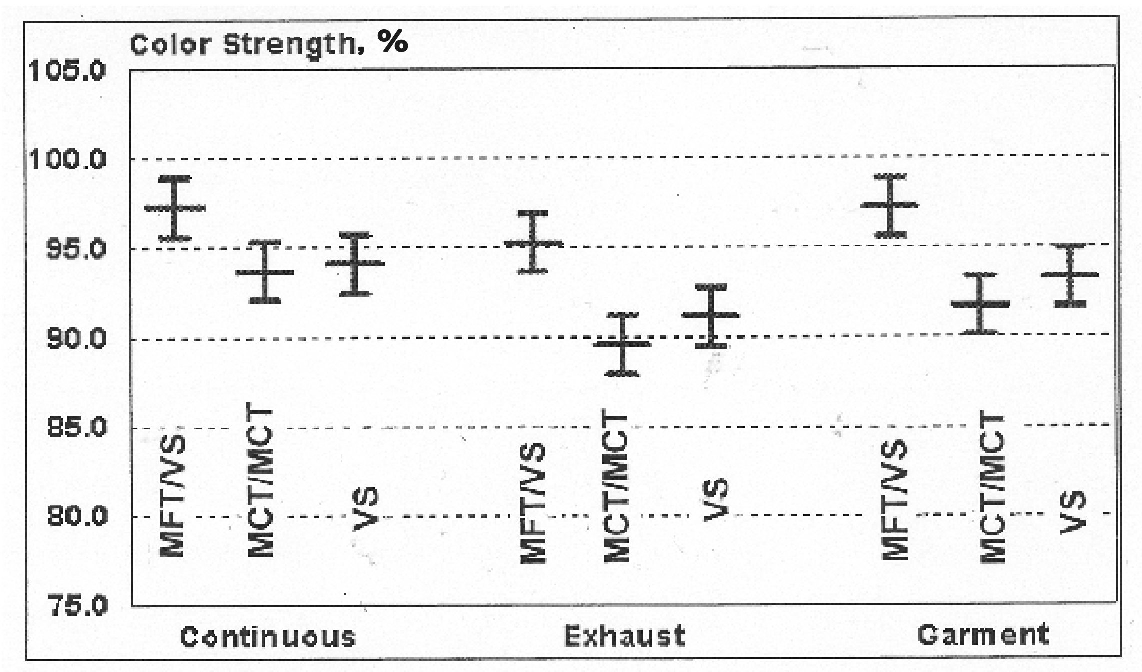


Figure 5. The effects of dyeing system and dyeing process on the color strength of the green shades finished with a conventional resin formula after 20 home laundry/tumble dry cycles.

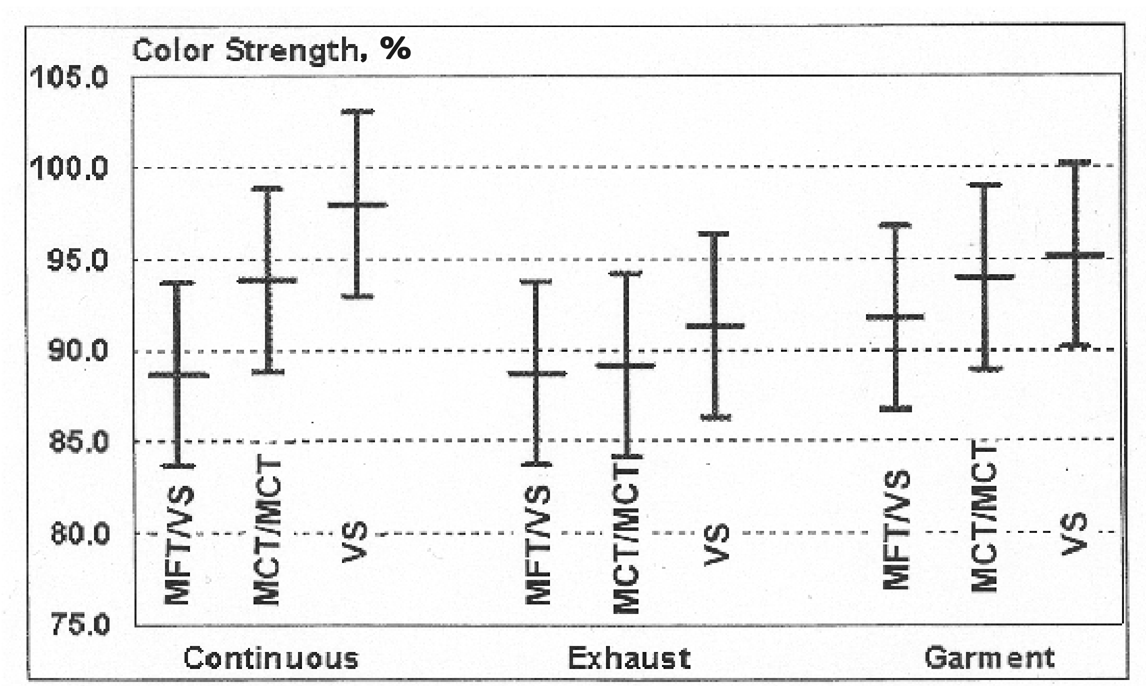
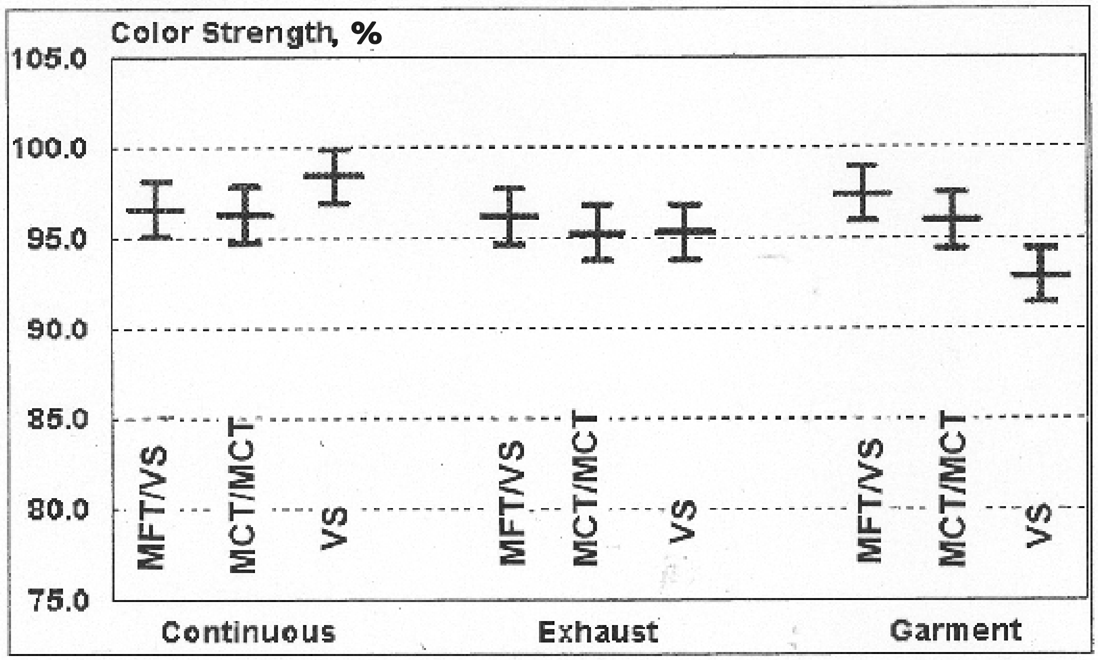


Figure 6. The effects of dyeing system and dyeing process on the color strength of the navy shades finished with a conventional resin formula after 20 home laundry/tumble dry cycles.



The preceding figures demonstrate that color retention values of at least ninety percent are achievable at twenty home laundering/tumble drying cycles on black and navy reactive shades using a conventional finish formulation regardless of how the fabric is dyed. High percent color retention results are also achievable on a dark green shade.

COLOR CHANGE

Figures 7-9 show DE or shade change values for black, green and navy colors respectively after 20 home laundering/tumble dry cycles. DE values range from 0.7 to 1.7. A DE value of 2.0 is what the AATCC manual defines as a visible color change. A value from 0.5 to 1.5 is considered as a good to excellent rating. Although quite a few of these fabrics have a DE value of 1.0 or greater, this is expected after 20 HLTD cycles.

Figure 7. The effects of dyeing system and dyeing process on the color change (DE) of the black shades after 20 home laundry/tumble dry cycles.

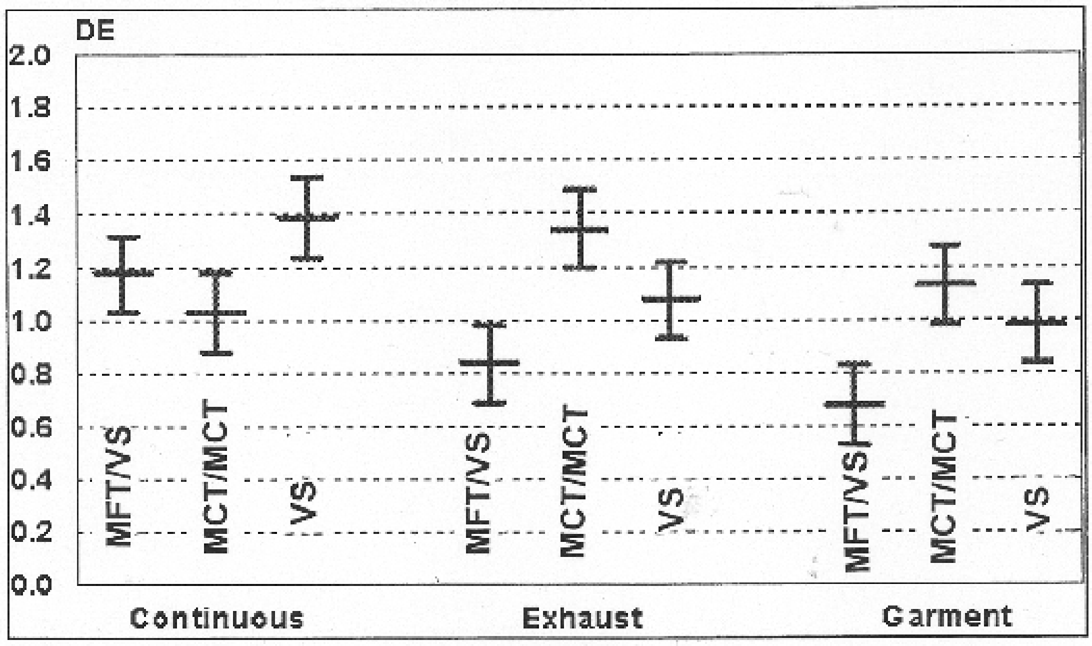


Figure 8. The effects of dyeing system and dyeing process on the color change (DE) of the green shades after 20 home laundry/tumble dry cycles.

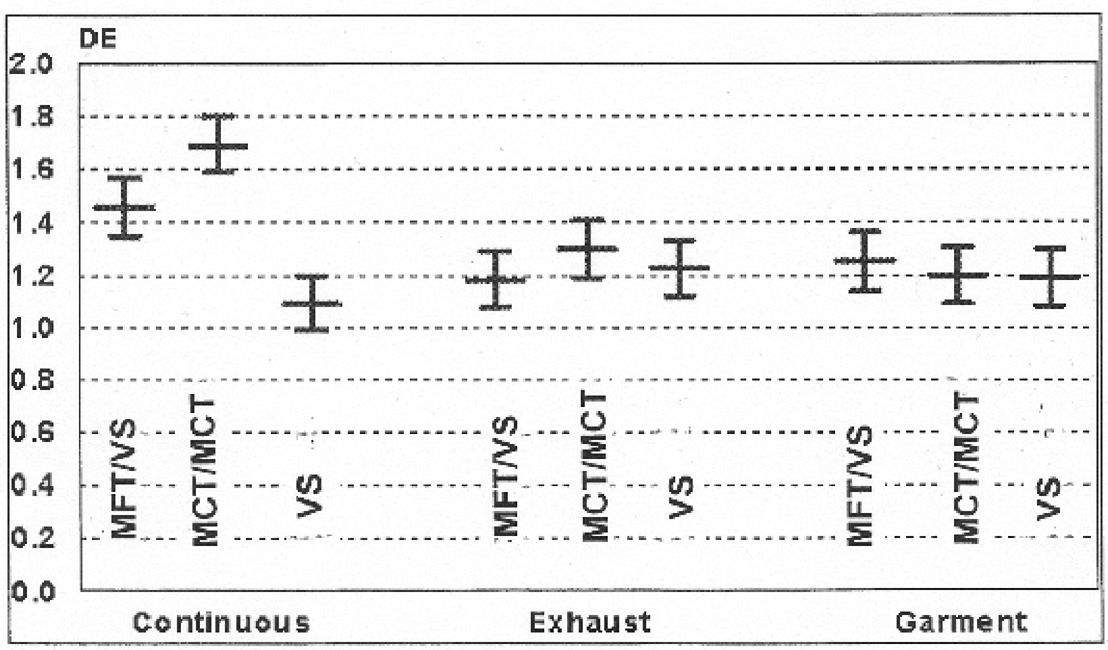
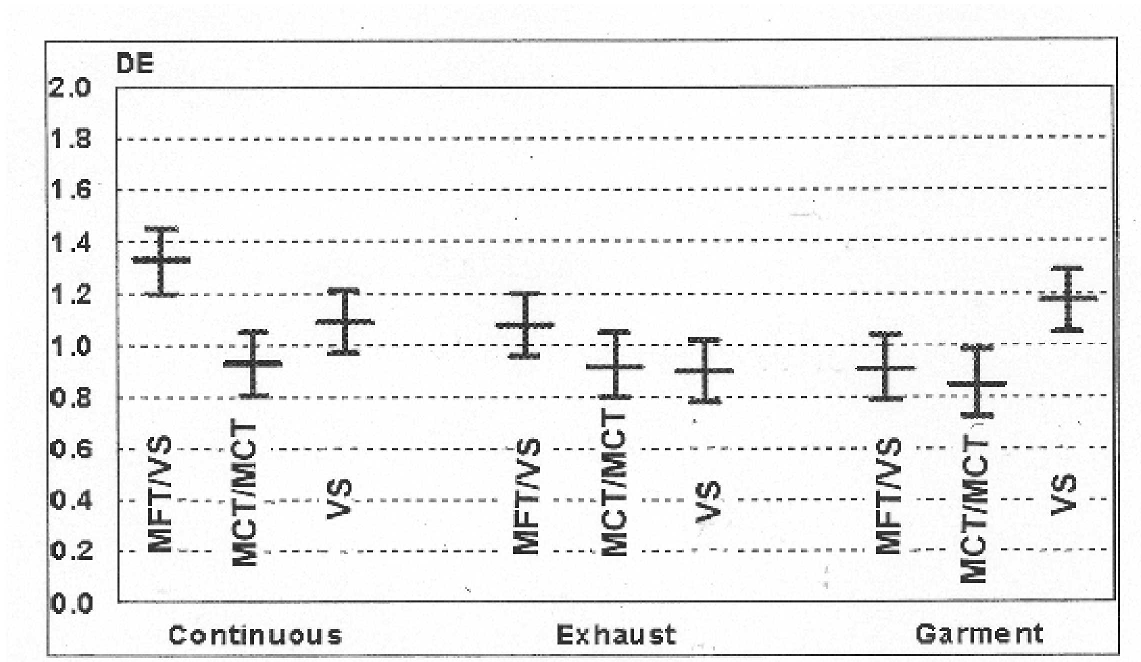


Figure 9. The effects of dyeing system and dyeing process on the color change (DE) of the navy shades after 20 home laundry/tumble dry cycles.



CREASE EDGE ABRASION

The crease edge rating is a measure of color loss along the raised area of the crease. A rating of 5 is perfect (no crease edge abrasion) and a rating of 1 is the poorest rating possible. The term frosting is used to describe overall color loss on raised areas of the garment created by abrasion. These raised areas include seams and pocket edge areas of the garment.

Resistance to crease edge abrasion or the frosting condition is color or shade dependent. Dye combinations and the amounts of dye in a particular formulation have an influence on the occurrence of the 'frosting' condition. The use of reactive dyes can dramatically impact crease edge abrasion by reducing the frosting condition on garments containing a crease. This is demonstrated in Figure 10 (black shade), Figure 11 (green shade), and Figure 12 (navy shade). Typical vat and sulfur shades dyed by continuous methods give a crease edge rating in the 2 range.

Figure 10. The effects of dyeing system and dyeing process on the crease edge abrasion of the black shades after 20 home laundry/tumble dry cycles.

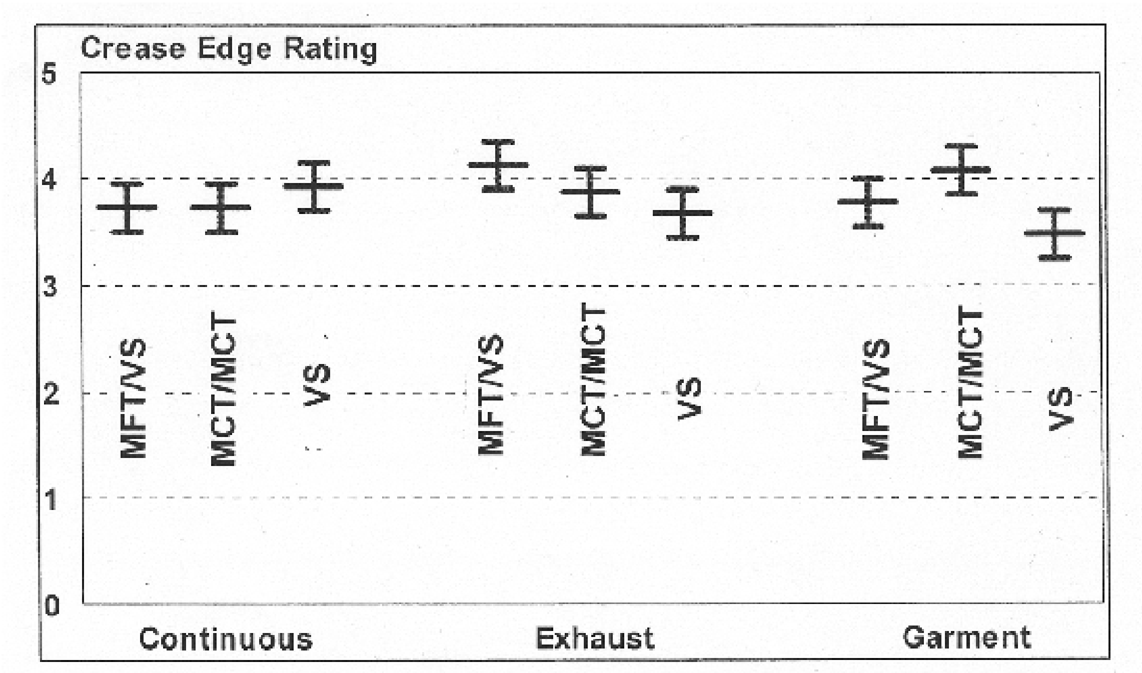


Figure 11. The effects of dyeing system and dyeing process on the crease edge abrasion of the green shades after 20 home laundry/tumble dry cycles.

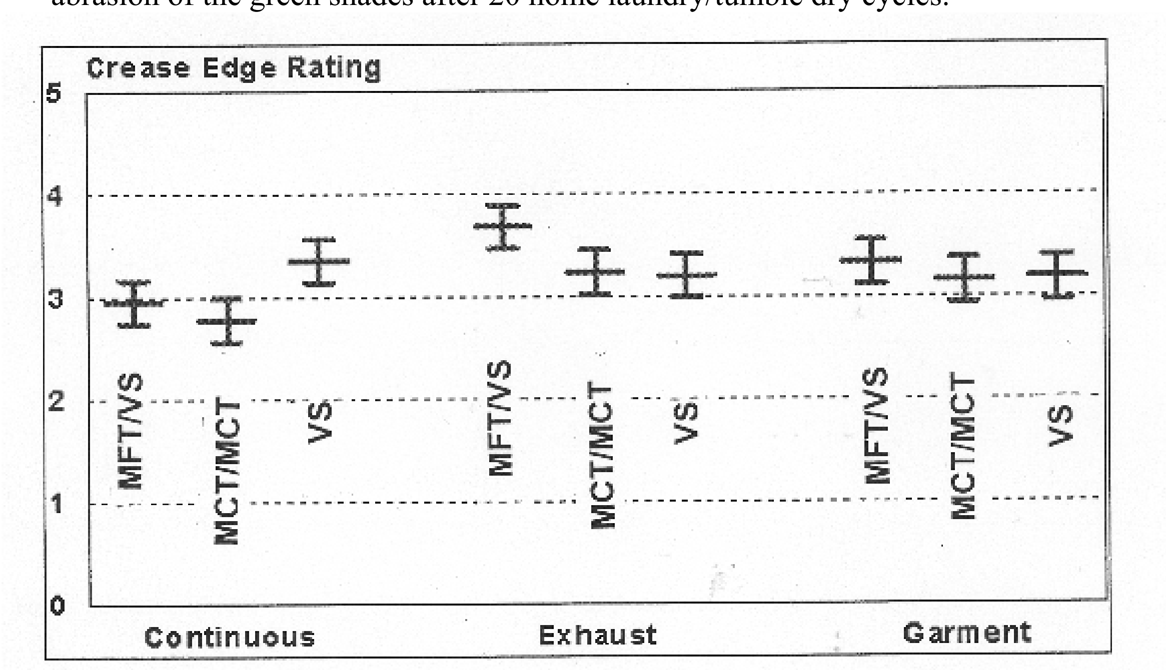
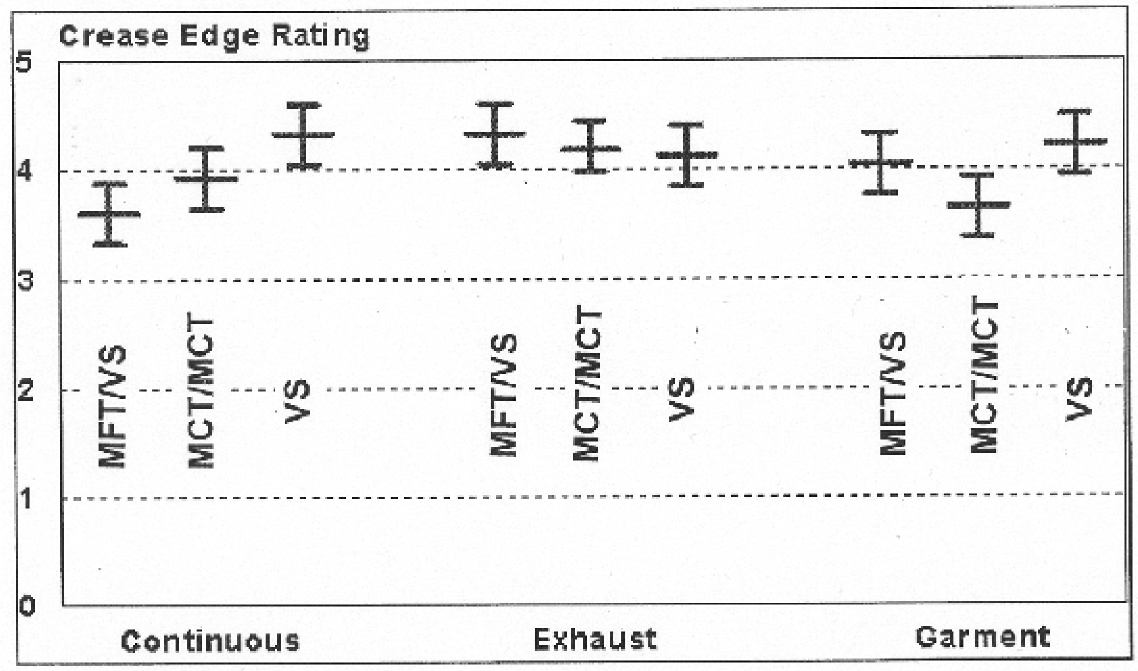


Figure 12. The effects of dyeing system and dyeing process on the crease edge abrasion of the navy shades after 20 home laundry/tumble dry cycles.



MERCERIZATION

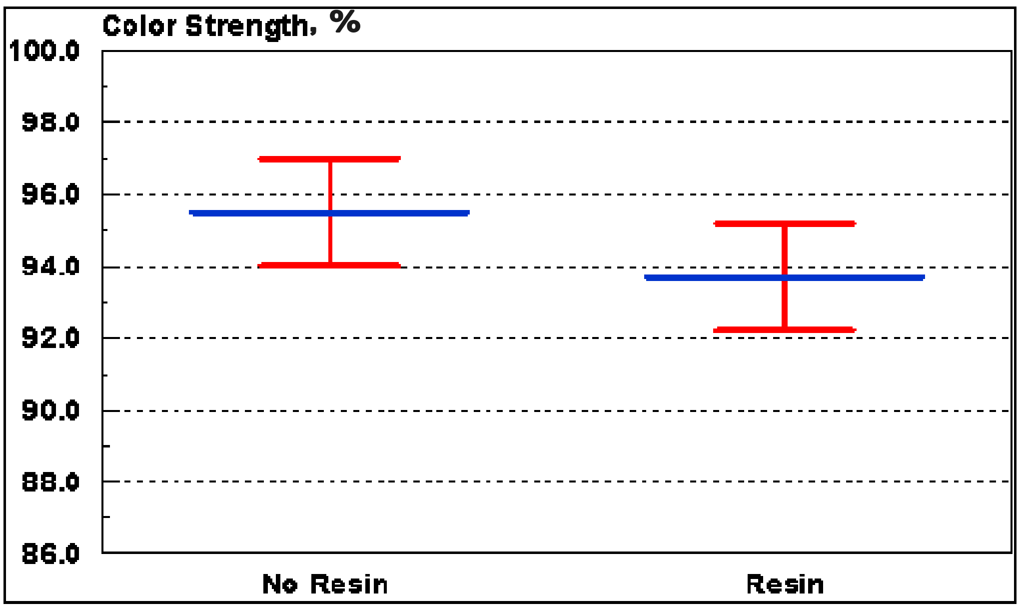
Generally, woven fabrics are mercerized before dyeing in order to improve immature cotton coverage, to achieve more uniform dye coverage of the fabric, to provide luster, and to increase dye yield or shade build on the fabric. Barium number is a measure of completeness or extent of mercerization. Caustic concentration, temperature of caustic application, and dwell time are important factors to consider in the mercerization process. Barium numbers of commercial woven fabrics that have been mercerized normally fall in the range of 120 to140. A higher barium number indicates a greater degree of mercerization compared to a lower number. The higher value will be reflected in greater dye yields and color values that can be achieved on a more thoroughly mercerized fabric.

Comparison of conventionally mercerized woven fabric to woven fabric manufactured from mercerized fiber (not widely practiced commercially) using a similar dye formula demonstrates that fabric constructed from mercerized fiber gives greater dye penetration under similar dyeing conditions, a higher frequency of thoroughly dyed fibers per unit cross-section, greater resistance to color wash down, and an improvement in the resistance to the formation of crease edge abrasion[6]. An example of improved dye penetration has been shown in Figure 3.

FINISHING APPLICATIONS

A durable press resin finish application, in general, may improve color strength and reduce the color change on dark colors, but is not always the case and is usually dye formula dependent. The effect of a resin finish on color strength or color retention of a woven fabric dyed to a black shade is shown in Figure 13.

Figure 13. The effects of resin treatment on the color strength of a black shade after 20 home laundry/tumble dry cycles.



The use of a resin finish can positively affect color change and improve color retention. Figures 14 and 15 show the effect of a resin finish for a green and navy shade respectively.

Figure 14. The effects of resin treatment on the color strength of the green shades after 20 home laundry/tumble dry cycles.

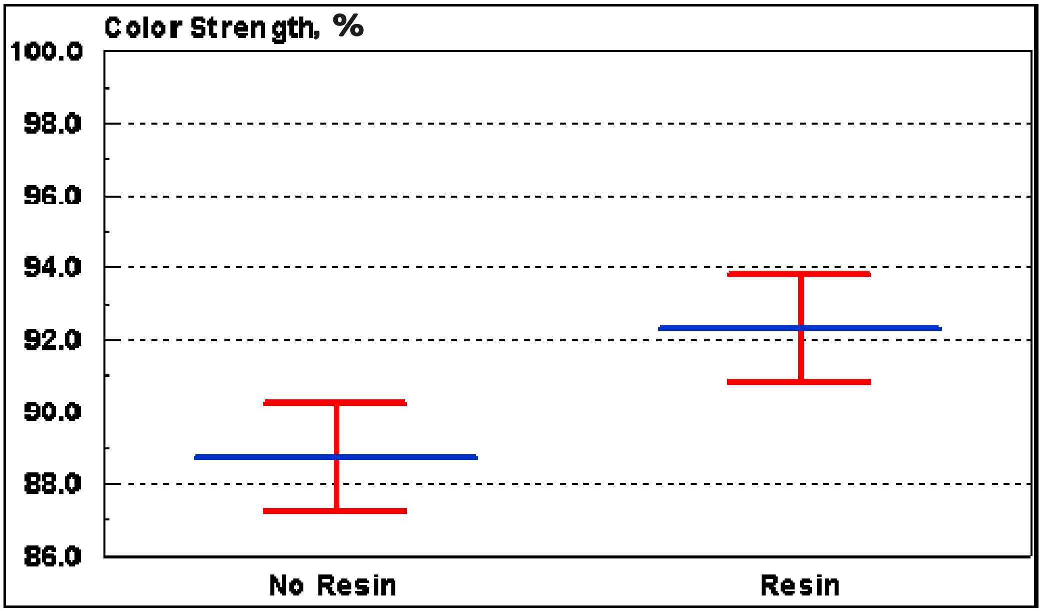
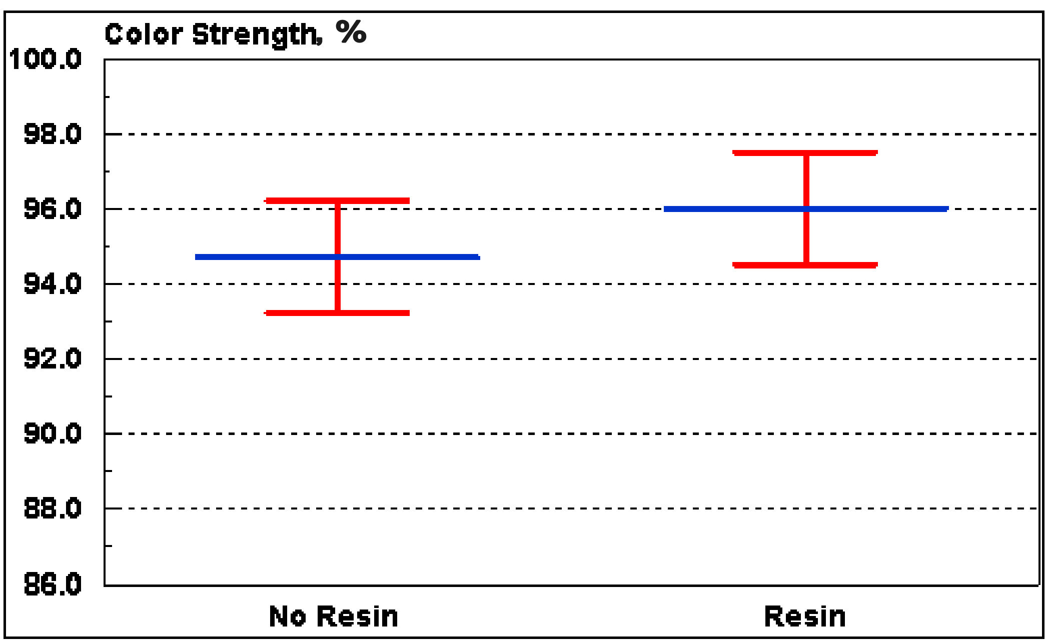


Figure 15. The effects of resin treatment on the color strength of the navy shades after 20 home laundry/tumble dry cycles.



Figures 16 through 18 show the reduction in color change (DE) when a finish with a cross-linking or durable press resin is used. Finishing applications can affect color retention (% strength) and color change (DE) in a positive way on woven fabrics. A lower DE value is preferred. The higher the DE, the greater is the color change.

Figure 16. The effects of resin treatment on the color change (DE) of a black shade after 20 home laundry/tumble dry cycles.

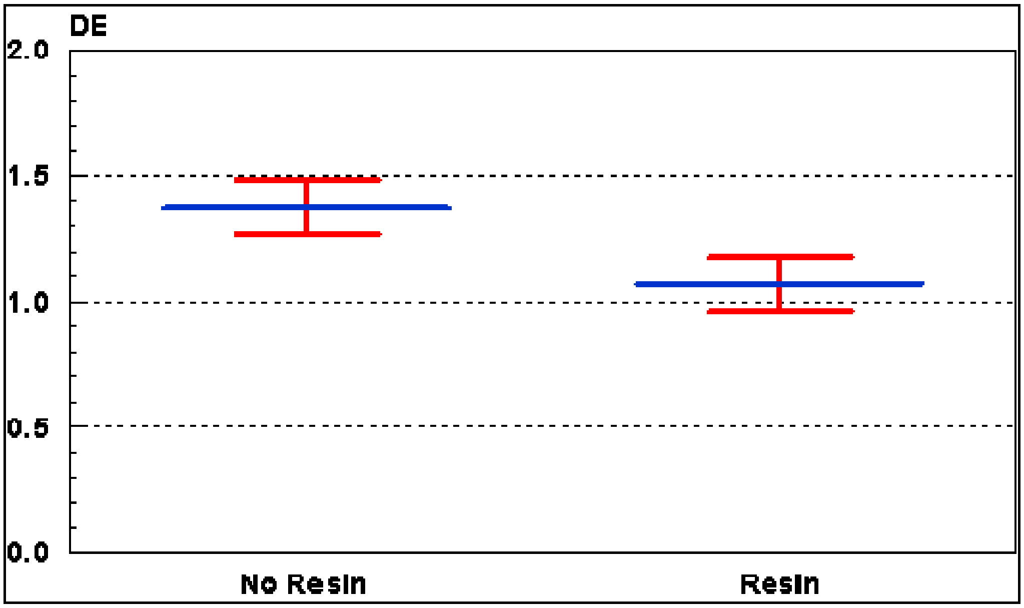


Figure 17. The effects of resin treatment on the color change (DE) of green shades after 20 home laundry/tumble dry cycles.

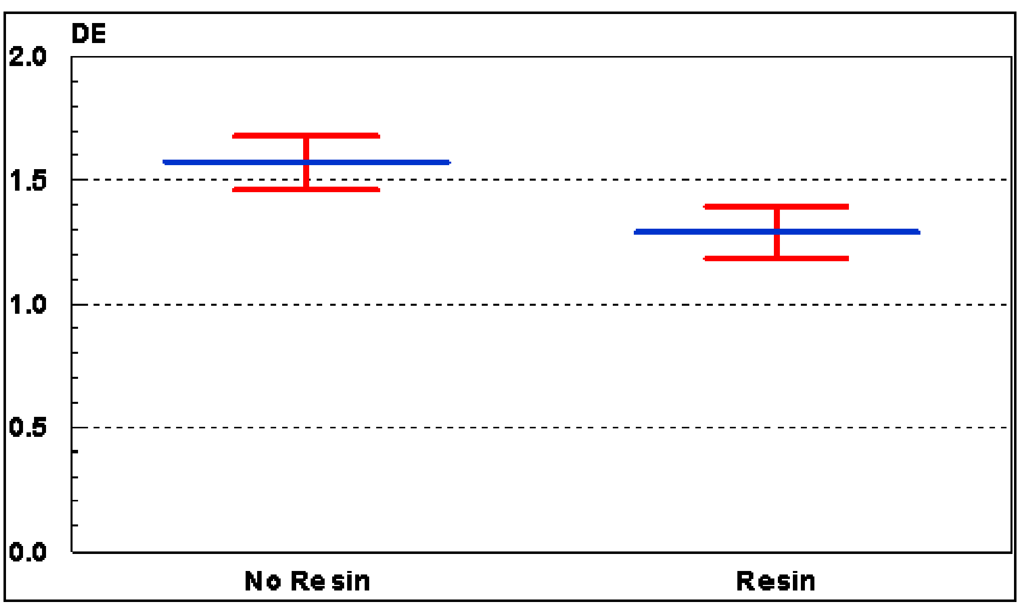
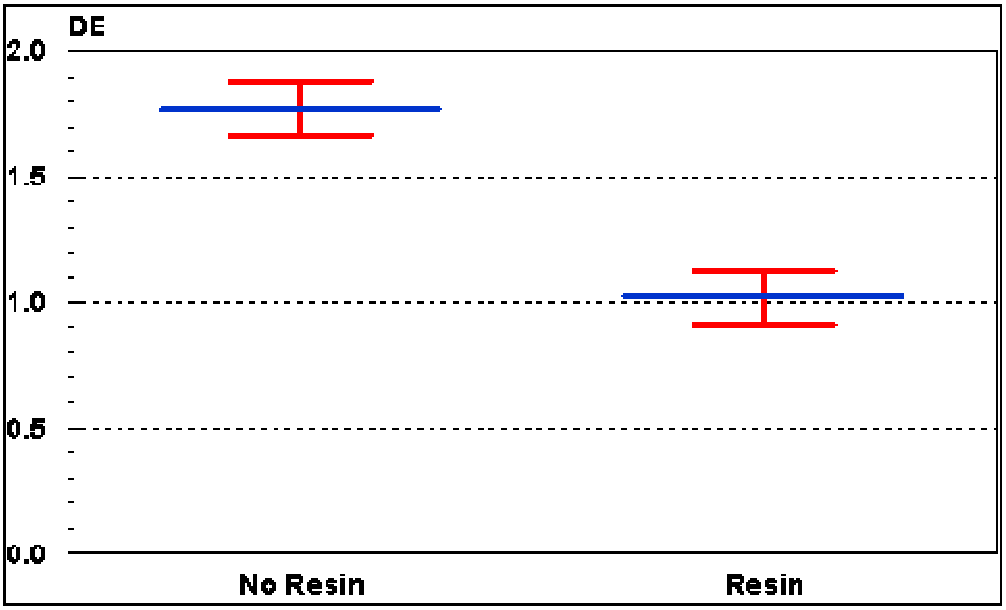


Figure 18. The effects of resin treatment on the color change (DE) of navy shades after 20 home laundry/tumble dry cycles.



Foam Finishing

Foam application methods, also known as foam finishing, can be used to apply single-sided finish formulas to woven fabric at very low wet pick up levels. Wet pick up levels of 20-30% can be employed and produce uniform and consistent application of chemical treatments. Foam application techniques may also be used to apply chemistry to both sides of a woven fabric at varying levels. A foam application technique lends itself to an application of one-type chemistry to one side of the fabric and another type of chemistry to the opposite side of the fabric if a two-sided finish is desired. Resin finishes applied to the face side of a woven fabric versus applied to the back side of a woven fabric have shown a lower degree of crease edge abrasion after repeated laundering cycles. In part, this improvement is likely due to the fact that a back-sided application yields a more pronounced crease than a face sided application. The exposure of a more distinct crease tends to produce more abrasion effects.

Other Chemistry

The use of an acrylic binder product[7] and other specialty polymers[8] has demonstrated positive effects on color retention and reduction in change of color (DE). Some chemical additives such as softeners may affect the color performance properties of a woven fabric either in a positive or negative fashion. Empirical evaluations must be conducted in order to determine performance attributes of finish formulations on various fabric constructions, weight ranges, yarn counts, and the various colors, as well as effect on hand.

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- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.
- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.
- Computerized fiber management techniques result from in-depth fiber processing research.
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- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.
- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.
- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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