A COMPARISON OF SELECTED UPHOLSTERY FABRICS FOR USE ON DINING ROOM CHAIRS

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THESIS

This is to certify that the

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Hazel B. Strahan
Major professor

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OF SELECTED UPHOLSTERY FABRICS
FOR USE ON DINING ROOM CHAIRS

By

Audrey Ann Collins

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INTRODUCTION

The modern trend in furniture and furnishings of today is based on function and simplicity in line and form. Household fabrics are selected in harmony with this trend. Fabrics with texture; based on variation in color, weave, yarn, and fiber content; are currently designed to complement the furniture with which it is used. Textured cotton, rayon, and increasing amounts of linen and plastic upholstery fabrics have dominated the retail market during the last few years.

The traditional fabrics used since the early eighteenth century include brocade, chintz, corduroy, cretonne, embroidery, damask, moire, sateen, satin, taffeta, and tapestry, among many others. These fabrics were usually of cotton and silk, with some of linen. The use of silk has practically been discontinued, but rayon has replaced it and is used extensively in upholstery fabrics of many different types. Although many novelty fabrics have been used, it has only been within the last few years that they have been readily available in the retail market.

In an AHEA Consumer Speaks project (35) on straight chairs, the consumers felt that when an upholstered seat was used, it should be covered with a durable, colorfast material which would be easy to clean. They also desired that the upholstery covers be replaceable by the homemakers themselves.

Therefore, suitable fabrics should be available from easily accessible sources.

Most consumers have to consider the serviceability and amount of wear they will get from an upholstery material in return for the money spent. Price is not necessarily a reliable guide as to the durability or serviceability of fabrics. Therefore, there are many things consumers need to know about the various upholstery fabrics available in order to make selections which will best meet their special needs.

The advantages and disadvantages of the various types of traditional upholstery fabrics have been learned over a long period of time through actual usage. Likewise, some laboratory research has also been conducted on them. However, the newer textured upholstery fabrics have not been used extensively enough to provide much information about their performance over a long period of use. Because of the many factors of variation in these textured fabrics achieved through varying weave and yarn structures, differences may be expected in their serviceability characteristics and performance in use.

Research studies have indicated that the inherent physical characteristics of the fiber, yarn structure, and fabric weave construction all play major roles in the performance and durability of any fabric. Comparatively little consumer research has been done on these relatively new textured upholstery fabrics, so it is the general purpose of this study to determine whether or not the serviceability and durability factors desired by consumers characterize these eight different fabrics regarded as typical of non-pile upholstery fabrics available in local department stores and interior designer's shops.

The general objective of this study then, is to compare the durability and serviceability of eight typical cotton, linen, rayon, and supported plastic upholstery materials as seat coverings for dining room chairs.

Specific objectives are: (1) to compare the specifications (yarn size, yarn twist, yarn count, weight, and thickness) of two groups of fabrics differing in cost; (2) to compare the two groups of upholstery materials for the following performance characteristics: resistance to abrasion, breaking strength, flammability, compressibility, and resilience; (3) to compare the serviceability of these two groups of material under conditions simulating normal home use and care, the tests to include: (a) colorfastness to light, crocking, and cleaning; and (b) ease and effectiveness in removal of general soil and specified stains; (4) to evaluate performance for the two groups in respect to initial cost, serviceability, and durability.

REVIEW OF LITERATURE

Research investigations and surveys on what factors constitute serviceability and durability for upholstery fabrics were reviewed. The physical properties of fibers, yarn and weave structures, geometry of fabrics, resistance to wear, and factors affecting the kinds and effects of soil encountered were also reviewed in relation to textured fabrics with end use as chair seat upholstery.

The opinions of homemakers regarding upholstery fabrics were reviewed in a marketing research report (42) of the Bureau of Agriculture Economics. Their findings indicated that persons interviewed were more likely to know and talk about the weaves of their upholstery fabrics than of their fiber content. Accordingly, the fabrics used in this survey of opinion were divided into two groups. The pile weave group consisted of velvet, velveteen, corduroy, mohair, and frieze; and the second or non-pile group, of heavy fabrics with a rough finish, as well as others characterized by a smooth, hard finish.

Among those reporting, more than one-half expressed preference for non-pile fabrics. The major reasons for this preference were related primarily to the cleaning properties of non-pile fabrics. More specific reasons indicated that they thought non-pile upholstery fabrics do not collect as much fuzz and dust, that the dirt stays on the surface where it can be readily seen, and can be brushed and cleaned more easily. Reasons given which did not relate to cleaning properties were that they thought non-pile fabrics did not stick to one's clothing, were not as scratchy, and were cooler to sit on than pile upholstery fabrics.

It was interesting to note that among the 1800 women interviewed, the majority of those preferring non-pile fabrics were under 30 years of age, with higher educational background, and from higher social-economic classes than those reporting preference for pile fabrics. The majority of the women with expressed preference for pile fabrics were from the lower income groups, of lower social status classification, and older than those preferring non-pile fabrics.

Most articles on upholstery fabrics stress decorative value and appropriateness to other furnishings with which they are to be used. Comparatively little information was given on the physical structure and durability characteristics of fabrics designed for this end use.

Some of the methods by which texture is produced in non-pile fabrics include variations in color and fibers, use of yarns of different weights and sizes, as well as novelty yarns. Among the various yarns used to create the desired texture effects are singles, plies, ratine or gimp, and cored and slub yarns. Novelty yarns are usually created through various combinations of cotton with other cellulosic or synthetic fibers.

In the study on proposed minimum requirements of upholstery fabrics (40), six groups or 62 different fabrics were evaluated in terms of their serviceability characteristics. Serviceability factors investigated were colorfastness to light, rubbing, and cleaning; resistance to pulling or slipping when attached to a chair frame; and ability to withstand wear. Differences in total serviceability were primarily determined by the kind and quality of specific fibers used, the weave and yarn count of the fabric, number or size of yarns, fabric breaking strength, resistance to abrasion, and colorfastness to light. The proposed minimum requirements for different types of upholstery fabrics were based upon the findings of this comprehensive study on serviceability.

The characteristics of different types of fibers or fabrics in the following discussion is limited to a review of those inherent physical properties which indicate potential advantages or limitations when used in upholstery fabrics.

The cotton fiber is a long, continuous, single cell that looks like a twisted, flattened, or collapsed tube or ribbon with delicately thickened edges and slight twist. These twists, which may run as high as 150 to 400 per inch, allow the fibers to cling together to form yarns with durability and strength. Because the cotton fiber is practically pure cellulose, it absorbs and releases large quantities of water through the pores of the fiber walls. As its frictional hold is increased by water, cotton fibers are stronger when wet. The ability of the fibers to absorb moisture also make them readily susceptible to a wide range of dyestuffs and finishes. Mercerization gives increased luster, soft hand, added strength, and improved dyeing qualities to the yarns or fabrics.

Records show linen to have been used in Egypt along the valley of the Nile at least as far back as 5000 B.C. Since then, its use and prestige have spread throughout the rest of the world. Since 1890, the United States Department of Agriculture has carried on experiments in an attempt to produce new varities of flax and to develop a retting process which conforms with mass production methods characteristic of our economy. Since 1932, most of the experimentation has been carried on in Oregon because of its ideal climate for growing flax. With the curtailment of foreign imports during World War II, the production of flax for textile use on a commercial basis was begun. In 1948, a project (43) was undertaken to investigate additional uses for Oregon flax since its commercial value had assumed significance. It was recognized by the industry that Oregon flax could find a good market only if the character of domestic fabrics produced from it were distinctive, and competitive in price with imported linens.

Textured fabrics had been produced from almost every fiber except linen, so research in the designing of fabrics made from Oregon flax was concentrated on drapery and upholstery fabrics with a third dimensional effect created by use of varying weights of yarns. This fabric development produced fabrics which were suitable in character for use with

modern or traditional furniture. Manufacturing costs for these fabrics proved to be comparable to those made from other fibers. Costs, however, could be partially adjusted by the type of linen yarns used in construction of the fabrics. Within the last two years, there has been increasing consumer buyer acceptance of these textured fabrics, of linen or linen combined with other fibers, for use on upholstered furniture.

Although linen is one of the strongest fibers grown, it has less elasticity than the other natural fibers. Fabrics woven with yarns of line fibers have tremendous durability. Therefore, linen is desirable for fabrics that need to be strong and taut, that do not tear easily, and that do not appreciably expand or contract with changes in atmospheric conditions. Such fabrics are desired for upholstery coverings.

The linen or bast fiber is of cellulose, although it is not as pure as cotton because some of the encrusting matter generally remains on the fiber. This fiber, ranging from 12 to 36 inches in length, has the appearance of a long, cylindrical tube with a minute channel down the center. Throughout the length of the fiber are distinct joints, swellings, or nodes which appear at irregular intervals and prevent the fiber from collapsing. These nodes hook onto the nodes of other fibers, allowing the fibers to cohere and cling together to form yarns. Linen absorbs moisture rapidly due to the capillary attraction between the cells comprising the fiber. Linen absorbs and gives off moisture more rapidly than cotton and therefore dries more quickly. It is also stronger than cotton and does not fluff nor lint. Linen is least receptive to dyes among the natural fibers. Its natural color is gray with a brownish tinge.

Manufacture of viscose rayon in the United States was begun in 1903, and today is a significant competitor of the natural fibers because of the lower cost of production. Physical properties of significance for consideration of its use in upholstery fabrics are indicated by characteristics of absorbing water readily, its resultant swelling, loss of strength when wet, and a tendency for extensive elongation. These properties indicate viscose as potentially less durable than the natural fibers.

Many of the physical properties of the cuprammonium rayon fibers resemble those of viscose fibers, although its wet strength is somewhat higher. The dyeing properties of both viscose and cuprammonium rayon are similar to cotton, although cuprammonium dyes more satisfactorily in darker shades.

Development of vinyl plastic on a commercial basis has largely been confined to the period since 1940. Vinyl resins are most commonly used today in plastic-coated fabrics, sheetings, and films. A few of the trade names for vinyl plastics are "Vinylite", "Saran", "Geon", "Monsanto Vinyl Butyral", "Fabrilite", and "Marvinol".

Plastic sheetings with a supporting fabric back vary in thickness of the plastic coating, and in the type of backing. The fabric backing is available in plain, twill, and knit constructions. Plastic-coated fabrics and fabric-backed sheetings can be worked without difficulty by an amateur upholsterer, because the added strength in both cases minimizes complications in handling and applying. When introduced by the DuPont Company, "Fabrilite" was described in the Testing League Bulletin (46):

> "'Fabrilite' supported vinyl plastic upholstery is not a conventional coated fabric nor a plastic sheeting, but a combination of the two - a plastic sheeting (supported with a fabric) that combines the workability of a plastic coated fabric with the eye appeal of a plastic sheeting (without fabric back). It can be sewed, tacked, padded, and formed without special handling."

Developed to meet a wartime need for superior upholstery, vinyl resins have established entirely new standards of quality with their superior resistance to oils and grease, to flexing and cracking at low temperatures, and to abrasion. Vinyl plastics are non-toxic, will not rust, corrode, nor mildew. They are non-combustible and fire resistant.

According to advertising claims, vinyl plastics are 100% waterproof, impervious to most organic chemicals (if wiped off immediately), to alcohol, perspiration, and most stains (except caustics and strong bleaches). They also claim vinyl plastics to be easily and safely cleaned either with soap or synthetic detergents.

Many lacquers and varnishes are harmful to plastic materials. Nail polish remover and ball point ink may permanently damage some vinyl plastics. Foam rubber, when in direct contact with plastic, tends to discolor and embrittle it. However, plastics with cloth backing as protection may be used with foam rubber without ill effects (47).

The vinyl plastics have outstanding ability to withstand weathering and most colors withstand long exposure to the sun without fading. In "A Study of the Effects of Exposure to Sunlight Upon Seven Brands of Plastic Upholstery Materials" (8), conducted at Ohio University, the green colored plastics seemed to withstand fading better than other colors tested.

Vinyl plastics are composed of vinyl resins, plasticizers, stabilizers, pigments, and lubricants. The minimum amount of plasticizer incorporated in making the plastic fabric must be that required to produce a dispersion of a viscosity suitable for coating. The surface of the fabric thus produced is often too soft to give maximum abrasion resistance in service. However, these soft coats are necessary to produce the desired flexibility. Therefore, the application of a thin, hard, top coat is used to increase abrasion resistance and give the material the desired dry hand.

Techniques of embossing vinyl coated fabrics have gradually developed until now it is possible to obtain almost any desired effect in design. Decorative finishes can be applied by a coating knife, roll, or by printing with an overall engraved shell. By clear coating, woven or printed designs can be protected and given a durable, washable finish (27).

The vinyl fabrics are becoming increasingly popular with consumers for many different products. Gradually, vinyl coated fabrics are replacing leather applications in automobiles because of price and quality control (7). Automobile seat covers and flat upholstery were reported to be the two biggest markets for vinyl fabrics in Rubber Age (44) for January, 1954.

According to Kaswell (25), the "performance of any structure is dependent upon a combination of inherent fiber properties as well as upon the geometric arrangement of fibers in yarns, and yarns in fabric". Because of the complexity of fabric geometry studies, few investigations have been conducted on this subject, as compared with fiber properties.

Although two fabrics may have comparable resiliency, they may not have the same compressibility since a softer fabric will have a greater amount of compressibility than a harder fabric. Therefore, Schiefer (48) suggests that compressibility as well as compressional resilience should be studied in as much as compressibility denotes deformation, while compressional resilience depicts the percent energy recovered. End use requirements such as retention of shape, hand, thickness, and bulk are all dependent on the resilience of the fabric structure. When resilience is applied to upholstery, the rate of strain is slow, consisting of a constant maximum strain under a dead load, followed by long periods of rest under no stress, so that secondary creep is important.

According to Dillon (10), elastic resilience is an expression of elastic reversibility, and is therefore related to creep and relaxation properties of both fibers and fabrics.

There is considerable confusion in the literature concerning the definitions of the terms serviceability, wear, and abrasion. Serviceability is generally concerned with all criteria of performance which permits a fabric to be accepted or rejected for use. Wear usually implies the combined effect of several factors resulting from every-day use and service. Some of these factors are abrasion, stressing, straining, laundering or cleaning, pressing, and bending. The term abrasion is generally applied to actions or tests in which rubbing is the major characteristic. As abrasion is often considered the most important single factor in wear, most studies are concerned with resistance to abrasion rather than general wear. However, the results of laboratory abrasion tests mean little by themselves, and must be considered along with other properties of a fabric.

According to Gagliardi and Nuessle (16), a fabric in actual use is usually subjected to relatively low abrasive forces, which are generally far apart so that there is time for stress and strain relaxation. Their general criticism of laboratory abrasion testing is the rapid rate at which a specimen is destroyed by repeated stresses which are much more severe than those commonly encountered in normal use. When laboratory tests were conducted with low applied stresses and strains more similar to those encountered in actual use, performance results were more comparable to those obtained in practical wear tests.

Various methods or criteria have been set up as a means of evaluating or measuring the effects of abrasion. Visual observations of change used in evaluation included (a) loss of luster, (b) surface changes, (c) color changes, (d) appearance of first broken yarns, (e) appearance of three broken yarns, (f) appearance of a hole, and (g) complete breakdown. While determining the number of rubs required to produce a certain visual change is the most extensively used method, it involves a significant human element of variation (9, 17, 62).

Other methods of measurement for the effects of abrasion include tensile strength, thickness, weight, and air permeability. These four were considered by Hamburger and Lee (17) to be more dependable tests, but even these methods had drawbacks. The least objectionable method used as a measure of the extent of damage from abrasion, was the percent loss in unabraded strength. The use of percent loss rather than absolute loss in strength permitted the comparison of materials of unlike initial strengths.

Some of the geometric aspects affecting abrasion were discussed by Backer and Tanenhaus (3). These included the geometric area of contact between the fabric and abradant, threads per inch, crown height, yarn size, fabric thickness, yarn crimp, compressive compliance, fabric tightness and cover factor. The importance of the direction of abrasion was also discussed. They found that as the area of contact between yarns or crowns and the abradant surface increased, the load on these points decreased. This resulted in less frictional wear at the points of contact and reduced surface cutting of the fibers, fiber plucking, slippage, and tensile fatigue. Consequently, they concluded that the greater the number of crowns and the lesser the stress concentration of force per crown, the greater or better the wear resistance of the fabric. The use of heavy yarns increase the wear life of a fabric, provided the yarns are uniform. If they are not uniform, these yarns serve as focal points for high pressure concentrations and more rapid fabric degradation results.

The compressive behavior of the surface structure of a fabric also affects its wear performance. A low compressive modulus and high rate of recovery will enhance abrasion resistance by reducing the normal pressures on protruding fibers or yarns. Although a closer weave and/or a higher twist will aid in preventing fiber plucking during abrasion, it may lower the ability of the surface fibers to move or avoid the abradant if the fibers or yarns are too rigid. In this same study on textile geometry and abrasion resistance (3), major differences were noted in the abrasion resistance of textile fabrics when the direction of rubbing was altered with respect to warp and filling coordinates. They found that generally, the yarns which projected on the rubbing surface of the fabric suffered greatest damage when abrasion took place in a direction perpendicular to their float lengths. They therefore concluded that maximum resistance was achieved when the non-stress-bearing yarns were presented at the rubbing surface with their floats running in the direction of the rubbing.

A meager amount of technical information has been reported either on the factors which contribute to the tendency of fabrics to become soiled, or to the degree of difficulty in removing soil. However, a report (29) presented by the New York Section of the American Association of Textile Chemists and Colorists discussed many laboratory and service tests which have been conducted on this subject. These studies constitute the most significant research which had been done on soiling. These investigations recognized impingement and retention as separate factors in soiling. Impingement was defined as a function of the service or test condition, while retention was a function of the fabric. The degree of soiling was a result of both impingement and retention. Major conclusions reached in the various studies reported are:

(1) Soil may be brought into contact with fibers by direct transfer of soil and by deposition of air-borne soil.

(2) Soil may be retained on the fibers by occlusion in pits and crevices on the fiber surfaces, by oil binding, and by electrical forces.

(3) Fine fibers retain soil more readily than coarse fibers.

(4) Fibers having uneven cross-sectional contours retain soil more readily than those which have smooth circular contours.

(5) Soil particles commonly encountered range in size from 50 microns or less.

In order to evaluate comparative soiling rates, three methods for soiling fabrics are listed by Kaswell (25). These methods are the (a) blower test for fabrics exposed to impingement of suspended particles, (b) tumbler test for impingement occuring principally by deposition and direct transfer, and (c) floor soiling for fabrics normally exposed to direct transfer and deposition. The above methods are chiefly concerned with air-borne particles or soiling through direct contact. Other methods of staining or spotting entail the direct application of a liquid or liquid-borne soil. The degree of mutual compatability of the particle, the liquid or soil-bearing substance, and the fiber govern the extent of soiling. Because the hydrophilic fibers as cotton, rayons, and linen, are susceptible to water, they may be readily and extensively penetrated by soil.

Various procedures have been used to measure the degree of soiling and soil removal. One method is the quantitative reflectance measurements based on the surface appearance of the fabric. A second method is the quantitative chemical analysis which measures the amount of soil present. Results from these two methods of measuring degree and retention of soil are not always in agreement. The requirements of the fabric largely determine whether visual cleanliness constitutes a sufficient measurement or whether quantitative measurement of the amount of soil retained must be known. It was concluded from these studies that when subjected to visual observations, the reflectance change for darker fabrics show less change than a lighter fabric. Moreover, they concluded that factors which influence the rate and extent to which fibers and fabrics soil, undoubtedly play an equally important part in soil removal.

According to Kaswell (25), in evaluating the ability of fibers to be cleaned, consideration must be made of the physical and chemical properties of the fiber as well as the fabric structure for the proposed cleaning method. Each fiber and fabric should be cleaned under conditions which are optimum for it. He stated that when experiments with fabrics composed with different fibers are conducted under identical conditions, the results will not necessarily be comparable.

Hydrophilic fibers which soil easily, also appear to clean easily (25). Cotton fabrics soil easily, but can be equally easily laundered to a sterile condition if necessary. The fact that cotton is stronger when wet than dry is of great advantage in resisting mechanical stresses encountered in cleaning. Linen is somewhat more susceptible to chemical and mechanical damage, but otherwise reacts similarly to cotton in cleaning. As viscose loses approximately one-half of its strength when wet, more care must be used in cleaning. This fiber is also more susceptible to permanent deformations, principally secondary creep, as a result of mechanical agitation during laundering. Since viscose fibers show a greater amount of swelling than cotton or linen, they also have greater shrinkage resulting from the yarn take-up and crimp interchange.

According to Edelstein (11), soil removal is a complicated process involving wetting action, emulsification, and deflocculation. Wetting action causes the liquid to come in contact

with the fabric and the dirt held by the fabric on its surface and between the yarns. Emulsification separates the dirt particles from the fabric surface, and holds them in solution. Deflocculation is the electrical attraction for the dirt particles by the detergent solution, which prevents the soil from being redeposited on the fabric.

Some factors that may influence the detergent power of a solution are the (1) chemical composition and concentration of the detergent, (2) nature of surface and type of fiber to be cleaned, (3) amount and type of impurities of soil to be removed, (4) temperature and hardness of water used, and (5) nature of mechanical treatment applied and length of application (18, 51).

The fact that the types of soils to be removed, the surfaces to be cleaned, and the purposes of soil removal tests are so varied, precludes the possibility of any single standard soil being used for all of the different types of tests which are conducted on this subject. Generally, when fabrics are tested for soil removal identified with their end use, an especially prepared soil is used which is of a composition providing a representative sampling of the type of soil which might be found on the particular fabric to be tested.

Dining room chair coverings, because of their rugged use, require frequent cleaning. As in cleaning any fabric, the nature of the fiber, and the type of construction and finish will determine the procedure to be followed. Most of the literature on the home cleaning of upholstery fabrics recommends a dry-suds soap shampoo for the cleaning of washable glazed chintz, rep, denim, frieze, tapestry, mohair pile, homespun, and other similar upholstery fabrics, but not velvets nor velours. Some references suggested the addition of household ammonia, borax, glycerine, or water softeners to the soap shampoo.

Success in the removal of stains (5) often depends upon immediate action. Stains are removed more easily when fresh, as exposure to air, drying, and heat often change the character of the stain. The type of fiber and stain determines the remover that is safe to use, as well as the proper method of application. The three ways most commonly cited as means of stain removal are by absorbing, by dissolving, and by bleaching. As some stains are set by detergents and heat, the best procedure for removing an unidentified stain (20) from fabrics not injured by water is to apply cold water. If this fails, warm water should be used. If the fabric should not be treated with water, the other solvents should be tried.

Burning matches and hot cigarette ashes are frequently dropped on the seats of dining room chairs. Therefore, flammability of seat covers is of interest to the consumer. Fireproof or incombustible textile materials are defined as those which show no degradation or alteration of their basic character upon prolonged exposure to an open flame. Flameproofed fabrics refer to fabrics which do not support an open flame when the source of ignition is removed. Flame-resistant or flame-retardant refers to slow burning fabrics, whereas flammability designations refer to fabrics which ignite easily and burn rapidly.

Johnstone (23) suggests factors other than the rate of burning which should be considered when measuring the flammability of textiles. Among these factors are (a) the ease of ignition, (b) the volume and temperature of flame and obnoxious vapors evolved during combustion, (c) the total heat produced, (d) ignition of adjacent layers of fabric, and (e) the ease of extinguishing the burning material.

Most studies of flammability indicate that the degree of flammability in textile products is due to fabric construction, particularly to the length of fibers brushed upwards on the fabric surface. These studies of flammability indicate that plain, tightly woven fabrics generally are much slower to ignite and burn than the sheer, heavily napped or long pile fabrics.

The Hatch Textile Research and Testing Laboratories have compiled a table (13) of fade-ometer and sunlight equivalents. According to this table, 40 hours of exposure in the fade-ometer is the minimum number of hours satisfactory upholstery fabrics should withstand without fading. In this table, one day is considered equivalent to six hours of sunlight. The 40 hours exposure in the fade-ometer would be equivalent to 8.4 days of sunlight during the months of June, July, and August; 25.2 days during September, April, and May; 50 hours in October, November, and March; and 150 hours during the months of December, January, and February. However, these equivalents would be subject to variation according to geographical location, atmospheric conditions, humidity, air polution, and similar factors.

METHODS AND PROCEDURES

For this study, eight plain weave upholstery fabrics differing in appearance were chosen from two price ranges. Group I were medium priced upholstery fabrics ranging from $4.00 to $5.00 per yard. Group II ranged in price from $6.00 to $7.50 per yard. The eight fabrics varied in their fiber content, some of which were all cotton, others were all rayon or all linen. The remaining ones were mixtures of rayon with cotton or linen, or of cotton with linen. One fabric-backed plastic upholstery covering was included in each price group.

Specification analysis of the fabrics consisted of chemical and microscopical identification for fiber content, calculation of cost and weight per square yard, thickness, and yarn count. Yarn analysis included determination of yarn size and the direction and amount of twist per inch.

Fabric performance characteristics included tests for compressional resilience, resistance to abrasion, breaking strength before and after abrasion, as well as flammability before soiling and after cleaning.

Potential serviceability of the fabrics was based upon tests for colorfastness to light and crocking, soil retention, and ease and effectiveness in the removal of general soil and specified stains.

Unless otherwise stated, test procedures conformed to the specifications of the American Society for Testing Materials Standards on Textile Materials, 1950 (1), under standard conditions of 65% ± 2% relative humidity and 70° ± 2° Farenheit.

In the appendix (page 116) is to be found the cutting chart for test specimens.

TESTING PROCEDURES

Fiber identification. Verification of fiber content was determined by microscopic analysis and fiber identification stain tests.

Cost per square yard. The cost per square yard of each fabric was determined by the following formula:

$$\frac{36'' \times 36'' \times \text{cost of the fabric per running yard}}{36'' \times \text{width of fabric in inches}} = \text{cost per square yard.}$$

Weight per square yard. The Becker Chainomatic Analytical Balance was used to determine the weight per square yard. Five specimens (2" x 2") were conditioned and weighed three times. The sum of the averages for each of the five specimens was used in calculating the weight per square yard. The formula used was:

$$\frac{45.71 \times \text{grams}}{\text{area in inches}} = \text{ounces per square yard.}$$

Thickness. The thickness of the various fabrics was measured with the Schiefer Compressometer to the nearest .001 inch. The standard thickness, or thickness of the specimen when the pressure is increased to one pound per inch, was used as the basis for comparison. Fifteen determinations, corrected for the zero reading of the compressometer, were averaged and recorded as the thickness of the fabric.

<u>Yarn count</u>. The number of yarns per inch were counted with a Lowinson Micrometer on 40 tensile strength strips, none of which came from areas including the same set of warp or filling yarns. The average of 20 determinations for both warp and filling yarns was recorded as the yarn count for warp and filling, respectively.

<u>Yarn number or size</u>. The yarn number for cotton, linen, and spun rayon yarns, and denier of the rayon filament yarns were read directly from the Universal Yarn Numbering Balance. Standard lengths could not be used because of the coarseness of the yarns, so shorter lengths were used with corresponding adjustments made in the readings. Depending on the size of the cotton yarn, twelve and six inch lengths were used; twelve inch lengths for the spun rayon, six and one-half inch for the linen, and 30 centimeters for the filament rayon yarns.

Because of the variations in yarns, the number of determinations varied with the total number of like yarns in three inches of the fabric, rather than the customary procedure in yarn analysis. The number of determinations ranged between 28 and 117 for each type of yarn. Yarn number or denier was recorded for each yarn in three inches of fabric. The average for each group differing in type or color was recorded and calculated for one inch. The arithmetical average of each of these three averages was recorded as the yarn number or denier for each type and color of yarn respectively, in warp and filling.

Twist per inch. The Alfred Suter Twist Tester was the instrument used to determine the direction and number of twists per inch in both warp and filling yarns. In accordance with standard procedures of A.S.T.M., a one inch gauge length was used for single and filament yarns. A ten inch gauge length was used for ply yarns. Because of marked variation within these complex yarns, the twist for each component yarn in the ply was also determined.

Twist in consecutive yarns in three inches of fabric in both warp and filling directions was recorded. Twist per inch was then calculated for the different yarn types or colors, and recorded as the average number of twists per inch for each corresponding group of yarns for warp and filling, respectively.

Compressibility. The compressibility of a fabric is the ratio of the decrease in thickness at a pressure of one pound per square inch to standard thickness. Fifteen determinations were made on the Schiefer Compressometer. The following formula was used:

$$\frac{\text{Thickness at 0.5 lb. pressure per inch} - \text{thickness at 1.5 lbs. pressure per inch}}{\text{Standard thickness}} = C$$

Compressional resilience. The compressional resilience of fabric or the amount of work recovered from the specimen when the pressure is decreased from 2.0 to 0.1 pounds per square inch and expressed as a percentage of the work done on the specimen when the pressure is increased from 0.1 to 2.0 pounds per square inch, was measured on the Schiefer Compressometer. Fifteen determinations were recorded in accordance

with the method of test described by Schiefer for the Schiefer Compressometer. Calculations were made by the formula:

$$\frac{\text{Recovery value}}{\text{Compression value}} = \text{Compressional resilience in percent.}$$

The average of the 15 percentages was recorded as the compressional resilience for each fabric.

Abrasion resistance. Resistance to abrasion was determined on the United States Testing Company Abrasion Machine. Two specimens, 4.5" by 6.5" (clamped on the flat bed of the carriage which reciprocated in a horizontal direction under a stationary abradant) were abraded in the direction of the longer dimension, simultaneously. After every 50 double strokes, the machine was stopped, the arms lifted, and the lint removed from the specimen by lightly picking off the large lint rolls and gently brushing with a soft textile brush. A new abradant cloth was used for each specimen, or after each 2500 double strokes. Testing was done with Number 320 Aloxite Metal Cloth, having an area of contact with the specimen of 4" x 0.44".

Sixteen specimens, eight with the longer dimension parallel to the warp and eight with the longer dimension parallel to the filling, were abraded for determinations of (1) first sign of wear, arbitrarily defined as discoloration; (2) first yarn break; (3) for hole or rupture of two yarns at right angles to each other; and (4) for complete breakdown, arbitrarily defined as the stage where the abradant might rub against the bed plate of the carriage through a large hole or break in the specimen. At each stage of abrasion, the machine was stopped, the specimen was lightly brushed, removed from the machine and weighed on the Becker Chainomatic Balance. The specimen was again placed in the machine and abraded to the next stage of wear. After these determinations were completed for each fabric, a constant number of double abrasion strokes was arbitrarily established for the purpose of comparing the fabrics after the same amount of wear. The arbitrary numbers chosen fell within the maximum and minimum range of double strokes for all fabrics abraded to first sign of wear and complete breakdown. Eight specimens from each fabric were abraded in the direction of the warp and eight in the direction of the filling yarns for each of the three constant numbers. Following abrasion, each specimen was cut into three strips for determination of the breaking strength of the abraded fabric.

<u>Breaking strength</u>. Breaking strength was determined by the raveled-strip method on the Scott Tensile Strength Machine in accordance with standard procedure as designated in A.S.T.M. (1). Forty specimens, 1-1/2 inches in width and 12 inches long, were cut, one-half with the longer dimension in the direction of the warp. The remaining twenty were cut with the longer dimensional parallel to the filling. Each strip was raveled to one inch in width by taking approximately the same number of yarns from each side. The specimen was then cut into two 6 inch lengths, one for dry tensile strength tests, the other for wet tensile strength tests. No two speci-

mens contained the same set of warp or filling yarns. The average of 20 breaks each for both dry and wet warp strength was recorded. Dry and wet filling strengths were recorded similarly.

Three breaking strength strips (1-1/2" x 6-1/2") were cut from each 4-1/2" x 6-1/2" abrasion specimen after a constant number of abrasion strokes on the United States Testing Company Abrasion Machine. Each strip was raveled to exactly one inch in width, with approximately the same number of yarns taken from each side. Nine strips each for dry and wet breaking strength in both warp and filling directions were broken under the same test conditions as the original fabric. The average of nine breaks each was recorded as dry and wet warp and filling breaking strength after abrasion to 100, 250, and 500 double strokes.

Flammability. Six specimens, 2" x 6", of the original fabric, and also from the cleaned fabric were tested in the United States Testing Company Flammability Tester to determine their flammability classification. Specimens were cut with the long dimension in the direction which burned most rapidly as determined by preliminary tests. Specimens were clamped individually in the specimen holders of the flammability tester and dried for 30 minutes in a horizontal position in an oven at 105° C. They were then removed from the oven, and placed over anhydrous calcium chloride in a desiccator for at least 15 minutes or until cool. The mounted specimen was then removed from the desiccator and placed in position on a rack in the draft-free chamber of the tester so that the surface of the specimen was five-sixteenths of an inch from the tip of the gas nozzle at the starting position. The test specimen was ignited, within 45 seconds after removal from the desiccator, by the flame applied for a period of one second. The time of flame spread was recorded, and the average of the six readings for each fabric recorded and classified according to the flammability classification given in the United States Testing Company Flammability Tester Instruction Sheet (57).

Colorfastness to light. In accordance with the recommendations of the Hatch Textile Research and Testing Laboratories (13), 40 hours exposure in the Atlas Fade-Ometer constituted the minimum hours for satisfactory colorfastness to light for upholstery fabrics. Because of the small area exposed, two specimens were used for each light period of 40, 60, 80, 100, and 120 hours, respectively. Classification of colorfastness to light was made in accordance with Commercial Standards CS59-44 (41).

Colorfastness to crocking. Ten specimens (2" x 5" with the longer dimension parallel to the warp yarns) were tested for colorfastness to crocking on the Crock Meter. A two inch square of unsized white muslin was attached to the finger on the top arm of the machine and rubbed against the specimen on the base of the machine for a total of ten double strokes under a constant load of 32 ounces. Five specimens were tested against a dry muslin square, and five against a wet muslin square. The white cloth was compared with the original white cloth against the Munsell Neutral No. 7 color chart for change in color, and reported as colorfast to crocking in accordance with the classification in Commercial Standard CS59-44 (41).

Soil retention. For comparison of the soil retention properties of the selected upholstery fabrics, the following test was made. Two samples (12" x 24") of each of the eight fabrics were conditioned and weighed. Twenty-five grams of a standard soil of the following consistency: 32.5% by weight cracker crumbs; 30% sand; 10% each of sugar, salt, and carbon black; 5% mineral oil; and 2.5% cirgarette ashes and tobacco was applied to each sample. For each of the remaining four applications, ten grams of standard soil was applied.

In order to simulate actual use, the soil was rolled into the fabric with a wooden rolling pin with ten double strokes in the direction of the warp, followed by five in the direction of the filling, and again ten double strokes in the direction of the warp. The fabric was then brushed with a three inch brush in the direction of the warp for 12 overlapping strokes, followed by 24 overlapping strokes in the direction of the filling and again warpwise for 12 strokes. The rolling procedure was repeated and the specimen then vacuumed with the furniture brush attachment of the Singer Hand Vacuum. Each fabric was vacuumed by brushing lightly over the surface with the same number and order of directional strokes as used with the three-inch brush during the application of the standard soil. This method of soiling and vacuuming was followed for each of the five soil applications on each fabric.

At the conclusion of the soil application, the specimens were conditioned, weighed, and then subjectively compared with a control sample for determination of soil retention and change in color of the soiled fabrics.

Soil removal. The soiled fabrics were cleaned by two different methods. A dry suds shampoo and a foam type commercial upholstery cleaner, Mystic Foam, were used. The dry suds shampoo was made by whipping a soap jelly made of five cups of soft water and one-half cup shaved soap, heated until the soap was dissolved, and cooled to a gelatinous mass. One-half cup of the soap jelly was whipped to a lather-like consistency and applied with a sponge to the fabric with a circular motion. The soiled suds were scraped off and clean suds applied. The specimen was then rinsed with a damp cloth wrung out of warm tap water, and wiped with circular overlapping strokes. This procedure was repeated, after which the specimen was allowed to dry. The same procedure was used in the application and removal of the Mystic Foam.

For the second cleaning, one-half the amount of soap jelly and Mystic Foam was used. The specimens were again dried, conditioned, and weighed.

Subjective comparison with samples of the original fabrics for cleanliness, change in color, surface texture and roughness, and dimensional change were then made.

Stain removal. In an average home, especially where there are children in the family, dining room chair seats are subject to many stains from food spilled or dropped during a meal, as well as to miscellaneous accidents resulting from varied activities. It is therefore of value to the consumer to know which fibers and textures are most easily and/or effectively cleaned.

In order to simulate conditions of actual use, each specimen was clamped in an embroidery hoop and placed over a foam rubber sponge to simulate an upholstered chair seat. Fourteen common stains, namely butter, sweet chocolate, milk, orange juice, egg, coffee, coke, chewing gum, medicine with an alcoholic base, nail polish, indelible pencil, writing ink, lipstick, and tar were applied to fabric specimens and removed immediately by appropriate procedure. The same stains were again applied but allowed to stand 24 hours before attempting to remove the stain. The fabric specimens were then subjectively evaluated for ease and effectiveness in removal of the various stains, bleeding of dyes, presence of rings, change in surface texture and quality, and comparison made between the two procedures used.

INTERPRETATION OF RESULTS

ANALYSIS OF FABRIC SPECIFICATIONS

Fiber identification. In analyzing the fabrics, the E. R. Multicolor Tweed (II) was found to be 100% cotton, the Heavy Textured Linen (VI) was 100% flax; and the Barretta Cloth (III) of 100% rayon, the warp of viscose and the filling of cuprammonium yarns. The rayon-linen (IV) was linen fillingwise and viscose rayon warpwise. In the D.A.C. Rosemont fabric (V), linen and cotton were combined in a ply and used for both warp and filling. In the D.A.C. Tweed (I), the

TABLE I

FABRIC IDENTIFICATION

Group	Fabric Code*	Fabric	Fiber Content Warp	Fiber Content Filling
A	II-C	E. R. Multicolor	Cotton	Cotton
	IV-RL	McKay, Davis, & McLane, Inc. Rayon-Linen	Viscose	Linen
	VI-L	Konwiser, Inc. Heavy Linen Texture	Linen	Linen
	VII-P_1	Dupont "Fabrilite", Quality 180	Plastic with cotton backing	
B	I-CR	D.A.C. 4200 Cotton Tweed	Cotton, Viscose	Cotton
	VIII-P_2	Dupont "Fabrilite", Quality 200	Plastic with cotton backing	
	III-R	Greef's Barretta Cloth	Viscose	Cuprammonium
	V-LC	D.A.C. Rosemont	Linen, Cotton	Linen, Cotton

*Fabric Code: Numbers: Fabric number
Letters: First letter of each fiber in fabric, with either type of rayon designated by R

majority of the yarns were of cotton, with an occasional viscose yarn inserted at intervals throughout the warp. Both "Fabrilite" fabrics (VII and VIII) were cotton backed plastics.

Cost per square yard. When fabric cost per linear and per square yard was compared, there was less difference in price than indicated by their purchase cost per yard. Based on cost per square yard, the fabrics remained in the same price order with the exception of the heavy linen upholstery (VI-L) and the fabrilite covering (VII-P), which were reversed in their price position.

TABLE II

COMPARISON OF FABRIC COST

Group	Fabric Code	Width	Price per Linear Yard	Price per Square Yard
A	II-C	54"	$4.00	$2.67
	IV-RL	51"	4.15	2.93
	VI-L	50"	4.50	3.24
	VII-P_1	56"	5.00	3.21
B	I-CR	54"	6.00	4.00
	VIII-P_2	56"	6.50	4.18
	III-R	52"	6.75	4.67
	V-LC	49"	7.50	5.51

Weight per square yard. There were no significant weight differences in the six woven fabrics although the cotton-rayon tweed (I) and the all linen (VI) were half again heavier than the other four. Both plastics were approximately twice as heavy as the woven coverings.

used in these two fabrics were designed to achieve texture and color interest.

<u>Yarn analysis</u>. Warp yarns in the cotton-rayon tweed of fabric I consisted of two gimp yarns, a brown and a gray; and two-ply yarns, a white cotton and a white spun viscose. There was no orderly or regular sequence in their arrangement. Both the brown and the gray yarns were similar in size as well as in amount and direction of twist. Further analysis of the

TABLE IV

YARN ANALYSIS OF FABRIC I
(COTTON-RAYON)

Yarn Direction	Color & type	Single	Ply	Size	T.P.I.*	D.T.#
Warp		1	-	5	9	Z
		1	-	7	8	Z
		-	2	-	9	S
	Brown	1	-	10	21	Z
	Gimp	-	2	-	6	Z
Warp		1	-	5	10	Z
		1	-	7	8	Z
		-	2	-	9	S
	Gray	1	-	10	21	Z
	Gimp	-	2	-	6	Z
Warp	White	1	-	11	13	Z
	Cotton	1	-	11	13	Z
	Ply	-	2	-	8	S
Warp	White	1	-	9	13	Z
	Viscose	1	-	9	13	Z
	Ply	-	2	-	8	S
Filling		1	-	6	5	Z
		1	-	4	5	Z
	Light	-	2	-	9	S
	Green	1	-	9	21	Z
	Gimp	-	2	-	6	Z
Filling	Green Single	1	-	2	7	Z

* Twists per inch
\# Direction of twist

Standard thickness. There was no apparent relationship between standard thickness and fabric weight. In order of thickness, the plastics were thinnest as well as heaviest. The two rayon fabrics (III and IV) and the linens (V and VI) were less thick than the two cotton tweeds (I and II).

Yarn count. The warp yarn count was greater than filling count for all fabrics except in the rayon (III), in which the filling count was approximately twice that of its warp. In the majority of the fabrics, the warp and filling yarn counts were quite well balanced. Moderately coarse yarns were used in all of the six woven upholstery fabrics. In the cotton-rayon tweed (I) and the all cotton (II), the yarns varied not only in color, but in structure as well. Obviously, the yarns

TABLE III

FABRIC ANALYSIS

Fabric Code	Thickness[1] in inches	Weight per Square Yard	Yarn Count per Inch[2] Warp	Filling
I-CR	.090"	14.8855 oz.	25	15
II-C	.070"	11.3843 oz.	27	25
III-R	.048"	9.6270 oz.	25	47
IV-RL	.039"	11.3784 oz.	39	24
V-LC	.053"	12.1744 oz.	13	12
VI-L	.060"	16.7321 oz.	18	14
VII-P_1*	.028"	18.6878 oz.	59	54
VIII-P_2*	.032"	22.9471 oz.	59	52

[1]Average of 15 determinations
[2]Average of 20 counts
*Yarn count of the cotton backing yarns

gimp yarn structure showed that two single yarns of Z twist were plied with an S twist, and subsequently wrapped around a fine single yarn with Z twist to form the gimp yarn. The two white yarns, consisting of Z twist singles, were formed into a ply with an S twist. The cotton yarns were slightly finer than the rayon yarns, and when plied, had a higher twist than the rayon ply.

The filling contained two light green gimp yarns alternated with two single yarns of dark green. The light green yarns were constructed in the same manner as the gimp yarns

TABLE V

YARN ANALYSIS OF FABRIC II
(COTTON)

Yarn Direction	Color & type	Single	Ply	Size	T.P.I.*	D.T.#
Warp	Light	1	-	11	14	Z
	Brown	1	-	11	14	Z
	Ply	-	2	-	8	S
Warp	Dark	1	-	11	14	Z
	Brown	1	-	11	14	Z
	Ply	-	2	-	8	S
Warp		1	-	11	14	Z
	Yellow	1	-	11	14	Z
	Ply	-	2	-	8	S
Filling		1	-	11	15	Z
	Yellow	1	-	11	15	Z
	Ply	-	2	-	7	S
Filling		1	-	22	23	Z
		1	-	22	23	Z
	White	-	2	-	14	S
	Green	1	-	5	9	Z
	Green & white	-	2	-	11	S
	White	1	-	11	20	Z
	Green & white gimp	-	2	-	6	Z

* Twists per inch
\# Direction of twist

used in the warp, but one of the component yarns of the basic ply was slightly coarser than the other. Both basic yarns were less tightly twisted than the brown and gray gimp yarns in the warp. The dark green single yarns which were used were coarse and of low Z twist.

Three different 2-ply yarns; a yellow, a light brown, and a dark brown, alternating in groups of two; were used in the warp in fabric II. The filling consisted of one 2-ply yellow yarn, and one green and white gimp yarn alternately in groups of two. The 2-ply yarns used in both warp and filling were similar in twist and size. The gimp yarn in the filling consisted of four Z twist single yarns, and was formed by twisting two fine, highly twisted, white single yarns together with an S twist, and around this yarn was twisted a coarse, low twist green yarn with an S twist. This yarn was then wrapped, with a Z twist, around a high twist white yarn, thus forming the complex gimp yarn.

The warp yarns in the rayon fabric (III) were 2-ply yarns which were formed by a coarse, loosely Z twisted single yarn plied with a finer, high Z twist yarn. The two single yarns comprising the ply were then given an S twist. Filament yarns of dark green and blue green and of low twist were used in the filling. The denier of each of the filament yarns was similar. In size, they appeared to be the same as the ply yarns used in the warp.

Fabric IV consisted of rayon filament yarns in the warp and linen single yarns in the filling. The amount of twist in

TABLE VI

YARN ANALYSIS OF FABRIC III
(RAYON)

Yarn Direction	Color & type	Single	Ply	Size	T.P.I.*	D.T.#
Warp		1	-	5	12	Z
	Green	1	-	19	21	Z
	Ply	-	2	-	8	S
Filling	Dark green Multi-filament	1	-	793 den.	3	S
Filling	Blue green Multi-filament	1	-	773 den.	4	S

* Twist per inch
# Direction of twist

the warp and filling yarns was similar. The filament rayon yarns had been given an S twist, whereas the linen filling yarns had been given a Z twist. The filament yarns appeared much finer than the linen, for the flax yarns were thick and thin and sufficiently lacking in uniformity to give the characteristic slub appearance identified with many linen fabrics.

TABLE VII

YARN ANALYSIS OF FABRIC IV
(RAYON-LINEN)

Yarn Direction	Color & type	Singles	Size	T.P.I.*	D.T.#
Warp	Green rayon Multi-filament	1	931/140	9	S
Filling	Green Linen	1	8	10	Z

* Twist per inch
# Direction of twist

Both the warp and filling yarns in the linen-cotton fabric (V) were similar in size and twist. Two single yarns, one each of cotton and linen, were combined to form the ply yarns used. The cotton single yarns were of a slub type, being twice as coarse and twice as tightly twisted as the linen yarns with which they were combined.

TABLE VIII

YARN ANALYSIS OF FABRIC V
(LINEN-COTTON)

Yarn Direction	Color & type	Single	Ply	Size	T.P.I.*	D.T.#
Warp	Cotton	1	-	4	11	Z
	Linen	1	-	8	5	Z
	Green ply	-	2	-	4	S
Filling	Cotton	1	-	3	11	Z
	Linen	1	-	8	6	Z
	Green ply	-	2	-	5	S

* Twist per inch
# Direction of twist

The all linen upholstery fabric (VI) was composed of single yarns in both the warp and filling. Each had been given the same amount and direction of twist. However, the yarn were unlike in size, the filling yarns being slightly coarser.

TABLE IX

YARN ANALYSIS OF FABRIC VI
(LINEN)

Yarn Direction	Color & type	Singles	Size	T.P.I.*	D.T.#
Warp	Green linen	1	5	7	Z
Filling	Green linen	1	4	7	Z

* Twists per inch
# Direction of twist

ANALYSIS OF PERFORMANCE CHARACTERISTICS

In the specification analyses of the eight fabrics, it was evident there were marked differences among them in weight, thickness, yarn count, type, size, and the amount of yarn twist. They likewise differed in fiber content, so it was to be expected that they would show marked variance in performance tests.

The eight fabrics were tested for the following performance characteristics, namely resistance to abrasion, breaking strength before and after abrasion, flammability before and after cleaning, and compressional resiliency.

Initial performance in resistance to abrasion and compressional resilience is discussed for each fabric, and comparisons made between the eight fabrics. Breaking strength before and after abrasion, and flammability before and after cleaning for each fabric are likewise discussed and comparisons made between the different fabrics constituting the group.

Abrasion resistance. Fabric I resisted approximately twice as many abrasion strokes before a yarn was broken when abraded in the direction of the warp than when abraded in the direction of the filling. However, continued abrasion to a hole and complete breakdown gave evidence of the deterioration of the warp yarns which had occurred earlier. The filling withstood prolonged abrasion much better, in fact, for nearly

TABLE X

PERFORMANCE IN ABRASION RESISTANCE

Fabric	Number of Double Strokes(1)							
	First Sign of Wear		First Yarn Break		Hole		Complete Breakdown	
	W*	F*	W*	F*	W*	F*	W*	F*
I-CR	35	41	270	144	432	788	935	1695
II-C	23	24	244	140	305	496	1164	1539
III-R	46	25	57	38	162	715	658	1327
IV-RL	22	12	61	26	222	668	843	1051
V-LC	28	31	588	583	1184	1127	1397	1308
VI-L	11	12	378	324	1047	763	2155	1373
Average	26	24	266	209	559	760	1192	1382

(1) Average of eight determinations
* W: Warp, F: Filling, direction of abrasion

twice as many strokes. This may be explained, in part, by the fact that the filling yarns were obviously stronger as well as more uniform. The yarns of the warp varied in both size and structure. Moreover, they followed no regular sequence or order, and because of that, showed greater variance in their resistance to abrasion than the more uniform yarns of the filling.

Fabric II showed almost twice the resistance at the first yarn break when abraded in the direction of the warp rather than the filling. Regardless of the direction in which this fabric was abraded, the warp yarns were the first to break. The filling yarns in this fabric withstood more abrasion than the warp yarns, as evidenced by the fact that one and one-half

times the number of strokes were required to reach the hole stage when abraded in the direction of the filling.

Approximately three times as many strokes were necessary for complete breakdown (that point when the abradant rubs directly on the base plate) as required for evidence of a hole. The ratio of the number of strokes from the hole stage to complete breakdown were comparable for abrasion in either direction.

In fabric III, signs of wear did not appear as early when abrasion was parallel with the filling. The first yarn (a warp) broke very soon after abrasion was started. Nineteen additional strokes were required for a yarn break when abraded in the direction of the warp.

Abrasion to a hole required a break in the spun viscose warp yarns as well as in the cuprammonium filling yarns. The difference in resistance of the cuprammonium filling yarn to lengthwise and crosswise abrasion was significant. More than four times as many strokes were required when abraded parallel with the filling yarn than when parallel with the warp. At the stage of complete breakdown, the fabric resisted twice as many strokes when abraded fillingwise as warpwise.

Fabric IV resisted twice as many abrasion strokes before the first sign of wear when abraded with the warp as when abraded with the filling. The rayon warp yarns were the first to break regardless of the direction of abrasion. Only 26 abrasion strokes were necessary to break a warp yarn when abrasion was perpendicular to it. Warpwise, the fabric withstood two and one-half times as many abrasion strokes for the first yarn break as it did fillingwise.

As abrasion continued, the fabric showed greater resistance when abraded parallel with the filling. At the hole stage, the fillingwise abraded specimens resisted three times the number of strokes required for warpwise abrasion. At complete breakdown, it withstood one-fourth again as many strokes as when subjected to perpendicular abrasion.

Fabric V showed comparable abrasion resistance to warpwise and fillingwise abrasion. Discoloration showed at an early stage of wear. The first yarn break did not occur until the fabric had been subjected to 20 times the number of abrasion strokes required for first sign of wear. To reach the hole stage required approximately twice as many strokes (1184) as for the first yarn break (588). Between 1300 and 1400 strokes were required for complete breakdown. Differences between warpwise and fillingwise abrasion at any of the four stages of abrasion were slight. This fabric was well balanced both in yarn count and yarn structure, which obviously accounted for its comparable resistance to abrasion in either direction.

Fabric VI showed greater resistance to warpwise abrasion than to fillingwise abrasion. Although the difference in amount of abrasion required to break the first yarn was not large, the differences were greater at the hole stage, and were even more pronounced at complete breakdown. In this fabric, the finer warp yarns resisted wear longer than the filling yarns. Abrasion in the direction of the warp was less damaging to the fabric than abrasion fillingwise.

In preliminary tests for abrasion resistance, the plastic materials were subjected to 15,000 double strokes. As only surface markings were removed, the plastic upholstery fabrics are not included in the discussion of abrasion resistance results with the other fabrics.

Among the six woven fabrics, abrasion resistance to first sign of wear was low in both warp and filling directions. The range for the warpwise abrasion was 11 to 46 strokes. The fillingwise range was 12 to 41. The average warpwise was 26 double strokes, and fillingwise was 24.

Resistance to abrasion was greater in the direction of the warp at the first yarn break on every fabric. Both the rayon (III) and rayon-linen (IV) fabrics showed particularly low resistance to abrasion. The linen-cotton (V) showed the highest resistance in both warp and filling directions at this point.

At the hole and complete breakdown stages, abrasion resistance was better in the direction of the filling, except for the linen (VI) and linen-cotton (V) fabrics.

Comparison of abrasion resistance in warp and filling directions for each fabric showed the linen-cotton, fabric V, as having the most comparable wear resistance. This particular fabric had a well balanced warp and filling yarn count, and yarns of comparable structure.

After ranking each fabric for warp and filling abrasion at each stage of observation, the composite ranking from best to poorest was: the linen-cotton (V); linen (VI); cotton-

rayon tweed (I); cotton tweed (II); rayon (III); and rayon-linen (IV). The greater the similarity in yarn structure in the warp and filling of the fabric, the greater was their similarity in resistance to abrasion in either direction.

Weight loss after abrasion. Fabric I, cotton-rayon, showed a similar percent loss in weight regardless of the direction of abrasion. The rate of loss appeared to be fairly consistent with progressive abrasion, although it showed more severe loss after prolonged abrasion, particularly in the last 250 strokes.

In fabric II, the loss of weight was similar and progressive regardless of the direction of abrasion. This was shown when abraded the constant number of strokes which were 100, 250, and 500 strokes; likewise, when abraded to each wear stage: first sign of wear, first yarn break, hole, and complete breakdown.

TABLE XI

PERCENT LOSS IN WEIGHT AFTER ABRASION

Fabric	First Sign of Wear		First Yarn Break		Hole		Complete Breakdown	
	W*	F*	W*	F*	W*	F*	W*	F*
I-CR	0.40	0.45	3.06	1.78	4.66	8.54	11.10	21.85
II-C	0.43	0.46	3.93	2.24	4.91	7.18	18.53	26.27
III-R	0.89	0.81	1.18	1.22	2.38	22.39	9.76	35.17
IV-RL	0.24	0.11	0.68	0.31	2.04	8.88	8.67	17.02
V-LC	0.49	0.58	8.74	8.77	20.69	18.80	27.19	23.46
VI-L	0.25	0.30	3.25	3.12	7.45	6.27	19.12	13.26

* W: Warp, F: Filling, direction of abrasion
Average of eight determinations

In fabric III, the loss in weight was approximately twice as great for a constant number of strokes when the abrasion was in the direction of the filling, rather than the warp. The viscose surface yarns were the first to show discoloration and effects of abrasion. This was especially noticeable when abraded perpendicular to their length, since the spun viscose warp yarns were much more subject to wear than the filling yarns. A greater loss in weight occurred when the fabric was abraded in the direction of the filling.

TABLE XII

PERCENT LOSS IN WEIGHT AFTER CONSTANT NUMBER OF DOUBLE ABRASION STROKES

Fabric	100(1)		250(1)		500(1)	
	W*	F*	W*	F*	W*	F*
I-CR	1.18	1.24	2.50	2.63	5.13	5.15
II-C	1.41	1.76	3.59	3.52	6.90	6.08
III-R	1.43	2.11	2.47	4.95	4.39	9.62
IV-RL	0.91	1.18	1.65	2.68	3.72	5.27
V-LC	1.47	1.54	3.41	3.24	6.09	6.26
VI-L	1.35	1.31	2.39	2.40	3.71	3.44
Average	1.29	1.52	2.67	3.24	4.99	5.97

(1)Number of double strokes abraded
* W: Warp, F: Filling, direction of abrasion
Average of eight determinations

At first, fabric IV showed little difference in weight loss resulting from abrasion in either direction. However, as abrasion continued, greater differences were noted, particularly when abraded in the direction of the filling. This was due to the weaker rayon warp yarns wearing off first. When abraded in the direction of the warp, less damage occurred to these weaker yarns than when abrasion was perpendicular to them.

In fabric V, the percent loss of weight due to abrasion was comparable, and showed a direct relationship to the number of strokes. After prolonged abrasion, greater loss was noted in the direction of the warp. This was accounted for by the fact that the warp yarns were stronger and more resistant to abrasion than the filling yarns. This was especially true when abrasion was perpendicular to rather than parallel to the yarns.

In fabric VI, the percent loss in weight was progressive and consistent, showing a direct relationship to the number of abrasion strokes. The loss due to abrasion in either direction was not significantly different for a constant number of strokes.

In general, the percent change in weight showed consistent and progressive loss and a direct relationship to the number of abrasion strokes applied. Loss in weight after abrading for the same number of strokes indicated that there was no significant difference in the weight loss due to the direction of abrasion except in the rayon (III) and rayon-linen (IV) fabrics. These showed greater differences when abraded in the direction of the filling. When ranked for weight loss resulting from abrasion, the linen showed the least loss. In ascending order of percent loss of weight, was the linen (VI), followed by the rayon-linen (IV), cotton-rayon (1), linen-cotton (V), cotton (II), and rayon (III) fabrics.

Initial breaking strength. The initial warp breaking strength of fabric I, the cotton-rayon tweed, was much lower than that of the other fabrics. The original dry strength of the warp in this fabric was 40 pounds, and slightly lower when tested wet. The initial low warp breaking strength may have been due to the presence of viscose yarns, which have a much lower breaking strength than cotton, and were generally the first to break.

TABLE XIII

ORIGINAL BREAKING STRENGTH IN POUNDS

Fabric	Warp		Filling	
	Dry*	Wet*	Dry*	Wet*
I-CR	40	37	75	93
II-C	71	94	62	82
III-R	93	43**	60	29
IV-RL	122	47#	93	167
V-LC	116	72	108	69
VI-L	108	182	73	126
VII-P_1	58	74	49	66
VIII-P_2	63	80	52	67

* Average of 20 determinations
**Average of 17 determinations
\# Average of 10 determinations

The cotton filling yarns had approximately twice the dry strength of the warp. When the wet strength of the warp and

filling were compared, differences were even greater due to the presence of rayon in the warp. The filling yarns of fabric I showed higher wet than dry strength, which is characteristic of cotton.

The cotton, fabric II, showed a higher warp breaking strength than fabric I, breaking at 71 pounds when dry and even higher when wet. The filling yarns, which contained a complex gimp yarn as well as 2-ply yarns similar to those in the warp, broke at a lower poundage than the warp. Again, as is characteristic of cotton, wet strength was greater than dry.

Fabric III showed a high dry breaking strength in the direction of the warp. However, the wet strength of these spun viscose yarns was but one-half of their dry strength. The breaking strength of the cuprammonium filament yarns of the filling was approximately one-third lower than that of the warp. The dry filling strength of the cuprammonium rayon yarns was twice its wet strength, and is characteristic of dry-wet strength relationship for rayon.

Fabric IV had the highest dry warp strength (121.5 pounds) of any of the eight fabrics. However, its wet strength was approximately 61% less. This lower wet strength was characteristic of viscose. The linen filling yarns had the strongest wet filling strength (167 pounds) of any of the eight fabrics. The dry strength was 44% lower, or 93 pounds. However, this was only 23% lower than the dry strength of the warp, which shows this fabric to be well balanced in its initial strength.

Two-ply linen and cotton yarns were used in both the warp and filling of fabric V. Both the warp and filling dry strengths were high when compared with the other fabrics. The dry filling strength was eight pounds lower than the dry warp strength. The wet strength was somewhat lower in both the warp and filling. This is contrary to strength performance expected of cotton and linen, and may have been partially due to the character of the yarns. Both the linen and cotton yarns were coarse with practically no twist in the slub areas of the yarns, and very low twist between slubs. This may account for their lower than average wet strengths. The warp was slightly stronger than the filling, but the filling count was one yarn less per inch than the count of the warp. As both warp and filling yarn count was low, even one yarn may account for the strength difference.

The wet warp strength of fabric VI (182 pounds) was the highest of any of the fabrics, either wet or dry. It exceeded the highest warp or filling strength of any of the fabrics in this study. As is characteristic of flax, the dry strengths for both warp and filling were lower than their wet strengths. Comparison of the warp and filling strengths for this fabric show the warp approximately 31% stronger than the filling. This may have been influenced by several factors; namely, a higher yarn count and uniformity of the warp yarns. Although the #4 filling yarns had the same number of twists per inch as the #5 yarns of the warp, these filling yarns were characterized by numerous thick and thin areas throughout their length. This could account for its lower strength.

The tensile strengths of plastic fabrics VII and VIII were based on the cotton backing. These backing yarns broke, whereas the plastic coating merely stretched. The resulting breaking strengths showed a higher wet than dry strength in both warp and filling. Warp strength was higher than the filling; also, the yarn count was slightly higher in the warp. Fabric VIII, which had breaking strengths slightly above those of fabric VII, also had a slightly higher yarn count.

Breaking strength after abrasion. Very little difference in strength was noted in the warp strength of fabric I after abrasion. Wet strength was slightly higher after 100 abrasion strokes, and after 250 and 500 abrasion strokes was equivalent to its initial strength. Dry strength was the same as its initial strength after 250 double strokes, but slightly lower after 100 and 500 strokes.

Possibly, the small differences in strength after abrasion may have been due to the gimp yarns used in the warp. These cotton gimp yarns tended to project above the surface of the other yarns and received a greater amount of abrasive action; leaving the smaller 2-ply yarns virtually untouched even after 500 abrasion strokes. Although these smaller 2-ply viscose yarns were generally the first yarns to break, breaking strength after abrasion indicated that they were only slightly affected by abrading.

After 100 and 250 abrasion strokes, the dry filling strength of fabric I was higher than its original strength. In dry and wet tests, greater loss occurred during the last abrasion period. The increase in dry filling strength after abrasion may be explained by the fact that the weaker yarns were worn off early in abrasion, leaving only the stronger yarns which subsequently indicated breaking strength higher than the recorded initial strength.

On a percentage basis, greater loss of strength after 500 abrasion strokes occurred in the filling than in the warp of fabric I. However, in pounds (67 and 74), the filling yarns were stronger than the warp yarns (40 and 37 pounds) were initially. The warp strength after 500 abrasion strokes was 37 pounds dry or wet.

Fabric II, of 100% cotton, showed higher wet than dry strength after abrasion. At first the loss was insignificant. After 250 abrasion strokes, the warp loss in dry strength was less pronounced than loss in wet strength. There was a 45% loss in dry strength after the terminal 500 abrasion strokes, whereas wet strength loss was only 29%.

The gain in both wet and dry filling strengths after 100 abrasion strokes was probably caused by the early loss of the weaker fibers which left only the stronger yarns. The greatest loss in strength occurred in the last period of abrasion. The 16% loss in wet and 18% loss in dry breaking strengths after 500 strokes, were not significantly different.

There was a greater percentage loss of strength (both wet and dry) for the warp than the filling. This may be due to differences in yarn structure. The single green in the filling gimp yarn was very coarse and protruded above the

TABLE XIV

COMPARISON OF WARP BREAKING STRENGTH BEFORE AND AFTER ABRASION

Fabric	No. of Strokes Abraded Warpwise	Breaking Strength in Pounds*#		Change in Breaking Strength after Abrasion#			
				Pounds Lost		Percent Lost	
		Dry	Wet	Dry	Wet	Dry	Wet
	Original	40	37	-	-	-	-
I-CR	100	39	39	1	+2	2.5	+5.5
	250	40	37	0	0	0	0
	500	37	37	3	0	7.5	0
	Original	71	94	-	-	-	-
II-C	100	70	88	1	6	1.4	6.4
	250	62	69	9	25	12.7	26.6
	500	39	67	32	27	45.1	28.7
	Original	93	43	-	-	-	-
III-R	100	38	16	55	27	59.1	62.8
	250	22	11	71	32	76.4	74.4
	500	8	7	85	36	91.4	83.7
	Original	121.5	47	-	-	-	-
IV-RL	100	68	37	53.5	10	44.0	21.3
	250	38	18	83.5	29	68.7	61.7
	500	21	11	100.5	36	82.6	76.6
	Original	116	72	-	-	-	-
V-LC	100	112	69	4	3	3.4	4.2
	250	106	67	10	5	8.6	6.9
	500	106	65	10	7	8.6	9.7
	Original	108	182	-	-	-	-
VI-L	100	94	173	14	9	13.0	4.9
	250	88	162	20	20	18.5	11.0
	500	85	157	23	25	21.3	13.7
VII-P_1	Original	58	74				
VIII-P_2	Original	63	80				

* Original - average of 20 determinations
\# After abrasion - average of 9 determinations
\+ Amount gained

TABLE XV

COMPARISON OF FILLING BREAKING STRENGTH BEFORE AND AFTER ABRASION

Fabric	No. of Strokes Abraded Fillingwise	Breaking Strength in Pounds*#		Change in Breaking Strength after Abrasion#			
				Pounds Lost		Percent Lost	
		Dry	Wet	Dry	Wet	Dry	Wet
	Original	75	93	-	-	-	-
I-CR	100	82	91	+7	2	+9.3	2.2
	250	76	86	+1	7	+1.3	7.5
	500	67	74	8	19	10.7	20.4
	Original	62	82	-	-	-	-
II-C	100	65	87	+3	+5	+4.8	+6.1
	250	62	79	0	3	0	3.7
	500	51	69	11	13	17.7	15.9
	Original	60	29	-	-	-	-
III-R	100	57	27	3	2	5.0	6.9
	250	53	25	7	4	11.7	13.8
	500	52	26	8	3	13.3	10.3
	Original	93	167	-	-	-	-
IV-RL	100	104	172	+11	+5	+11.8	+3.0
	250	95	160	+2	7	+2.2	4.2
	500	77	152	16	15	17.2	9.0
	Original	107.5	69	-	-	-	-
V-LC	100	99	68	8.5	1	7.9	1.4
	250	94	64	13.5	5	12.6	7.2
	500	91	63	16.5	6	15.3	8.7
VI-L	Original	73	125.5	-	-	-	-
	100	64	114	9	11.5	12.3	9.2
	250	54	97	19	28.5	26.0	22.7
	500	48	75	25	50.5	34.2	40.2
VII-P_1	Original	49	66				
VIII-P_2	Original	52	67				

* Original - average of 20 determinations
# After abrasion - average of 9 determinations
Amount gained

surface of the other yarns. Although the fibers of this green yarn were generally the first ones pulled out by the abrasive action, the strength of the fabric was apparently not greatly affected. The warp yarns crossing the gimp filling yarns were also subjected to abrasion before the other yarns, and were markedly weakened before most of the filling yarns were affected. This may explain the greater loss of strength in the warp than in the filling.

Warp yarns in fabric III (rayon barretta cloth) were 2-ply spun viscose yarns. Although the original dry strength of these yarns was very high, there was a 60% loss of strength after 100 abrasion strokes. After 500 abrasion strokes, the fabric had but 9% of its original warpwise dry strength. Initially, both warp and filling yarns were nearly twice as strong dry than wet. After 500 abrasion strokes, however, wet and dry strengths were approximately equivalent.

In the filling direction, there was little difference between initial strength and strength at the various abrasion periods. The low filling strength loss after abrasion was primarily due to the fact that the warp yarns, perpendicular to the direction of abrasion, were on the surface of the fabric and received most of the rubbing action. Actually, these warp yarns were practically worn off before the abrasive came in contact with the filling yarns.

Viscose filament yarns constituted the warp fabric IV. After abrasion for 100 double strokes, dry strength loss was 44%, and after 250 double strokes, 69 percent. After 500 strokes, warp strength was about 17% of its initial dry strength, and 23% of its initial wet strength. This wet to dry strength relationship is characteristic of viscose. The great decrease in strength after abrasion was due to fabric construction. The warp yarns were much finer and more pliable than the coarser, stiff, linen filling yarns, and because of their unlike size, a ribbed appearance resulted. When abraded, the rayon warp yarns, covering the coarse filling yarns, quickly deteriorated and ultimately resulted in excessive loss of strength.

Gains in filling strength were noted after 100 abrasion strokes. However, as abrasion continued, loss in strength was noted. The slight gain after 100 double strokes may be explained by the fact that as the weaker yarns were worn off, only the stronger yarns remained. The lesser loss of strength in the filling direction may have been due to two factors. First, linen yarns are not as readily affected by abrasion as rayon. The second contributing factor was the fabric construction. As stated above, it was the warp yarns which received the first impact of abrasion. The linen yarns showed less damage when abraded in the direction of the filling because of their higher inherent resistance to abrasion.

In fabric V, the dry warp was very strong, and showed little loss in strength after abrasion. The wet strength of the warp showed approximately the same percentage loss of strength after abrasion as dry. However, in each case, the wet strength was lower than the dry strength, which is the opposite of what is usually expected of cotton and linen yarns.

Characteristic of linen, fabric VI, 100% linen, was stronger when broken wet. A higher percentage loss after abrasion was observed for dry warp strength than for wet strength. The wet filling strength was stronger than the dry, but wet and dry filling determinations were not significantly different in the percent of strength loss resulting from abrasion. After being abraded 500 strokes, the filling showed 35 to 40% loss of strength. The warp strength was much higher, both wet and dry, than the filling and did not show as great a percent loss in strength as a result of abrasion. Evidently, the filling yarns received more damaging abrasive action because of the yarn structure.

<u>Flammability</u>. Six specimens each for the original fabric, the fabric cleaned with mystic foam, and the fabric shampooed with soap were tested for comparison of ignition rate for the eight different fabrics in the study. The average of the six determinations for each specimen constituted the burning rate for that specimen. Likewise, comparison of any change in the burning rate or characterisitics as a result of the two different methods of cleaning was possible.

Each of the fabrics were tested in the direction which the pre-test showed to be less resistant to flammability. As none of the eight fabrics showed rapid burning characteristics, they were exposed to the flame for at least five seconds if they had not previously ignited.

The cotton-rayon fabric (I), which was tested in the direction of the warp, began to smolder after two seconds exposure to the flame, but stopped smoldering soon after removal of the flame. This occurred on the fabric cleaned with mystic foam, whereas the original and soap cleaned fabrics were not affected until after five seconds.

Fabric II which was cotton, showed less resistance to flammability when tested in the direction of the filling. After exposure to the flame for one second, the fabric cleaned with mystic foam began to smolder, but stopped when the flame was removed. The original and soap cleaned specimens of fabric II did not begin to smolder until after contact with the flame for three seconds.

Fabric III, of rayon, was tested in the direction of the filling. This fabric was unaffected after exposure to the flame for five seconds.

The rayon-linen (fabric IV) was tested in the direction of the warp, as the rate of burning was more rapid for the rayon yarns. No effect was noted after five seconds contact with the flame on the original or either of the cleaned fabrics.

The cotton-linen, fabric V, showed less resistance to burning in the direction of the filling. The fabric which had been cleaned with mystic foam smoldered after four seconds exposure to the flame. However, this slow burning was extinguished with the removal of the flame. The other specimens of fabric V were not affected after five seconds.

Fabric VI, linen, showed no effects from exposure to the flame for five seconds when tested in the direction of the filling.

Fabrics VII and VIII tended to melt when exposed to the flame for three seconds, but stopped upon removal of the flame. These fabrics were tested in the direction of the filling.

Flammability classification is based on the exposure to a flame for one second. Class I is defined as normal flammability, with no unusual burning characteristics. However, fabrics may vary in their burning characteristics with the type of weave construction and finish of the fabric. Therefore, textiles without nap, pile, tuftings, flock or other texture having a projecting fiber surface, in either the original state and/or after dry cleaning and washing, are classified as Class I when the flame does not spread within a period of four seconds. Napped, pile, tufted, flocked, or other textiles having raised fiber surfaces, in their original state and/or after being dry cleaned or washed, are also classified as Class I (a) when flame spread is of seven or more seconds in duration, or (b) when the fabric burns with a rapid surface flash (in less than seven seconds) but does not ignite or fuse the base fabric.

Each of the eight fabrics qualified as Class I in flammability designation or rating. None of the fabrics, either in the original or after either cleaning method, were ignited during the standard period of time for application of the flame.

However, when the period of flame contact was increased, fabrics I, II, and V, all of which contained cotton, showed a tendency to smolder if they had been cleaned with mystic foam. This evidence of burning soon stopped after the flame was removed from contact with the fabric. The plastic coated fabrics showed a tendency to melt upon prolonged exposure to the flame. The remaining fabrics, III, IV, and VI were unaffected after five seconds contact with the flame.

Compressibility. Compressibility, or rate of compression in relation to fabric thickness, was much higher for the cotton (II) and cotton-rayon (I) fabrics. These were the two fabrics in which gimp yarns were used. The fabrics containing cotton yarns were the softest, while the linen (VI) and linen-rayon (IV) combination fabrics were wiry and stiff in handling. Between these two extremes were the rayon (III) and the plastics.

TABLE XVI

COMPRESSIBILITY AND COMPRESSIONAL RESILIENCE

Fabric Code	Compressibility In. per Lb. (1)	Compressional Resiliency in Percent (1)
I-CR	0.116	35.62
II-C	0.145	31.27
III-R	0.088	31.71
IV-RL	0.056	40.02
V-LC	0.098	39.12
VI-L	0.054	34.84
VII-P_1	0.072	53.29
VIII-P_2	0.069	40.32

(1) Average of 15 determinations

<u>Compressional resilience</u>. Compressional resilience varied, but tended to relate to fiber content. The fabrics of 100% cotton, rayon, or linen content were the slowest to return to their original state following compression. The cotton-rayon, linen-cotton, and rayon-linen fabrics fell midway in order of resilience with the two plastics having the greatest resilience of any of the eight fabrics.

COMPARISON OF SERVICEABILITY

In order to compare the eight upholstery fabrics upon their probable serviceability in use as upholstery coverings for dining room chair seats, modified tests simulating normal use and care for fabrics for this particular end use were conducted. Data on colorfastness to light and crocking, the tendency of the fabric to retain soil, and the ease and effectiveness with which the general soil and specific stains could be removed from the fabrics studied are evaluated and discussed in the following section.

Colorfastness to light. The plastic fabrics rated Class 4 in colorfastness to light--that is they showed no appreciable color change after 80 hours exposure in the Fade-Ometer. There was a very slight yellowing of the fabric after 120 hours exposure. The cotton tweed (I), rayon (III), and rayon-linen (IV) fabrics showed appreciable change in color after 80 hours exposure, but no appreciable color change after 40 hours. The rayon and rayon-linen fabrics also showed slight fading after 60 hours, although it was not objectionable. The three fabrics which showed definite color change after 40 hours were the multicolor tweed (II), the linen and cotton (V), and the linen (VI). In other words, these three fabrics barely qualified for the minimum number of hours of light exposure which upholstery fabrics should withstand.

<u>Colorfastness to crocking</u>. All the fabrics except the 100% linen (fabric VI) rated Class 4 colorfastness to dry crocking, as there was no appreciable discoloration on the white cloth. These fabrics are therefore considered fast to dry crocking, and expected to give excellent service in this respect.

TABLE XVII

COLORFASTNESS TO LIGHT AND CROCKING

Fabric	Light	Classification Crocking	
		Dry	Wet
I-CR	3	4	3
II-C	2	4	3
III-R	3	4	3
IV-RL	3	4	1
V-LC	2	4	4
VI-L	2	3	3
VII-P_1	4	4	4
VIII-P_2	4	4	4

The linen, fabric VI, was rated Class 3 in colorfastness to dry and wet crocking. Class 3 refers to a discoloration of a white cloth rubbed against the tested fabric, which is less than that corresponding to Munsell neutral 7.0, but which discoloration disappears after scrubbing. Therefore, this linen fabric may show slight discoloration of white or light-colored fabrics with which it comes in contact, but this discoloration would be removable with soap and water.

After wet crocking, the cotton-rayon (I), cotton (II), and rayon (III) were also rated class 3. Fabric V, the linen-cotton combination, and both plastics were fast to crocking and rated Class 4. Fabric IV (rayon-linen) showed the least colorfastness to wet crocking, as it yielded a discoloration of the white cloth in the crocking test less than that corresponding to Munsell neutral 7.0, but which discoloration does not disappear after scrubbing. It was rated Class I to wet crocking. This fabric would not be considered satisfactory in contact with white or light-colored fabrics, when wet.

Soil retention. The cotton-rayon tweed fabric (I) was the most soiled in appearance, but did not show the greatest increase in weight after soiling. The use of white with the dark colored yarns may have given the fabric a more soiled appearance than the others which initially were more uniform in color or value. The protruding yarns tended to show more soiling than the other yarns in this fabric, and appeared pulled and roughened in appearance from the brushing and vacuuming.

The cotton fabric (II) was second in respect to a heavily soiled appearance. It also had the greatest increase in weight of any of the eight fabrics. The yellow and white yarns, as well as textured yarns, were heavily soiled. The gimp yarns were pulled and the surface roughened and less attractive in appearance as a result of the soiling process and vacuuming.

TABLE XVIII

SOIL RETENTION

Fabric	Fabric Specimen	Percent Weight Gain after Soiling	Rank after Soiling*
I-CR	S	2.27	8
	M	1.41	8
II-C	S	3.17	7
	M	2.94	7
III-R	S	2.56	3
	M	2.64	3
IV-RL	S	1.28	4
	M	1.67	4
V-LC	S	3.07	6
	M	2.91	6
VI-L	S	1.64	5
	M	1.93	5
VII-P_1	S	0.10	2
	M	0.02	1
VIII-P_2	S	0.04	2
	M	0.12	1

* Ranked 1 to 8 in order of least to most soiled.

Fabric III, of rayon, was fairly evenly soiled. More discoloration was evident on the blue-green yarns than the darker yarns. This fabric did not have as great a gain in weight after soiling as the fabrics containing cotton. This may be accounted for by the smoothness of the fabric surface, which did not catch and hold the soil as readily. A slight roughening of the fabric from the soiling procedure was evident.

The rayon-linen, fabric IV, showed an accumulation of soil caught and held between the yarns, being particularly noticeable on the coarser yarns and slubs. Although this fabric appeared more heavily soiled than the all-rayon fabric, it had even less increase in weight after soiling than some of the other fabrics.

Fabric V, a linen and cotton combination, showed evenly distributed soiling, and a marked change in appearance. Increase in weight after soiling was approximately 3% or second highest among the eight fabrics in the retention of soil.

The linen fabric (VI) showed an accumulation of soil on the coarser yarns and slubs, but did not appear as heavily soiled as V (the linen and cotton fabric). Neither did it have as great an increase in weight from retained soil as the fabrics containing an appreciable amount of cotton.

The two plastic fabrics appeared comparably soiled, but less soiled in appearance than the woven fabrics. Lighter colored streaks on the surface were caused when the vacuum cleaner brush was forced against the fabric by the vacuum suction, so that the rubber molding in the brush tended to rub and streak the plastic. Insignificant increases in weight after soiling indicated minimum retention of soil.

All of the fabrics were soiled to a degree beyond that which they would normally receive in the home. However, the textured fabrics with the gimp yarns, slubs, and yarns unlike in size, twist, and structure tended to hold soil more than the fabrics with yarns which were smoother and more uniform in size and twist. The amount of soil retained by the fabrics,

judged subjectively by careful visual observation and more objectively by change in weight, varied with each fabric. Although one fabric appeared to be more soiled than another, it did not necessarily mean that a greater amount of soil, by weight, had adhered to it. Therefore, an evaluation of soiling characteristics were made for the extent of change in appear- as well as the amount of actual soil retained in the fabric.

Soil removal. None of the fabrics cleaned effectively.

TABLE XIX

RANK OF FABRICS IN SOIL RETENTION AND EASE AND EFFECTIVENESS OF SOIL REMOVAL

Fabric	Cleaning Method	Soil Retention[1]	Ease of Cleaning[2] 1st	2nd	Effectiveness of Cleaning[3] 1st	2nd
I-CR	S	8	8	8	14	14
	M	8	8	8	13	13
II-C	S	7	7	7	16	16
	M	7	7	7	15	15
III-R	S	3	2	1	4	4
	M	3	1	1	3	3
IV-RL	S	4	3	6	2	1
	M	4	3	6	1	2
V-LC	S	6	4	3	12	11
	M	6	4	3	11	12
VI-L	S	5	1	2	6	5
	M	5	2	2	5	6
VII-P_1	S	2	6	4.5	7.5	9.5
	M	1	6	4.5	7.5	7.5
VIII-P_2	S	2	5	4.5	7.5	7.5
	M	1	5	4.5	7.5	9.5

* S: Soap Shampoo, M: Mystic Foam

1 Ranked 1 to 8 in order of least to most soiled in appearance.

2 Ranked 1 to 8 in order of easiest to most difficult to clean, after 1st and 2nd cleanings.

3 Ranked 1 to 16 in order of most effectively to least effectively cleaned, after 1st and 2nd cleanings.

This was partially due to the initial excessive soiling of the fabrics. In actual use these fabrics would not have acquired such extreme soiling, and no doubt more effective cleaning results could be obtained. Ease of cleaning the fabrics in this study was determined more by fiber content and fabric construction than by either the cleaner or procedure used. However, the mystic foam was more easily handled; and after cleaning, the fabrics were less stiff than these same fabrics cleaned with the soap shampoo. All of the woven fabrics showed a gain in weight after cleaning indicating that some of the suds or foam remained in the fabrics after rinsing.

Fabric I, cotton-rayon, was the hardest and one of the least effectively cleaned materials. The specimen cleaned with mystic foam appeared better than the one cleaned with soap. A small amount of shrinkage took place in this fabric, primarily in the direction of the filling. This fabric increased in weight after cleaning, with greater gain occurring after cleaning with the soap shampoo.

The cotton upholstery fabric (II) was also difficult to clean. In appearance it was the least effectively cleaned of any of the eight fabrics. The specimen cleaned with mystic foam appeared somewhat cleaner. A 4% warp shrinkage on the fabric cleaned with mystic foam was slightly higher than the shrinkage on the other specimen. However, shrinkage was greater in the direction of the filling than the warp. Approximately a 7% shrinkage occurred in the filling direction of the fabric specimen which was cleaned with the soap shampoo. The gain in weight was also greater on the specimen cleaned with soap.

TABLE XX

PERCENT CHANGE IN WEIGHT AFTER CLEANING

Fabric	Method* of Cleaning	After First Cleaning From Weight of: Original	Soiled	After Second Cleaning From Weight of: Original	Soiled
I-CR	S	5.09	2.76	5.67	3.33
	M	2.05	.62	4.00	2.55
II-C	S	6.83	3.54	8.44	5.11
	M	4.42	1.44	5.96	2.94
III-R	S	6.60	3.96	8.05	5.36
	M	3.97	1.30	5.68	2.96
IV-RL	S	4.06	2.74	5.32	3.99
	M	3.82	2.12	6.55	4.80
V-LC	S	5.89	2.74	6.21	3.04
	M	3.96	1.02	5.41	2.42
VI-L	S	3.43	1.76	4.06	2.38
	M	2.03	.10	2.87	.92
VII-P_1	S	.08	- .03	0.00	- .10
	M	- .07	- .09	- .16	- .17
VIII-P_2	S	- .04	- .07	- .14	- .18
	M	- .06	- .18	- .13	- .25

* S: Soap shampoo
  M: Mystic foam

This rayon fabric (III) was easily and quite successfully cleaned; although, when compared with the control specimen it appeared dingy and roughened. Better cleaning was achieved with mystic foam than with soap. Shrinkage was quite high in both warp and filling, but less for the specimen cleaned with mystic foam. This rayon fabric responded to cleaning as one might expect. When wetted by the shampoo, it stretched and as it dried, shrank back to its normal area or less. The gain

TABLE XXI

DIMENSIONAL CHANGE IN INCHES AFTER SOIL REMOVAL

Fabric	Cleaning Method[1]	Warp *After Cleaning No. 1	Warp *After Cleaning No. 2	Filling *After Cleaning No. 2	Filling *After Cleaning No. 2
I-CR	S	0	- 1/16	- 1/4	- 1/4
	M	0	- 1/16	0	- 1/8
II-C	S	- 1/8	- 3/16	- 7/8	- 7/8
	M	- 1/4	- 1/4	- 3/8	- 5/8
III-R	S	- 1/2	- 1/4	- 7/8	- 3/4
	M	1/8	- 1/4	- 1/4	- 5/8
IV-RL	S	- 1½	- 1½	0	0
	M	- 1	- 5/8	0	0
V-LC	S	- 1/2	- 9/16	0	0
	M	- 3/8	- 7/16	- 3/8	- 1/2
VI-L	S	- 1/2	- 9/16	- 1/4	- 1/8
	M	- 1/4	- 3/8	0	1/8
VII-P_1	S	0	0	0	0
	M	0	0	0	0
VIII-P_2	S	0	0	0	0
	M	0	0	0	0

* Amount of change in 12 inches
1 S: Soap shampoo, M: Mystic foam

in weight was high by either method of cleaning. The specimen after one cleaning with soap had approximately three times the gain in weight of the specimen cleaned with mystic foam. After the second cleaning, the gain in weight was approximately twice as great.

Fabric IV, of rayon and linen, was not as difficult to clean as some of the other fabrics, and it was rated as the most effectively cleaned of the eight fabrics. The specimen cleaned with soap appeared to be cleaner than its paired sample.

However, both fabrics were slightly roughened, dull, and gray in appearance when compared with the control sample. Shrinkage was very high in the direction of the warp, with none in the direction of the filling. More shrinkage occurred in the fabric cleaned with soap, and for some reason was greater after the first cleaning than the second. The warp viscose filament yarns apparently relaxed during cleaning, but when dry returned to either their original length or even shorter. While gain in weight was greater for the soap-cleaned fabric after the first cleaning, it was greater in the other specimen after the second cleaning.

Fabric V, the linen and cotton combination, did not clean easily nor effectively, although the soap shampoo specimen appeared better than the other. The surface was roughened and left with a dull, grayed appearance when compared with the control specimen. Shrinkage was about equal in the warp and filling on both specimens, but slightly greater in the direction of the warp on the specimen cleaned with soap. The soap-treated fabric showed a greater gain in weight.

Fabric VI, 100% linen, was one of the easier fabrics to clean, although it retained its dull grayed appearance. After the second cleaning, the specimen cleaned with the soap shampoo was slightly cleaner in appearance than the other. There was shrinkage warpwise in the soap cleaned specimen, with no significant change in the fillingwise dimensions of either specimen. This fabric showed the least gain in weight of any of the woven fabrics.

The plastic, fabric VII, was not too easily cleaned. After the second cleaning, it still looked soiled. The specimen cleaned with mystic foam appeared slightly cleaner. There was no dimensional change in this fabric after either method of cleaning. Both specimens showed a loss in weight after both the first and the second cleaning.

Fabric VIII, the heavier plastic upholstery, was neither easily nor effectively cleaned. It also retained its soiled appearance. A loss of weight occurred after both cleanings, with the greater loss noted for the specimen which had been cleaned with the mystic foam. There was no dimensional change resulting from cleaning.

Stain removal. Each of the fabrics was submitted to 14 different stains which were removed immediately. A second application of each stain was left on the fabric for 24 hours before the applicable stain removal procedure was begun. As each fabric was treated, it was noted whether or not there was any noticeable bleeding of color from the upholstery fabric in the process of removing the stain. A comparison of the ease in removal of each specified stain was also noted. After the treated fabric had been dried, the following appearance factors were noted and comparisons made on (a) the presence of a ring surrounding the treated area, (b) the permanency of the stain, and (c) the change in texture of the fabric. Finally, the eight fabrics were compared and given a specific rating on the effectiveness of each procedure in the removal of each specific stain. A composite ranking for the eight fabrics was then made from the individual ratings for each stain. (Charts on stain removal performance and ratings for each fabric are in the appendix, pages 105 to 111.

The 14 stains applied were butter, chocolate, milk, egg, coffee, coke, orange juice, medicine, gum, ink, indelible pencil, lipstick, nail polish, and tar.

The cotton-rayon fabric (I) frequently showed signs of bleeding of the dark green dye, which was readily absorbed by the white viscose yarns. This was especially noted when warm water was used. Rings were not readily formed on this fabric. When they were, they were usually caused by the quick absorption of the diluted stain and solvent by the viscose yarns.

Because of the gimp yarns, the surface of this fabric was easily roughened. Some stains tended to become lodged between the rough gimp yarns, and were not easily removed. This cotton-rayon fabric ranked sixth in effectiveness of stain removal.

Fabric II, the 100% cotton, retained only those stains which were most difficult to remove. The most outstanding effect noticed was the roughening of the fabric. The loosely held fibers in the gimp yarns were easily pulled and gave a roughened, distorted appearance. Because of its rough uneven surface and light color, it was quite difficult to clean. Among the six woven fabrics, this fabric ranked highest in the effective removal of the different stains.

The rayon fabric (III) was one of the least satisfactory fabrics when results for the various stains were compared. It was permanently stained by butter, milk, and egg which were quite easily removed from many of the other fabrics. Many cleaning rings formed on this fabric. The surface was badly roughened, being more evident on the spun viscose yarns. When compared with the other seven materials, fabric III ranked lowest in ease of treatment, although in effectiveness of stain removal, it ranked fifth.

The least serviceable fabric in respect to removing stains was the rayon-linen, fabric IV. This fabric was more permanently stained than any of the other fabrics. For all but two stains, rings formed on the fabric as the viscose filament yarns were easily spotted by water. The fabric was badly roughened in texture due to the fine filaments which were easily broken in the stain removal procedure. Although this fabric cleaned more easily than the rayon (fabric III), it ranked lower in effective removal of the various stains.

Fabric V, the linen and cotton combination, showed noticeable bleeding of the dyes when treated with hot water. Many stains remained on the fabric and showed more prominently than on some of the other fabrics. This was partially due to the fact that this fabric was of one color and smoother in texture. Some rings formed on this fabric and were more apparent in the linen yarns as liquids spread more quickly along these yarns.

As the cotton fibers were not tightly anchored in the yarns, many of the fiber ends pulled out readily when rubbed, and gave a roughened appearance. This fabric ranked highest among the woven fabrics in ease of stain removal. Although in effectiveness of stain removal it was slightly lower, the composite ranking for this fabric was the best of the six woven fabrics.

The 100% linen fabric (VI) showed permanent staining, particularly when the fabric was not cleaned immediately. Several rings appeared on this fabric, but again, this was due to the rapid absorption of liquids by the linen yarns.

This fabric showed the least surface change in texture among the woven fabrics. This was due to the long linen fibers which did not easily pull out of the yarns. In ease of removal, this linen fabric ranked second among the six woven fabrics. In effectiveness it ranked fifth among the woven fabrics. This was partially due to the unevenness of the yarns, as the solid stains became lodged between the coarser yarns. Liquid stains readily spread through the yarns; and when dry, a larger stained area was apparent.

The two fabric-backed plastics (VII and VIII) ranked highest on all criteria by which these fabrics were judged. There was no bleeding of color nor formation of rings on these fabrics. For most of the stains, scraping or blotting removed much of the stain. Wiping with a damp cloth tended to remove any remaining foreign matter. However, this was not true for lipstick, nail polish, nor tar stains.

When nail polish was allowed to remain on the fabric for 24 hours before its removal was attempted, it was the least effectively removed from these two plastics. It was particularly difficult to remove the nail polish without removing the vinyl surface of the plastic. Acetone, often recommended for removing nail polish, immediately attacked the surface, destroyed the protective outer coating and obliterated the fabric design in a pretest. Therefore, carbon-tetrachloride was used to remove the nail polish and also the lipstick. Care was needed in using this solvent, for if too much were applied, the surface softened.

When the eight fabrics were compared to determine which of the stains were most satisfactorily removed, it was indicated that gum, butter, coke, orange juice, milk, coffee, and egg stains showed least lasting effects. The stains most objectionable and obstinate to remove were the tar, ink, medicine, lipstick, and nail polish.

Each fabric was compared to determine differences between immediate or delayed removal for each stain. Generally, more effective removal was achieved when the stain was removed immediately. The fabrics also tended to be less roughened and cleaned more easily.

When a composite comparison was made, the plastics were the least affected and the most effectively cleaned of the eight fabrics. Of the woven fabrics, the linen-cotton (V) ranked highest. This was followed in descending order by the cotton tweed (II), 100% linen (VI), cotton and rayon tweed (I), rayon (III), and lowest, the rayon-linen (IV).

CONCLUSIONS

Interpretation of the laboratory test data showed significant similarities and differences in the eight upholstery fabrics. Conclusions resulting from an evaluation of the data follow:

1. Yarn analysis indicated that there were wide differences in the structure of the yarns within each fabric as well as among the eight fabrics.
2. There appeared to be no significant relationship between fabric weight or thickness, and fabric compressibility or compressional resilience.
3. Analysis of compression and compressional resilience indicated fabrics predominantly cotton were easily compressed, but low in their compressional resilience; while the linen fabrics showed low compressibility and high resilience.
4. Analysis of abrasion test data for the six woven fabrics indicated:
   - (a) Resistance to abrasion was primarily due to yarn and weave structure and the direction of abrasion rather than fiber content.
   - (b) Fabrics showed more resistance when abraded parallel with the float yarns than when abraded at right angles to them.

(c) Notable differences in abrasion resistance in the fabrics of different fiber content when abrasion was continued beyond the hole stage.

5. Change in weight after abrasion indicated:

   (a) Weight loss was consistent and directly related to the total number of abrasion strokes.

   (b) Similar weight loss among the fabrics when abraded to the stage of a hole.

   (c) Significantly greater and variable weight loss for the various fabrics when abraded beyond the hole stage.

   (d) No significant difference was noted in respect to direction of abrasion until marked fabric deterioration had occurred.

6. Evaluation of breaking strength test data indicated:

   (a) All of the fabrics except the linen-cotton showed dry and wet breaking strength relationships consistent with their fiber content.

   (b) No significant differences between dry and wet determinations in percent loss in strength.

   (c) Retention of strength was generally consistent with and directly related to the direction of resistance to abrasion.

   (d) Progressive loss in strength was consistent with the degree of deterioration.

   (e) Tensile strength before and after abrasion was comparable for warp and filling when the yarns were of comparable structure.

7. All fabrics showed high resistance to burning with only slight impairment after cleaning.
8. Serviceability data indicated:
   (a) Yarn structure and fiber content were the significant factors bearing a relationship to the degree of colorfastness, extent of soiling, and effectiveness and ease in cleaning and stain removal.
   (b) With the exception of the linen, all fabrics showed excellent colorfastness to light and crocking.
   (c) In terms of appearance, surface texture, and fabric hand, none of the fabrics studied cleaned effectively.
   (d) Fabrics with a smooth surface retained less soil and were more easily and effectively cleaned than those with rough surfaces.
   (e) Fiber content and fabric construction determined ease and effectiveness in cleaning more than either the cleaner or procedure used.
   (f) Fabrics cleaned with mystic foam were not only more easily cleaned, but had a better hand and lower shrinkage than those cleaned with soap shampoo.
   (g) Change in weight of the respective fabrics showed that neither soil nor cleaning medium were completely removed from the fabrics in the rinsing process.

(h) Immediate removal of stains resulted in easier and more complete removal.

(i) Stain removal from fabrics with high rayon content was less effective than for fabrics made from other fibers.

(j) Common food stains did not alter fabric appearance and were not as difficult to remove as non-food stains.

9. Composite rating of performance and serviceability test data indicated:

   (a) Yarn structure was significant in the over-all performance and serviceability factors among the woven fabrics.

   (b) No significant relationship between the price of the fabric and its performance characteristics.

   (c) Outstanding performance and service for the two fabric-backed plastic coverings.

   (d) The linen-cotton tweed and 100% linen as the most satisfactory woven fabrics in serviceability and potential durability, and the rayon-linen and 100% rayon as the least satisfactory upholstery coverings.

SUMMARY

The purpose of this study was to evaluate the specifications and compare the performance and serviceability characteristics of eight cotton, linen, rayon, and supported plastic upholstery materials suitable as coverings for dining room chairs.

The upholstery fabrics investigated included two fabric-backed plastic sheetings and six textured fabrics of plain weave consisting of 100% linen, cotton, and rayon, and combinations of cotton and rayon, rayon and linen, and cotton and linen.

The eight fabrics were analyzed in the laboratory for specification and performance characteristics in accordance with ASTM methods and instruments of test under standard conditions for testing. Specification tests included fiber identifaction, analysis of yarn structure (type, size, and twist) and yarn count, fabric weight and thickness. Compressibility and resilience, resistance to abrasion, breaking strength before and after abrasion, and flammability before and after soil removal were the performance tests made.

Serviceability characteristics in colorfastness to light and crocking, soil retention, and ease and effectiveness in removal of general soil and specified stains were evaluated and compared. The soiling and cleaning test methods were modified to simulate normal use and care for upholstery coverings.

Specification analysis showed no significant differences in fabric weight, and no relationship between thickness and weight. The six fabrics showed wide differences in the type of yarns used, which accounted for differences in compressibility and resilience. In fact, the appearance and performance differences among the six woven fabrics were essentially due to variations in the structure of the yarns.

Performance analysis showed the plastic fabrics had superior resistance to abrasion when compared with the woven fabrics. Among the woven fabrics, significantly different results were noted in all performance tests due primarily to variations in their yarn and fabric structures. Similar resistance to abrasion as well as breaking strength were noted for fabrics with comparable warp and filling yarn count and yarn structure. Fabrics were more resistant to abrasion when abraded parallel with the float yarns than when abraded at right angles to them. In general, there was a wide variation in tensile strength, which showed a relationship to the inherent fiber characteristics and particularly to the yarn structures of the different fabrics. For each fabric, loss in strength varied directly with its warpwise and fillingwise resistance to abrasion.

These upholstery fabrics had consistently high resistance to burning before as well as after either method of cleaning.

Evaluation of serviceability characteristics revealed that the linen fabrics and the low priced all-cotton fabrics had minimum resistance to light fading. The other woven fabrics were satisfactory, but the plastics were superior in colorfastness to light. Only the rayon-linen combination showed significantly poor colorfastness to crocking.

The fabrics with smooth surfaces retained less soil and were more easily and effectively cleaned than the fabrics which were rough in texture. Both fiber content and yarn structure were significant in the ease and effectiveness in removal of stains.

An evaluation based on the composite performance and serviceability test data for each of the eight fabrics constituted the over-all comparison rating for each fabric. Analysis of this composite rating showed the fabrics grouped themselves by similarity in yarn structure. The two fabric-backed plastics were rated superior to any of the woven fabrics. Among the six woven fabrics, the linen-cotton combination was rated best and the 100% linen as second best. The two predominantly cotton fabrics were less satisfactory. The rayon-linen and especially the all rayon fabric were considered least satisfactory for use as upholstery coverings on dining room chair seats.

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APPENDIX

CHART I

YARN ANALYSIS
FABRIC I

I-CR Warp	White Cotton Ply T.P.I.	Single Size	Single T.P.I.	Ply a. T.P.I.	Single Size	Single T.P.I.	Brown Gimp Ply b. T.P.I.	Single L. Size	Single L. T.P.I.	Single Size	Single T.P.I.
1	7.72	10.55	13.3	5.5	9.6	22.2	9.0	4.8	8.4	6.2	8.2
2	7.36	10.48	14.0	5.8	10.1	18.2	8.9	4.9	9.5	6.4	7.8
3	7.78	10.60	13.0	6.1	10.3	21.5	9.2	5.4	10.5	6.2	7.8
4	7.93	10.56	13.7	6.0	11.0	19.8	8.7	5.0	8.4	6.0	7.2
5	8.00	10.34	12.8	6.5	8.7	22.3	9.1	5.5	8.8	7.5	8.8
Average	7.8	10.50	13.4	6.0	9.9	20.8	9.0	5.1	9.1	6.5	8.0
Twist	S		Z	Z		Z	S		Z		Z
I-CR Warp	**White Viscose**						**Gray Gimp**				
1	6.08	8.70	11.6	5.7	10.8	23.0	9.7	5.5	12.0	6.4	8.0
2	6.47	8.90	13.9	5.9	10.9	19.4	8.5	5.1	9.9	7.7	7.6
3	6.32	8.96	11.9	5.8	10.1	21.2	8.7	5.2	9.4	6.1	7.4
4	6.06	8.34	12.5	5.9	8.9	21.6	9.4	5.4	9.2	6.4	8.0
5	6.30	8.38	12.8	5.9	10.4	21.6	9.1	5.7	9.4	6.3	8.0
Average	6.3	8.7	12.5	5.8	10.2	21.4	9.1	5.4	10.0	6.6	7.8
Twist	S		Z	Z		Z	S		Z		Z
I-CR Filling	**Dark Green**						**Light Green**				
1		2.2	7.3	5.7	9.6	22.6	9.4	3.7	4.9	3.1	4.4
2		2.2	7.1	6.0	9.4	21.0	9.2	3.5	5.4	4.2	4.6
3		2.2	6.6	6.0	9.4	21.0	9.6	3.5	5.4	4.0	5.4
4		2.1	7.1	6.1	8.9	19.3	9.2	3.4	5.3	3.7	4.7
5		2.1	7.0	6.1	9.8	19.4	9.2	3.2	5.3	3.6	5.1
Average		2.2	7.0	6.0	9.4	20.7	9.3	5.5	5.3	3.7	4.8
Twist			Z	Z		Z	S		Z		Z

Each is the average for the like yarns in one inch
Size: Yarn number or size, T.P.I.: Twists per Inch.

Chart I (continued)

II-C Warp	Light Brown Ply T.P.I.	Light Brown Single Size	Light Brown Single T.P.I.	Dark Brown Ply T.P.I.	Dark Brown Single Size	Dark Brown Single T.P.I.	Yellow Ply T.P.I.	Yellow Single Size	Yellow Single T.P.I.
1	7.6	11.0	14.4	7.6	11.3	14.0	7.8	11.0	13.8
2	7.6	10.3	14.1	7.6	10.6	15.6	7.6	10.4	14.7
3	7.9	10.7	13.9	7.6	11.3	14.2	7.7	10.9	13.8
4	7.5	10.5	13.9	7.5	10.6	13.5	7.7	10.8	13.3
5	7.6	10.5	14.4	7.8	10.8	14.3	7.9	10.5	13.8
Average	7.6	10.6	14.1	7.6	10.9	14.3	7.7	10.7	13.9
Twist	S		Z	S		Z	S		Z

II-C Filling	Green and White Complex Gimp Ply a.	Single-White		Ply b.	Single-Green		Ply c.	Single-White	
1	5.9	9.5	20.2	10.7	5.0	9.0	13.8	21.5	20.9
2	6.1	11.2	20.0	10.5	5.1	7.9	14.3	21.7	23.6
3	6.1	11.2	18.4	10.5	5.2	8.6	14.2	22.4	23.0
Average	6.0	10.6	19.5	10.6	5.1	8.5	14.1	21.9	22.5
Twist	Z		Z	S		Z	S		Z

II-C Filling	Yellow Ply Ply	Singles	
1	7.3	10.6	14.3
2	7.2	10.9	15.1
3	7.3	11.1	14.6
Average	7.3	10.9	14.7
Twist	S		Z

Each figure is the average for the like yarns in one inch
Size: Yarn number or size, T.P.I.: Twists per inch. Gimp yarn in order of breakdown

Chart I (continued)

FABRICS III AND IV

III-R Warp	Ply T.P.I.	Green Single L. Size	Green Single L. T.P.I.	Single Size	Single T.P.I.
1	7.9	19.3	21.3	5.1	12.6
2	8.1	18.9	20.7	5.2	12.0
3	8.0	19.0	21.6	5.2	12.0
Average	8.0	19.1	21.2	5.2	12.2
Twist	S		Z		Z

III-R Filling	Dark Green Multi-filament Denier	Dark Green Multi-filament T.P.I.	Blue Green Multi-filament Denier	Blue Green Multi-filament T.P.I.
1	777.0	2.6	791.6	3.2
2	784.8	3.2	765.9	3.9
3	818.1	3.7	761.8	3.7
Average	793.3	3.2	773.3	3.6
Twist		S		S

IV-RL Warp	Green	
1	933.2	9.2
2	925.8	9.6
3	935.0	9.1
Average	931.3	9.3
Twist		S

IV-RL Filling	Green Single Size	Green Single T.P.I.
1	7.9	10.4
2	7.4	9.4
3	7.3	9.9
Average	7.5	9.9
Twist		Z

Each is an average of the like yarns in one inch
Size: Yarn number
T.P.I.: Twists per inch

Chart I (continued)

FABRICS V AND VI

V-LC Warp	Ply T.P.I.	Green Cotton Single Size	Green Cotton Single T.P.I.	Green Linen Single Size	Green Linen Single T.P.I.
1	4.3	3.7	10.5	8.2	5.2
2	4.2	3.4	12.6	8.0	4.9
3	4.2	3.7	10.3	7.3	5.2
Average	4.2	3.6	11.1	7.8	5.1
Twist	S		Z		Z
V-LC Filling					
1	4.6	3.1	12.1	9.0	5.4
2	4.7	3.2	11.2	7.0	5.5
3	4.7	3.2	10.6	7.9	5.6
Average	4.7	3.2	11.3	8.0	5.5
Twist	S		Z		Z

VI-L Warp	Green Single Size	Green Single T.P.I.
1	4.5	6.9
2	4.6	7.4
3	5.1	7.8
Average	4.7	7.4
Twist		Z
VI-L Filling		
1	4.4	7.8
2	4.5	6.8
3	3.9	7.4
Average	4.3	7.3
Twist		Z

Each is an average of the like yarns in one inch
Size: Yarn number
T.P.I.: Twists per inch

CHART II

FABRIC WEIGHT, THICKNESS, COMPRESSION AND COMPRESSIONAL RESILIENCE

Fabric		Weight[1]	Thickness[2]	Compression[2]	Percent Compressional Resilience
I-CR	1	1.3291	.089	.124	33.42
	2	1.2971	.090	.122	29.52
	3	1.2811	.088	.102	52.59
	4	1.3098	.090	.111	32.27
	5	1.3003	.092	.120	30.31
Average		1.3035	.090	.116	35.62
II-C	1	.9999	.071	.155	32.20
	2	.9768	.071	.141	32.91
	3	.9897	.071	.141	32.52
	4	.9776	.069	.145	26.67
	5	1.0371	.070	.143	32.04
Average		.9962	.070	.145	31.27
III-R	1	.8486	.048	.125	29.84
	2	.8406	.046	.065	47.98
	3	.8304	.048	.083	30.85
	4	.8531	.048	.083	21.51
	5	.8395	.049	.083	28.39
Average		.8424	.048	.088	31.71
IV-RL	1	1.0217	.040	.050	38.70
	2	1.0191	.040	.050	33.42
	3	.9707	.039	.051	48.85
	4	.9737	.038	.053	37.99
	5	.9933	.040	.075	41.16
Average		.9957	.039	.056	40.02
V-LC	1	1.1162	.053	.094	39.18
	2	1.0726	.053	.094	42.77
	3	1.0128	.054	.111	28.47
	4	1.0799	.052	.096	44.28
	5	1.0453	.054	.093	40.89
Average		1.0654	.053	.098	39.12
VI-L	1	1.4804	.062	.032	21.82
	2	1.4198	.060	.067	39.37
	3	1.4924	.058	.052	35.54
	4	1.4765	.060	.067	38.33
	5	1.4519	.058	.052	39.12
Average		1.4642	.060	.054	34.84

Chart II (continued

Fabric		Weight[1]	Thickness[2]	Compression[2]	Percent Compressional Resilience
VII P_1	1	1.6242	.028	.071	73.09
	2	1.6366	.027	.074	55.20
	3	1.6638	.028	.071	44.61
	4	1.6248	.028	.071	42.46
	5	1.6273	.028	.071	51.11
Average		1.6353	.028	.072	53.29
VIII-P_2	1	2.0369	.032	.031	49.87
	2	2.0101	.032	.063	38.00
	3	1.9971	.032	.094	36.03
	4	2.0030	.032	.094	40.11
	5	1.9932	.032	.063	37.60
Average		2.0081	.032	.069	40.32

[1] Grams per 4 square inches
[2] In inches

CHART III

RESISTANCE TO ABRASION

Fabric		First Sign of Wear	First Yarn Break	Hole	Complete Breakdown
I-CR					
Warp	1	34	175	214	916
	2	26	168	490	1034
	3	33	380	533	826
	4	47	234	465	963
	5	33	372	416	916
	6	26	169	490	1033
	7	33	328	380	826
	8	47	336	466	966
Average		35	270	432	935
I-CR					
Filling	1	36	139	766	1675
	2	38	152	786	1617
	3	53	181	1108	1853
	4	36	99	737	1765
	5	36	139	600	1675
	6	37	151	829	1684
	7	53	125	608	1621
	8	37	165	867	1672
Average		41	144	788	1695
II-C					
Warp	1	21	250	294	1226
	2	21	287	385	1182
	3	24	165	248	1101
	4	26	299	323	1202
	5	20	294	328	1225
	6	22	288	314	1183
	7	24	249	376	1124
	8	26	116	170	1072
Average		23	244	305	1164
II-C					
Filling	1	22	159	275	1534
	2	24	130	525	1654
	3	24	126	685	1642
	4	27	168	632	1573
	5	23	160	374	1463
	6	23	165	549	1551
	7	23	90	587	1409
	8	28	118	338	1487
Average		24	140	496	1539

Chart III (continued)

Fabric		First Sign of Wear	First Yarn Break	Hole	Breakdown
III-R					
Warp	1	45	71	96	660
	2	47	47	110	654
	3	48	48	117	588
	4	42	42	201	725
	5	46	72	196	536
	6	48	86	201	845
	7	47	47	176	711
	8	43	43	136	547
Average		46	57	162	658
III-R					
Filling	1	22	46	659	1242
	2	23	42	829	1066
	3	29	40	751	1494
	4	25	52	822	1447
	5	22	22	720	1242
	6	22	41	652	1329
	7	28	39	700	1493
	8	25	25	588	1305
Average		25	38	715	1327
IV-RL					
Warp	1	24	49	169	767
	2	18	51	211	915
	3	22	46	178	930
	4	17	29	151	737
	5	24	130	169	856
	6	22	40	208	952
	7	22	51	267	829
	8	28	89	420	756
Average		22	61	222	843
IV-RL					
Filling	1	22	31	560	986
	2	9	23	822	1135
	3	10	30	490	892
	4	14	23	779	1184
	5	9	29	762	1168
	6	9	22	664	1096
	7	9	29	489	800
	8	14	24	779	1147
Average		12	26	668	1051

Chart III (continued)

Fabric		First Sign of Wear	First Yarn Break	Hole	Complete Breakdown
V-LC					
Warp	1	33	516	1310	1364
	2	23	545	1239	1405
	3	29	593	1297	1481
	4	32	653	1296	1486
	5	20	676	1247	1428
	6	23	555	1161	1350
	7	30	593	1007	1280
	8	32	572	914	1380
Average		28	588	1184	1397
V-LC					
Filling	1	31	603	923	1215
	2	30	528	1023	1217
	3	30	397	1105	1366
	4	32	559	1335	1407
	5	32	732	1172	1295
	6	30	515	947	1217
	7	31	736	1223	1367
	8	32	594	1290	1376
Average		31	583	1127	1308
VI-L					
Warp	1	12	513	1408	2152
	2	10	444	959	2034
	3	11	778	932	2322
	4	11	226	581	2438
	5	11	511	1458	2151
	6	10	292	800	2056
	7	11	212	1263	2069
	8	10	49	973	2021
Average		11	378	1047	2155
VI-L					
Filling	1	11	354	745	1412
	2	12	421	607	1452
	3	11	471	727	1508
	4	12	342	655	1260
	5	11	265	647	956
	6	12	514	874	1505
	7	11	87	871	1453
	8	12	138	977	1441
Average		12	324	763	1373

CHART IV

WEIGHT IN GRAMS BEFORE AND AFTER ABRASION: I

Fabric*		Original	First Sign of Wear	% Loss	First Yarn Break	% Loss	Hole	% Loss	Complete Breakdown	% Loss
I-CR	W	9.2124	9.1790	0.40	8.9333	3.06	8.7761	4.66	8.1902	11.10
	F	9.2481	9.2063	0.45	9.0835	1.78	8.4589	8.54	7.2275	21.85
II-C	W	6.9851	6.9544	0.43	6.7105	3.93	6.6423	4.91	5.6911	18.53
	F	6.9375	6.9053	0.46	6.7824	2.24	6.4385	7.18	5.1145	26.27
III-R	W	5.8362	5.7869	0.89	5.7701	1.18	5.6997	2.38	5.2694	9.76
	F	5.8645	5.8173	0.81	5.7927	1.22	4.5511	22.39	3.8035	35.17
IV-RL	W	7.2102	7.1928	0.24	7.1609	0.68	7.0629	2.04	6.5851	8.67
	F	7.1324	7.1248	0.11	7.1103	0.31	6.4970	8.88	5.9162	17.02
V-LC	W	8.0349	7.9945	0.49	7.3326	8.74	6.3719	20.69	5.8506	27.19
	F	8.0636	8.0170	0.58	7.3576	8.77	6.5471	18.80	6.1728	23.46
VI-L	W	10.4253	10.3995	0.25	10.0859	3.25	9.6483	7.45	8.4324	19.12
	F	9.8976	9.8685	0.30	9.5909	3.12	9.1778	6.27	8.5851	13.26

Each is the average of 8 determinations.
* W: Warp, F: Filling,
Direction of abrasion and longest fabric dimension

CHART V

WEIGHT IN GRAMS BEFORE AND AFTER ABRASION: II

Fabric	*	Original	After 100	% Loss	Original	After 250	% Loss	Original	After 500	% Loss
I-CR	W	9.3375	9.2277	1.18	9.2172	8.9864	2.50	9.2314	8.7581	5.13
	F	9.2887	9.1743	1.24	9.2263	8.9836	2.63	9.2754	8.7980	5.15
II-C	W	7.2527	7.1505	1.41	7.0762	6.8220	3.59	6.9330	6.4548	6.90
	F	7.0277	6.9044	1.76	7.1902	6.9373	3.52	6.9203	6.4999	6.08
III-R	W	6.0015	5.9158	1.43	5.9452	5.7983	2.47	5.8922	5.6335	4.39
	F	5.8234	5.7004	2.11	5.9562	5.6650	4.95	5.9128	5.3424	9.62
IV-RL	W	7.1285	7.0639	0.91	7.0395	6.9176	1.65	7.1576	6.8914	3.72
	F	7.1803	7.0954	1.18	7.1003	6.9102	2.68	7.0906	6.7177	5.27
V-LC	W	8.0606	7.9423	1.47	8.1496	7.8716	3.41	8.2279	7.7274	6.09
	F	8.0606	7.9362	1.54	8.1554	7.8909	3.24	8.2583	7.7414	6.36
VI-L	W	10.1697	10.0326	1.35	10.5378	10.2861	2.39	10.3731	9.9885	3.71
	F	10.4133	10.0155	1.31	10.2591	10.0131	2.40	10.4733	10.1146	3.44

Each is the average of 8 determinations.
* W: Warp, F: Filling
Direction of abrasion and longest fabric dimension

CHART VI

RANGE IN WARP BREAKING STRENGTH[1]

Fabric	Original		Strength after Abrasion					
			After 100		After 250		After 500	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
I-CR								
High	48	45	45	46	46	45	44	44
Low	35	29	30	31	31	24	28	23
Average	40	37	39	39	40	37	37	37
II-C								
High	80	103	80	95	71	83	49	79
Low	65	84	65	81	57	53	32	58
Average	71	94	70	88	62	69	39	67
III-R								
High	102	50	46	26	28	20	19	8
Low	87	36	28	8	7	8	1	2
Average	93	43	38	16	22	11	9	7
IV-RL								
High	126	48	85	47	46	26	40	23
Low	117	46	61	32	31	8	2	2
Average	122	47	68	37	38	18	21	11
V-LC								
High	135	83	119	78	114	74	110	72
Low	105	62	100	61	93	61	95	61
Average	116	72	112	69	106	67	106	65
VI-L								
High	126	210	115	228	102	215	102	193
Low	78	162	74	151	70	120	38	124
Average	108	182	94	173	88	162	85	157
VII-P_1*								
High	61	79						
Low	52	70						
Average	58	74						
VIII-P_2*								
High	70	86						
Low	60	76						
Average	63	80						

*Breaking strength not determined after abrasion

[1]Strength in pounds per inch

CHART VII

RANGE IN FILLING BREAKING STRENGTH[1]

Fabric	Original		Strength after Abrasion					
			After 100		After 250		After 500	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
I-CR								
High	87	103	98	102	90	102	83	85
Low	57	73	71	80	72	75	35	67
Average	75	93	32	91	76	86	67	74
II-C								
High	67	93	70	95	66	89	66	81
Low	57	71	62	78	50	72	37	60
Average	62	82	65	87	62	79	51	69
III-R								
High	70	40	60	40	56	30	56	31
Low	56	8	54	8	52	8	47	8
Average	60	29	57	27	53	25	52	26
IV-RL								
High	109	198	110	189	106	174	82	165
Low	77	133	99	156	78	145	71	141
Average	93	167	104	172	95	160	77	152
V-LC								
High	118	78	108	75	102	74	113	72
Low	95	57	84	61	82	50	71	55
Average	108	69	99	68	94	64	91	63
VI-L								
High	99	145	96	127	71	112	69	103
Low	60	102	40	94	42	86	32	45
Average	73	126	64	114	54	97	48	75
VII-P_1*								
High	55	72						
Low	37	59						
Average	49	66						
VIII-P_2*								
High	61	74						
Low	46	49						
Average	52	67						

[1]Strength in pounds per inch
*Breaking strength not determined after abrasion

CHART VIII

SOIL RETENTION DATA

Fabric	Method* Cleaned	Original	Fabric Weight in Grams					
			Soiled	% Change	First Cleaning	% Change	Second Cleaning	% Change
I-CR	S	91.13	93.20	2.27	95.77	5.09	96.30	5.67
	M	95.15	96.50	1.41	97.10	2.05	98.96	4.00
II-C	S	68.70	70.88	3.17	73.39	6.83	74.50	8.44
	M	72.10	74.22	2.94	75.29	4.42	76.40	5.96
III-R	S	58.63	60.13	2.56	62.51	6.60	63.35	8.05
	M	59.15	60.71	2.64	61.50	3.97	62.51	5.68
IV-RL	S	69.47	70.36	1.28	72.29	4.06	73.17	5.32
	M	71.90	73.10	1.67	74.65	3.82	76.61	6.55
V-LC	S	79.75	82.20	3.07	84.45	5.89	84.70	6.21
	M	79.00	81.30	2.91	82.13	3.96	83.27	5.41
VI-L	S	100.55	102.20	1.64	104.00	3.43	104.63	4.06
	M	101.20	103.15	1.93	103.25	2.03	104.10	2.87
VII-P_1	S	115.81	115.93	0.10	115.90	0.08	115.81	0.00
	M	114.58	114.60	0.02	114.50	- 0.07	114.40	- 0.16
VIII-P_2	S	141.65	141.70	0.04	141.60	- 0.04	141.45	- 0.14
	M	142.69	142.86	0.12	142.60	- 0.06	142.50	- 0.13

* S: Soap shampoo M: mystic foam

CHART IX

REMOVAL OF STAINS FROM FABRIC I, COTTON AND RAYON TWEED

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1	X			X	2	1
	2	X			X	3	1
Chocolate	1	X			X	5	2
	2	X			X	4	6
Milk	1	X				2	1
	2	X				3	1
Egg	1	X				5	2
	2	X	X			7	5
Coffee	1	X				3	4
	2	X			X	3	1
Coke	1					2	1
	2					2	1
Orange Juice	1	X				2	1
	2	X				2	1
Medicine	1		X		X	6	6
	2		X		X	6	5
Gum	1	X			X	7	1
	2	X			X	8	1
Ink	1		X		X	5	4
	2		X		X	2	3
Indelible Pencil	1		X		X	6	2
	2		X		X	4	3
Lipstick	1		X	X		8	7
	2		X	X		8	7
Nail Polish	1		X			7	7
	2		X		X	6	5
Tar	1		X	X	X	7	7
	2		X	X	X	7	7
Total		14	13	4	16	132	93
Composite Rank		8	4	3	4.5	7	6

(1) 1 = Stain removed immediately after application
    2 = Stain removed 24 hours after application
(2) Easy to remove = 1
(3) Most effective removal = 1

CHART X

REMOVAL OF STAINS FROM FABRIC II, COTTON TWEED

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1	X			X	5	1
	2	X			X	2	1
Chocolate	1				X	4	2
	2				X	5	2
Milk	1					2	1
	2					2	1
Egg	1					2	1
	2					2	1
Coffee	1					2	3
	2				X	2	1
Coke	1					2	1
	2					2	1
Orange Juice	1	X				2	1
	2	X				2	1
Medicine	1		X		X	5	4
	2		X		X	5	2
Gum	1				X	8	1
	2				X	7	1
Ink	1		X	X	X	4	2
	2		X	X	X	4	4
Indelible Pencil	1		X		X	5	3
	2		X		X	5	2
Lipstick	1		X	X		7	8
	2		X	X		7	8
Nail Polish	1		X		X	3	4
	2		X	X	X	5	6
Tar	1		X	X	X	6	6
	2		X	X	X	6	6
Total		4	12	7	17	113	75
Composite Rank		6	3	5	6	5	3

(1) 1 = Stain removed immediately after application;
2 = Stain removed 24 hours after application
(2) 1 = Easy to remove
(3) 1 = Most effective removal

CHART XI

REMOVAL OF STAINS FROM FABRIC III, RAYON BARRETTA

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1		X	X	X	7	3
	2		X	X	X	7	2
Chocolate	1			X	X	6	2
	2			X	X	6	3
Milk	1		X	X	X	2	5
	2		X	X	X	6	4
Egg	1	X	X	X	X	4	6
	2	X	X	X	X	5	4
Coffee	1				X	5	2
	2				X	4	1
Coke	1					3	1
	2					3	1
Orange Juice	1	X			X	3	1
	2	X			X	3	1
Medicine	1		X	X	X	7	3
	2		X	X	X	7	3
Gum	1					4	1
	2					3	1
Ink	1		X	X	X	6	5
	2		X	X	X	6	5
Indelible Pencil	1		X		X	7	7
	2		X		X	7	5
Lipstick	1		X	X	X	6	5
	2		X	X		5	5
Nail Polish	1					2	1
	2			X	X	1	1
Tar	1		X	X	X	4	2
	2		X	X	X	4	4
Total		4	16	17	22	134	84
Composite Rank		6	5	7	7	8	5

(1) 1 = Stain removed immediately after application
2 = Stain removed 24 hours after application
(2) 1 = Easy to remove
(3) 1 = Most effective removal

CHART XII

REMOVAL OF STAINS FROM FABRIC IV, RAYON AND LINEN

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1		X	X	X	6	4
	2		X	X	X	6	4
Chocolate	1			X	X	3	5
	2		X	X	X	5	7
Milk	1		X	X	X	2	4
	2		X	X	X	7	5
Egg	1	X	X	X	X	4	5
	2	X	X	X	X	6	3
Coffee	1				X	6	7
	2				X	5	1
Coke	1			X		2	2
	2			X		2	3
Orange Juice	1	X		X	X	3	1
	2	X		X	X	3	1
Medicine	1		X	X	X	3	5
	2		X	X	X	3	6
Gum	1			X	X	6	2
	2			X	X	6	2
Ink	1		X	X	X	7	6
	2		X	X	X	7	7
Indelible Pencil	1		X		X	4	4
	2		X		X	3	6
Lipstick	1		X	X	X	5	6
	2		X	X		6	6
Nail Polish	1			X	X	4	2
	2		X	X	X	4	4
Tar	1		X	X	X	5	5
	2		X	X	X	5	5
Total		4	18	24	25	126	108
Composite Rank		6	8	8	8	6	8

(1) 1 = Stain removed immediately after application
    2 = Stain removed 24 hours after application
(2) 1 = Easy to remove
(3) 1 = Most effective removal

CHART XIII

REMOVAL OF STAINS FROM FABRIC V, LINEN AND COTTON TWEED

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1				X	2	1
	2				X	4	1
Chocolate	1		X		X	2	4
	2		X	X	X	2	5
Milk	1				X	2	3
	2				X	5	3
Egg	1			X		3	4
	2		X			3	2
Coffee	1		X			7	5
	2		X			7	3
Coke	1					2	1
	2					2	1
Orange Juice	1	X				2	1
	2	X				3	2
Medicine	1		X		X	2	2
	2		X	X	X	2	4
Gum	1					5	1
	2				X	5	1
Ink	1		X	X	X	3	3
	2		X		X	3	2
Indelible Pencil	1		X			3	6
	2		X		X	2	4
Lipstick	1		X		X	4	4
	2		X			3	1
Nail Polish	1		X			5	5
	2		X		X	2	2
Tar	1		X	X	X	2	3
	2		X	X	X	2	3
Total		2	17	6	16	89	77
Composite Rank		3.5	6.5	4	4.5	3	4

(1) 1 = Stain removed immediately after application
    2 = Stain removed 24 hours after application
(2) 1 = Easy to remove
(3) 1 = Most effective removal

CHART XIV

REMOVAL OF STAINS FROM FABRIC VI, HEAVY LINEN

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1			X	X	2	2
	2		X	X	X	5	3
Chocolate	1		X		X	2	3
	2		X	X	X	2	4
Milk	1					2	2
	2					4	2
Egg	1					3	3
	2		X			4	2
Coffee	1					4	6
	2		X			6	2
Coke	1			X		2	2
	2			X		2	2
Orange Juice	1	X				2	1
	2	X		X		3	3
Medicine	1		X		X	4	7
	2		X	X	X	4	7
Gum	1					3	1
	2				X	4	1
Ink	1		X			2	7
	2		X			5	6
Indelible Pencil	1		X	X	X	2	5
	2		X	X	X	6	7
Lipstick	1		X		X	3	3
	2		X			4	2
Nail Polish	1		X			6	6
	2		X		X	3	3
Tar	1		X	X	X	3	4
	2		X	X	X	3	2
Total		2	17	11	13	95	98
Composite Rank		3.5	6.5	6	3	4	7

(1) 1 = Stain removed immediately after application
    2 = Stain removed 24 hours after application
(2) 1 = Easy to remove
(3) 1 = Most effective removal

CHART XV

REMOVAL OF STAINS FROM FABRICS VII AND VIII, PLASTICS

Stain	Application (1)	Bleeding of Colors	Permanency of Stain	Forms Rings	Texture Change	Ease of Removal (2)	Effective Removal (3)
Butter	1					1	1
	2					1	1
Chocolate	1					1	1
	2					1	1
Milk	1					1	1
	2					1	1
Egg	1					1	1
	2					1	1
Coffee	1					1	1
	2					1	1
Coke	1					1	1
	2					1	1
Orange Juice	1					1	1
	2					1	1
Medicine	1					1	1
	2					1	1
Gum	1					1	1
	2					1	1
Ink	1					1	1
	2					1	1
Indelible Pencil	1					1	1
	2					1	1
Lipstick	1		X			1	1* 3#
	2		X			2	2* 4#
Nail Polish	1		X			1	3
	2		X		X	8* 7#	7* 8#
Tar	1					1	1
	2		X			1	1
Total		0	5	0	1	36* 35#	37* 42#
Composite Rank		1.5	1.5	1.5	1.5	2* 1#	1* 2#

(1) 1 = Stain removed immediately after application
2 = Stain removed 24 hours after application

(2) Easy to remove = 1 (3) Most effective removal = 1

* Fabric VII # Fabric VIII

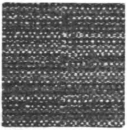
PLATE I

FABRICS AFTER ABRASION

WARP | FILLING

I-CR

AFTER 500

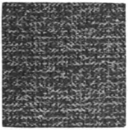


AFTER 500

AFTER 1034

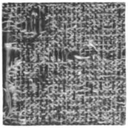
AFTER 1675

II - C

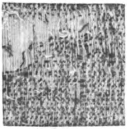


AFTER 500

AFTER 5



AFTER II-2



AFTER [illegible]

PLATE 2

FABRICS AFTER ABRASION

WARP

III-R

FILLING

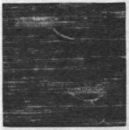
AFTER 500

AFTER 500

AFTER 654

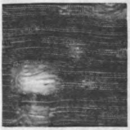
AFTER 1066

IV-RL



AFTER 500

AFTER 500



AFTER 915

AFTER 1295

PLATE 3

FABRICS AFTER ABRASION

V-LC

WARP

AFTER 500

FILLING

AFTER 500

WARP

AFTER 1428

FILLING

AFTER 1096

VI-L

WARP

AFTER 500

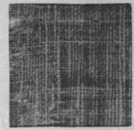
FILLING

AFTER 500

WARP

AFTER 2151

FILLING



AFTER 1508

PLATE 4

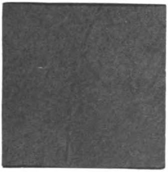
ABRADED PLASTICS

VII-P_1

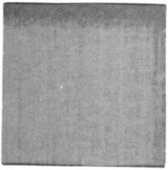
ORIGINAL

AFTER 15

VIII-P_2

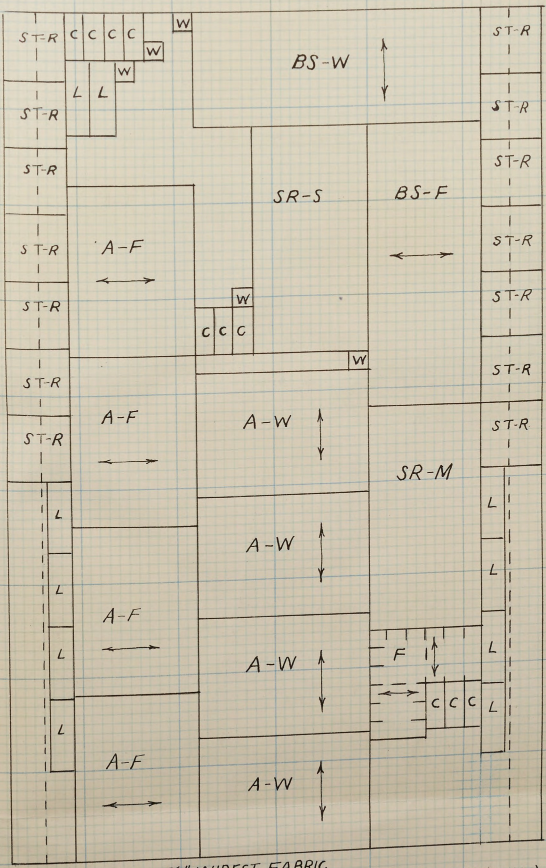


ORIGINAL



AFTER 15

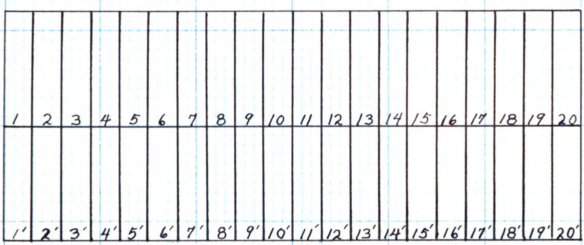
PLATE 5
FABRIC CUTTING CHART



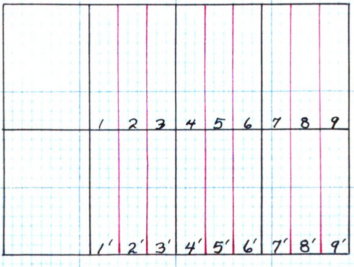
WIDTH = 56" WIDEST FABRIC
49" NARROWEST FABRIC (WITHIN DOTTED LINE)
A-F = ABRASION TEST-FILLING (SEE PLATE 6)
A-W = ABRASION TEST-WARP (SEE PLATE 6)
BS-F = BREAKING STRENGTH-FILLING (SEE PLATE 6)
BS-W = BREAKING STRENGTH-WARP (SEE PLATE 6)
C = COLORFAST TO CROCKING
F = FLAMMABILITY-WARP OR FILLING ACCORDING TO INDIVIDUAL FABRIC
L = COLORFASTNESS TO LIGHT
SR-M = SOIL RETENTION-REMOVAL BY MYSTIC FOAM
SR-S = SOIL RETENTION-REMOVAL BY SOAP SHAMPOO
ST-R = STAIN REMOVAL
W = WEIGHT PER SQUARE YARD

PLATE 6

DETAILED SAMPLING OF FABRICS



TENSILE STRENGTH - 1½" X 6"
1 = DRY BREAKING STRENGTH
1' = WET BREAKING STRENGTH

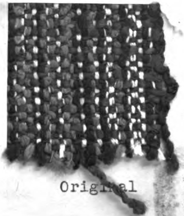


ABRASION SETS
4½" X 6½" = ABRASION
1½" X 6½" = BREAKING STRENGTH AFTER ABRASION
1 = DRY BREAKING STRENGTH
1' = WET BREAKING STRENGTH

PLATE 7

UPHOLSTERY FABRICS

I-CR

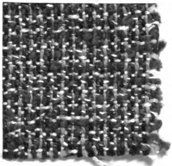


Original

Cleaned with
Soap Shampoo

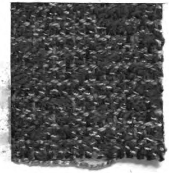
Cleaned with
Mystic Foam

II-C



Original

Cleaned with
Soap Shampoo

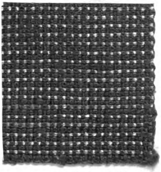


Cleaned with
Mystic Foam

PLATE 8

UPHOLSTERY FABRICS

III-R

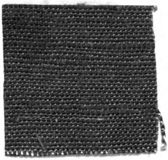


Original

Cleaned with
Soap Shampoo

Cleaned with
Mystic Foam

IV-RL



Original

Cleaned with
Soap Shampoo

Cleaned with
Mystic Foam

PLATE 9

UPHOLSTERY FABRICS

V-LC

Original

Cleaned with
Soap Shampoo

Cleaned with
Mystic Foam

VI-L

Original

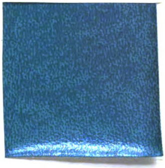
Cleaned with
Soap Shampoo

Cleaned with
Mystic Foam

PLATE 10

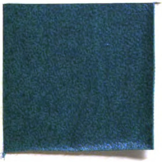
UPHOLSTERY FABRICS

VII-P_1



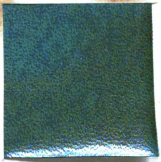
Original

Cleaned with
Soap Shampoo



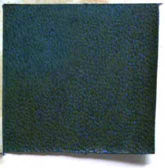
Cleaned with
Mystic Foam

VIII-P_2



Original

Cleaned with
Soap Shampoo



Cleaned with
Mystic Foam