

A COMPARISON OF SOIL REPELLENT vs. DUAL ACTION FLUOROCARBON FINISHES ON COTTON BLENDS

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Introduction

“Imagine clothes than can go from the laundry hamper into the washing machine, to the dryer and on to the office.”¹

As the textile and apparel industry moves into the twenty-first century, the expectation for performance has been added to the business of fashion as the industry attempts to meet the customers’ more demanding needs. Textiles that offer convenience appeal to the consumer’s busy life style and save time as well as money.

Performance textiles include technical textiles, smart textiles and functional textiles. Consumers no longer have to make apparel selections based on individual finishes such as wrinkle-resistant, easy-care and/or fabric protection. They can now have all of these bundled into one high performance textile finish. An example of this innovative technology can be demonstrated by the introduction of stain protection technology. In the spring and summer of 2002, Savane®, Dockers®, Lee® Jeans and Haggar®, all leading manufacturers of men’s and women’s pants, offered stain repellent finished bottom-weight twill fabrics that enabled soils to just roll off the pants.

The technology behind these products was a fluorocarbon finish that imparts a high-tech performance fabric protector, which enables the fabric to repel spills on contact. The finish imparts water repellency and stain resistance as it alters the surface properties of the fabric.

A study was conducted to compare care practices on soil repellent fluorocarbon treated garments. This study was published by the authors in the March 2004 AATCC Review.

Use of fluorochemicals, known for their unique surface properties, is a technology that imparts a barrier to water and soils due to the hydrophobicity that it imparts to the individual fiber. Fluorochemicals with a surface tension between 10 and 15 dynes/cm are applied to the surface of individual fibers. When a drop of water contacts a textile surface, wetting typically occurs. However, if the surface tension of the fabric has been altered with a fluorochemical, the fabric will allow a droplet of water (with a surface tension of 72 dynes/cm) to bead up and roll off without penetrating the fabric structure.

As fluorocarbon chemistries and chemical combinations have been developed, the applications of fluorocarbons as soil repellent and stain release finishes have expanded from their introduction on men’s pants to consumer and institutional apparel. The advantage of recent advancements in fluorocarbon stain repellent finishing is that it is an applied finish that does not affect other properties of the fabric. For example, the technology adds stain repel/release

functionality but permits cotton and cotton/blended fabrics to maintain their wrinkle resistant and easy care properties.

The introduction of soil repellency has been accepted by the apparel industry but some consumers have experienced problems when soil repellency fails allowing stains to become trapped or embedded in repellent finished fabrics. Repellent finishes prevent water from entering the fabric surface, thus decreasing their potential to remove stains during washing.

Some of the more recent stain protection technologies that have been introduced recently provide dual-action stain protection as they impart soil repellency combined with stain release technologies. These newest advancements in stain protection have been introduced as the next generation of stain protection products which include StainSmart® by Milliken, Advanced Care Teflon® by DuPont®, Scotchgard Protector™ by 3M®.

The new dual-action technologies provide the ‘best of both worlds’ in stain protection. The ‘repel’ function allows most liquid-based spills, such as coffee, cola or blood to bead up and be wiped off, thereby preventing soils from staining the fabric. The ‘release’ function works on soils that penetrate fabrics such as grass, mustard and motor oils.

A dual-action stain repellent/stain release technology functions by repelling water-based stains while at the same time allowing soils that become stains when they penetrate the finish to be released. The finish technologies work by allowing surfactants and detergents to move through the fabric and assist in the removal of the stain.

The Clothes Care Research Center™ (CCRC) took on the challenge of conducting a ‘head-to-head’ comparison of soil repellent and a stain repel/release product in the apparel market. CCRC is a cooperative effort among Cotton Incorporated; GE Consumer Products; Milliken & Company; Procter & Gamble; VF Imagewear; the University of Kentucky’s Textile Testing Laboratory and Northwestern University’s McCormick School of Engineering and Applied Science. The members represent every phase of clothing care in the home, from textiles and apparel to appliances and detergents. The mission of CCRC is to understand, evaluate and improve clothes care in the home.

Do the treated fabrics need special cleaning care? Are the finishes durable? To meet the challenge and answer these questions, the technical committee of the Clothes Care Research Center™ (CCRC) developed a series of designed experiments to assess the recommended care instructions for fluorocarbon-treated garments. A leading brand of fluorocarbon treated pants was selected. A member of the CCRC consortium provided the dual-action finished pants.

The objective of CCRC’s research project was to compare the appearance and performance characteristics of both finishes. The care instructions provided by the leading brand was used as a guideline for the care instructions for both soil repellent and stain repel/ release products.

“... should provide stain repellency for approximately 30 washings. Follow care instructions for optimal performance. Machine wash, warm with a liquid detergent.

Tumble dry, durable press cycle, remove promptly. Do not use fabric softener or dryer sheets. Wash and dry with like colors. For best stain repellency, iron after fifth washing.”

Experimental Design

A factorial research design was used to evaluate the soil repellent and stain repel/ release finishes. The aesthetic and functional characteristics of fluorocarbon-treated khaki pants were evaluated. The characteristics of water repellency, oil repellency, soil release, colorfastness, smoothness appearance, and edge abrasion were evaluated at wash/dry intervals of ten, twenty and thirty cycles. The effects of fabric softener and ironing on the aesthetic and functional performance of the finish were factors included in the research design. Two fabric finishes: “Soil Repellent” treated 60% cotton/40% polyester and dual-action “Soil Repel/Release” treated 60% cotton/40% polyester were used. The “Soil Repellent” pants were the ones used in the previously-published AATCC Review article.² The dual-action “Soil Repel/Release” fabric was woven, prepared, dyed and finished by one CCRC member that were made into garments by another CCRC member company.

The factorial experiment called for six garments from each fabric type to be washed with liquid fabric softener and a different six garments softened with a dryer sheet in the dry cycle. For each set of six, two were washed ten times, two were washed twenty times and two were washed thirty times. Another six garments from each fabric type were washed in the same way, but without any fabric softener. Thus a total of thirty-six garments were used in the design.

In addition to studying the effect of fabric softener, the factorial design enabled the evaluation of the effect of the ironing recommended on the care label using the following procedures:

- After the 5th, 10th, 15th, 20th, 25th and 30th, wash/dry cycle, the right pant leg of each garment was ironed (right side out) with the crease placed flat on an ironing board. Both sides of the right leg were ironed up to the intersection of the crotch seam using a hand iron – Synthetic Setting.
- The left leg of each garment was left un-ironed for comparison.

Cleaning Procedures: Based on the industry experience of CCRC’s corporate members, the following conditions were selected to represent a typical consumer practice:

- Vertical axis washing machine and electric dryer.
- Each load of laundry included 6 garments: Weight 7 ½ lbs.
- Detergent – A leading national brand of liquid detergent– 98 grams for all 10, 20 & 30 wash cycles. The wash cycle for stained pants - Liquid detergent – 120 grams.
- Temperature: Wash temperature was warm (90 ° F). All loads used a cold-water rinse.
- Fabric Softener – A leading national brand of liquid fabric softener - 30 grams or fabric softener dryer sheets from a leading national brand of softener sheets – 1 dryer sheet per load.
- Cycle Profile - Washer - Easy Care/Perm Press cycle as per recommended garment care label: soil level – medium; wash speed – medium; spin speed – fast; water usage

- load size large - 21 gallons of water per wash & rinse cycle; water hardness – 9.5 grains and time – 37 minutes of total cycle.
- Cycle Profile - Dryer – Easy Care/Perm Press Sensor Dryer Plus; dryness level – dry and heat setting – medium for a 56 minute dry time.

Performance Measurements: For each condition, after the 10th, 20th & 30th wash/dry cycles were complete; pants were evaluated for the performance measurements of appearance and stain repellency. The following test methods were used.

- AATCC 143-2001 Evaluation of Appearance of Garments After Repeated Home Laundering³ –
 - Color Change Rating – AATCC Evaluation Procedure 1 Gray Scale for Color Change⁴
 - Edge Abrasion Rating – Subjective Assessment
 - Smoothness Rating – AATCC 124-2001 Appearance of Fabrics after Repeated Home Laundering⁵
- Evaluation of Repellency –
 - 3M Oil Repellency Test I - Hydrocarbon Liquids of Known Surface Tension⁶
 - 3M Water Repellency Test II – Water/Alcohol of Known Surface Tension⁷
 - Water Repellency: Spray Test (AATCC #22-2001)⁸

To assess the effect of ironing, all performance evaluations were made on both the right and left pant legs. The section of the pant legs below the crotch seam was the only area examined when conducting the performance evaluations.

Stain Release Evaluation: After the pants were evaluated for performance, the pants were shipped to Procter & Gamble for application of soils to evaluate stain release. For each pant leg, for all garments, soils were applied and returned by shipment to the University of Kentucky. Four soils: bacon grease, spaghetti sauce, grape juice and dirty motor oil - were applied to both the right and left pant leg of each garment to test the effect of ironing after every 5th cycle. (The right leg had been ironed periodically according to the design.) This study was a follow up to the study in AATCC Review (March, 2004).² Since soil release evaluation had already been done in that study for the same type of “Stain Repellent” treated pants under the same wash conditions, it was not repeated. Thus, appropriate soil release data for the “Stain Repellent” treated pants from the original study was used to compare to the soil release data from the dual action “Stain Repel/ Release” pants from this study.

- All stained pants were washed one time, according to the same conditions called for that garment in the experimental design, except that the amount of detergent was increased to 148 grams of liquid detergent.
- After washing, the pants were hung to dry before being evaluated for stain release as per AATCC 130-2000 Soil Release: Oily Release Method.⁹

Data Analysis

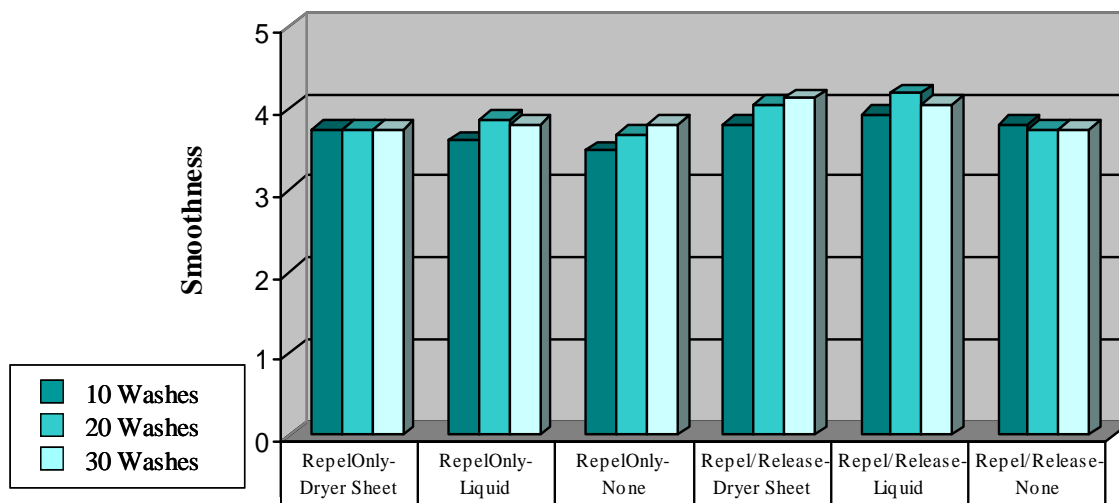
When the laboratory evaluations were complete, the data was sent to Northwestern University for statistical analysis. The data were analyzed as a single data set. For each of the tests performed (i.e. Smoothness, Color Change, Edge Abrasion, 3M Oil Repellency Tests, etc.), an Analysis of Variance (ANOVA) model was fit to the data and tests were conducted on the statistical significance of the main effects and two-factor interactions of the following factors: Finish (Repel Only or Repel/Release), Ironing (Ironed every 5th wash or Not Ironed), Fabric Softener (None or Liquid), and Washes (10, 20 or 30 Wash/Dry Cycles). All tests were conducted at the 99% confidence level. All statistically significant main effects and interactions were noted, displayed by plotting and discussed by the CCRC members. Many of the significant effects were no surprise. Other effects, although statistically significant, were not of sufficient size to be noticed by consumers. Due to the fact that the responses in this study do not follow a normal distribution, effects that were found to be significant using ANOVA were confirmed by the nonparametric Kruskal-Wallis test. Only effects that were confirmed to be significant and that represent noticeable improvement are discussed below.

Results

Evaluation of Appearance: The performance characteristics of smoothness, color, and edge abrasion were evaluated to support or dispute the claim that the addition of a soil repellent or stain repel/release finishes did not affect the interaction of these properties with the selected laundering conditions. Figures 1 - 3 show the results of evaluating the effect of finish on appearance. In every chart, higher ratings indicate better performance.

Figure 1. Evaluation of Smoothness – AATCC 124⁵

Smoothness after 10, 20 and 30 Wash/Dry Cycles



Smoothness: Figure 1 summarizes the effects of finish type and fabric softener for smoothness performance. When compared for smoothness, the Repel/Release garments

performed slightly better (4.0 on average) than the Repel Only fabric (3.7 on average). As expected, ironing improved the smoothness ratings (by about 0.4 points on average) for both finishes.

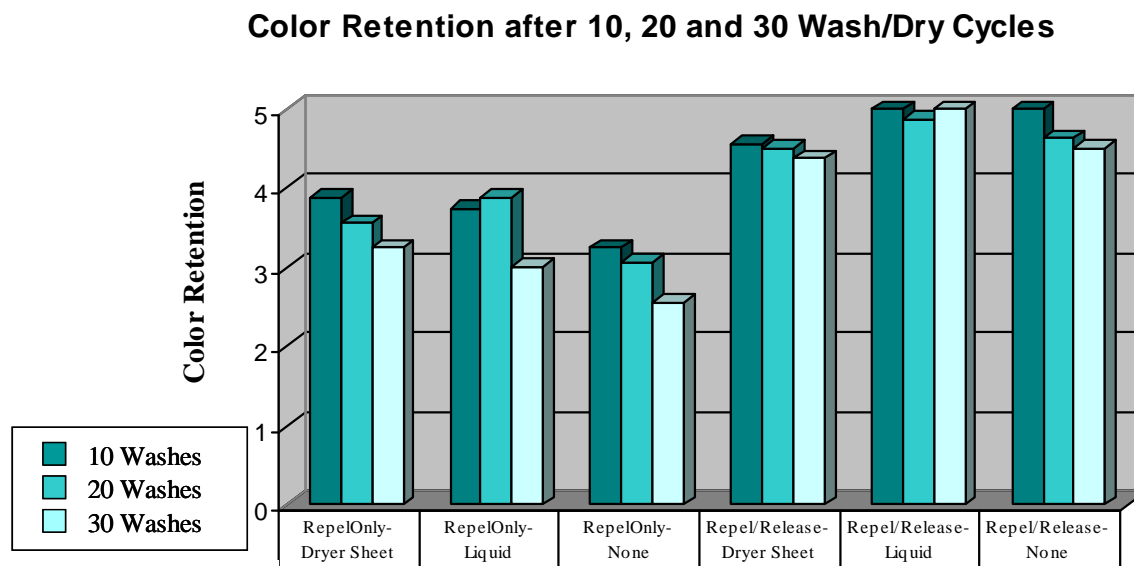
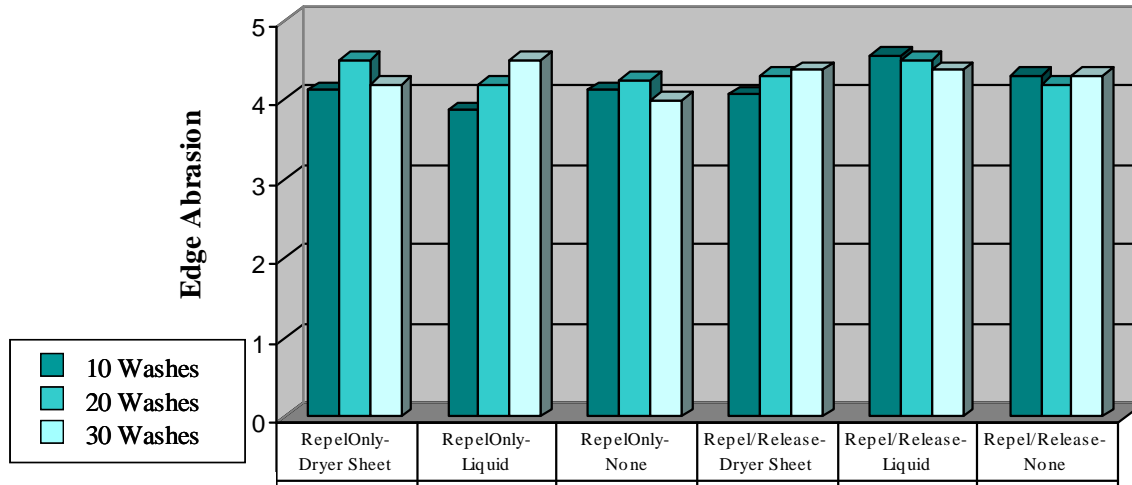


Figure 2. Evaluation of Color Retention – AATCC Gray Scale for Color Change⁴

Color: The original color of both pants was khaki. AATCC Evaluation Procedure 1⁴, subjective evaluation of color change was used to compare the two types of finishes after 10, 20 & 30 wash/dry cycles. The results showed that the Repel/Release finished pants performed much better (4.7 on average) than the Repel Only finish (3.2 on average). Regardless of the treatment, the Repel/Release finished pants rated 4.25 to 5.0 after 30 wash/dry cycles compared to ratings of 2.25 to 4.0 for the repellent finish. For the Repel Only pants, color retention was better when fabric softener was used (by 0.6 points on average). Use of fabric softener made little difference for the Repel/Release pants. Ironing had no effect on color retention. Figure 2 summarizes the effect of finishing and fabric softener on color retention.

Figure 3. Evaluation of Edge Abrasion

Edge Abrasion after 10, 20 and 30 Wash/Dry Cycles



Edge Abrasion: A common consumer complaint with twill pants has been the apparent edge abrasion with wear and/or care. Figure 3 presents the results of evaluating edge abrasion after 10, 20 and 30 wash/dry cycles for both types of finishes. Both fabrics performed well on edge abrasion and none of the factors had a significant effect on edge abrasion. Thus, all the variation seen in Figure 3 could be due to random variability.

Evaluation of Performance – Stain Repellency: The AATCC Water Repellency: Spray Test⁸ was used to evaluate water repellency. The evaluation of stain repellency utilized the 3M Oil and Alcohol tests^{6,7} and results were as follows:

Figure 4. Evaluation of Repellency after 10 wash/dry cycles^{6,7,8}

Stain Repellency After 10 Wash/Dry Cycles

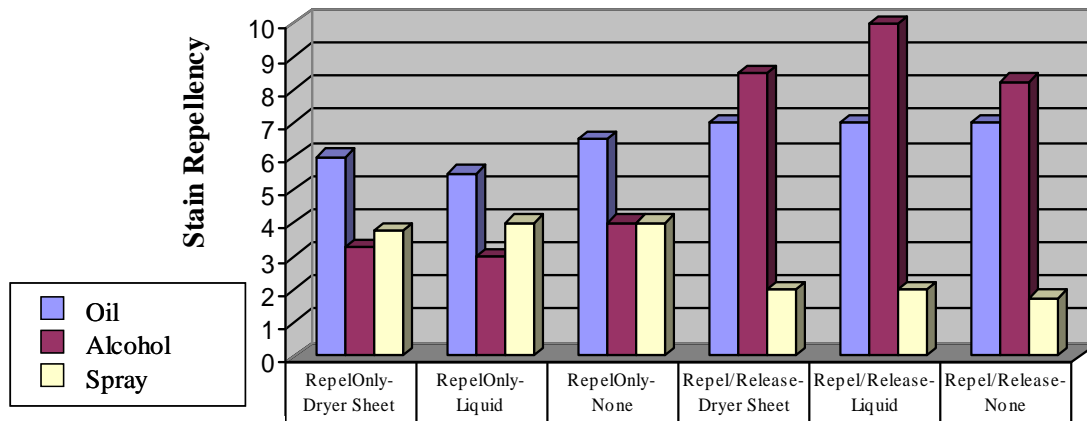


Figure 5. Evaluation of Repellency after 20 wash/dry cycles^{6,7,8}

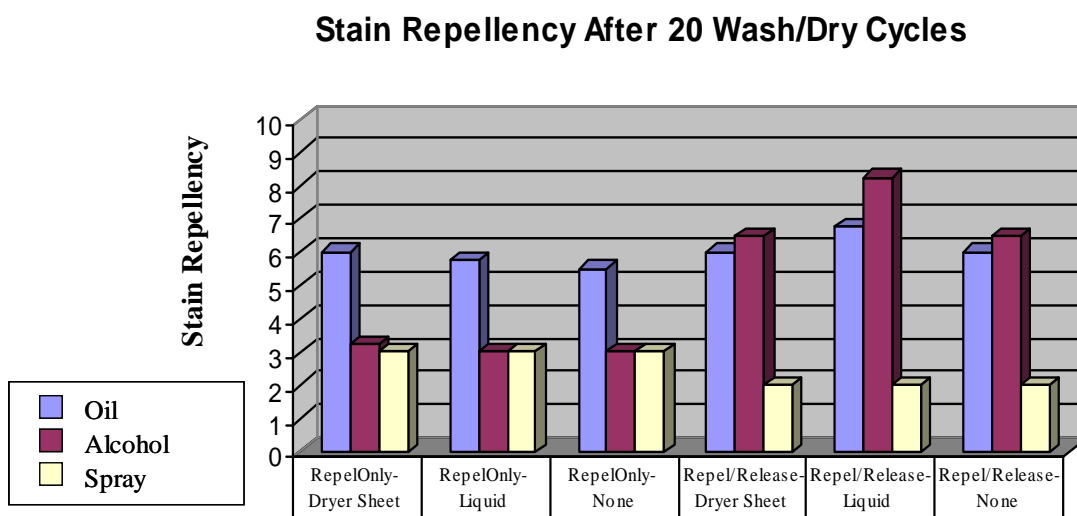
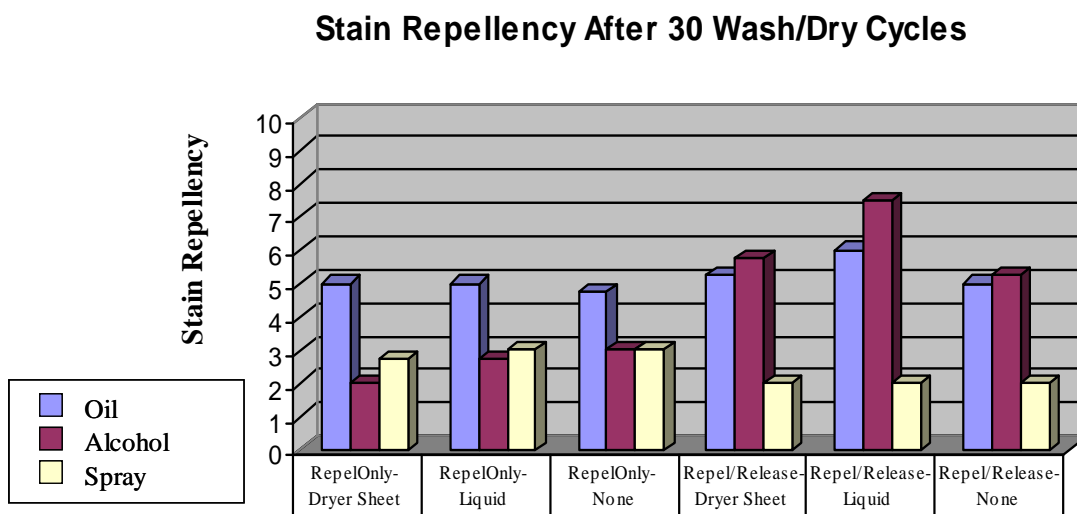


Figure 6. Evaluation of Repellency after 30 wash/dry cycles^{6,7,8}



The performance degrades as Wash/Dry cycles are increased from 10 to 30, but the trends in the plots are similar. We will concentrate on the performance after 30 Wash/Dry cycles shown in Figure 6. For performance in the Oil and Alcohol tests, the performance of the Repel/Release fabric is above the performance of the Repel Only fabric. After 30 washes, the Oil test performance for the Repel/Release fabric averages 5.4 whereas the Repel Only material

averages 4.9 (On its own this difference was not significant, but when averaged across all wash cycles the Repel/Release fabric showed significantly better performance). For the Alcohol test after 30 washes a significant difference was seen, the average ratings are 6.2 and 2.6 on average for the Repel/Release and Repel Only fabrics respectively. This can be seen by comparing the height of the first three red bars with the height of the last three red bars on Figure 6. However for the Spray test (the yellow bars in Figure 6), the Repel Only fabric (rating 2.9 on average after 30 washes) had a significantly higher rating than the Repel/Release fabric (rating 2.0 on the spray test for all conditions).

In the previous study in AATCC Review (March, 2004) ², we reported that the data showed a strong interaction resulting in high performance for Repel Only garments that were ironed and softened with dryer sheets. Since we could not find any good scientific explanation for this performance, we repeated the testing in this study. The strong interaction was not confirmed in this study and thus we feel that this apparent interaction was due to random variation in the garments and wash/dry process.

Evaluation of Performance – Stain Release: The soils that were applied by Procter & Gamble are used by the detergent manufacturer to develop and evaluate detergents. The soils were designed to discriminate between subtle changes made in detergent formulations. All soil applications were aged a minimum of 48 hours prior to washing. The stains enabled CCRC to evaluate stain release whereas the 3M oil and water and the AATCC Spray tests were performed to evaluate oil and water repellency. The effects of ironing and fabric softener use and type of fabric finish on stain release were also evaluated.

Both the Repel Only and Repel/Release pants, regardless of the conditions being evaluated, released the bacon grease, the grape juice, and the spaghetti sauce (see Figures 7-9). However, there was a significant difference in the stain release of dirty motor oil. The Repel/Release fabric after ten washes without fabric softener was able to release the motor oil stain to a level that would be acceptable to a consumer (an average rating of 4.1). The Repel Only fabric under the same conditions averages a rating of just 1.8. In every other condition, the Repel/Release fabric substantially outperforms the Repel Only fabric for stain release of the motor oil. The effect of fabric softener was not found to be significant.

Figure 7. Evaluation of Stain Release after 10 wash/dry cycles⁹

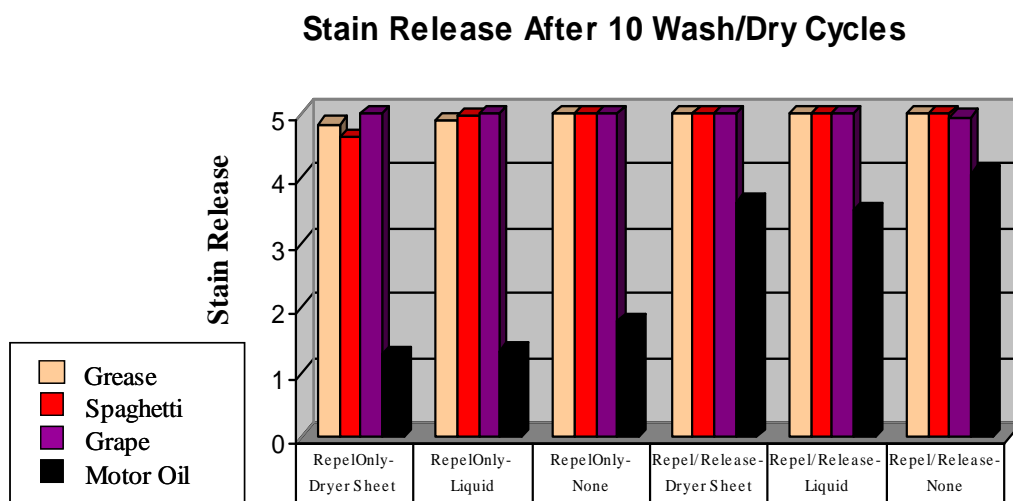


Figure 8. Evaluation of Stain Release after 20 wash/dry cycles⁹

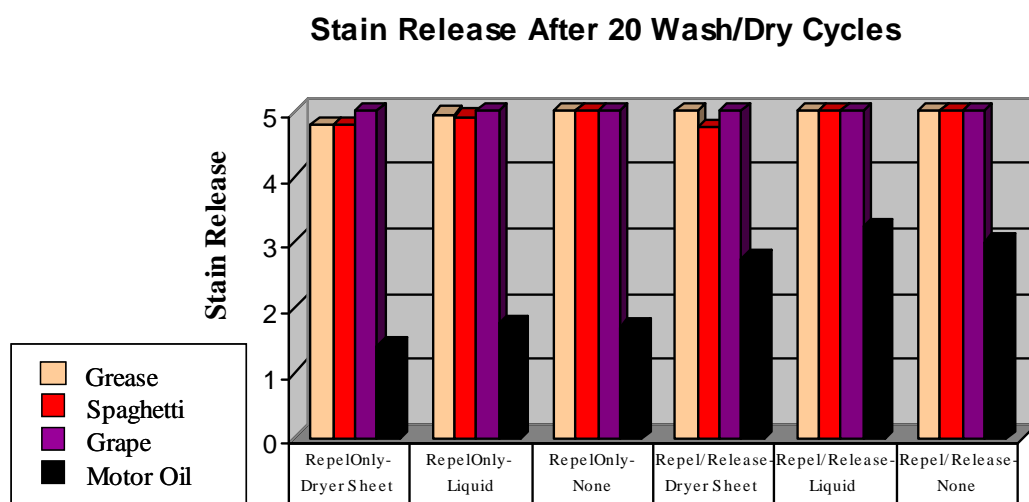
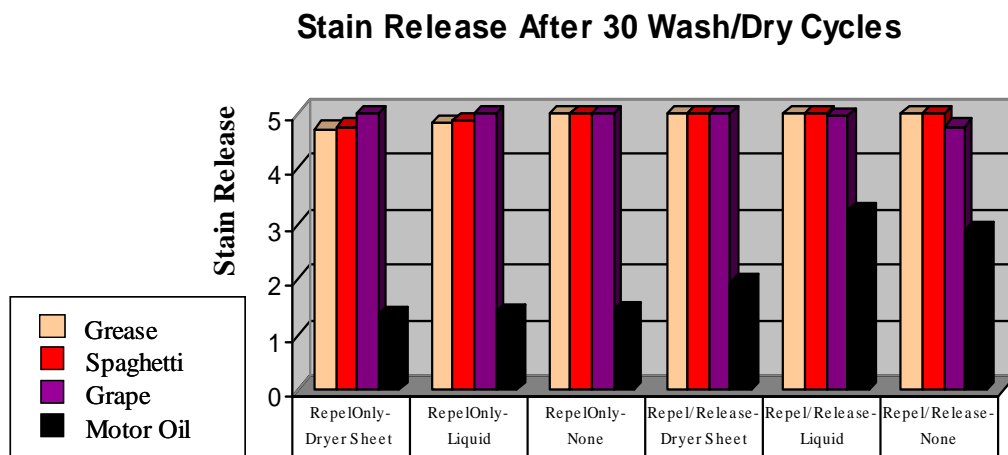


Figure 9. Evaluation of Stain Release after 30 wash/dry cycles⁹



Conclusions

In every performance test except the spray test, the Repel/Release fabric outperformed the Repel Only fabric. Most notably, the color retention, the performance in the alcohol test and the release of the dirty motor oil stains was substantially better for the Repel/Release fabric. Due to the fact that fabric softener and ironing had little to no effect on most of the Repel/Release performance results, we conclude that the warning against using fabric softener and the suggestion to iron after every 5th wash cycle would not be needed on the Repel/Release fabric. This is important since consumer research suggests that these recommendations are unlikely to be followed by the average consumer.

References

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