A COMPARISON OF THE SOILING BEHAVIOR OF DACRON-AND-COTTON FABRICS WITH THOSE OF SIMILARLY CONSTRUCTED ALL-COTTON FABRICS

by

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CHAPTER I

INTRODUCTION

The trend toward increased consumption of Dacron fibers has been influenced by the interest in the use of Dacron and cotton blends for apparel. The well known qualities of cotton blend with those of Dacron to form fabrics with consumer appeal in a variety of textures. There is also consumer appeal in those properties which contribute to the serviceability of the fabrics; particularly to those properties which contribute to their use in "wash and wear" apparel.

Cotton is noted for its response to moisture. Physically it is highly hydroscopic. It absorbs and releases large quantities of water.[1] Chemically speaking, except for impurities, cotton is pure cellulose. Cotton is a hydrophylic fiber because of the many exposed (OH) groups in it. Many of these groups swell as much as 40 per cent in volume upon immersion in water and practically all the increase occurs in the cross section of the cotton fiber. It is doubtful that solid soil greater than submicroscopic size can penetrate the interior deeply.[2]

Dacron, by contrast, is a man-made polyester fiber which is physiologically inert. It has good heat resistance, and shows no evidence of

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[1]Zelma Benhure and Gladys Pfeiffer, America's Fabrics, (New York: The MacMillan Company, 1947), p. 74.

[2]Ibid., p. 74-75.

irritating or causing skin reaction. It is washable or cleanable with standard cleaning procedures. It is a hydrophobic fiber since it does not absorb or release quantities of water. This quick-drying property contributes to wash-wear apparel.

The union of hydrophylic and hydrophobic fibers produces in fabrics of Dacron and cotton blends, problems in regard to soiling and the effectiveness of soil removal. It is a known fact that soil attaches itself to fabrics and as a result they become soiled. It is well known that some fabrics become soiled more readily than others and some parts of a fabric or garment become more soiled than others. For instance, collars and cuffs are usually very badly soiled at the end of a day's wear even though the rest of the garment appears clean. According to one authority it is believed that since Dacron is a hydrophobic fiber and does not swell in water or dye readily, any soil which is deposited must remain on the surface.

> . . . Since an important criterion for soil evaluation is visual appearance as measured by surface reflection, it appears logical to suppose that such surface soiling would be more obvious to the eye than would be the case if an equal amount of soil were deposited so that a portion of it could actually penetrate the fiber. On the other hand, the hydrophobic fibers probably resist soiling so that under equivalent exposure conditions, the total amount of soil accumulated would be less.[3]

It is also stipulated that whether the hydrophobic fibers actually soil more or less than the hydrophylic fibers is a subject on which more factual information is required.

In our modern age, with the emphasis on time-saving methods and devices, and fabrics requiring little care, Dacron is being accepted by

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[3]E. R. Kaswell, Textile Fiber, Yarns and Fabrics, (New York: Reinhart Publishing Corporation, 1953), p. 408-409.

the consumer as an "easy-to-care-for" fabric. However, there are complaints arising about its soiling properties. The consumer of Dacron fabrics is complaining that clothing made of Dacron will soil more readily than those made of all-cotton and that it not only soils more readily, but that it holds to soil more tenaciously.

There is very little information available on Dacron fabrics as to their ability to release soil when laundered with common household soaps and detergents. Since this is one of the foremost concerns to the individual in purchasing a garment containing Dacron, this study was initiated to indicate the soil behaviour of these fabrics when laundered with selected synthetic detergents.

This study, part of a larger research project, was planned as a means of comparing the affinity for soil of the 65 per cent Dacron and 35 per cent cotton blends used in shirtings with the affinity for soil of all-cotton fabrics of similar construction. Two types of fabric, Oxford and batiste have been used. By applying a standard soil solution to the fabrics their affinity for soil may be compared. Through the measurement of reflectance values before and after launderings, with selected synthetic detergents, the effectiveness of soil removal from the two types of fabrics may be calculated.

The remainder of the study includes Chapter 2, the review of literature which describes the soiling tendencies of fabrics, the use of soiling solutions, the measurements and evaluation of soil removal and the effectiveness of detergents in soil removal. Chapter 3 describes the procedure used in soiling the fabrics, in laundering and in determining the effectiveness of soil removal through the changes in light reflectance. The compilation and evaluation of the data from all laboratory tests are presented in Chapter 4. Chapter 5 includes the summary, conclusions and recommendations for further study.

CHAPTER II

REVIEW OF THE LITERATURE

Textile Soiling

Soil is a universal problem and thousands of dollars are spent every year in an effort to maintain a high standard of cleanliness in garments. It is a known fact that soil helps to wear clothes out through its abrasive action and through the resulting necessary cleaning operations.

> Since cottons are so often employed in the undyed or unbleached state where dirt and stains are readily visible they have become associated in the consumer's mind with frequent cleanings. They have thus acquired the reputation for being more easily soiled than other fibers.[4]

Any factor which alters the appearance of a fabric may come under the heading of soiling, but the form of soiling which presents the greatest problem and to which all fabrics are subject is the gradual change in appearance.

Dirt or soil is found everywhere. When it is uniformly distributed over the fabric it is called soil or dirt. When it is confined to a small area, it is called a stain or spot. In some cases laundering cannot remove the last trace of ingrained soil that builds up over a period of time. It is not the soil which can be easily removed which presents the problem but the soil that is tenaciously held and causes a gradual darkening of the fabric.

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[4]Nelson F. Getchell, "Cotton Quality Study III: Resistance to Soiling," Textile Research Journal, Vol. 25 (February, 1955), p. 151.

Comparatively little information is to be found in the literature on fabric soiling, the retention of soil, and the difficulty of soil removal. The earliest reference to work done on soiling dates back to 1929. Its history has recently been presented by the New York Section of American Association of Textile Chemists and Colorists and has been summarized by Kaswell.[5]

Early studies pertained to the particle size of smokes and fogs and absorption by cotton and wool fibers.

In 1936, Kruger studied soiling of textile goods with usage. It was concluded from these experiments with cotton fabrics of various constructions, that the degree of soilage and resistance to removal depended on the solubility of skin excretions and the nature of the fabric construction. Open weaves permitted dirt to penetrate and hindered cleaning, while surfaces which were close and even, with a tight layer of starch, were more resistant to contamination.[6]

The causes of soil retention on various fibers were studied by C. H. Masland who reported the following conclusions in 1939:

> (1) Fiber diameter and cross-sectional outline are factors of prime importance in soil retention.
>
> (2) These factors are interdependent. Only when a fiber has large diameter (above 27 microns) and smooth circular cross-section essentially free from indentions, can low retention be obtained.

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[5]E. R. Kaswell, Textile Fibers, Yarns and Fabrics, (New York: Reinhold Publishing Corp., 1953), p. 397, citing American Association of Textile Colorists, New York Section, "Measurement of Fabric Soiling" A. D. R., 41, (1952) p. 322.

[6]Ibid., p. 398, citing P. Kruger, "Soiling of Textile Goods with Usage," Seitung Ges. Textile Ind., 39, p. 221 (1936), Abstracted in Chemical Abstracts, 30, 4327 (1936).

(3) The origin of the fiber is of no moment, whether synthetic or natural, animal or vegetable, except as the origin influences morphology.[7]

Leonard reported in 1949 on the phenomenon of resoiling:

It was considered a condition of frequent occurrence wherein a washed carpet soils rapidly to a severe degree shortly after replacement in service. It was determined that if the detergent used in cleaning leaves an oily or liquid residue on the fibers, dirt particles will stick tenaciously, accumulating soil rapidly.[8]

Recent studies have directed attention to the mechanical and electro-static forces that affect the deposition of soil.

Kaswell, after carefully studying the history of soiling came to these conclusions:

(1) That dirt particles may be brought into contact with fibers by diffusion of deposition from quiet or slowly moving air, by direct transfer from another surface, or by electro-static forces.

(2) That having been brought in contact, the particles may adhere to the fibers by mechanical forces of occlusion in pits and crevices on the fiber surface; by "oil" bonding and possibly by electrical forces.

(3) That fine fibers having uneven cross-sectional contours retain soil more readily than those which have smooth circular contours.

(4) That fine fibers retain soil more readily than coarse fibers.[9]

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[7]Ibid., p. 398, citing C. H. Masland, "Soil Retention of Various Fibers," Rayon Textile Monthly, 19, 10 and 11 (1939).

[8]Ibid., p. 398, citing E. A. Leonard, "Combined Research about Location Cleaning Defines Important Factors," National Rug Cleaner, 22, #416 (1949).

[9]Ibid., p. 401.

Mechanical entrapment is undoubtedly responsible for the largest weight of dirt accumulated by most textile materials; it may also be the cause of some of the most tenaciously held soil.

Soil can be contained in a fabric structure in four areas:

(1) the relatively large spaces between the yarn.

(2) In the smaller system of pores between the fibers of a yarn.

(3) In the tiny angles formed by single fibers.

(4) In or on the tiny microscopic fiber surface itself.

The yarn and fabric construction determine the geometry of the first two areas while fiber morphology governs the latter two.

Theoretically, the fiber having the minimum amount of surface area per unit of volume will have the maximum resistance to mechanical entrapment.[10]

Thomas in studying the relation of particle size in relation to the process of soiling states the following:

> (1) Most soil particles are uncharged and are not drawn to fabrics by virtue of their own electrostatic conditions.
>
> (2) Frictional forces and other naturally occurring conditions can probably induce static charges of short duration on many soil particles. If these particles come close to a textile fabric before the charges are dissipated, they may be drawn into direct contact, where mechanical forces and oil-bonding can come into play.
>
> (3) Uncharged soil particles may be strongly attracted to fabrics which have become charged, e.g. nylon in processing.[11]

Doubtless the fabric itself contributes much to its soiling properties. While some fabrics may not necessarily soil readily, their very nature prohibits their use where soiling would be extensive.

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[10] Getchell, op. cit., p. 166.

[11] Kaswell, op. cit., p. 20.

Messiha and Selim concluded that:

> . . . the shorter the staple length, the greater the tendency to soil - probably because short staple length produces rougher fabrics and greater number of fiber ends through which soil can enter. This is especially true of the hydrophylic fibers.[12]

Staple fabrics which have rough surfaces and are porous and thick usually make good carriers of dry soil, especially dust. However, such dirt is not readily seen because of the entrapment rather than surface deposition. Staple fibers, because they are not so lustrous as continuous filament fabrics, are less prone to appear soiled. This is because a sharp contrast in luster may exist between the unsoiled and soiled areas.

<u>Composition of Soiling Mixtures</u>

Laboratory methods for measuring the degree of soiling and the efficiency of soil removal vary according to the particular laboratory. Work carried on in the area of soiling is done under controlled conditions with the use of artificially soiled fabrics. These fabrics are soiled with a standard soil solution rather than trying to duplicate soil which is contacted daily. There are many variations of the standard soil solution in use by research workers, but basically the solutions are made up of carbon, oil or fat and a grease solvent.

Soils are a hetergeneous mixture made up of many substances having varying degrees of chemical and physical properties.

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[12] <u>Ibid.</u>, p. 399, citing, <u>Atomic Energy Commission</u>, <u>Handbook on Aerosols</u>, 1950, pp. 62, 117.

Rhodes and Brainard agree the most common components of ordinary soil are probably carbon (soot and lampblack), fatty substances (from perspiration and grease), and oils.

What then is soil? Niven gives the following answer to this question:

A. Water-soluble organic and inorganic material.
  1. Sugars, starch, syrup, flour and urea.
  2. Organic acids, as fruit acids.
  3. Albuminous material, as blood, mucous, and egg white.
  4. Inorganic materials, such as salt and lime.

B. Water-insoluble inorganic material.
  1. Cement, plaster, soot, and lampblack.
  2. Earthy material, such as clay and silt.

C. Water-insoluble inert organic material.
  1. Hydrocarbon oils, such as lubricating oil and grease, fuel oil, road oil, asphalt, and tar.
  2. Paint and varnish.
  3. Inert fats, such as the greater part of animal and vegetable fats.

D. Water-insoluble reactive organic material.
  1. Particularly fatty acids, such as are present to some extent in fats and in perspiration.[13]

From the standpoint of detergency, the soils in group A present no problem of redeposition, provided they are rinsed well.

Those soils in groups B and C are more of a problem to remove since they require either physical or mechanical agitation to separate them from the fabric and to disperse them in the detergent solution.

The soils in group D, if they are in the presence of an alkali from the hydrolysis of a soap, may be converted chemically to water soluble material. Their disposal is then similar to group A soils.

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[13]William W. Niven, Jr., Fundamentals of Detergency, (New York: Reinhold Publishing Corporation, 1950), p. 187-188.

The ingredients used in soiling mixtures that are applied for the evaluation of soil removal are similar to those which are listed as the common components of ordinary soil.

Some of the mixtures that have been used consist of the following:

(1) Colloidal indigo paste with mineral oil and benzine.

(2) Charcoal, grease, and ether.

(3) Linseed oil, soot, blood, milk.

(4) Fruit juices, mixtures of various ingredients, farina, gravy, white of egg, lemon, milk, mustard, grease from fried onions and mixtures of different oils.

(5) Manganese resinate, paraffin oil and toluene.

(6) Lanolin, vaseline oil, water, turpentine oil, and wood charcoal.

Mixtures that have been accepted as more reliable and more easily standardized are the following:

(1) The formula developed by Rhodes and Brainerd[14] consisting of:

2 gms. lamp black
5 gms. lubricating oil
2,000 cc. carbon tetrachloride

(2) The formula developed by Morgan[15] consisting of:

2 gms. lamp black
10 gms. Nujol
3 gms. Russian mineral oil
2,000 cc. carbon tetrachloride

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[14] P. J. Wood, "Studies on Detergent Power," The American Dyestuff Reporter, Vol. 36, (August 25, 1947), citing Seifensieder - Ztg., 1929, No. 20, p. 172; Ind. Eng. Chem., 1929, 21, 60.

[15] Ibid., citing Grand, J. Research, 1932, 6, 292.

(3) The formula proposed by Szego and Beretta:[16]
2 gms. vaseline oil
1.6 gms. suet
0.4 gms. linseed oil
0.04 gms. oleic acid
1 gm. fume black
1,000 cc. benzine

Measurement and Evaluation of Soil Removal

Laboratory methods for studying the efficiency of soil removal vary according to the particular laboratory. The more frequently used pieces of equipment are the launder-ometer, the detergency comparator, and the tergo-to-meter.

Methods for measuring the degree of soiling or soil removal also vary. Generally there are two ways in which soil can be measured: (1) by the quantitative method which includes the spectrotometer and the reflectometer, (2) by quantitative chemical analysis. When the latter method is used, the exact type of soil must be known and then analytical methods can ascertain the amount of soil present.

Soil removal efficiency may be determined from reflectancy readings.

Soil removal, using the first method is determined from changes in reflectancy readings and by calculating mathematically the effectiveness or efficiency of removal. Fleming[17] used the following formula in calculating the efficiency:

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[16] Ibid., citing Giorm. Chim. Ind. Appl. (November, 1934), No. 11, p. 13.

[17] Marion Fleming, "A Further Study of Temperatures and Related Variables in Laundering" (Unpublished Master's thesis, Pennsylvania State College, Pennsylvania, 1947), p. 11.

$$E = \frac{RW - RS}{R - RS} \times 100$$

E = soil removal efficiency

RS = light reflectancy of the standard soiled cloth before washing

RW = light reflectancy of the standard soiled cloth after washing

R = light reflectancy of the original

Harris[18] obtains the per cent soil removal by using the same mathematical computation with different symbols. It is as follows:

$$\frac{(A - B)}{C - B} \times 100 = \text{per cent soil removal}$$

A = soiled fabric after wash

B = soiled fabric before wash

C = white fabric before soiling

<u>Detergents and Their Relation to Soil Removal</u>

While it is true that some soils can easily and efficiently be removed with the aid of water alone, the greatest number of soils require the aid of a detergent.

A detergent, in the broadest terms, is anything that cleans. Soap is one type of detergent. Synthetic detergents, or syndets which they are sometimes called, are another form of detergent.

These detergents, both the soaps and the synthetics can be divided into five classes for home laundering purposes as follows:

(1) <u>Light-duty, unbuilt soap</u>. This is pure soap without any additions, and is used for delicate, hand washable, and non-fast fabrics.

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[18] J. C. Harris, <u>Detergency Evaluation and Testing</u>, (New York: Interscience Publishers, Inc., 1954), p. 79.

(2) Heavy-duty, built soap. This, too, is pure soap with alkaline ingredients added to give increased cleaning power. This soap is used primarily in washing machines.

(3) Light-duty, mild, (sudsing) syndet. This is a syndet which is used for washing sheer, delicate fabrics, and does not have enough cleaning power to be used in the washing machine.

(4) Heavy-duty, all purpose (sudsing) syndet. This syndet contains builders to give greater cleaning power, plus a special ingredient to produce suds. It is used primarily in the washing machine.

(5) Heavy-duty (low sudsing) syndet. This syndet is unlike the others in that it is specially designed to give low-sudsing. It is widely used in automatic washers where heavy suds are unwanted.

Most of the soaps and the synthetic detergents have a special fluorescent dye which seemingly makes the fabric appear whiter, but this is deceiving because the fabric is not any cleaner.[19]

> The most direct way of describing what is probably the principal function of soaps or synthetic detergents, per se, in detergency is to say that they serve to render hydrophobic surfaces hydrophilic. Because of the detergent becoming positively adsorbed not only in the water but also on the surface of both soil and fabric, there is formed in effect a "detergent - water" or soil-water interface.[20]

Soaps or synthetic detergents aid the water and whatever mechanical force there is in both removing the soil from the fabric and to keep the dispersed soil in suspension.

It is not known definitely when or who made the first soap. Improvements in soaps have come down through the years until today there are soaps available for any job that needs to be done.

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[19] All About Modern Home Laundering, (Pennsylvania: Rudd Manufacturing Co.) 1953, pp. 25-26.

[20] Niven, op. cit., p. 225.

For most laundry purposes it is necessary to use what is called a "built" soap which is defined as follows:

> A built soap is an intimate uniform mixture of a neutral soap and more or less weakly alkaline substances in such proportions that the greatest detergent action and whiteness retention that are safe for the life and color of washed goods will be obtained. Detergent action being required for the actual removal of soil from goods and whiteness retention being the suspending power of the detergents.[21]

Builders are important in that they "stretch" the soaps. Usually better results can be obtained when built detergents are used than when unbuilt detergents are used.

Functions of builders may be summarized as follows:

a. Enhance the interfacial activity of soaps and synthetic detergents at a given detergent concentration;

b. Neutralize acidity in the soil (alkaline builders only) to conserve soap and to render acid soil more "soluble";

c. Partially act on saponifiable fatty soil (alkaline builders only) to render it more soluble;

d. Inhibit hydrolysis of soaps to fatty acids or acid soaps (if sufficiently alkaline);

e. Enhance spontaneous emulsification by "on-the-spot" formation of soaps from fatty acid soil (alkaline builders only);

f. Electrolytically stabilize emulsions and suspensions of soil in some cases;

g. Serve as protective colloids for stabilization of soil suspensions in some cases;

h. Enhance foam formation and foam stability;

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[21]Bruce E. Hartsuch, Introduction to Textile Chemistry, (New York: John Wiley and Sons, Inc., 1950, p. 60.

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[21] Bruce E. Hartsuch, Introduction to Textile Chemistry, (New York: John Wiley and Sons, Inc., 1950, p. 60.

i. Enhance electrical repulsion between fabric and soil.[22]

Synthetic detergents were introduced over twenty years ago. They were not developed as a low-cost substitute for soaps, instead they were developed to do jobs that soaps could not do well. One of the most common types of synthetic detergents is comprised of fatty alcohol sulfates.

The usability of soap is limited to alkaline solutions while the synthetic detergents can be used in either alkaline, neutral or acid solutions. When soaps are used in solutions other than alkaline, they break down to give fatty acids. Most soaps should be used in hot water to obtain their maximum efficiency whereas synthetic detergents can be used in either hot or cold water with satisfying results.

There are many synthetic detergents on the market today, but they can be divided into six main groups according to their chemical composition.

1. Alcohol sulfates

This was one of the first groups available commercially. These materials probably account for 20 per cent of the total production and show similarity to soaps in that they are derived from the same fatty acids.

2. Alkyl aryl sulfonates

Lather is fair, but they will not stand up at high temperatures. They are resistant to bleaching and oxidizing agents. They are effective in water up to 300 p.p.m. (parts per million) hardness. Production is about 50 per cent of the total volume of surface-active agents.

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[22]Niven, _op. cit._, pp. 228-229.

3. Alkyl sulfonates

They range in stability and detergency about half way between alkyl sulfates and alkyl aryl sulfonates.

4. Sulfated, sulfonated amides

This group accounts for about 5 to 10 per cent of the production sold.

5. Sulfated, sulfonated esters

These compounds are excellent detergents, but will not stand up to strong acid or alkali.

6. Sulfated, sulfonated amines

Under certain conditions, they make excellent detergents, but are expensive to produce.[23]

The major synthetic detergents that are on the market today for household use are either long chain alcohol sulfates or alkyl aryl sulfonate groups.

With all of the different kinds of soaps and synthetic detergents on the market today, how is the housewife able to determine which is best? The advice given by most authorities is that whatever gives one the best results is the best for one.

Some general rules do apply and may help one to decide which is best. When soap is used in hard water it must first soften the water before it can use any of its cleaning power. If all or a good portion of the soap is used for this purpose, one can readily see that much soap can

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[23] E. G. Thomssen, John W. McCutcheon, Soaps and Detergents, (New York: Macnair-Darland Company, 1949), pp. 402-406.

be wasted in this manner. The curds formed in hard water by the use of soap results in a gradual darkening of the fabric if extreme care is not taken to rinse them thoroughly.

It is true that a greater variety and quantity of soaps have been used in the past, but synthetic detergents are fast becoming good sellers, especially in hard water areas.

Regardless of which is used, the temperature of the water must be high enough to produce good cleaning. Also, it is best to use one or the other without changing back and forth. Never use both the synthetic detergent and the soap at the same time.[24]

[24] All About Modern Home Laundering, op. cit., p. 26.

CHAPTER III

METHOD OF PROCEDURE

Fabrics Used in the Study

The three all-cotton fabrics and three Dacron and cotton fabrics chosen for this study were selected from the fabrics used in a former study comparing performance features of Dacron and cotton fabrics with those of similar all-cotton fabrics. The all-cotton fabrics consisted of two of batiste (B 1 and B 2) and one of Oxford cloth (O 3). The Dacron and cotton fabrics selected for their similarity to these all-cotton fabrics also consisted of two of batiste (XB 6 and XB 8) and one of Oxford cloth (XO 4).

Four 10 x 10 swatches were cut from each of the selected fabrics and labeled to indicate the detergent with which each would be laundered. The four groups are represented as follows:

A Series - Alkyl-Aryl Sulfonate
(light duty detergent)

B Series - Alkyl Aryl Sulfonate
(heavy duty detergent)

C Series - Alcohol Sulfate
(light duty detergent)

D Series - Alcohol Sulfate and Alkyl Aryl Sulfonate
(heavy duty detergent)

After the swatches were properly labeled, they were washed to remove all sizing from the fabric. This precaution was necessary to prevent any subsequent interference in the soiling procedure.

Soiling Procedure

After careful evaluation of the many soiling solutions in use today the solution used by Brainerd and Rhodes was considered best suited to the needs of this study. It consisted of the following components:

2 grams lampblack
5 grams lubricating oil
2,000 cc. carbon tetrachloride[25]

The formula was tripled in order to obtain a quantity sufficient to soil the twenty-four swatches.

The actual soiling procedure followed was adapted from that used in numerous studies undertaken at the Ellen H. Richards Institute and described in detail by Fleming.[26]

The soiling mixture was prepared in a portable washing machine, and the swatches were thoroughly dried in a heated tumbler drier. They were put into the thoroughly mixed soiling solution carefully in order to prevent creasing or wrinkling.

The swatches were allowed to agitate in this mixture for thirty minutes, during which time they were checked to prevent any folding or creasing.

At the end of thirty minutes, the samples were removed from the soiling mixture and allowed to drip dry. Inspection revealed that all fabrics had not soiled to the desired 25 per cent maximum reflectance. The soiling and drying were repeated with more satisfactory results being obtained.

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[25]Wood, loc. cit.

[26]Fleming, loc. cit.

Next, the soiled samples were washed with a mild detergent to remove any excess or free soil. They were allowed to drip dry. Throughout the entire study the dried samples were ironed with the labeled side down and read on the reflectometer with the labeled side toward the light. This was necessary to prevent the iron from producing a sheen on the labeled side which would have caused inaccuracies in the readings on the reflectometer.

Four common household synthetic detergents were selected to use for this study. They were as follows:

(1) Detergent A - alkyl aryl sulfonate - light duty anionic, All the swatches labeled with "a" were washed in this synthetic detergent.

(2) Detergent B - Alkyl aryl sulfonate - heavy duty anionic. All the swatches labeled with "b" were washed in this synthetic detergent.

(3) Detergent C - Alcohol sulfate - light duty anionic. All the swatches labeled with "c" were washed in this synthetic detergent.

(4) Detergent D - Alcohol sulfate and alkyl aryl sulfonate - heavy duty anionic. All the swatches labeled with "d" were washed in this synthetic detergent.

The soiled swatches were washed in the launder-ometer, a machine which was developed by the American Association of Textile Chemists and Colorists for a variety of textile testing purposes. Glass jars, containing the fabric swatches were clamped to a rotating shaft and rotated at a constant speed. The jars were rotated in a water bath which was maintained at a given temperature. The rotating gave the swatches the mechanical action necessary for cleaning.[27]

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[27]Harris, _op_. _cit_., p. 60.

The procedure followed was adapted from the procedures suggested by the company manufacturing the Launder-ometer.[28] The L-2-Q Launder-ometer used was equipped to hold 3 two-quart jars on two opposite sides of the rotor. Jars of this size were necessary to provide sufficient mechanical action for the large swatches used.

Each series of soiled swatches was washed in 1/2 gram of the synthetic detergent and 500 cc. of water. They were allowed to wash for thirty minutes at a temperature of 105°F. At the end of the washing period, the swatches were rinsed thoroughly and allowed to drip dry. After they had dried, they were ironed with the labeled side down. This same procedure was repeated until each series of swatches had been washed fifty times.

Procedure for Evaluation

Since the soiling procedures are designed to give a spread of results from the original soil to the original white (which is seldom obtained), it is necessary to use a photometric method to measure the minute changes and to evaluate the soil removal. One photometric method utilizes the multipurpose Hunter reflectometer.

> This is a machine which was developed primarily to measure apparent reflectance. Because of its high precision, the instrument is well suited for measuring small differences in apparent reflectance of nearly identical samples.[29]

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[28]Atlas Launder-ometers, A Book of Instructions Prepared by the Atlas Electric Devides Company, Chicago, Illinois, p. 11a.

[29]Richard S. Hunter, A Multipurpose Photoelectric Reflectometer, (Washington: U. S. Department of Commerce, Vol. 25, November, 1940), p. 581.

A specimen is placed in the instrument and readings through three filters, in three different places on the fabric are taken consecutively. By taking measurements in this manner, positioning errors and separate-filter-standardization errors are eliminated. The relative reflectances through the different tristimulus filters indicate color and the instrument will determine these differences with high precision.[30]

Illumination at 45° and viewing at 0° have been internationally adopted as standard conditions for the colorimetry of opaque surfaces, because they represent a satisfactory average of the directional conditions under which surfaces are observed in everyday life.[31]

Readings were taken on each swatch. They were made on the original white fabric, the original soiled fabric and after the first, second, fifth, tenth, twentieth, thirty-fifth and fiftieth washings. From these readings, averages were obtained which gave the per cent light reflectance.

Using the per cent light reflectance averages, calculations were made to obtain the per cent soil removal. The formula used for these calculations was as follows:

$$E = \frac{RW - RS}{R - RS} \times 100$$

E = soil removal efficiency

R = light reflectancy of the original

RS = light reflectancy of the standard soiled cloth before washing.

RW = light reflectancy of the standard soiled cloth after washing.[32]

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30 The Gardner Multipurpose Reflectometer, A Booklet of Instructions published by Gardner Laboratory, Bethesda, Maryland, p. 2.

31 Richard S. Hunter, Photoelectric Tristimulus Colorimetry with Three Filters, (Washington: U. S. Government Printing Office, 1942), p. 6.

32 Fleming, loc. cit.

CHAPTER IV

PRESENTATION OF DATA

Fabrics Used in the Study

The fabrics used in this study were selected from those purchased for a research project sponsored by the North Carolina Experiment Station to compare the serviceability of Dacron and cotton fabrics used for shirts and blouses with similar all-cotton fabrics.

The three Dacron and cotton fabrics were selected for their similarity to the three white all-cotton fabrics which were considered most appropriate for use in shirts and blouses.

The fabric specifications given by the manufacturer or supply house are given in Table I. The detailed features of fabric construction as shown by laboratory analysis are presented in Table II.

Fiber Content. The fiber content of the two batiste fabrics B 1, B 2, and the Oxford type fabric, O 3, was 100 per cent cotton.

The fiber content of the batiste type blended fabrics XB 6 and XB 8 ranged from 68.7 to 69.3 per cent Dacron and 30.7 to 31.3 per cent cotton. The average fiber content of the two batiste fabrics was 69.5 per cent Dacron and 31.0 per cent cotton.

The fiber content of the Oxford type blended fabric XO 4 was 68.9 per cent Dacron and 31.3 per cent cotton.

Weave. The all-cotton fabrics B 1 and B 2 and the Dacron and cotton fabrics XB 6 and XB 8 were all of a fine plain weave.

TABLE I

FABRIC SPECIFICATIONS GIVEN BY MANUFACTURER OR SUPPLIER

	Fabric Number	Fiber	Percentage composition	Cost/Yd.		Manufacturing firm	Supplier	Miscellaneous information
				Retail	Wholesale			
All Cotton	B 1	Cotton	100	1.29	--	Jackson & Jackson	Belk's Department Store	Batiste
	B 2	Cotton	100	.98	--	Logantex, Inc.	Meyer's Department Store	Batiste, 40" wide
	O 3	Cotton	100	1.19	--	Logantex, Inc.	Pomeroy's Department Store	Oxford
Dacron/ Cotton	XB 6	Cotton Dacron	40 60	--	1.30	--	Travis Fabrics	"Cairo"
	XB 8	Egyptian Cotton Dacron	33 1/3 66 2/3	--	1.35	--	Travis Fabrics	"Pyramid"
	XO 4	Cotton Dacron	35 65	--	1.25	Deering, Milliken & Company	Manhattan Shirt Company	Finished at Bradford Dyeing Association Name: Daeford

TABLE II

LABORATORY ANALYSIS OF FABRIC CONSTRUCTION

	Fabric number	Fiber content (Per cent)		Weave	Width (Inches)	Thickness (Inches)	Weight (Oz./ sq.yd.)	Thread count		Yarn number		Staple length (Inches)		Twist count	
		Dacron	Cotton					Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
All cotton	B 1	—	100.0	Plain	38	.004	1.4	114	108	93.8	135.8	1.6	1.5	32Z	32Z
	B 2	—	100.0	Plain	40	.005	1.9	96	98	62.6	80.8	1.2	1.3	26Z	32Z
	O 3	—	100.0	2x1 Basket	38	.023	4.0	94	45	42.2	13.5	1.3	1.1	20Z	11Z
Dacron and Cotton	XB 6	69.3	30.7	Plain	45	.008	2.4	91	79	49.0	56.0	1.6	1.6	29Z	28Z
	XB 8	68.7	31.3	Plain	46	.008	2.9	103	98	46.0	60.0	1.6	1.6	26Z	33Z
	XO 4	68.9	31.3	2x1 Basket	45	.021	4.4	94	46	39.9	12.1	1.5	1.7	26Z	14Z

The all-cotton fabric O 3 and the Dacron and cotton fabric XO 4 were both of a 2 x 1 basket weave.

Width. The fabric ranged in width from 38 inches to 46 inches.

Thickness. The all-cotton batiste fabrics B 1 and B 2 were .004 and .005 inches respectively. The Oxford type all-cotton fabric O 3 was .023 inches in thickness.

The Dacron and cotton blended batiste type fabrics XB 6 and XB 8 both were .008 inches in thickness. The oxford type Dacron and cotton fabric XO 4 was .021 inches in thickness.

This indicated that the Dacron and cotton batiste fabrics were thicker than the all-cotton batiste fabrics; however, the all-cotton Oxford type fabric was thicker than the Dacron and cotton oxford type fabric.

Weight. The weight of the all-cotton batiste fabrics B 1 and B 2 was 1.4 and 1.9 ounces per square yard respectively. The weight of the all-cotton Oxford type fabric O 3 was 4.0 ounces per square yard.

The weight of the Dacron and cotton batiste fabrics XB 6 and XB 8 was 2.4 and 2.9 ounce per square yard respectively. The weight of the Dacron and cotton fabric XO 4 was 4.4 ounce per square yard.

The total weight of all the Dacron and cotton fabrics was heavier than the total weight of the all-cotton fabrics.

Thread count. The warp thread count of the all-cotton batiste fabrics B 1 and B 2 was 114 and 96 respectively, and the filling count was 108 and 98. The warp thread count for the all-cotton Oxford type fabric was 94 and the filling count was 45.

The warp thread count of the Dacron and cotton fabrics XB 6 and XB 8 was 91 and 103 and the filling count was 79 and 98 respectively. The warp thread count for the Dacron and cotton oxford type fabric was 94 and the filling count was 46.

Yarn number. The yarn number is a standard measure of the fineness of yarn.

The yarn number of the all-cotton batiste type fabric B 1 ranged from 93.8 in warp to 135.8 in the filling. The warp was 80.8 in the filling. The yarn number of the all-cotton Oxford type fabric ranged from 42.2 in the warp to 13.5 in the filling.

The yarn number of the Dacron and cotton batiste type fabric XB 6 ranged from 49.0 in the warp to 56.0 in the filling. The fabric XB 8 ranged from 46.0 in the warp to 60.0 in the filling. The yarn count of the Dacron and cotton Oxford type fabric XO 4 ranged from 39.9 in the warp to 12.1 in the filling. There was greater variation between all-cotton batiste type fabrics and the Dacron and cotton batiste type fabrics than there was between the two Oxford type fabrics.

Staple length. The staple length of the all-cotton batiste type fabric B 1 ranged from 1.6 inches in the warp to 1.5 inches in the filling. The all-cotton batiste type fabric B 2 ranged from 1.2 inches in the warp to 1.3 in the filling. The staple length of the all-cotton Oxford type fabric ranged from 1.3 inches in the warp to 1.1 inches in the filling.

There was less variation in the staple length of the Dacron and cotton fabrics than there was in the all-cotton fabrics selected. The staple length of the Dacron and cotton batiste type fabrics XB 6 and XB 8 both were 1.6 inches in the warp and 1.6 inches in the filling. The Dacron and cotton Oxford type fabric ranged from 1.5 inches in the warp to 1.7 inches in the filling.

Twist count. Both the all-cotton fabrics and Dacron and cotton fabrics used in this study had a Z twist in both the warp and the filling yarns.

The amount of twist in the all-cotton batiste type fabric B 1 was 32 turns per inch in both the warp and the filling. The fabric B 2 ranged in amount of twist from 26 turns per inch to 30 turns per inch. In the Oxford type fabric O 3, the amount of twist ranged from 20 turns per inch in the warp to 11 turns per inch in the filling.

In the Dacron and cotton batiste type fabric XB 6, the amount of twist ranges from 29 turns per inch in the warp to 28 turns per inch in the filling. The amount of twist in the Dacron and cotton batiste fabric XB 8 ranged from 26 turns per inch in the warp to 33 turns per inch in the filling. The amount of twist in the Dacron and cotton Oxford type fabric XO 4 ranged from 26 turns per inch in the warp to 14 turns per inch in the filling.

Comparison of Light Reflectance Values of Test Fabrics

The whiteness of the fabrics was measured by the use of a Hunter Reflectometer. The percentage light reflectance of the six fabrics before soiling is shown in Table III.

Each of the three all-cotton fabrics showed a higher original white percentage reflectance than the three Dacron and cotton fabrics. The average of the all-cotton group was 83.0 per cent as compared with an average reflectance of 76.0 per cent for the Dacron and cotton fabrics.

Differences were noted in the soiling behavior of the two types of fabric. Part of the difference was noticed during the soiling process.

TABLE III

AVERAGE LIGHT REFLECTANCE OF ORIGINAL WHITE AND SOILED FABRICS

	All-Cotton				Dacron and Cotton		
	White	Soil	Difference		White	Soil	Difference
	Per Cent				Per Cent		
B 1	80.2	22.5	57.7	XB 6	73.7	11.8	61.9
B 2	85.4	22.8	62.6	XB 8	77.5	13.2	64.3
O 3	83.3	25.1	58.2	XO 4	76.8	14.4	62.4
Average	83.0	23.4	59.5		76.0	13.1	62.9

The all-cotton fabrics absorbed the solution readily. The Dacron and cotton fabrics absorbed the solution more slowly, but were more heavily soiled and the soil was distributed more evenly. A second soiling treatment was necessary to meet the desired percentage reflectance.

The reflectance values of the six fabrics after soiling are also shown in Table III. Each of the three Dacron and cotton fabrics soiled more than the three all-cotton fabrics. The average light reflectance of the Dacron and cotton fabrics was 13.1 as compared with the higher average reflectance of 23.4 for the all-cotton fabrics.

The differences between the original white reflectance and the reflectance after soiling were slightly greater in the Dacron and cotton fabrics indicating that the Dacron and cotton fabrics had a slightly greater affinity for the soil solution.

Differences in the Per Cent Light Reflectance Before and After Laundering

This study was initiated to study and compare the soiling behavior of the three all-cotton fabrics with three similarly constructed Dacron and cotton fabrics when laundered with common household synthetic detergents. The six fabrics were grouped for use with the four synthetic detergents. The first group was washed with detergent A, a light duty anionic alkyl aryl sulfonate, pH approximately 6.9. Group two was washed with detergent B, a heavy duty anionic alkyl aryl sulfonate, pH approximately 9.1. Group three was washed with detergent C, a light duty anionic alcohol sulfate, pH approximately 9.3. The fourth group was washed with detergent D, a heavy duty anionic alcohol sulfate, pH approximately 9.2.

The total number of fifty launderings for each group of samples was an arbitrary figure and was not established to represent the number of launderings a fabric would be given with consumer use. The fabrics were tested following the first, second, fifth, tenth, thirty-fifth and fiftieth launderings. These intervals were selected to determine the behavior of the detergents and the fabrics throughout an extended laundering period.

Reflectance readings for each fabric before and after each laundering period are shown in Table IV. The changes in reflectance at each laundering period are shown graphically in Figures 1 through 4.

According to the average reflectance of all fabrics in each group, the Dacron and cotton fabrics tended to lose the soil a little more readily after the first wash than the all-cottons. The Dacron and cottons had increased 4.0 per cent in light reflectance from the original soil reflectance as compared with a 2.6 per cent increase for the all-cottons.

TABLE IV

AVERAGE PER CENT LIGHT REFLECTANCE

(Three filters averaged)

All-Cotton Fabrics										Dacron and Cotton Fabrics									
Fabric number	Original white	Original soil	Times laundered							Fabric number	Original white	Original soil	Times laundered						
			1	2	5	10	20	35	50				1	2	5	10	20	35	50
Detergent A (Alkyl Aryl Sulfonate)																			
B 1	80.2	20.0	20.9	21.0	21.4	23.4	25.9	27.3	27.5	XO 4	76.8	14.5	16.4	17.4	19.1	24.0	25.0	26.9	27.3
B 2	85.4	20.5	25.4	25.9	27.0	29.2	30.3	31.3	31.6	XB 6	73.7	11.3	12.7	15.0	20.4	23.2	26.6	29.0	29.1
O 3	83.3	24.7	26.6	27.0	28.5	31.1	32.0	33.6	33.4	XB 8	77.5	11.2	12.4	13.2	16.6	19.4	23.5	25.2	24.9
Av.	83.0	21.7	24.3	24.6	25.6	27.9	29.4	30.7	30.8		76.0	12.3	13.8	15.2	18.7	22.2	25.0	27.0	27.1
Detergent B (Alkyl Aryl Sulfonate)																			
B 1	80.2	23.2	25.5	25.9	30.7	32.0	35.4	38.0	41.8	XO 4	76.8	13.9	18.5	18.6	22.1	24.8	27.7	29.4	31.6
B 2	85.4	23.1	25.0	27.4	29.4	30.2	31.0	34.4	37.2	XB 6	73.7	11.4	13.5	15.4	20.9	21.9	23.8	27.0	30.0
O 3	83.3	26.4	26.5	30.2	32.7	34.1	35.7	38.5	40.7	XB 8	77.5	13.7	14.3	19.1	21.3	21.8	23.0	25.5	28.7
Av.	83.0	24.2	25.7	27.8	30.9	32.1	34.0	37.0	39.9		76.0	13.0	15.4	17.7	21.4	22.8	24.8	27.3	30.1
Detergent C (Alcohol Sulfate)																			
B 1	80.2	23.2	26.1	26.0	27.2	29.9	34.1	37.4	38.4	XO 4	76.8	14.2	15.8	19.4	21.2	22.9	26.2	30.2	31.3
B 2	85.4	23.5	25.2	27.6	28.4	30.9	35.0	35.9	36.4	XB 6	73.7	11.8	16.3	18.0	19.5	21.9	25.5	29.0	30.2
O 3	83.3	25.9	29.1	30.4	32.8	35.0	38.1	39.3	40.4	XB 8	77.5	15.8	20.3	21.4	22.2	23.5	24.8	27.9	29.1
Av.	83.0	24.2	26.8	28.0	29.5	31.9	35.7	37.5	38.4		76.0	13.9	17.5	19.6	21.0	22.8	25.5	29.0	30.2
Detergent D (Alcohol Sulfate and Alkyl Aryl Sulfonate)																			
B 1	80.2	23.4	28.4	29.6	35.2	37.6	39.6	41.5	45.5	XO 4	76.8	14.9	21.9	22.9	27.6	30.2	35.7	38.1	41.2
B 2	85.4	23.2	25.7	27.1	30.2	32.3	34.4	37.2	39.3	XB 6	73.7	12.1	22.1	23.6	26.8	28.6	31.6	35.2	40.5
O 3	83.3	23.5	27.2	28.7	32.7	34.5	38.2	40.1	43.2	XB 8	77.5	14.3	19.2	21.6	24.4	26.4	28.2	31.1	34.3
Av.	83.0	23.4	27.1	28.5	32.7	34.8	37.4	39.6	42.7		76.0	13.8	21.1	22.7	26.3	28.4	31.8	34.8	38.7
Av. of all detergents	83.0	23.4	26.0	27.2	29.7	31.7	34.1	36.2	38.0		76.0	13.3	17.0	18.8	21.9	24.1	26.8	29.5	31.5

DETERGENT A

(Alkyl Aryl Sulfonate - light duty anionic)

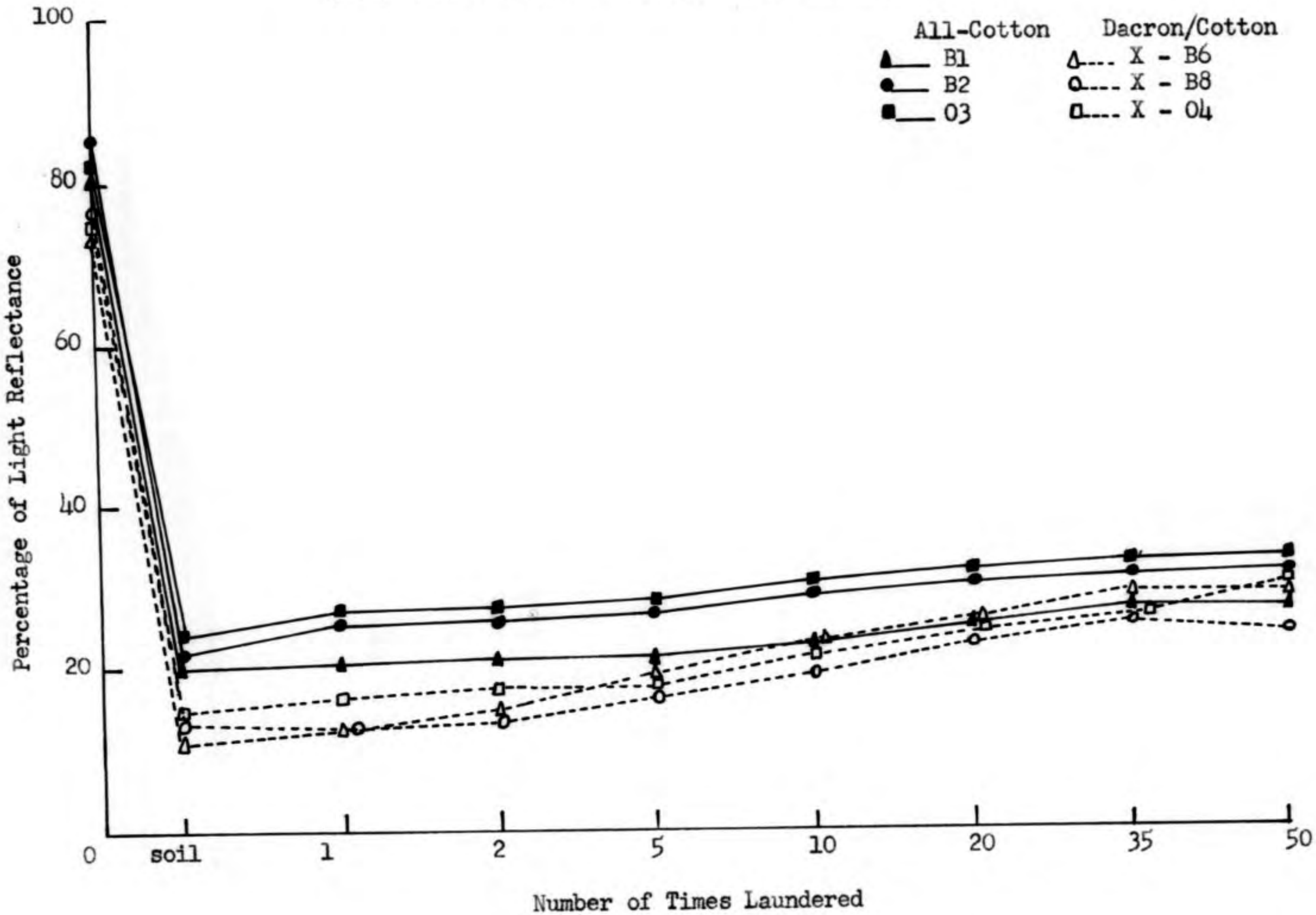

Figure 1. Per Cent Light Reflectance Before and After Laundering

DETERGENT B

(Alkyl Aryl Sulfonate - heavy duty anionic)

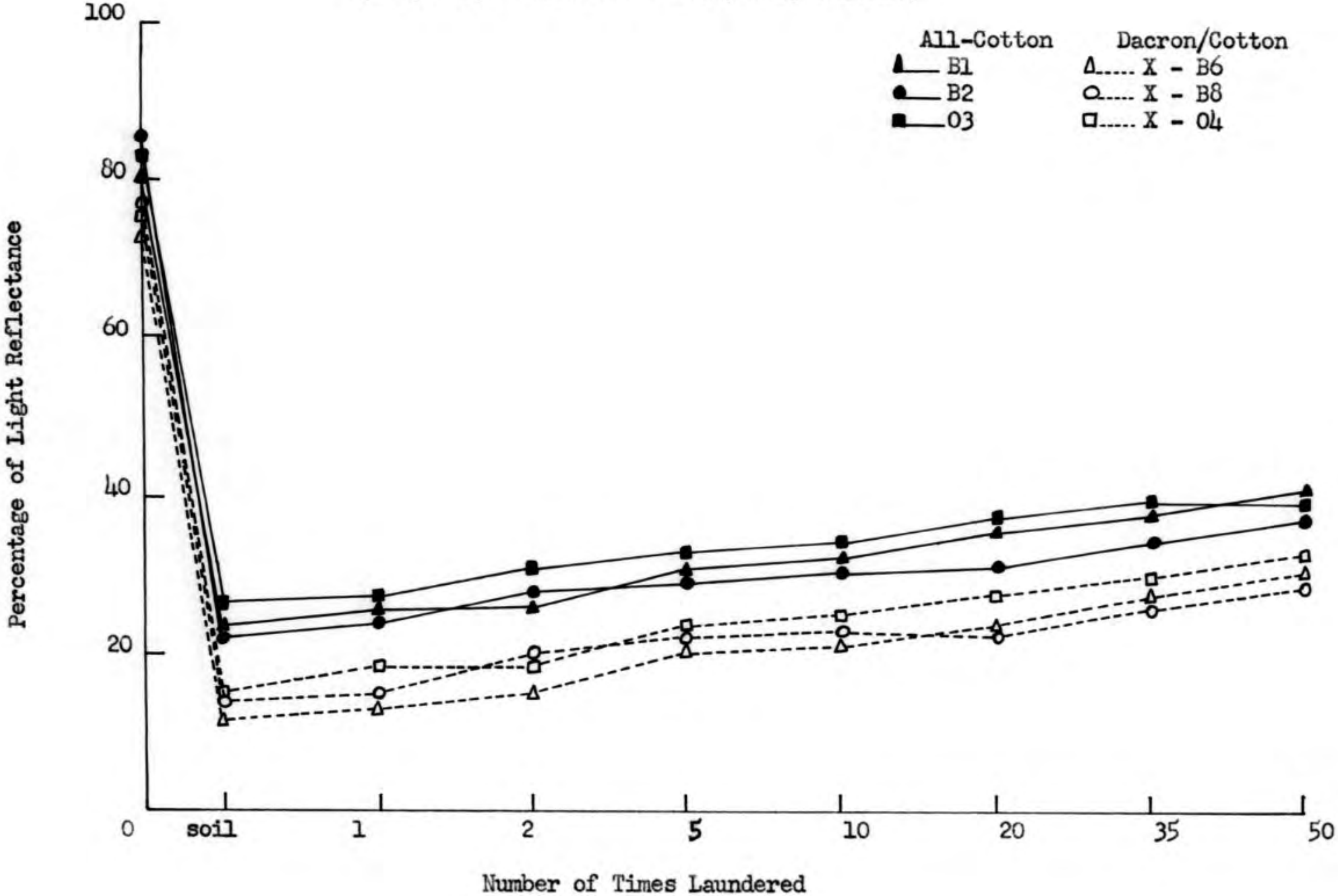

Figure 2. Per Cent Light Reflectance Before and After Laundering

DETERGENT C

(Alcohol Sulfate - light duty anionic)

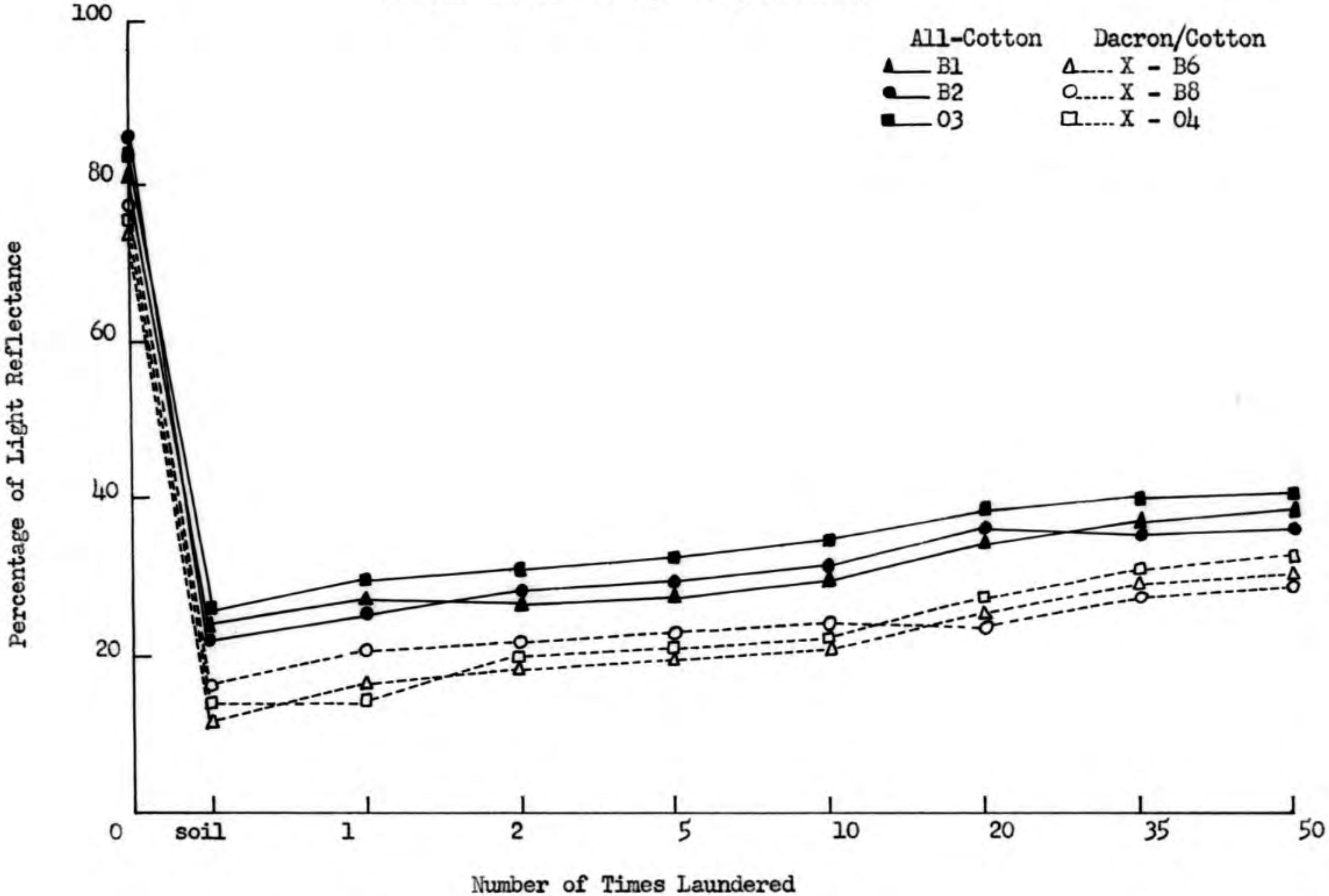

Figure 3. Per Cent Light Reflectance Before and After Laundering

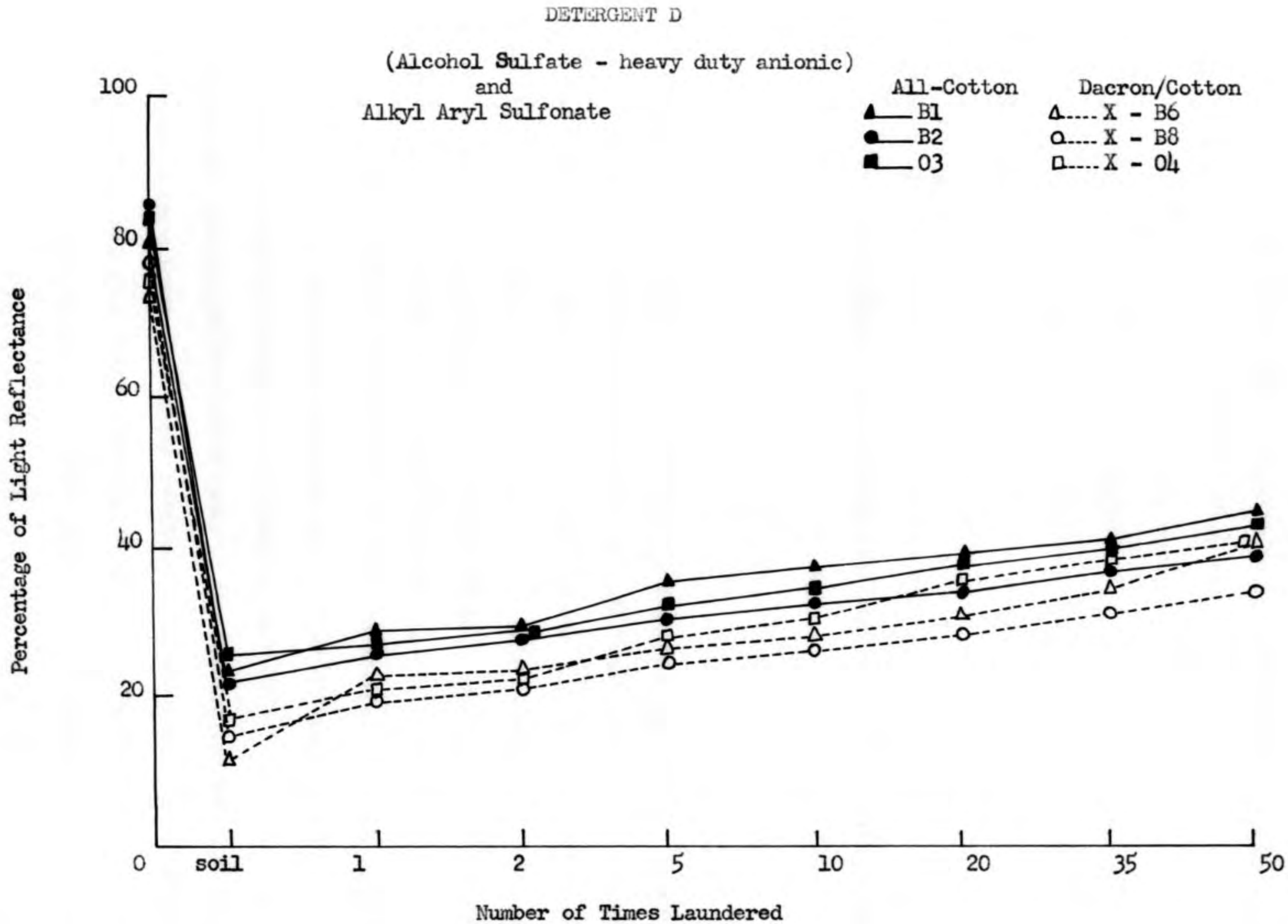

Figure 4. Per Cent Light Reflectance Before and After Laundering

There was only a small increase in reflectance for both the all-cottons and the Dacron and cottons after the second wash. The all-cottons showed an increase of 1.2 per cent as compared with 1.8 per cent increased reflectance for the Dacron and cottons.

The highest increase in reflectance for both the Dacron and cottons and the all-cottons occurred between the second and fifth washings. The Dacron and cottons showed an increase in reflectance of 3.1 per cent as compared with a 2.5 per cent increase for all the all-cottons.

The Dacron and cottons and the all-cottons showed similar increases in reflectance after the tenth wash. The Dacron and cottons showed a 2.7 per cent reflectance as compared with a 2.4 per cent increase for the all-cottons.

The gradual changes in reflectance continued through the twentieth, thirty-fifth and fiftieth laundering. At this final point, the average reflectance of the Dacron and cotton fabrics was 31.5 per cent and that of the all-cotton fabrics was 38.0 per cent. This represented increased reflectance from the original soil values of 18.2 per cent for the Dacron and cotton fabrics and 14.6 per cent for the all-cotton fabrics.

There seemed to be little difference in changes in light reflectance of the all-cotton fabrics as affected by the four different synthetic detergents. Detergent D seemed to be slightly more effective after the tenth laundering. Changes in the reflectancy of the fabrics laundered with Detergent A were lower than those laundered with the other three detergents.

There was also little difference in changes in light reflectance of the Dacron and cottons as affected by synthetic detergents A, B, and C.

Detergent D seemed more effective in the removal of soil than the other three detergents at each laundering period.

Since the reflectance values of the original soil fabrics varied considerably, the per cent soil removal was calculated to show more distinctly the individual differences between the fabrics and the effectiveness of the four detergents. The per cent soil removal is presented in Table V and shown graphically in Figures 5-8.

According to this method of interpreting the data, the removal of soil from the Dacron and cotton fabrics was slightly more effective than the removal of soil from the all-cotton fabrics. After the first wash, the Dacron and cottons lost 6.0 per cent soil as compared with a loss of 4.3 per cent soil for the all-cottons. This was the highest per cent of soil removal at any laundering interval during the entire study. A smaller percentage of soil was removed with subsequent launderings; however, there was a consistency in the amount of soil removed from both the Dacron and cotton fabrics and the all-cotton fabrics, with the former losing a higher percentage of soil after each testing period.

The three Dacron and cotton fabrics lost 3.0 per cent soil as compared to a 2.2 per cent loss for the all-cotton fabrics. There was a slight increase in the amount of soil removed after the fifth wash. The Dacron and cottons lost 4.8 per cent of soil as compared with a loss of 4.3 per cent for the all-cotton fabrics.

The number of launderings between the fifth and tenth launderings was greater but the amount of soil removed did not go up in the same proportion. After the tenth wash, the Dacron and cottons showed a 3.4 per cent loss of soil as compared to a 3.2 per cent loss for the all-cotton fabrics.

TABLE V

AVERAGE PER CENT SOIL REMOVAL

Fabric	All-Cotton Fabrics: Times Laundered							Fabric	Dacron and Cotton Fabrics: Times Laundered						
	1	2	5	10	20	35	50		1	2	5	10	20	35	50
Detergent A (Alkyl Aryl Sulfonate)															
B-1	1.5	1.7	2.3	5.7	9.8	12.1	12.5	XO-4	3.1	4.7	7.4	15.3	16.9	20.0	20.5
B-2	7.6	8.3	11.6	13.4	15.1	16.6	17.1	XB-6	2.2	5.9	14.6	19.1	24.5	28.4	28.5
O-3	3.2	3.9	6.5	10.9	12.5	15.2	14.9	XB-8	1.8	3.0	8.1	12.4	18.6	21.1	20.7
Av.	4.1	4.6	6.8	10.0	12.5	14.7	14.8	Av.	2.4	4.5	10.0	15.6	20.0	23.1	23.2
Detergent B (Alkyl Aryl Sulfonate)															
B-1	4.0	4.7	13.2	15.4	21.4	26.0	32.6	XO-4	7.3	7.5	13.0	17.3	21.9	24.6	28.1
B-2	3.1	6.9	10.1	11.3	12.7	18.1	22.6	XB-6	3.4	6.4	15.3	16.9	19.9	25.0	29.9
O-3	.2	6.7	11.1	13.5	16.3	21.3	25.1	XB-8	1.0	8.5	11.9	12.7	15.6	18.5	23.5
Av.	2.4	6.1	11.5	13.4	16.8	21.8	26.8	Av.	3.9	7.5	13.4	15.6	18.8	22.7	27.2
Detergent C (Alcohol Sulfate)															
B-1	5.1	4.9	7.0	11.8	19.1	24.9	26.7	XO-4	2.6	8.3	11.2	13.9	19.2	25.6	27.3
B-2	2.8	6.6	7.9	12.0	18.6	20.0	20.8	XB-6	7.3	10.0	12.4	16.3	22.1	27.8	29.7
O-3	5.6	7.8	12.0	15.9	21.3	23.3	25.3	XB-8	8.2	10.0	11.2	13.3	15.4	20.4	22.3
Av.	4.5	6.5	9.0	13.2	19.7	22.8	24.3	Av.	6.0	9.4	11.6	14.5	18.9	24.6	26.5
Detergent D (Alcohol Sulfate and Alkyl Aryl Sulfonate)															
B-1	8.8	10.9	20.8	25.0	28.5	31.9	38.9	XO-4	11.3	12.9	20.5	24.7	33.6	37.5	42.3
B-2	4.0	6.3	11.3	14.6	18.0	22.5	25.9	XB-6	16.2	18.7	23.9	26.8	31.7	37.5	46.1
O-3	6.1	8.7	15.4	18.4	24.6	27.8	32.9	XB-8	7.8	11.6	16.0	19.1	22.0	26.6	31.6
Av.	6.3	8.6	15.8	19.3	23.7	27.4	32.6	Av.	11.8	14.4	20.1	23.5	29.1	33.7	40.0
Av. of all detergents	4.3	6.5	10.8	14.0	18.2	21.6	24.6		6.0	9.0	13.8	17.3	21.7	26.0	29.2

DETERGENT A

(Alkyl Aryl Sulfonate - light duty anionic)

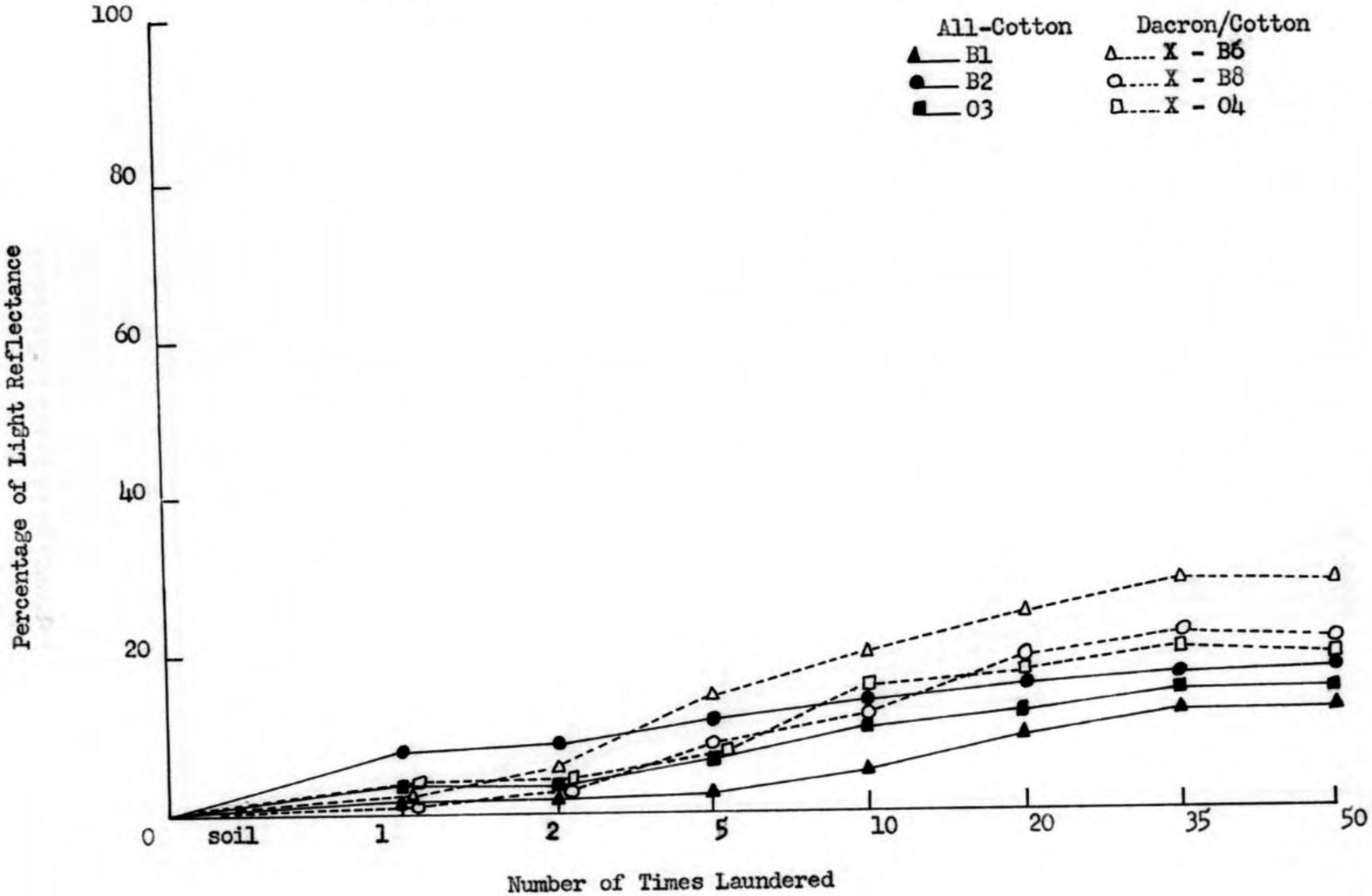

Figure 5. Per Cent Soil Removal After Laundering

DETERGENT B

(Alkyl Aryl Sulfonate - heavy duty anionic)

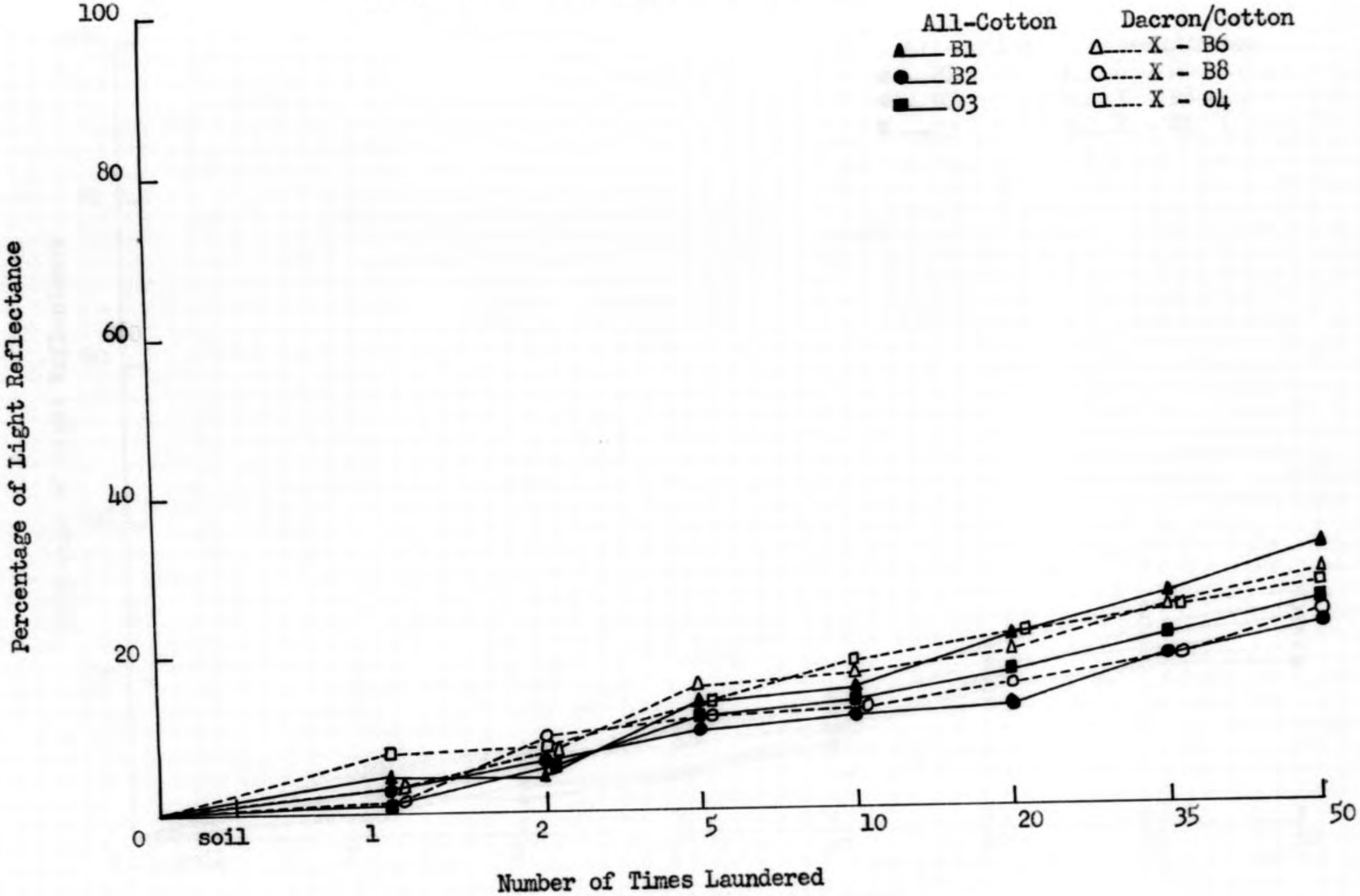

Figure 6. Per Cent Soil Removal After Laundering

E

DETERGENT C

(Alcohol Sulfate - light duty anionic)

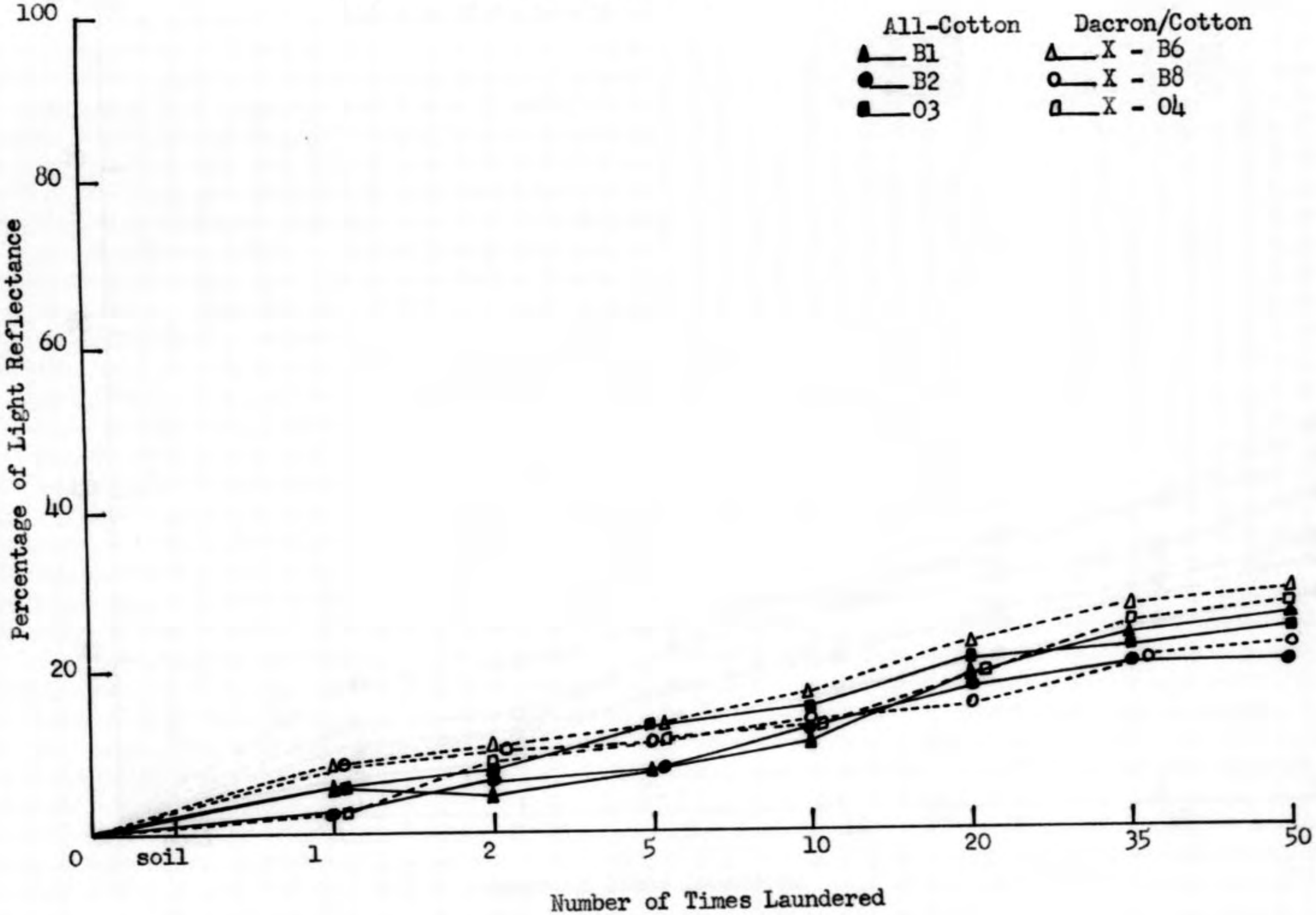

Figure 7. Per Cent Soil Removal After Laundering

DETERGENT D

(Alcohol Sulfate - heavy duty anionic)
and
Alkyl Aryl Sulfonate

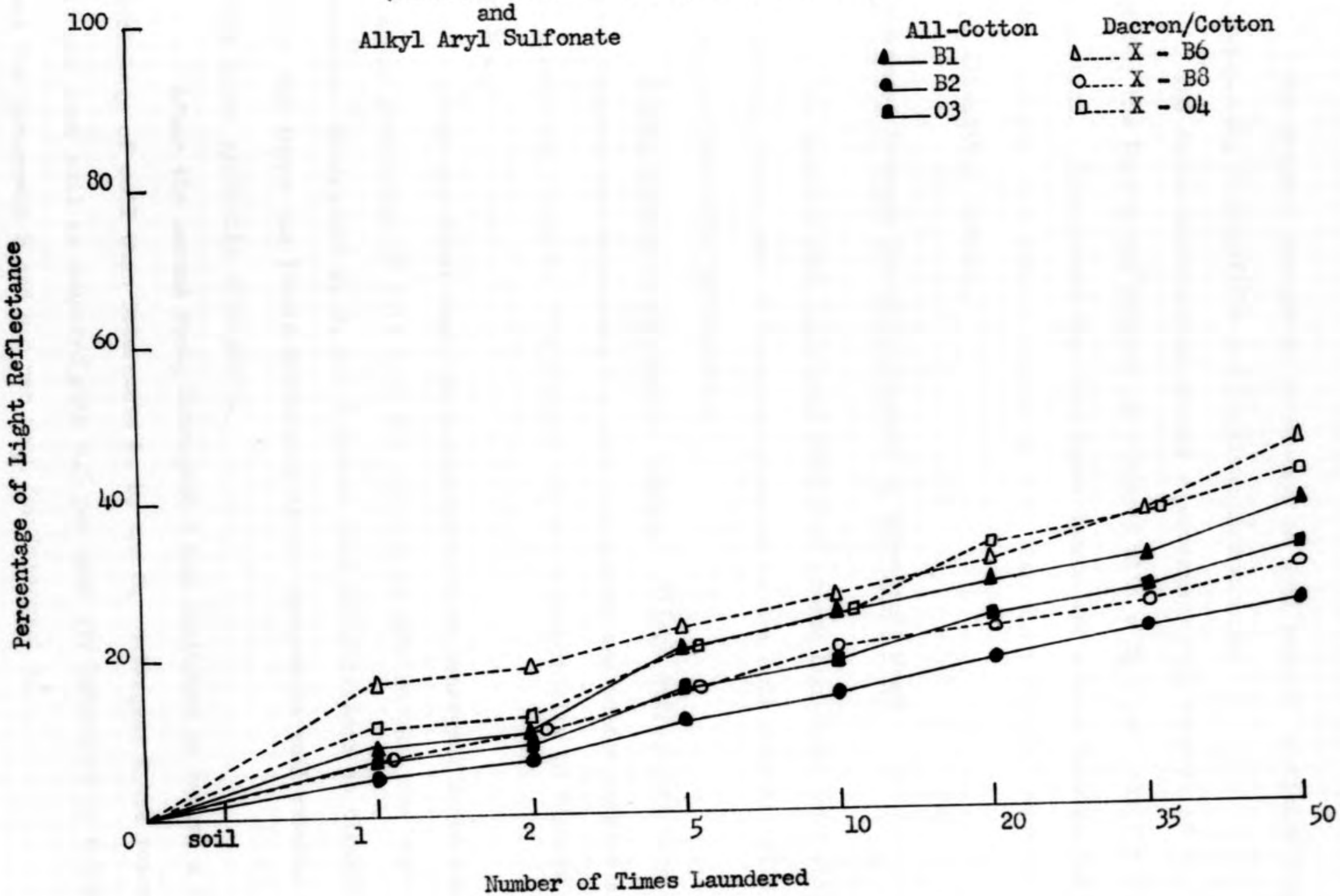

Figure 8. Per Cent Soil Removal After Laundering

The gradual changes in percentage of soil removal continued through the twentieth, thirty-fifth and fiftieth launderings.

The final calculations showed a percentage soil removal of 29.2 per cent for the Dacron and cottons as compared with a 24.6 per cent for the all-cottons. This showed that the three Dacron and cotton fabrics had lost a 4.6 per cent greater amount of soil than the similarly constructed three all-cotton fabrics.

Differences Between the Effectiveness of Detergents Used

The fabrics were laundered with four common household synthetic detergents. There were differences observed in the soil removal efficiency of the four synthetic detergents.

Effectiveness on all-cotton fabrics. Slight differences were observed between the detergents for both the Dacron and cotton fabrics and the all-cotton fabrics. The changes are shown graphically in Figures 9 and 10.

After the first wash, it was observed that Detergent D had removed a higher percentage of soil from the all-cotton fabrics than the other detergents. Detergents A, B, and C showed less effectiveness as cleaning agents and there was little difference in the percentage soil removal of these three synthetic detergents.

After the second wash, Detergent D had continued to remove a higher percentage of soil than Detergents A, B, and C. Detergent D had removed 8.6 per cent soil as compared with 6.5 per cent for Detergent C; 6.1 per cent for Detergent B and 4.6 per cent for Detergent A.

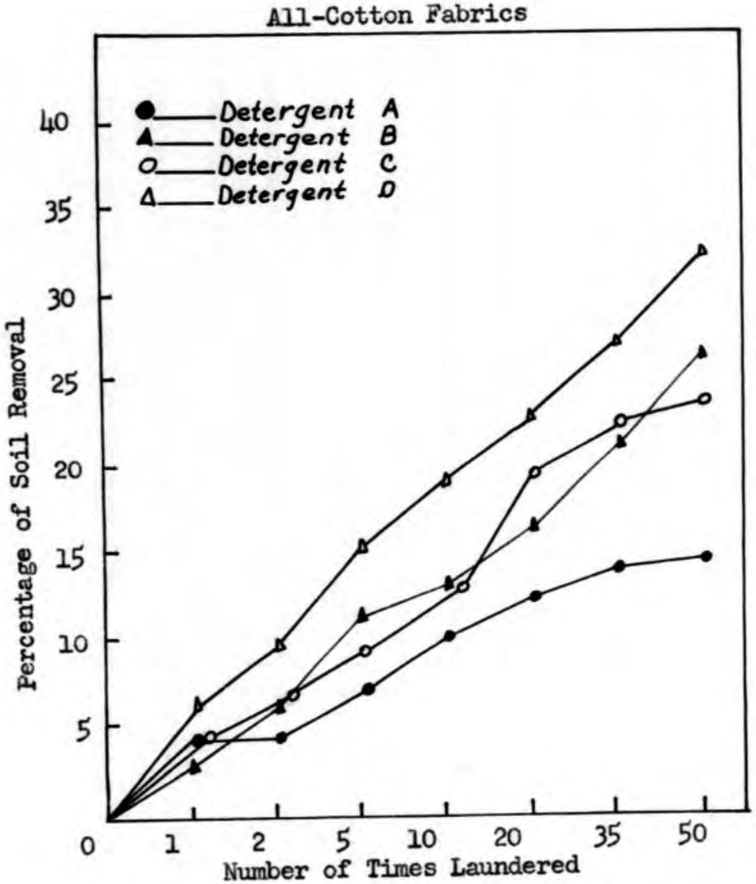

Figure 9. Percentage Differences Between the Effectiveness of Detergents Used

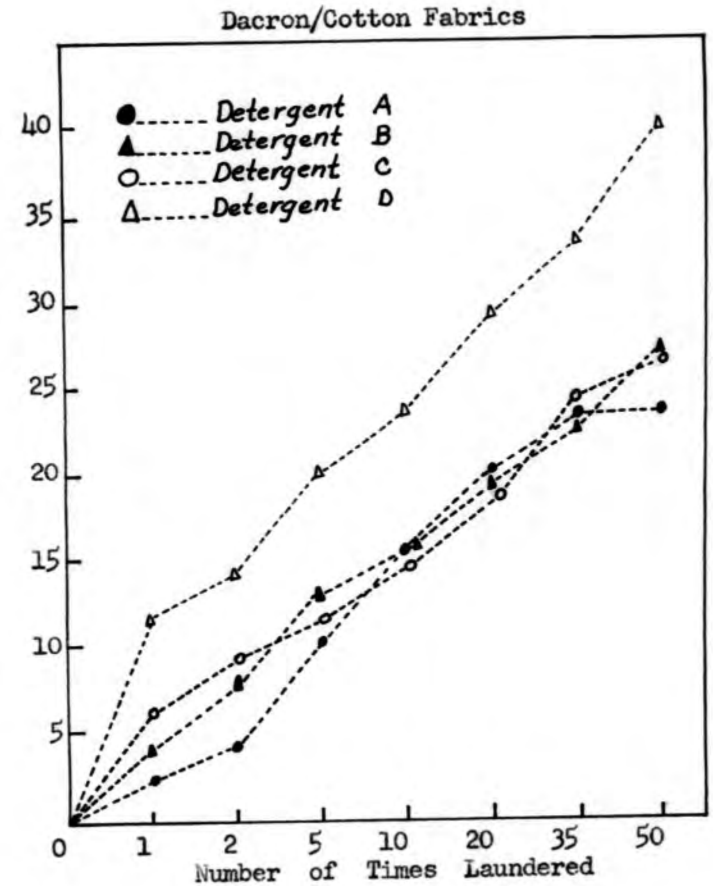

Figure 10. Percentage Differences Between the Effectiveness of Detergents Used

There was a variation in the cleaning effectiveness of the detergents after the fifth wash. The soil removal by Detergent D showed a 15.8 per cent soil removal as compared to a 9.0 per cent removal for Detergent C; 11.5 per cent for Detergent B, and 6.8 per cent for Detergent A.

Through the tenth, twentieth and thirty-fifth launderings, there continued to be gradual increases in the percentage of soil removal. There was a greater variation in effectiveness between Detergents D and A than there was between Detergents B and C.

Between the thirty-fifth and fiftieth launderings, Detergent A leveled off with only a small percentage of soil removed. Detergents B, C, and D continued to remove soil through the fiftieth wash.

The final calculations showed that Detergent D had removed the highest percentage of soil, 32.6 per cent as compared with 26.8 per cent for Detergent B; 24.3 per cent for Detergent C and a low of 14.8 per cent for Detergent A.

Effectiveness on Dacron and cotton blends. The detergents followed a similar pattern of behavior in their removal of soil from the Dacron and cotton fabrics as that shown by the all-cotton fabrics.

From the first wash through the fiftieth wash, Detergent D showed a higher percentage of soil removal than the other three detergents.

After the first wash, Detergent D removed 11.8 per cent soil as compared with 6.0 per cent for Detergent C; 3.9 per cent for Detergent B and to a low of 2.4 per cent for Detergent A.

The behavior of the detergents was very much the same after the second wash. After the fifth, tenth, twentieth, and thirty-fifth launderings the variation in effectiveness between Detergents A, B, and C became smaller. Detergent D continued to make distinct increases in soil removal through the fiftieth laundering. Detergent A leveled off in effectiveness between the thirty-fifth and fiftieth launderings with only a very slight increase in percentage soil removal.

With the final calculations, Detergent D showed a high of 40.0 per cent soil removal as compared to 26.5 per cent removal for Detergent C; 27.2 per cent removal for Detergent B, and 23.2 per cent removal for Detergent A.

Differences Between the Effectiveness of Soil Removal from the Six Fabrics

There were slight differences in soil removal behavior of the six fabrics during the laundering process. These changes are shown graphically in Figures 11 and 12.

After the first wash, the three all-cotton fabrics lost almost the same percentage of soil. The same pattern of behavior was observed after the second wash.

It was noted that after the fifth laundering there was slight evidence of some differences in the fabrics. Fabrics B 1 and O 3 were beginning to show slightly more effectiveness of soil removal than Fabric B 2.

This same pattern continued at the tenth laundering period with the removal of soil from the fabric B 2 slightly inferior to that of the fabrics B 1 and O 3. This difference continued to increase at the twentieth laundering period.

All-Cotton Fabrics

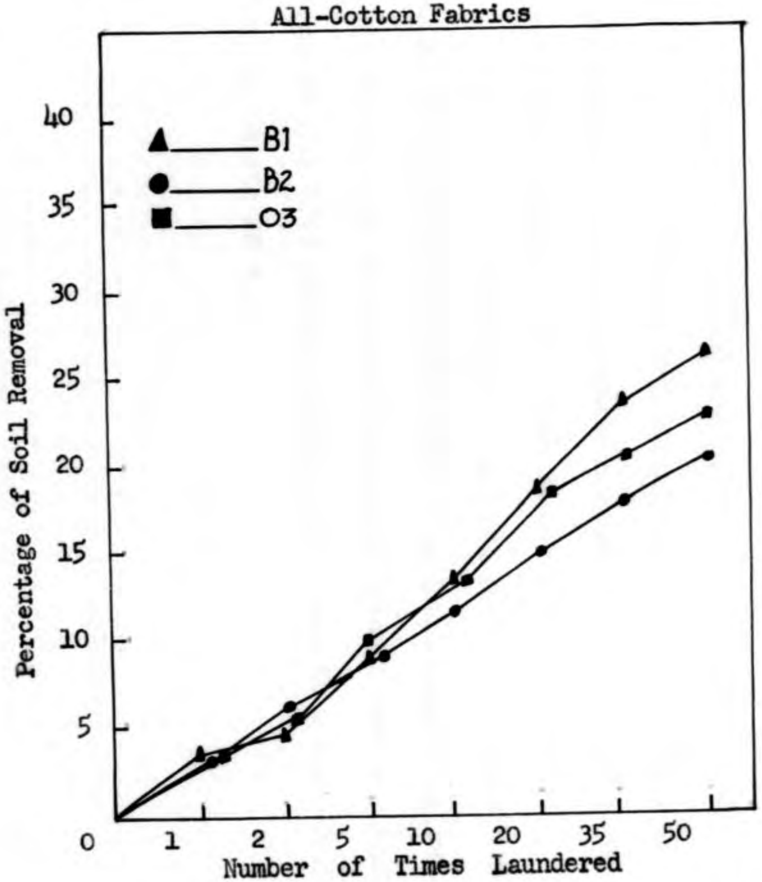

Figure 11. Percentage Differences Between the Effectiveness of Soil Removal from the Six Fabrics

Dacron/Cotton Fabrics

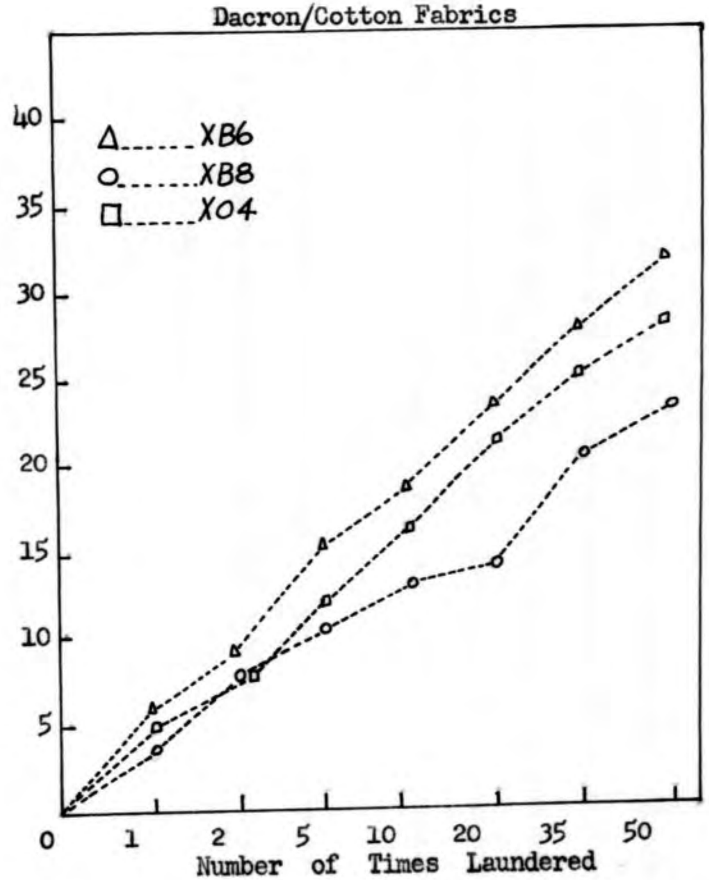

Figure 12. Percentage Differences Between the Effectiveness of Soil Removal from the Six Fabrics

Between the thirty-fifth and fiftieth laundering a distinct variation in the behavior of the fabrics appeared. Fabric B 1 showed the highest percentage of soil removal, 27.7 per cent as compared with 24.4 per cent for fabric O 3 and a low of 21.6 per cent for fabric B 2.

The Dacron and cotton fabrics followed a somewhat similar pattern of behavior in percentage soil removal.

After the first wash the three Dacron and cotton fabrics lost almost the same percentage of soil. The same pattern of behavior was observed after the second wash.

It was observed that after the fifth laundering, there was a variation in the amount of soil that each fabric was losing. Fabrics XB 6 and XO 4 were beginning to show evidence of slightly more effectiveness in soil removal than fabric XB 8.

The same pattern continued at the tenth laundering with the soil removal of Fabrics XB 6 and XO 4 distinctly superior to that of fabric XB 8.

At the end of the twentieth laundering period, there was a wide variation in the amount of soil that each fabric had lost.

This distinct variation in the soil removal continued through the thirty-fifth and fiftieth launderings. The final laundering period showed that Fabric XB 6 had the highest percentage of soil removal, 33.1 per cent as compared with 29.6 per cent removal for Fabric XO 4 and a 24.5 per cent removal for Fabric XB 8.

CHAPTER V

SUMMARY OF RESULTS AND CONCLUSIONS

In recent years, time has become one of man's greatest concerns; therefore, he has endeavored to use it wisely. To this end, he has developed many time-saving devices. In keeping with this trend, the textile industry has produced many fabrics that require a minimum amount of care. One such fabric is a blend of Dacron and cotton.

This relatively new man-made blend seems to have the potential qualities for an easy-to-care for fabric. However, there have been complaints about the soiling properties of this fabric. The consumer claims that the Dacron and cotton blended fabric soils more readily, and holds its soil more tenaciously than all-cotton fabrics. In order to prove or disprove this claim, it was necessary to make a thorough study of the soiling properties of both the Dacron and cotton fabrics and the all-cotton fabrics. The purposes of the study were as follows:

1. To compare the soiling behavior of Dacron and cotton fabrics with those of similarly constructed all-cotton fabrics.

2. To study the whiteness reflectance values of both fabrics.

3. To study and compare the efficiency of the removal of soil from the two types of fabrics.

4. To investigate the efficiency of four different synthetic detergents in the removal of soil from the fabrics.

As a result of this study, the following conclusions can be drawn:

1. The original unsoiled Dacron and cotton fabrics had a lower reflectance value than the all-cotton fabrics.

This represents a slight difference in the whiteness with the Dacron and cotton fabrics being slightly darker than the all-cotton fabrics.

2. The Dacron and cotton fabrics had a slightly greater affinity for the soiling solution than did the all-cotton fabrics. The Dacron and cotton fabrics were visibly darker than the all-cotton fabrics and showed reflectance values approximately 10.0 per cent lower than those of the all-cotton fabrics.

3. A difference was also noticeable at the conclusion of the fifty launderings, but the percentage of soil removed from the Dacron and cotton fabrics was greater than that of the all-cotton fabrics.

4. The synthetic detergents showed different efficiencies in the removal of soil from both the Dacron and cotton fabrics and the all-cotton fabrics.

   a. The heavy-duty anionic alcohol sulfate, detergent D, showed the highest efficiency of soil removal from both the Dacron and cotton fabrics and the all-cotton fabrics.

   b. The light-duty anionic alkyl aryl sulfonate, detergent A, showed the least efficiency of soil removal for both the Dacron and cotton fabrics and the all-cotton fabrics.

From these findings, it can be concluded that the consumer's concern over the soiling behavior of the Dacron and cotton fabrics as compared with the all-cotton fabrics is supported in only one respect. These Dacron and cotton fabrics did have a slightly greater affinity for soil than did the all-cotton fabrics. However, the consumer's concern that the Dacron and cotton fabrics hold their soil more tenaciously than do the all-cotton fabrics was not found to be true in this study, since the percentage of soil removed from the Dacron and cotton fabrics after each laundering period was greater than that removed from the all-cotton fabrics.

Differences were noted in the four different detergents used. However, they were not necessarily in accord with the advertising claims made for the specific products or the types of detergents used. One of the most highly advertised built detergents showed no greater efficiency of soil removal than the two unbuilt detergents.

It is suggested that further study be made:

1. To investigate the efficiency of soaps as compared with synthetic detergents for the removal of soil.

2. To investigate the effect that various soaps and detergents have upon the strength of a fabric.

3. To investigate the strength of a fabric after it has been soiled slightly and washed frequently as compared with a fabric that has been soiled heavily and washed less frequently.

4. To investigate the amount of soil that can be removed by mechanical action alone.

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