THE USE OF THE ACCELEROTOR IN DEVELOPING AN ACCELERATED ABRASION TEST TO PREDICT FABRIC SERVICEABILITY

by

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This study was undertaken as a project related to the Southern Regional Research Project, SM-18. The purpose of this regional project was to obtain a means of selecting cottons for specific end-uses by studying the relationship of fiber properties. This study was designed to use the Accelerotor in developing an accelerated abrasion test to predict fabric serviceability.

The four types of cotton sheetings distributed to the North Carolina station for use in Phase I of the Regional Project were sampled (1) to determine the bursting strength after wear and laundering, and (2) to develop an accelerated abrasion test using the Accelerotor.

The Accelerotor was used to subject prepared specimens to grit abrasion for established variables of liner, time and speed. The fabric serviceability was determined by the Mullen Tester. The Mullen Tester evaluation was the basis for comparison between the used and laundered sheet samples and the Accelerotor abraded specimens. The comparison was essential to the determination of the accelerated abrasion test that would produce results in the laboratory similar to the results of service testing on the same type of fabric.

It was concluded from the determination of the bursting strength of used and unused cotton sheetings that there was no significant difference between the four cotton types before use and after thirty and sixty intervals of use and laundering. It was also concluded that an abrasion test using the Accelerotor was developed to produce results in the laboratory comparable to the results of service testing on the fabrics used in this study.

ACKNOWLEDGEMENT

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CHAPTER I

INTRODUCTION

"Textiles and their end products constitute the world's second largest industry. . . ."[1]

The growth and development of the textile industry owes its present status to the increased emphasis placed upon research. Textile testing is an integral part of textile research. Both laboratory and service tests are incorporated into textile testing. Abrasion is one of the tests essential to laboratory testing, and is of particular value in determining fabric serviceability. Wear testing is a comparable service test. Attempts have been made to simulate wear test results in the laboratory. Abrasion testing has dominated the research done to achieve this result. Many methods and machines have been developed to test the abrasion resistance of fabrics. However, none of these methods or machines satisfies the requirements for a standard method or produces results comparable to actual wear.

Dr. Harold W. Stiegler, former Director of Research of the American Association of Textile Chemists and Colorists emphasized the need for a standardized abrasion test machine and method when he stated:

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[1]American Fabrics Magazine (ed.), A F Encyclopedia of Textiles (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1960), p. xiii.

The increased importance of end-use requirements of textiles particularly with respect to wear and laundering abrasion, emphasizes the need for realistic test methods closely related to characteristic end-use effects.[2]

Under the direction of Dr. Stiegler, the Accelerotor was developed with the scope and versatility to fulfill this need. This abrasion testing machine was presented in 1953.

This study was designed to use the Accelerotor in developing an accelerated abrasion test to predict fabric serviceability. It was assumed that an accelerated abrasion test using the Accelerotor could reproduce end-use performance results; and that the Accelerotor could be used to predict differences in fabric serviceability.

Therefore, the primary objectives of the study were:

1. To use the bursting strength to determine the serviceability of cotton sheetings after thirty and sixty periods of use and laundering.

2. To develop an accelerated abrasion test using the Accelerotor and incorporating the best combination of variables such as liner, time and speed which would reproduce the results of service tests.

Cotton sheetings made from selected strains of cotton varying in physical properties were the media used to establish the accelerated abrasion test and also to indicate the value of the instrument in predicting end-use.

The Mullen Tester was the instrument used to measure the extent of fabric degradation following wear testing and following abrading with the

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[2]Harold W. Stiegler, Harlan E. Glidden, George J. Mandikos, G. Robert Thompson, "The Accelerotor for Abrasion Testing and Other Purposes," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLV (September 10, 1956), 685.

Accelerotor.

The Importance of This Study

Certain research workers consider "abrasion . . . the most important single factor in wear."[3]

Abrasion has been defined ". . . as the type of destruction resulting from frictional forces on fabrics . . . ."[4]

"Wear . . . is a more inclusive term and . . . is the amount of deterioration of a fabric which results from breaking, cutting, or removal of fibers."[5]

Since abrasion is such an important aspect of textile testing many methods have been employed to produce the most accurate test of textiles for abrasion. Doubt remains as to the complete competency of any of the existing methods.

Authorities have indicated the importance of undertaking a study of this type.

There is a serious need for a method to relate accelerated abrasion testing with actual wear life.[6]

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[3]Margaret Harris Zook, "Historical Background of Abrasion Testing," American Dyestuff Reporter, XXXIX (September 18, 1950), 625.

[4]John H. Skinkle, Textile Testing (New York: Chemical Publishing Company, Inc., 1940), p. 97.

[5]Ibid.

[6]John P. McNally, and Frank A. McCord, "Cotton Quality Study, V: Resistance to Abrasion," Textile Research Journal, XXX (October, 1960), 744, citing H. F. Schiefer, and C. W. Werntz, Textile Research Journal, XXII (January, 1952), 1-12.

> Development of new machines and improvement of existing ones to achieve reproducibility and correlation between laboratories, machines, and operators is an important objective.[7]

> The need for standardization of abrasion test procedures becomes more accentuated as an increasingly large number of new fibers, fabrics, finishes and allied textile products appear on the market.[8]

> . . . Competition from certain synthetic fibers, particularly nylon, has made reappraisal of cotton's abrasion performance desirable.[9]

Thus the need for this study is evidenced by the current questionable variability in results on a fabric from the present abrasion testing methods. The Accelerotor procedures must be substantiated in order to be of value in stabilizing this variability in abrasion testing.

The succeeding chapters will report on the development, progress and conclusions of this study.

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[7]John P. McNally, and Frank A. McCord, "Cotton Quality Study, V: Resistance to Abrasion," Textile Research Journal, XXX (October, 1960), 745.

[8]Zook, op. cit., 627.

[9]McNally and McCord, op. cit., 715.

CHAPTER II

REVIEW OF LITERATURE

I. ABRASION AND TEXTILE TESTING

Abrasion testing is neither a new nor conquered area of textile testing. It is a complex area which as yet has not developed an acceptable standard method of testing the abrasion resistance of fabrics. The present methods are tentatively recommended practices.

Definitions

The term "abrasion" has been used interchangeably with wear and serviceability throughout the early history of wear testing. The distinction now made is more realistic.[1]

According to Skinkle:

> "Serviceability" of a fabric is its length of life up to its end of usefulness which is when one necessary property becomes deficient. "Wear" is the amount of deterioration of a fabric due to breaking, cutting, or removal of fibers. . . . an indeterminate quality because conditions of wear vary so much and also because we do not know quantitatively the effect of the different factors involved in wear.
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> . . . Abrasion is the most important factor in wear in most cases and . . . consists of friction between the cloth and some other material.[2]

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[1]John H. Skinkle, Textile Testing (New York: Chemical Publishing Company, Inc., 1940), p. 97.

[2]Ibid., pp. 97-98.

The Standard of the American Society for Testing Materials defines abrasion as "the wearing away of any part of a material by rubbing against another surface."[3]

Factors and Philosophies

The factors affecting the abrasion of textile materials as summarized from the *A.S.T.M. Standards on Textile Materials* include:

A. Textile Material

1. The inherent mechanical properties of the fibers
2. The dimensions of the fibers
3. The structure of the yarns
4. The texture of the fabrics
5. Type, kind and amount of finishing material added to the fibers, yarns, or fabrics

B. Test

1. Conditions of the tests
   a. as nature of abradant
   b. variable action of the abradant over the area of specimen abraded
   c. the variations during a test of:
      (1) the abradant
      (2) the tension on the specimen
      (3) the pressure between the specimen and abradant
      (4) the dimensional changes in the specimen

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[3]A.S.T.M. Committee D-13, *A.S.T.M. Standards on Textile Materials* (Philadelphia: American Society for Testing Materials, 1961), p. 17.

C. Measurement

1. Method of evaluation of the amount of abrasion

2. The judgment of the operator.[4]

The underlying problem in the field of abrasion testing has been the consistent questioning of the extent to which laboratory wear tests should compare with actual service. Zook has stated the two divergent philosophies held by authorities which attempt to solve this problem.

1. To duplicate the actual conditions of wear

2. To select the most important causes of wear and correlate them with service tests.[5]

The philosophy supported by the person who invents and develops a wear and abrasion testing machine determines the principles employed. Mann and Tait stated that "abrasion (is) . . . the most important single factor in wear." Many textile technologists have used this reasoning and studied the resistance of fabrics to abrasion rather than wear in general.[6]

Developments in Abrasion Testing

As of 1950 more than fifty wear and abrasion testing machines had been developed. Of these, many had been discarded often because of insufficient

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[4]Ibid., p. 354.

[5]Margaret Harris Zook, "Historical Background of Abrasion Testing," American Dyestuff Reporter, XXXIX (September 18, 1950), 625.

[6]Ibid.

investigation of their value.[7]

In the results of a poll reported by Tanenhaus and Winston, the three most commonly used machines were the Taber Abraser, the Abrader of the U. S. Testing Company and the Wyzenbeek Precision Wear Test Meter. The Schiefer Abrasion Testing Machine and Multipurpose Abrasion Tester developed by Stoll and others of the research program of the Quartermasters Corps also received notable mention.[8]

The A.S.T.M. Committee D-13 on Textile Materials has tentatively recommended five practices that may be used for testing the abrasion resistance of textile fabrics. These now widely used practices are:

A. Inflated Diaphragm Method . . . for use in determining the resistance to abrasion of woven and knitted textile fabrics when the specimen is inflated over a rubber diaphragm under controlled air pressure and rubbed either unidirectionally or multidirectionally against an abradant of given surface characteristics under controlled pressure conditions.

B. Flexing and Abrasion Method . . . for use in determining the resistance of woven fabrics to flexing and abrasion when the specimen is subjected to unidirectional reciprocal folding and rubbing over a bar having specified characteristics, under known conditions of pressure and tension.

C. Oscillatory Cylinder Method . . . is used for determining the abrasion resistance of textile fabrics when the specimen is subjected to unidirectional rubbing action under known conditions of pressure, tension, and abrasive action. The abrasion resistance is evaluated in terms of an objective end point.

D. Rotary Platform, Double Head Method . . . for use in determining the abrasion resistance of fabrics or cloth durability when the specimen is

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[7] Ibid., 625-626.

[8] Ibid., 626.

subjected to rotary rubbing action under controlled conditions of pressure and abrasive action.

E. Uniform Abrasion Testing Machine Method . . . is applicable to testing the resistance to abrasion of a wide range of textile materials under a very great range of constant testing conditions. The abrasive action is applied uniformly in all directions in the plane of the surface of the specimen about every point in it.[9]

The Stoll-Quartermaster machine fulfills the requirements established in the first two methods described. The Wyzenbeek Precision Wear Test Meter meets the requirements of the Oscillatory Cylinder Method. The Taber Abraser and Schiefer machine meet the requirements, respectively, of the Rotary Platform, Double Head Method and the Uniform Abrasion Testing Machine Method.[10]

The two main aspects that have been investigated in the field of abrasion are:

(1) The relationship of fabric construction to resistance to dry and . . . to wet abrasion . . .; and

(2) attempts . . . to evaluate the results of abrasion testing on the various machines to ascertain (a) whether or not their results may be correlated with one another; (b) whether or not they reproduce service tests; and (c) whether or not they may be correlated with service tests.[11]

Notable research pertaining to these aspects has been reviewed by Zook. Studies reported in accordance with the first aspect include a study by Tait, in 1945, on the determination of the fiber and fabric characteristics of selected lining fabrics, that would give the greatest abrasion resistance. In 1928

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[9]A.S.T.M. Committee D-13, op. cit., pp. 454-470.

[10]Ibid.

[11]Zook, op. cit., 626.

Morton and Turner reported the effect of the closeness of weave and yarn twist on the wear resistance by rubbing. The study by Hamburger in 1949 was concerned with yarn structure and its relationship to abrasion resistance. Also in 1949, Schiefer and Krasny reported the effects of wet and dry abrasion on wool fabrics.

Abrasion research pertinent to the second aspect was reported by Tanenhaus and Winston on an interlaboratory study of the Wyzenbeek machine. Hays, in 1944, attempted to correlate the results of the Taber and Wyzenbeek machines. Russman reported a study of men's and women's suit and coat materials. He first evaluated the wear of the worn garments and then attempted to correlate the results of the Wyzenbeek machine with this evaluated wear in order to be able to predict the length of normal wear the garment would endure. Kaswell and Tanenhaus studied the correlation between accelerated wear from use on an army combat course and the results of a type of normal wearability test.[12]

More current research in reference to the relation of fabric construction to abrasion has been reported by Gagliardi and Nuessle from their study of the relation between fiber properties and abrasion resistance.[13] Backer and Tanenhaus, in 1951, reported the mechanics of fabric abrasion when considering

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[12] Ibid.

[13] D. Donald Gagliardi, and Albert C. Nuessle, "The Relation Between Fiber Properties and Apparent Abrasion Resistance," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XL (June 25, 1951), 409-415.

the relationship between the structural geometry and physical properties of a textile fabric.[14] Emphasis in this phase of research was also placed on fabric finishes. Studies reported in 1958 by Reinhardt, Kullman, Moore and Reid were concerned with the improved strength and abrasion resistance of after-mercerized wrinkle-resistant cottons.[15] Pope and Weiner investigated the effects of a surface finish on the flex-abrasion resistance of cotton sateen.[16]

Zook has stated that:

> Although many laboratories currently use abrasion tests to aid in the determination of fabric quality, and much research is in progress in the field of abrasion testing, there is no standardized procedure in general use. Lack of a generally accepted standard procedure becomes evident from visits to research laboratories, scrutiny of the minutes of the recent meetings of the Task Group on Abrasion Testing of the American Society for Testing Materials, and private conversations with persons in the fore-front of the fabric testing field. The need for standardization of abrasion test procedures becomes more accentuated as an increasingly large number of new fibers, fabrics, finishes and allied textile products appear on the market.[17]

This statement describing the need for a standardized abrasion test procedure is as true today as it was when the article was published in 1950.

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[14]S. Backer, and S. J. Tanenhaus, "The Relationship Between the Structural Geometry of a Textile Fabric and Its Physical Properties," Textile Research Journal, XXI (September, 1951), 635-654.

[15]Robert M. Reinhardt, Russell M. H. Kullman, Harry B. Moore, J. David Reid, "After-Mercerization of Wrinkle-Resistant Cottons for Improved Strength and Abrasion Resistance," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLVII (November 3, 1958), 758-764.

[16]Clarence J. Pope, and Louis I. Weiner, "The Influence of a Surface Finish on the Flex-Abrasion Resistance of Cotton Sateen," American Dyestuff Reporter, L (September 18, 1961), 702-705.

[17]Zook, op. cit., 627.

Organizations are currently developing new abrasion testing machines and experimenting with them to produce the desired standardization.

II. THE ACCELEROTOR

Basic Concepts and Principles

An aim in abrasion testing has been the development of a laboratory-scale instrument that would produce results comparable to those from full-scale equipment and from end-use. This laboratory-scale instrument must also embody simplicity, speed, accuracy, reproducibility and sound scientific principles in the production of realistic tests.[18]

The rubbing or scraping of a hole in an immobilized test specimen has thus far been the basis of most abrasion testing machines. However, this method incorporates but a few characteristics of natural wear and end-use treatments.[19]

> Therefore, instrumentation and procedures were sought which would include as many as possible of the factors which contribute most to the degradation and unserviceability of textiles and other flexible materials.[20]

To achieve this end the Accelerotor was designed and developed by the

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[18] Harold W. Stiegler, Harlan E. Glidden, George J. Mandikos, G. Robert Thompson, "The Accelerotor for Abrasion Testing and Other Purposes," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLV (September 10, 1956), 685.

[19] Ibid., 686.

[20] Ibid.

American Association of Textile Chemists and Colorists and presented in 1953.[21]

The attempt to fulfill the requirements of dry and wet abrasion testing and other textile applications motivated the design of the Accelerotor. These requirements were met by the insertion of suitable collars, fitted with a liner; the addition of liquids; and non-abrasive and abrasive liners ranging ". . . from smooth or ribbed no-grit surfaces to those of low-grit through high-grit content of the liners' coatings . . ." for varying degrees of abrasion.[22]

The theory of this instrument is contained in six principles.

> (1) Velocity. The substitution of high velocity for large mass, whereby, light-weight laboratory specimens moving freely at high speed receive increased kinetic energy of impact and so approach the effects of the heavy, slow-moving loads and forces of end-use wear and mechanical cleansing.
>
> (2) Random Motion. . . . permits response of the unfettered specimen to the imposed forces whereby it is free to move in any direction at any time. . . . permits constant flexing and change of position, which in turn causes changes of surface contacts, stresses and strains throughout the fabric and its components similar in effect to end-use wear and cleansing. Random motion and the high number of flexings and impacts tend to average out extremes of action much as in natural wear. Rotor blades are pitched to cause the specimen to flutter in a "zig-zag" path around the interior of the chamber and carom forcefully back from the sides.
>
> (3) Types of Action. Flexing, rubbing, scuffing, shock, compression, stretch and other forces occur throughout the test in any desired degree. Thus abrasion is caused throughout the body of the cloth by surface against surface, surface against metal or abradants, yarn against yarn and fiber against fiber.

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[21] 1953 Technical Manual and Yearbook of the American Association of Textile Chemists and Colorists Volume XXIX (New York: Howes Publishing Company, Inc., 1953), p. 75.

[22] Stiegler, et al., op. cit., 686.

(4) Versatility. . . . achieved in numerous ways. Speed . . . sacrificed at the expense of time. Varied length and shaped rotors alter severity and types of action and are inter-relations to time and types of liners.

(5) Evaluation. . . . means . . . used: percent weight loss of the specimen, visual appearance, color loss, light transmission through the worn fabric, air permeability, hand, time to reach comparable end points, microscopic evaluation of detritus, fibers and yarns, which often yields valuable information about the nature of the material and the action imposed.

(6) Reproducibility. . . . obtained . . . with reasonable care and attention in test operation.[23]

Scope and Operational Aspects

Within the broad scope of Accelerotor applications described by Stiegler were included these possibilities of investigation: abrasion by dry, moist, wet laundering, and drycleaning means; dye formulations and penetration; fabric and abrasion-sensitive color life wear prediction; felting; shrinkage; pilling; edge wear; effects of finishes; dimensional change; evaluation of detergents and soils; leather scuffing and penetration; and the abrasion resistance of glass, plastic, knitted and coated fabrics.[24]

The Accelerotor is used in conjunction with the Launder-Ometer in testing for colorfastness to washing, especially in relation to "abrasion-sensitive dyed materials."[25]

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[23] Ibid., 686-687.

[24] Ibid., 687-689.

[25] Ibid.

In the operation of the Accelerotor the fabric and the intended application determined the speed, time, collar, liner, size and type of rotor and specimen size.[26]

Guides have been formulated for each of these variables to aid the research worker in establishing a testing method.

Speed. The speed is dependent upon the ". . . size, weight, thickness and stiffness . . ." of the test specimen. The range of speeds for most dry abrasion tests is from two thousand to thirty-five hundred revolutions per minute and from fifteen hundred to twenty-five hundred revolutions per minute for liquid tests.[27]

Time. The time may vary ". . . from a few seconds to five or ten minutes duration," and be automatically or manually controlled.[28]

Collar. Lined plastic collars are used in dry wear testing and metal or rubber ribbed collars in wash or drycleaning testing.[29]

Liner. In dry abrasion testing the coating mixture on the flexible liner fabric varies to produce either a grit or a frictional abrasive. The liner surface for frictional abrasion may be smooth, stippled or slightly roughened. The grit abrasive liners vary according to the percentage and grade (fine to coarse)

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[26]A.A.T.C.C. Accelerotor, Bulletin No. 1111-A, A Pamphlet of Instructions Prepared by the Atlas Electric Devices Company, Chicago 13, Illinois.

[27]Stiegler, et al., op.cit., 690-691.

[28]Ibid., 691.

[29]Ibid.

of the grit contained in the coating mixture. The liners have a multiple use quality and may be washed or scrubbed to revive the surface.

A layer of sponge or foam rubber has been used between the collar and liner ". . . to soften and approach more realistic frictional and abrasive action . . ."[30]

Test specimen. The specimen size is determined by the weight, bulk and stiffness of the fabric. It is usually a square of approximately five inches or less.[31] The specimen is prepared by pinking or slightly raveling the edges and then applying a thin coat of adhesive to these edges.[32]

Test Procedure Variations

The two main procedural variations are the constant-speed and the uncontrolled-speed methods.

The constant-speed method of testing requires the operator to maintain the selected speed throughout the duration of the test. Generally the speed will increase as the specimen decreases in weight and firmness. The weight-loss method of evaluation is usually employed.

In the uncontrolled-speed method the specimen regulates the speed after the initial setting is made. This setting would be lower for a heavy,

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[30]Ibid.

[31]Ibid.

[32]William Appel (ed.), 1961 Technical Manual of the American Association of Textile Chemists and Colorists, Volume XXXVII, "Abrasion (Wear) Resistance of Fabrics: Accelerotor Method" (New York: Howes Publishing Company, Inc., 1961), p. 113.

stiff fabric than for a lighter fabric.[33]

Comparison of Grit and No-Grit Abrasion

Although grit abrasion is more often used in abrasion testing a better comparison is made with a fabric that has been submitted to harsher wear. The effects of frictional abrasion are more indicative of ordinary garment wear. According to Stiegler, "grit (abrasion) . . . causes formation of fibrils, nicks and cuts . . . frictional abrasion leaves the fibers and yarns cleaner and free of fibrils."[34]

Evaluation of Abrasion

In evaluating the effects of abrasion on textile materials certain methods have been recommended for each of the types of abrasive action.

The methods usually recommended for dry abrasion tests were weight loss of the specimen, microscopic examination, strength tests, light transmission, air permeability, stiffness and visual tests.

Reflectance and visual evaluations were advised for use with wet abrasion tests.[35]

Research in Which the Accelerotor Has Been Used

Since the introduction of the Accelerotor to the field of abrasion testing

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[33]Stiegler et al., *op. cit.*, 692.

[34]*Ibid.*

[35]*Ibid.*, 693-694.

in 1953 a number of investigations have been undertaken to determine the validity and reliability of this instrument.

Investigation results led to the development and adoption of "Abrasion (Wear) Resistance of Fabrics: Accelerotor Method," (Tentative Test Method 93-1959T) in 1959;[36] and "Colorfastness of Textiles to Industrial Laundering," (Accelerated Test, Tentative Test Method 87-1958), in 1958, by the American Association of Textile Chemists and Colorists.[37]

Dry abrasion research. The report by Stiegler et al. cites a variety of Accelerotor applications on which preliminary investigation has been done. The applications that were investigated included the reproduction of end-use wear; abrasion resistance of glass fabrics and finishes, paper and nonwoven fabrics; and dimensional change in relation to shrinkage.[38]

In 1958, the A.A.T.C.C. Committee on Resistance to Abrasion presented a report of interlaboratory investigation on the extent of the reproducibility of specimen weight loss when using the Accelerotor.[39]

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[36]Appel, op. cit., pp. 112-114.

[37]William Cady (ed.), 1958 Technical Manual of the American Association of Textile Chemists and Colorists Volume XXXIV, "Colorfastness of Textiles to Industrial Laundering" (New York: Howes Publishing Company, Inc., 1958), pp. 95-96.

[38]Stiegler et al., op. cit., 693, 696-697.

[39]Theodore F. Cooke, "Abrasion Testing of Textiles with the Accelerotor: Reproducibility in Interlaboratory Tests," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLVII (October 6, 1958), P679-P683.

From the tests results and statistical analysis it was concluded that:

1. In all three categories of fabrics, cotton sheeting, twill and rayon, the agreement between Accelerotors and operators was excellent.

2. Equivalent sample rankings resulted from the constant-speed and uncontrolled-speed methods, however, on the whole the constant-speed method was more exact than the uncontrolled-speed method.

3. The testing order did not significantly affect the abrasion resistance of the fabrics ". . . indicating that the wearing down of abrasive efficiency of the liner for the duration of the interlaboratory test was not affecting the results."[40]

Briar reported on research concerned with the operation of the Accelerotor under controlled power. The methods previously studied were the constant-speed method, where the operating speed was controlled, and the uncontrolled-speed method, where the initial speed was set. Briar assumed that by controlling the energy input certain parameter effects would be minimized.[41]

In evaluating the investigation of the control power method Briar stated:

> The method should allow comparison of a wide range of fabric weights and styles without changes in the nature of the abradant or other machine parameters.
>
> Certainly, the constant power method should help eliminate machine parameter, fabric parameter interactions.[42]

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[40]Ibid., 682.

[41]H. P. Briar, "A Study of the AATCC Accelerotor While Operating At Constant Power," American Dyestuff Reporter, XLIX (August 8, 1960), 27.

[42]Ibid., 32.

This research also attempted to relate the constant-speed and constant-power methods. The results suggested that the constant-speed method be used to collate treatments of the same fabric and the constant-power method be used to permit basic evaluation of a specific fabric parameter.[43]

An investigation by Macormac and Richardson dealt with arriving at a method for the comparative evaluation of the durability of wool fabrics and a possible method of determining the interrelationship of fabric degradation and running time in the Accelerotor. The noteworthy result of this research was:

> The percentage of worn wool ends consistently increased with increased time in the Accelerotor, indicating a good method for measuring the abrasive damage received by wool fabrics in this machine.[44]

In 1962, the A.A.T.C.C. Committee on Resistance of Fabrics to Abrasion began conducting "round robin" experimentation using the Accelerotor on grab-break specimens that were partially folded warpwise. This research continues on a variety of fabrics.[45]

Wet abrasion research. The research leading directly to the establishment of the tentative accelerated test for laundering cotton work clothes was

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[43] Ibid.

[44] Alfred R. Macormac, and F. M. Richardson, "Wear Tests with the Accelerotor," American Dyestuff Reporter, XLVI (February 25, 1957), 151.

[45] Percy J. Fynn, "Committee RA29, Resistance of Fabrics to Abrasion," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, LI (November 26, 1962), 49.

carried out by the A.A.T.C.C. Committee on Colorfastness to Washing.

A variety of fabrics industrially laundered were used as standards in the development of an accelerated test to predict the colorfastness of fabrics after a specified number of industrial washings.

The conclusions, based on the comparison of industrial launderings and the Accelerotor accelerated test, recommended application of the accelerated test only to cotton fabrics, and fabrics showing "good colorfastness to the Accelerated III A Test."[46]

Paulk conducted a comparative study using the Accelerotor for laundering terry towels. The comparison was made with a previous laboratory study using a home laundering procedure. Evaluation was made on the changes in thickness, weight and absorption.

The comparative results indicated similarity in the effect of home laundering and laundering with the Accelerotor. Thickness and absorbency increased to the same degree in the three towelings tested. Weight loss increased with the Accelerotor. The advantage derived from the Accelerotor was speed and uniformity of results.[47]

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[46]Ralph B. Smith, "Colorfastness of Textiles to Industrial Laundering," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLVII (October 6, 1958), P684-P685.

[47]R. H. Paulk, "Use of the Accelerotor for Laundering Terry Towels, Measured by Changes in Thickness, Weight and Absorption," Journal of Home Economics, XLIX (March, 1957), 192-196.

III. METHOD USED TO EVALUATE ABRASION

"A measure of the abrasion resistance of the test specimen depends upon an accurate method of evaluating the amount of damage which took place."[48]

The Mullen Tester is an instrument for testing the strength of a fabric as indicated by its resistance to a bursting force. The resistance of the fabric is measured by subjecting the fabric specimen surface, warp and filling yarns combined, to maximum perpendicular projected pressure.

This method of testing the fabric strength may be applied to knit, non-woven and lightweight woven fabrics.[49]

Research With the Mullen Tester

The "Comparison of Breaking and Bursting Strength Values with the Taber Abraser" was a study conducted at The Ellen H. Richards Institute of The Pennsylvania State College, by Zook and Mack.

Experimental rayon fabrics, varying in degrees of weight, were used in this study.

The comparisons were based on the strength loss as measured by the breaking strength test on four established combinations of abrasion and test directions, and the bursting strength test taken in three specified locations on

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[48] John P. McNally, and Frank A. McCord, "Cotton Quality Study, V: Resistance to Abrasion," Textile Research Journal, XXX (October, 1960), 740.

[49] Elliot B. Grover, and D. S. Hamby, Handbook of Textile Testing and Quality Control (New York: Textile Book Publishers, Inc., 1960), p. 535.

the defined abrasion ring.

The Mullen Tester was used for the bursting strength tests.

In summarization the study concluded:

1. In the four established combinations of abrasion and test directions the compared breaking strength losses were "affected by the position of the yarns which caused warp and filling to receive the greatest impact from the abrasive action and by other factors."

2. There was no significant difference between the three specifically located bursts, although average differences did appear.

3. Although there were some variations in curves plotted to show the comparison of breaking and bursting strength values at early cycle stations, essentially the same order of rank was evident at the one hundred per cent loss level.[50]

Bursting strength, not hitherto reported as a method of evaluating strength loss following this type of abrasion test, gave uniform results unquestionably related to the resistance of the fabrics to abrasion in its two combined directions. The test has the advantage of simplicity and saving in time.[51]

IV. PREVIOUS RESEARCH WITH THE COTTON FABRICS USED IN THIS STUDY

Service tests have made a twofold contribution to textile development. The results of this type of testing have aided the textile manufacturer in im-

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[50]Margaret Harris Zook, and Pauline Berry Mack, "Comparison of Breaking and Bursting Strength Values with the Taber Abraser," American Dyestuff Reporter, XL (October 15, 1951), 661-666.

[51]Ibid., 666.

proving product quality and have aided the textile technologist in developing comparable laboratory tests in order to alleviate the time and financial expenditure now necessary.

"The Relation of Selected Properties of Raw Cotton to Product Quality and End Product Performance" is a service study now being conducted by Home Economics Research personnel of six Southern states. The testing is designed to investigate the fiber properties of length, strength, fineness and elongation. The study is being conducted in two phases. The first phase studied the property of fiber elongation; the second phase will study the properties of fiber length, strength and fineness.

Sheets have been made from four types of cotton for use in certain college dormitories. The laundering is done in commerical launderies.

Fabric serviceability determination is made by performing certain laboratory tests on the sheets at established intervals of use and launderings.[52]

There have been other service tests and research done in this area of cotton fiber properties as related to fabric performance. Two studies have been done at the University of North Carolina at Greensboro in connection with this master project. Henkel reported on the "Serviceability of Sheets Made From Selected Cottons of High and Low Elongation."[53] Guin studied "The

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[52]Technical Committee Project SM-18, "The Relation of Selected Properties of Raw Cotton to Product Quality and End Product Performance" (Manual of Procedure, Southern Regional Research Project SM-18).

[53]Shirley L. Henkel, "Serviceability Features of Sheets Made from Selected Cottons of Low and High Elongation" (unpublished Master's thesis, Consolidated University of North Carolina, Greensboro, 1961).

Relation of Fiber Elongation to Selected Serviceability Features of Experimental Cotton Sheetings.[54] None of the fabric serviceability test data used in these studies were related to abrasion.

Both of these studies were concerned primarily with methods for statistical analysis and development of programs for the computation of data using the IBM 1105 Digital Computer. The fabric serviceability data obtained from testing at the early intervals of use and launderings in the master project were used for these studies. Some indication of serviceability features affecting the selected cottons tested through the fifteenth interval of use and launderings was shown by Henkel.[55]

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[54]Ruth Guin, "The Relation of Fiber Elongation to Selected Serviceability Features of Experimental Cotton Sheetings" (unpublished Master's thesis, Consolidated University of North Carolina, Greensboro, 1961).

[55]Henkel, loc. cit.

CHAPTER III

PROCEDURE

This study is a research project contributing to the Southern Regional Research Project, SM-18, undertaken by Home Economics Research personnel of six Southern states.[1] Insufficient investigation of the relationship between cotton fiber properties and in-service performance of products led to the establishment of Project SM-18. The purpose of the project was to obtain a means of selecting cottons for specific end uses by studying the relationship of fiber length, strength, fineness and elongation to product performance. Phase I of the project was undertaken to study the effect of fiber elongation in relation to serviceability. Phase II of this project, currently in progress, is concerned with the effect of fiber length and strength in relation to serviceability.[2]

I. FABRICS USED IN THIS STUDY

The fabrics used in all testing were taken from sheets distributed to the North Carolina station for use in Phase I of the Regional Project. The sheets withdrawn at the original, thirtieth and sixtieth intervals of Phase I were used:

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[1]Technical Committee Project SM-18, "The Relation of Selected Properties of Raw Cotton to Product Quality and End Product Performance" (Manual of Procedure, Southern Regional Research Project SM-18), Phase I.

[2]*Ibid.*, Phase II.

(1) to determine the bursting strength after wear and laundering, and (2) to develop an accelerated abrasion test using the Accelerotor.

Sampling of Fabrics Used to Determine Changes in Bursting Strength After Wear and Laundering

Since the major purpose of this study was to develop an accelerated abrasion test to simulate abrasion from actual wear, it was necessary to obtain data from controlled worn and unworn fabrics. Samples were cut from the cotton sheetings used in Phase I of the Regional Project. These sheets were made from four bales of experimental strains of cotton selected for their similarity in length, strength, and fineness. The major difference was that of fiber elongation.[3] A detailed report of the fiber properties is included as Appendix A.

The sheets were first desized through the regular laundering procedure. Wear was introduced to these sheets through use in the dormitories of The Woman's College of the University of North Carolina and by commercial laundering following each week of use. Sixty weeks of use and laundering were designated by the committee as the end point since the cotton sheeting at this point would have received extensive wear and could still be sampled for the many tests required.

The samples selected to obtain the bursting strength data of the sheets

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[3]Shirley L. Henkel, "Serviceability Features of Sheets Made From Selected Cottons of Low and High Fiber Elongation" (unpublished Master's thesis, Consolidated University of North Carolina, Greensboro, 1961), p. 14.

in Phase I were taken from the desized and unused sheets and from those withdrawn following thirty and sixty intervals of use and laundering. Six sheets of each of the four types of cottons were sampled at each testing interval making a total of seventy-two individual samples.

All sampling placement was determined with the sheet spread face up as hemmed, and as it would have been placed on the bed. The use of a five and one quarter inch square sample that allowed a minimum of a five square inch area for the bursting strength test was based on the size of the sample to be employed in developing the accelerated abrasion test using the Accelerotor.

The unused quality of the original sheetings permitted the sample to be taken from any area of the sheet. A measurement standard of twenty-two inches plus or minus one from the left side of the sheet and three inches plus or minus two from the lower hem of the sheet was selected for simplification of the cutting procedure.

The samples from the sheets withdrawn after the thirtieth and sixtieth intervals of use and laundering were cut from a location directly below Area A. Both Area A and the sample area were within the thirty inch square designated in the Manual of Procedures for the Regional Project as the part of the sheet that would receive wear. This placement was determined by measuring forty-five inches plus or minus two from the top of the sheet, and twenty-three inches plus or minus three from the right side of the sheet, as shown in Figure 1. The tolerance allowed in these measurements was made to correct irregularities in previous sampling and to establish the correct grain line. The direct center

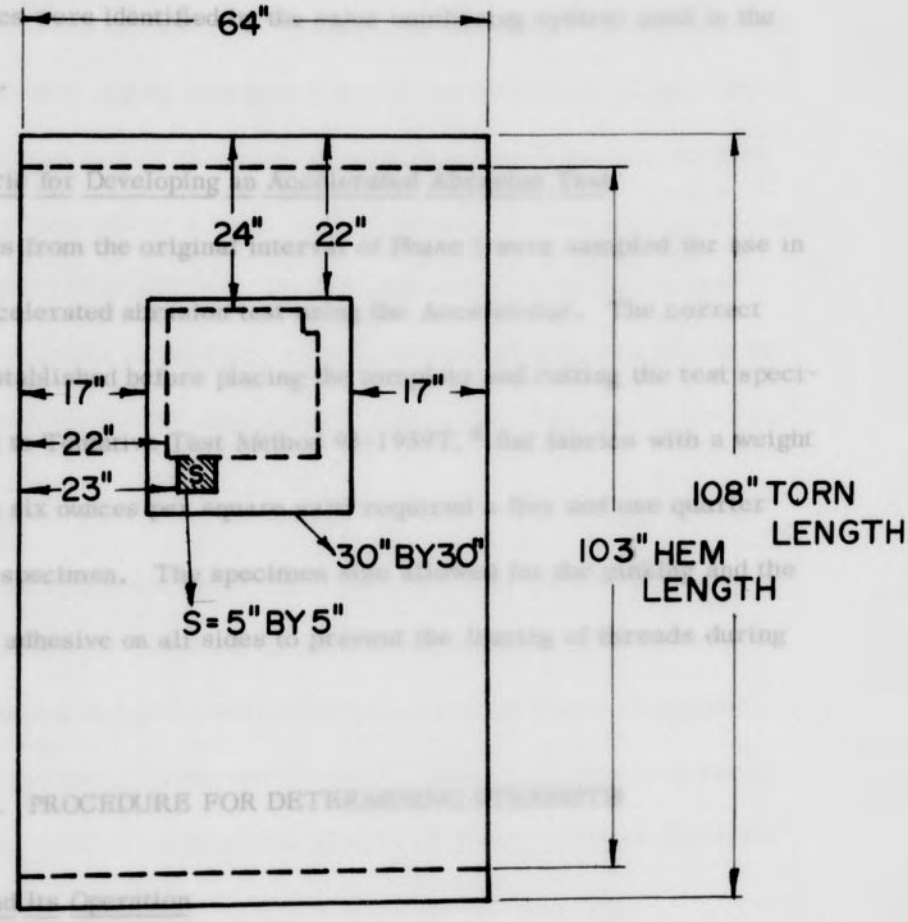

FIGURE 1

Placement of Sample Cut from Sheets of the Thirtieth and Sixtieth Intervals

Scale .25" = 5"

of the complete test area was not used because of the unnatural wear produced at the center fold of a sheet.

The samples were identified by the same numbering system used in the Regional Project.

Sampling of Fabric for Developing an Accelerated Abrasion Test

The sheets from the original interval of Phase I were sampled for use in developing an accelerated abrasion test using the Accelerotor. The correct grain line was established before placing the template and cutting the test specimen. According to Tentative Test Method 93-1959T,[4] flat fabrics with a weight range of three to six ounces per square yard required a five and one quarter inch square test specimen. The specimen size allowed for the pinking and the application of an adhesive on all sides to prevent the fraying of threads during testing.

II. PROCEDURE FOR DETERMINING STRENGTH

Mullen Tester and Its Operation

The Mullen Tester, Model C, was used in testing the cotton sheeting for loss in fabric strength. This tester is operated on the hydraulic principle to indicate the actual bursting strength of the fabric irrespective of any other factor. The instrument searches out any imperfection or small weak section of

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[4]William Appel (ed.), 1961 Technical Manual of the American Association of Textile Chemists and Colorists Volume XXXVII, "Abrasion (Wear) Resistance of Fabrics: Accelerotor Method" (New York: Howes Publishing Company, Inc., 1961), pp. 112-114.

the fabric being tested, protrudes into that weakness wherever located and registers the resultant break in terms of actual pounds per square inch.

The machine was prepared for operation by inserting each sample to be tested under the tripod, and by clamping it into place by the cam lever. The Mullen tester was operated by throwing the operating handle into the forward position and at the first sign of a break in the material, throwing the same control lever into the reverse position. The bursting pressure in pounds per square inch was indicated on the gauge. When the operating handle was in reverse position the gauge needle automatically returned to the neutral position.[5]

Sample Preparation

Three bursting strength tests were made on each of the samples cut from the cotton sheetings. A stencil designating the actual test areas was designed for convenience in testing and control of the bursting test placement. The criterion for the design of the stencil was to locate each area of burst so that there would be little or no repetition of warp or filling yarns in the three areas to be burst.

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[5]The Mullen Tester, A Pamphlet of Instructions Prepared by B. F. Perkins & Son, Inc., Holyoke, Massachusetts.

III. PROCEDURE FOR DEVELOPING AN ACCELERATED ABRASION TEST

Principles of the Accelerotor

The principles of the Accelerotor have been very clearly and concisely explained by the men most concerned with the development of the instrument.

> The Accelerotor is an instrument for subjecting textiles and other flexible materials to abrasion. Dry, moist and wet wear abrasion tests . . . may be accomplished at a highly accelerated rate within a few minutes. Many other applications are available.
>
> The instrument consists primarily of a chamber within which rotors or impellers of special design revolve at controllable high speeds. High speeds impart high velocity and kinetic energy to the test specimens with resultant extremely rapid and forceful impacts. The various types of abrasion and flexing achieved produce results within a few minutes, which bear close and realistic relationship to the effects of ponderous, slow moving forces encountered in wearing, laundering or drycleaning garments and other textiles over a long period of time.[6]
>
> . . . frictional abrasion is caused by the action of fabric surface against fabric surface, fabric surface against metal and different abradents, yarn against yarn and fiber against fiber.[7]

The general procedure for use was based on the method established in the Tentative Test Method 93-1959T.[8]

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[6]Harold W. Stiegler, Harlan E. Glidden, George J. Mandikos, G. Robert Thompson, "The Accelerotor for Abrasion Testing and Other Purposes," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XL (September, 1956), P. 686.

[7]A. A. T. C. C. Accelerotor, Bulletin No. 1111-A, A Pamphlet of Instructions Prepared by the Atlas Electric Devices Company, Chicago 13, Illinois.

[8]Appel, op. cit., pp. 112-114.

Preparation of the Accelerotor

The simple function of the Accelerotor is regulated by a variable voltage transformer, which is manually operated to control the speed; and the electric tachometer which registers the speed on the scale.[9]

Adjustment of the tachometer. The accuracy of the tachometer was checked with a neon lamp according to the directions given in the test procedure. Distinct rotor patterns were recognized at 1800 and 3600 r.p.m. At 1800 r.p.m. the rotor blade appeared as a stationary two bladed figure. At 3600 r.p.m. the hub of the rotor was a stationary blur. Two slight lobes were apparent on the sides of the hub.[10]

Preparation of liners. Liners were prepared for installation by fitting a sixteen and one-half inch strip of the selected abrasive inside the foam-lined collar, according to the directions given in the test procedure. The prepared collar was then inserted into the Accelerotor and the directions of the test procedure for breaking in the liner were followed.[11] The liner was replaced after each thirty minutes of testing time.

Preparation of Test Specimen

The five and one-quarter inch square for testing was cut with pinking

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[9] Stiegler et al., op. cit., 689.

[10] Appel, op. cit., p. 113.

[11] Ibid.

shears and a thin coat of Vulcanol AL-100-5S adhesive was applied to each pinked edge on one side of the specimen. After the adhesive had dried the test specimen was conditioned at 65 - 2 per cent relative humidity and 70 - 2 degrees F. for a minimum of four hours before testing.[12]

Development of Accelerated Abrasion Test

The preparation and adjustment of the Accelerotor prior to testing was based on the Tentative Test Method 93-1959T.[13]

1. Equip the Accelerotor with the selected rotor.
2. Insert the collar prepared with the abrasive liner.
3. Use the neon lamp to check the accuracy of the Tachometer and make an adjustment if necessary.
4. Use a 4 1/2" x 4 1/2" prepared specimen of 80 x 80 finish-free cotton to break in the abrasive liner. Follow these directions:
   a. The door should be closed before starting the machine.
   b. Start the Accelerotor and maintain a speed of 3000 r.p.m. for 12 minutes.
   c. Stop the Accelerotor upon completion of the test, open the door and remove the specimen. The detritus is brushed from the abrasive liner.

All the abrasion testing in this study stemmed from the interlaboratory research of the AATCC Committee on Resistance to Abrasion and the AATCC Research Laboratories. The results, as written by T. F. Cooke, Chairman of

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[12] Ibid.

[13] Ibid., pp. 112-114.

the Committee, were published in the American Dyestuff Reporter.[14]

The constant speed method of testing cotton sheeting in the interlaboratory research project was used as the first test for this study. The suggested test method for cotton sheeting was:

1. Test the specimens in the order assigned.
2. Start on signal.
3. Run at 3000 r.p.m. for two minutes.
4. Stop on signal.[15]

This test was used in preliminary investigation to guide the development of the experimental design. The design included all possible combinations of the established variables, two types of grit liner, three speeds and three periods of time.

The experimental design used in this study is presented in Table I.

After consultation with research personnel familiar with the Accelerotor, this study was planned to include grit liners and the S-shaped rotor. The two grit liners were the fine grit abrasive, numbered two hundred and fifty and the medium grit abrasive, numbered one hundred and eighty. Instead of reversing the liner after six testings, as suggested in Tentative Test Method 93-1959T,

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[14]Theodore F. Cooke, "Abrasion Testing of Textiles With the Accelerotor: Reproducibility in Interlaboratory Tests," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLVII (October 6, 1958), P679-P683.

[15]Ibid., 680.

TABLE I

EXPERIMENTAL DESIGN USED IN DEVELOPING AN ACCELERATED ABRASION TEST

Key for Symbols Denoted Variables:

Liner	Speed	Time
A^1 - 250 (fine grit)	B^1 - 3000 r.p.m.	C^1 - 2 minutes
A^2 - 180 (medium grit)	B^2 - 4000 r.p.m.	C^2 - 8 minutes
	B^3 - 5000 r.p.m.	C^3 - 10 minutes

	Liner	Speed	Time*
Section I	A^1	B^1	C^1
	A^1	B^1	C^2
	A^1	B^1	C^3
	A^2	B^1	C^1
	A^2	B^1	C^2
	A^2	B^1	C^3
Section II	A^1	B^2	C^1
	A^1	B^2	C^2
	A^1	B^2	C^3
	A^2	B^2	C^1
	A^2	B^2	C^2
	A^2	B^2	C^3
Section III	A^1	B^3	C^1
	A^1	B^3	C^2
	A^1	B^3	C^3
	A^2	B^3	C^1
	A^2	B^3	C^2
	A^2	B^3	C^3

*A replicate of three samples was used to test at each time interval.

the liner was exchanged for another of the same type after each thirty minutes of testing time. This was done to keep the abrasive quality of the liner more constant throughout the various tests.

The weight loss method was used in conjunction with the Mullen test in evaluating the effect of the abrasive action of the Accelerotor. The Mullen test was used as the basis for comparison between the actually worn sheet samples and the Accelerotor "worn" specimens in the developing of an accelerated abrasion test that would reproduce the wear at the end-use point as designated in Phase I of the Southern Regional Research Project.

Sample Selection for Testing

The samples selected for each individual test in the experimental design were drawn without replacement. The number of individual tests executed for one specific time within a section of the experimental design, six, and the number of time variations, three, determined the design for the completely randomized selection of the samples for abrasion testing. This design is given in Table II.

The six sheets of Cotton Type IV of the original interval in Phase I were keyed by ordinal numbers.

Using a table of random permutations of nine[16] the numbers representing the six sheets were randomly divided into two equal halves. The first three numbers were randomly selected to establish the random first half and the re-

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[16]William G. Cochran and Gertrude M. Cox, Experimental Designs (New York: John Wiley and Sons, Inc., 1957), p. 422.

maining three numbers automatically became the random second half.

The same design of randomly selected samples was followed in each of the three sections of the experimental design.

A replicate of three samples was used with each combination of the three variables. Samples were replaced to maintain this replicate whenever necessary and possible.

TABLE II

SAMPLE SELECTION FOR ACCELEROTOR TESTING

Sheet Number:	43	44	45	46	47	48
Key Number:	1	2	3	4	5	6

Test	Replicates	Time intervals C^1	C^2	C^3
A^1B^1	a	5	1	5
	b	6	6	3
	c	1	3	1
A^2B^1	a	2	4	2
	b	3	2	4
	c	4	5	6

<u>Fabric Used to Develop an Accelerated Abrasion Test</u>

No significant difference was found among the four types of cotton used in Phase I, according to an analysis of the results of the Mullen test on the original fabrics and the worn sheets sampled at the thirtieth and sixtieth intervals of use and laundering. For this reason, it was decided that one cotton type could be used to develop an accelerated abrasion test using the Accelerotor. Cotton Type IV was selected because the mean and percentage of strength loss was nearest or identical to the mean and percentage of strength loss of the four cottons collectively in three of the five categories of comparison.

Selection of an Accelerated Abrasion Test

Upon completion of the testing, which followed the experimental design used to develop an accelerated abrasion test, one test was selected as the accelerated abrasion test.

This specific test was selected because the mean of the Mullen test evaluation of the Cotton Type IV specimens so abraded most nearly duplicated the mean of the Mullen test evaluation of the sixtieth interval samples taken from the worn sheets of Cotton Type IV.

This test was then run on three samples cut and prepared from each of the remaining Cotton Types, I, II and III, according to the established procedure. The purpose of these further tests was to verify the results obtained with Cotton IV.

CHAPTER IV

PRESENTATION OF DATA

I. PRELIMINARY TESTING TO DETERMINE STRENGTH OF COTTON SHEETINGS

Strength Before and After Use and Laundering

The four types of cotton sheetings used in Phase I of the Regional Project were sampled and subjected to strength testing using the Mullen Tester.[1] The effects of use and laundering were determined by testing samples from sheets of each cotton type before use and after thirty and sixty intervals of use and laundering. Results of these strength tests are shown on Table III. The mean strengths represent the average of three bursts applied to each of the six sheets sampled within each cotton type.

There were slight differences in strength of the four cottons at each of the three intervals. The low elongation cottons were slightly stronger than the high elongation cottons before laundering. The losses in strength following thirty and sixty intervals of use and laundering indicated little difference in the serviceability of the four cotton sheetings and also little difference between the cottons of low and high fiber elongation.

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[1]Technical Committee Project SM-18, "The Relation of Selected Properties of Raw Cotton to Product Quality and End Product Performance" (Manual of Procedure, Southern Regional Research Project, SM-18), Phase I.

TABLE III

CHANGES IN STRENGTH OF THE FOUR TYPES OF COTTON SHEETING AFTER USE AND LAUNDERING AS INDICATED BY BURSTING STRENGTH

Cotton type	Fiber elongation	Testing intervals				
		0	30		60	
		Strength in pounds	Strength in pounds	Per cent strength loss	Strength in pounds	Per cent strength loss
Cotton I	Low	165.4	83.9	49	51.3	69
Cotton II	Low	160.2	88.0	45	50.8	68
Mean	Low	162.8	86.0	47	51.0	68
Cotton III	High	158.3	87.1	45	49.0	69
Cotton IV	High	157.8	85.3	46	48.3	69
Mean	High	158.0	86.1	46	49.8	68
Mean of four cottons		160.4	86.1	46	49.85	69

<u>Significance of Differences in Strength</u>

These data were analyzed using the Remington Rand 1105 Digital Computer and the program developed for Phase I of the Regional Project, SM-18. The analysis of variance and test of significance indicated no significant difference in bursting strength between the four cotton types before use and after thirty and sixty intervals of use and laundering. The results of the analysis of variance are given on Table IV.

There was also no significance in the differences between the cottons of low and high elongation or in the differences between the two replicate cottons within each fiber elongation classification.

Since no significant differences were found in the four cotton sheetings, it was decided that one cotton type could be used in the development of an accelerated abrasion test using the Accelerotor. Cotton Type IV was selected since the mean and percentage of strength loss of this cotton most closely approximated the general means and percentage of strength losses of the four types of cotton at each of the three service testing intervals.

II. DEVELOPMENT OF AN ACCELERATED ABRASION TEST USING THE ACCELEROTOR

The main purpose of this study was to develop an accelerated abrasion test which would produce results in the laboratory similar to the results of service testing on the same type of fabric. The instrument used was the Accelerotor, an abrasion machine developed by the American Association of Textile Chemists

TABLE IV

SIGNIFICANCE OF DIFFERENCES IN MEANS OF THE FOUR COTTON SHEETINGS AS DETERMINED BY THE ANALYSIS OF VARIANCE

Source of variation	Degrees of freedom		F values at testing intervals			F	
			0	30	60	.05	.01
Cottons	3		1.12	0.62	0.80	3.10	4.94
Low vs. high		1	2.12	0.01	2.25	4.35	8.10
Between low		1	1.23	1.54	0.64	4.35	8.10
Between high		1	0.01	0.31	0.88	4.35	8.10
Sheets treated alike	20						

and Colorists in an attempt to stabilize and standardize the field of abrasion testing.

Sampling of Fabric for Test Specimens

A minimum of nine test specimens were cut from each of the six unused sheets of Cotton Type IV at the original interval of Phase I, according to the method described in the Procedure. Several additional specimens were cut from each of the six sheets and were used when replacements were necessary.

The specimens were cut so that there would be little or no repetition of warp and filling yarns in any of the specimens cut from the one sheet. The successive gradation was achieved by placing the template one inch to the left of the right edge of the previously cut specimen.

Whenever necessary and possible test specimens were replaced in order to maintain the replicate of three specimens for each combination of the three variables.

Trial Methods, Preparation of Test Specimens for Abrasion

The final technique used in preparing specimens was determined after three attempts to prepare specimens that could be abraded in the Accelerotor for the periods of time indicated in the experimental design. Each of the trial methods was based on Tentative Test Method 93-1959T,[2] as explained in detail

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[2]William Appel (ed.), 1961 Technical Manual of the American Association of Textile Chemists and Colorists Volume XXXVII, "Abrasion (Wear) Resistance of Fabrics: Accelerotor Method" (New York: Howes Publishing Company, Inc., 1961), pp. 112-114.

in the Procedure.

Considerable difficulty was encountered during preliminary testing following an American Association of Textile Chemists and Colorists procedure established for sample preparation. The specimens prepared with the adhesive Ubabond H-511 on one side raveled during testing in the Accelerotor and caused the machine to stop. This necessitated the replacement of the specimen. After consultation with others acquainted with the operation of the instrument, the Ubabond H-511 adhesive was applied to both sides of the test specimen to control raveling.

Difficulty was also encountered in tests using samples with Ubabond H-511 adhesive on both sides. Even though the adhesive was dried after application the treated sections adhered to other sections of the specimen. The pockets and loops that formed from this adherence caused the machine to vary from its established speed and to stop. Since this technique was not conducive to valid and reliable testing a third method of preparation was attempted.

The third and final technique involved the use of a pinked edge rather than a raveled edge and the use of the adhesive Vulcanol AL-100-5S rather than Ubabond H-511.

The procedure of the final technique was as follows:

1. Cut the five and one quarter inch square from the specified cotton sheeting with pinking shears
2. Apply a thin coat of prepared Vulcanol AL-100-5S adhesive to each edge on one side of the specimen
3. Allow the adhesive to dry thoroughly

4. Condition the specimen at 65 ± 2 per cent relative humidity and 70 ± 2 degrees F. for a minimum of four hours before testing.

This technique provided for more consistency in testing. However, some difficulty was still encountered which required specimen replacement.

Abrasion Testing with the Accelerotor

The testing procedure developed was applied in varying degrees of rigorousness in an attempt to duplicate the results of bursting strength tests applied to service tested Cotton Type IV.

Abrasive characteristics varied in testing were:

A. The use of two liners
   1. A fine grit liner, number 250
   2. A medium grit liner, number 180

B. Three rotor speeds
   1. 3000 r.p.m.
   2. 4000 r.p.m.
   3. 5000 r.p.m.

C. Three time intervals
   1. Two minutes
   2. Eight minutes
   3. Ten minutes

The data in Table III, page 41, were used as the comparative standard in this study. The combination of abrasive characteristics most nearly duplicating the 46 and 69 per cent losses in bursting strength following thirty and sixty intervals of use and laundering respectively was selected as the accelerated abrasion test. The results compared were in terms of the mean of the means of the three bursts for each of the three replicates used with each accelerated abrasion test.

Table V presents the data which shows the effect of abrasion testing using the Accelerotor on the strength of the specified cotton sheeting as evaluated by the Mullen Tester.

Results of Testing Using the Fine Grit Liner

The first group of accelerated abrasion tests combined the fine grit liner, number 250; a speed of 3000 r.p.m.; and the time variations of two, eight and ten minutes. The two, eight and ten minute tests showed some loss of strength, but relatively no change when compared to the desired end point. The eight and ten minute tests showed greater strength loss from the original strength. The 43 per cent strength loss of the ten minute tests was comparable with the 46 per cent loss at the midpoint.

This group of tests showed some change in the strength of the fabrics tested but this was very small when considering the 69 per cent strength loss at the end point.

The second group of accelerated abrasion tests used the fine grit liner, number 250; a speed of 4000 r.p.m.; and the time intervals of two, eight and ten minutes. The 31 per cent of strength loss resulting from the two minute tests was relatively small when compared to the desired end point. There was a greater amount of strength loss in the eight and ten minute tests when compared to the original strength. The strength losses of these two tests were greater than at the midpoint, but did not reproduce the loss characteristic of the end point. The 66 per cent strength loss resulting from the ten minute tests was comparable with the 69 per cent strength loss.

TABLE V

RESULTS OF ABRASION TESTS USING THE ACCELEROTOR AND VARYING LINER, SPEED, AND TIME

Test	Fine grit liner (A^1)		Medium grit liner (A^2)	
	Strength in pounds*	Per cent strength loss	Strength in pounds*	Per cent strength loss
Three thousand revolutions per minute (B^1)				
2 minutes (C^1)	114.8	27	118.2	25
8 minutes (C^2)	95.8	39	86.4	45
10 minutes (C^3)	89.5	43	90.5	43
Four thousand revolutions per minute (B^2)				
2 minutes (C^1)	109.2	31	114.3	28
8 minutes (C^2)	68.4	57	61.6	61
10 minutes (C^3)	54.3	66	67.2	57
Five thousand revolutions per minute (B^3)				
2 minutes (C^1)	100.2	37	101.8	35
8 minutes (C^2)	39.4	75	48.5	69
10 minutes (C^3)	41.1	74	32.2	80

*The mean strength representing the average of three bursts applied to each of the three replicates tested at each time interval.

The tests showed appreciably more loss of strength due to testing in the Accelerotor than the first group of tests. These, however, did not reproduce the strength loss characteristic of the end point of the service tested fabric.

The third group of Accelerotor tests incorporated the fine grit liner, number 250; the speed of 5000 r.p.m.; and the time variations of two, eight and ten minutes. The two minute tests produced a 37 per cent strength loss from the original strength. The extreme losses of strength of 75 and 74 per cent from the eight and ten minute tests respectively, were greater than the 69 per cent strength loss at the desired end point.

None of these tests produced the end point strength loss desired. It is notable, however, that the eight and ten minute tests produced strength losses greater than that desired to be ascertained in this study.

Results of Testing Using the Medium Grit Liner

The fourth group of accelerated abrasion tests combined the variables of the number 180, medium grit liner; the speed of 3000 r.p.m.; and two, eight and ten minutes of abrasion. The results of the two minute tests showed a small change in strength from the original strength. The eight and ten minute tests resulted in a 45 and 46 per cent strength loss, respectively. These results were very comparable to the 46 per cent strength loss at the designated midpoint.

These tests produced a varying degree of change in strength, but the change was not comparable to the desired end point. The per cent of strength loss resulting from the eight minute tests, however, most nearly simulated the 46 per cent of strength loss at the midpoint of the service tested fabrics.

The combination of the medium grit liner, number 180; the speed of 4000 r.p.m.; and the time variations of two, eight and ten minutes made up the fifth group of tests using the Accelerotor. The two minute tests showed a 28 per cent strength loss from the original strength of 157.8 pounds. The eight and ten minute tests resulted in strength losses of 61 per cent and 57 per cent, respectively. These strength losses were greater than the 46 per cent loss at the midpoint but were not comparable to the 69 per cent strength loss at the end point. The desired end point was not realized in the results of this group of tests.

The last group of Accelerotor tests combined the medium grit liner, number 180; the speed of 5000 r.p.m.; and the time variations of two, eight and ten minutes. The 35 per cent strength loss of the two minute tests was relatively large when compared with the original strength. The eight minute tests produced a great change in the strength of the fabric tested. The strength losses of both the service test standard and the eight minute accelerated abrasion test were 69 per cent. An extreme change in strength was evident from the ten minute tests. The resulting 80 per cent strength loss was much greater than that of the 69 per cent strength loss at the established end point.

Optimum Test for Accelerated Abrasion Using the Accelerotor

The test incorporating the medium grit liner, number 180; the speed of 5000 r.p.m.; and eight minutes of abrasion was the selected accelerated abrasion test. This test most nearly reproduced the strength characteristic of the end point as determined in the service testing. The service test end point standard showed a mean strength of 48.3 pounds. This accelerated abrasion test showed a mean strength of 48.5 pounds. The strength losses of both service test standard and the accelerated abrasion test were 69 per cent.

Problems Encountered in the Use of the Accelerotor

Difficulties that arose during the running of the test in the Accelerotor warranted the replacement of the specimen. Some of the difficulties encountered in the testing were:

1. Test specimen caught on the rotor
   a) because of frayed threads
   b) because of a hole forming in the specimen
   c) because the adhesived areas adhered to each other creating a ring.

2. Liner came loose in the chamber, sometimes becoming caught on the rotor.

3. The fuse in the Accelerotor blew out causing the machine to stop.

In all cases where replacements were made the same liner was used as had been used for the other replicates of that testing combination.

Verification of the Selected Accelerated Abrasion Test

The purpose of this further testing was to verify the results of the selected accelerated abrasion test using the Accelerotor obtained with fabric from Cotton Type IV. Fabric from Cotton Types I, II, and III were used in the attempt to verify these results. Three specimens were cut and prepared from the sheets sampled at the original interval of each of the three cotton types according to the established procedure. The test incorporating the variables of the medium grit liner, number 180; the speed of 5000 r.p.m.; and the time of eight minutes was run on each specimen.

The data obtained from the Mullen Tester evaluation of the strength of specified cotton sheetings after service testing and after testing with the selected accelerated abrasion test are presented in Table VI.

Difficulties in running the tests made a replicate of three specimens with each cotton type impossible. Tests were successfully completed on two specimens for both Cotton Type I and II. Only one specimen from Cotton Type III was successfully tested.

The results compared were in terms of the mean of the means of the three bursts for each of the specimens tested.

Testing with Cotton Type I. The results of the selected accelerated abrasion test on Cotton Type I showed a 76 per cent strength loss. The strength loss was somewhat greater than the 69 per cent strength loss at the established end point.

Testing with Cotton Type II. The selected accelerated abrasion test on specimens from Cotton Type II resulted in a definite loss from the original strength. The 74 per cent strength loss was slightly greater than that at the established end point.

Testing with Cotton Type III. The Cotton Type III specimen showed a great change in strength after being tested with the selected accelerated abrasion test. The 80 per cent strength loss was much greater than the 69 per cent strength loss at the established end point.

TABLE VI

POUNDS AND PER CENT OF STRENGTH LOSS AFTER SERVICE TESTING AND ACCELEROTOR ABRASION TESTING ON COTTON SHEETING AS EVALUATED BY THE MULLEN TESTER

Cotton type	Intervals of use and laundering: 0			Abraded with liner #180 at 5000 r.p.m. for 8 minutes	
		60			
	Strength in pounds	Strength in pounds	Per cent strength loss	Strength in pounds	Per cent strength loss
Cotton I	165.4	51.3	69	37.8+	76+
Cotton II	160.2	50.8	68	41.0+	74+
Cotton III	158.3	49.0	69	32.0*	80*
Cotton IV	157.8	48.3	69	48.5	69
Mean of Means	160.4	49.9	69	36.9	77

+The mean was based on results of two specimens because of the inability to complete the test on the third replicate.

*The mean was based on only one specimen because of the inability to complete the other specimen testing.

The results of the selected accelerated abrasion test on Cotton Type I, II, and III varied with the cotton type. No one resulting mean strength or per cent of strength loss reproduced the results of the testing on Cotton Type IV. However, the 76 and 74 per cent strength losses of Cotton Type I and Cotton Type II respectively, closely simulated the results of tests applied to Cotton Type IV.

Weight Loss Evaluation of Test Specimens

The weight loss method was also used in evaluating the effect of the abrasive action of the Accelerotor on the cotton sheetings. Each test specimen was weighed on the Torsion Balance after conditioning at 65 ± 2 per cent relative humidity and 70 ± 2 degrees F. and before placement in the Accelerotor for abrasion testing. A second weighing was made on each specimen after testing in the Accelerotor and reconditioning and before being tested on the Mullen Tester.

The per cent of weight loss was calculated from the two weight readings of the three replicates for each combination of variables. The results of the weight loss evaluation are given in Table VII.

An analysis of the weight loss evaluation indicates that:

1. Within each set of combined variables, the per cent of weight loss increased as the time increased.

2. In every set of combined variables the greatest increase in per cent of weight loss occurred between the two minute tests (C^1) and the eight minute tests (C^2).

3. With each liner type the per cent of weight loss increased as the time and speed increased.

TABLE VII

WEIGHT LOSS OF COTTON SHEETING AFTER ABRASION TESTING

WITH THE ACCELEROTOR

Test	Fine grit liner (A^1)	
	Weight loss (grams)	Per cent weight loss
Three thousand revolutions per minute (B^1)		
2 minutes (C^1)	.436	4.7
8 minutes (C^2)	1.099	11.6
10 minutes (C^3)	1.276	13.2
Four thousand revolutions per minute (B^2)		
2 minutes (C^1)	.074	7.4
8 minutes (C^2)	2.357	24.8
10 minutes (C^3)	2.418	25.3
Five thousand revolutions per minute (B^3)		
2 minutes (C^1)	1.574	16.3
8 minutes (C^2)	3.296+	51.7 +
10 minutes (C^3)	5.289	56.5

+ The mean is based on two replicates because of the inability to successfully complete the third replicate test.

TABLE VII (continued)

Test	Medium grit liner (A^2) Weight loss (grams)	Per cent weight loss
Three thousand revolutions per minute (B^1)		
2 minutes (C^1)	.371	4.0
8 minutes (C^2)	1.145	12.2
10 minutes (C^3)	1.175	12.7
Four thousand revolutions per minute (B^2)		
2 minutes (C^1)	.615	6.5
8 minutes (C^2)	2.420	25.8
10 minutes (C^3)	3.032	32.3
Five thousand revolutions per minute (B^3)		
2 minutes (C^1)	1.247	13.5
8 minutes (C^2)	4.578	49.1
10 minutes (C^3)	5.490	58.1

4. The greatest per cent of weight loss resulted from the combination of variables incorporating the medium grit liner, number 180 (A^2); the highest speed, 5000 r.p.m. (B^3); and the longest time, ten minutes (C^3).

The weight loss evaluation of the abrasion tested specimens contributed interesting data to this study. No attempt was made to correlate the results with the abrasion testing because of the difficulty to standardize the amount of adhesive applied to each test specimen.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study was undertaken as a project related to the Southern Regional Research Project, SM-18.[1] The purpose of this regional project was to obtain a means of selecting cottons for specific end-uses by studying the relationship of fiber properties such as length, strength, fineness and elongation to product performance.

This study was designed to use the Accelerotor in developing an accelerated abrasion test to predict fabric serviceability. It was assumed that an accelerated abrasion test using the Accelerotor could reproduce end-use performance results; and that the Accelerotor could be used to predict differences in fabric serviceability.

Therefore, the primary objectives of this study were:

1. To use the bursting strength to determine the serviceability of cotton sheetings after thirty and sixty periods of use and laundering.

2. To develop an accelerated abrasion test using the Accelerotor and incorporating the best combination of variables such as liner, time and speed which would reproduce the results of service testing.

Such an accelerated abrasion test using the Accelerotor could be used to

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[1]Technical Committee Project SM-18, "The Relation of Selected Properties of Raw Cotton to Product Quality and End Product Performance" (Manual of Procedure, Southern Regional Research Project SM-18), Phase I.

predict fabric serviceability.

I. FABRICS USED IN THIS STUDY

The fabrics used in this study were the cotton sheetings distributed to the North Carolina station for use in Phase I of the Regional Project. These sheets were made from four bales of experimental strains of cotton selected for their similarity in length, strength and fineness. The major difference was that of fiber elongation.[2] Phase I of the project was undertaken to study the effect of fiber elongation on serviceability. The sheets used in determining the serviceability of the four types of cottons through extended use and laundering provided all samples. These were used: (1) to determine the bursting strength after wear and laundering, and (2) to develop an accelerated abrasion test using the Accelerotor. Sampling procedures for each of the above sections differed.

II. DETERMINATION OF SERVICEABILITY USING THE MULLEN TESTER

This study used the Mullen Tester to determine serviceability by indicating the bursting strength of the test fabrics. This method measures the strength necessary to rupture warp and filling yarns simultaneously making the testing process a simple one and quickly performed.

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[2]Shirley L. Henkel, "Serviceability Features of Sheets Made from Selected Cottons of Low and High Fiber Elongation" (unpublished Master's thesis, Consolidated University of North Carolina, Greensboro, 1961), p. 14.

Sampling of Fabrics Used to Determine Changes in Bursting Strength After Wear and Laundering

The samples used to determine the changes in bursting strength after wear and laundering were cut from the cotton sheetings used in Phase I of the Regional Project. The samples were taken from the desized and unused sheets and from those withdrawn following thirty and sixty intervals of use and laundering.

One sample of the size required for the Accelerotor was taken from a specified location in each of the six sheets, of the four cotton types sampled at each of the aforementioned intervals of use and laundering.

Sample Preparation

The cut samples were prepared for testing with the Mullen Tester by conditioning at a temperature of 70 ± 2 degrees F. and at 65 ± 2 per cent relative humidity for a minimum of four hours. Three bursting strength tests were made on each of the samples cut from the cotton sheeting. The placement of each area of burst was designated in order that there be little or no repetition of warp or filling yarns in the three areas to be burst.

Results of Serviceability Evaluation Using the Mullen Tester

There were slight differences in strength of the four cotton types at each of the following three intervals of use and laundering. The low elongation cottons were slightly stronger than the high elongation cottons before laundering. The losses in strength following thirty and sixty intervals of use and laundering indicated little differences between the cottons of low and high fiber elongation.

The analysis of variance and test of significance indicated no significant difference in bursting strength between the four cotton types before use and after thirty and sixty intervals of use and laundering. There was also no significance in the differences between the cottons of low and high elongation or to the difference in the two replicate cottons within each fiber elongation classification.

Strength losses of the cottons ranged from 45 to 49 per cent of the original strength after thirty intervals of use and laundering and from 68 to 69 per cent of the sixtieth interval.

III. DEVELOPMENT OF AN ACCELERATED ABRASION TEST USING THE ACCELEROTOR

The Accelerotor is an abrasion testing machine developed by the American Association of Textile Chemists and Colorists in an attempt to stabilize and standardize the field of abrasion testing. This is an area of textile testing that has had difficulty developing a standard and reliable laboratory test to produce results similar to service test results.

Sampling of Fabric for Developing an Accelerated Abrasion Test

An analysis of the results of the bursting strength test on the original fabrics and the worn sheets sampled at the thirtieth and sixtieth intervals of use and laundering indicated no significant differences in strength of the four cottons. Therefore, it was decided that sheets of one cotton type could be used in the development of an accelerated abrasion test using the Accelerotor. The sheets of Cotton Type IV were selected since both the mean and the percentage strength loss of this cotton most closely approximated the mean and percentage of strength loss of the four types of cotton sheetings at each of the three service testing intervals.

A minimum of nine test specimens were cut from each of the six unused sheets of Cotton Type IV. The specimens were taken from the desized sheets representing the original interval of Phase I. They were cut so that there would be little or no repetition of warp and filling yarns in any of the specimens cut from the one sheet. The successive gradation was achieved by placing the template one inch to the left of the right edge of the previously cut specimen. Additional specimens were cut from each of the six sheets for use as replacements when necessary.

Specimen Preparation

The final technique used in preparing specimens was determined after three attempts to prepare specimens which could be abraded in the Accelerotor for the time periods indicated in the experimental design. Each trial method was based on the Tentative Test Method established for the use of this instrument.[3]

The major difficulties encountered in determining this technique were:

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[3]William Appel (ed.), *1961 Technical Manual of the American Association of Textile Chemists and Colorists Volume XXXVII*, "Abrasion (Wear) Resistance of Fabrics: Accelerotor Method" (New York: Howes Publishing Company, Inc., 1961), pp. 112-114.

1. The raveling of the specimen during testing in the Accelerotor causing the machine to stop.

2. The adherence of the Ubabond H-511 adhesived sections to other sections of the specimen forming pockets and loops that caught and varied the speed of the machine.

The final technique involved the use of a pinked edge rather than a raveled edge and the use of the Vulcanol AL-100-5S adhesive rather than the Ubabond H-511. This technique seemed more conducive to valid and reliable testing. However, difficulties were still encountered that necessitated the replacement of some test specimens.

Abrasion Testing with the Accelerotor

The general procedure for the use of the Accelerotor was also based on the method established in the Tentative Test Method 93-1959T.[4] This method subjects fabric specimens to abrasion by use of a rotor which moves at a high velocity and forces the fabric against the abrasive liner of the testing chamber.

The experimental design used in this study included all possible combinations of the following established variables:

1. Two types of grit liners (fine and medium)

2. Three speeds (3000, 4000 and 5000 revolutions per minute)

3. Three periods of time (2, 8 and 10 minutes)

The constant speed method of testing cotton sheeting, as described by

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[1] Ibid.

Cooke,[5] was used in developing the experimental design. This method of testing cotton sheeting was also used as the first test for this study. The use of the S-shaped rotor was constant throughout the testing.

The specimens for each individual test in the experimental design were selected by means of a table of random numbers. A replicate of three specimens was used with each combination of the three variables. Specimens were replaced during testing to maintain this replicate whenever necessary and possible.

The Mullen Tester and the weight loss method were used to evaluate the effect of the abrasive action of the Accelerotor. The Mullen Tester evaluation was the basis for comparison between the used and laundered sheet samples and the Accelerotor abraded specimens. The comparison was essential to the development of an accelerated abrasion test that would reproduce the wear recorded at the end point or sixtieth interval of use and laundering. For further comparison of data the midpoint was established at the thirtieth interval of use and laundering.

The service tests bursting strength data were used as the comparative standard in this study. Only the Cotton Type IV data were compared with the accelerated abrasion tests results for only that fabric was used in these tests. The Cotton Type IV bursting strength data indicated a 69 per cent strength loss

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[5]Theodore F. Cooke, "Abrasion Testing of Textiles with the Accelerotor: Reproducibility in Interlaboratory Test," Proceedings of the American Association of Textile Chemists and Colorists, American Dyestuff Reporter, XLVII (October 6, 1958), P679-P683.

at the sixtieth interval of use and laundering. At the thirtieth interval of use and laundering a 46 per cent strength loss was noted. The results compared were in terms of the mean of the means of the three bursts for each of the three replicates used with each accelerated abrasion test.

Results of Testing Using a Fine Grit Liner

The first group of accelerated abrasion tests combined the fine grit liner; a speed of 3000 r.p.m.; and the time intervals of two, eight and ten minutes. This group showed no appreciable change in strength when compared to the 69 per cent strength loss at the designated end point.

The second and third groups of accelerated abrasion tests combined the fine grit liner; the speeds of 4000 r.p.m. and 5000 r.p.m., respectively; and the time variations of two, eight and ten minutes. Both groups of abrasion tests showed appreciable losses of strength. Of special note in the second group was the 66 per cent strength loss from the ten minute tests. In the third group it was noted that the eight and ten minute tests produced strength losses greater than desired to be ascertained in this study. None of these tests produced the desired 69 per cent loss.

Results of Testing Using a Medium Grit Liner

The fourth and fifth groups of accelerated abrasion tests incorporated the medium grit liner; the speeds of 3000 r.p.m. and 4000 r.p.m., respectively; and the time variations of two, eight and ten minutes. These tests produced varying degrees of change in the strength of the specimens tested.

Notable within the fourth group was the 45 per cent of strength loss from the eight minute tests. This result most nearly simulated the 46 per cent strength loss at the desired midpoint. Both the eight and ten minute tests in the fifth group exceeded the 69 per cent strength loss. No test in these groups produced the desired end point.

The sixth and last group of accelerated abrasion tests combined the medium grit liner; the speed of 5000 r.p.m.; and the time intervals of two, eight and ten minutes. Neither the two nor ten minute tests produced the desired strength loss. The ten minute tests produced the greatest change in strength of all the Accelerotor tests.

The eight minute tests most nearly reproduced the strength characteristic of the end point determined in the service tests. The strength loss of this eight minute accelerated abrasion test and the strength loss of the sheets from the sixtieth laundering interval were both 69 per cent.

Thus the accelerated abrasion test using the Accelerotor was a combination of the medium grit liner, number 180; the speed of 5000 r.p.m.; and the abrasion time of eight minutes.

Verification of the Selected Accelerated Abrasion Test

The selected accelerated abrasion test was applied to three samples cut and prepared from each of the remaining Cotton Types I, II and III, according to the established procedure. The purpose of these further tests was to verify the results obtained with Cotton Type IV.

Difficulties in running the tests made a replicate of three specimens with each cotton type impossible.

The results of the selected accelerated abrasion test on Cotton Types I, II and III varied with the cotton type. No one resulting mean strength or per cent of strength loss reproduced the results of the testing on Cotton Type IV. The 74 per cent strength loss of Cotton Type II most closely simulated the 69 per cent strength loss of Cotton Type IV.

Weight Loss Evaluation of Test Specimens

The specimens were weighed before and after testing in the Accelerotor as a means of determining fabric degradation.

The weight loss evaluation of the abrasion tested specimens contributed interesting supporting data to this study.

An analysis of the weight loss evaluation showed that:

1. Within each set of combined variables the per cent of weight loss increased as the time increased.

2. In every set of combined variables the greatest increase in per cent of weight loss occurs between the two minute tests (C^1) and the eight minute tests (C^2).

3. With each liner type the per cent of weight loss increases as the time and speed increase.

4. The greatest per cent of weight loss resulted from the combination of variables incorporating the medium grit liner, number 180 (A^2); the highest speed, 5000 r.p.m. (B^3); and the longest time, ten minutes (C^3).

IV. CONCLUSIONS

It may be concluded that:

1. The determination of the bursting strength of used and unused cotton sheetings showed no significant difference between the four cotton types before use and after thirty and sixty intervals of use and laundering.

2. An abrasion test using the Accelerotor was developed to produce results in the laboratory comparable to the results of service testing on the fabrics used in this study.

3. Experimentation with the Accelerotor indicated specific patterns of fabric degradation:

   a. There is a similar tendency for the per cent of strength loss and the per cent of weight loss to increase as the time and speed in the variable combinations increase.

   b. The greatest per cent of strength loss occurred at the same test interval. The test was the combination of the medium grit liner, number 180; the speed of 5000 r.p.m.; and the time of ten minutes.

   c. In two of the three groups of tests with the fine grit liner the effect of abrasion toward greater strength loss successively increased with the increase in speed.

   d. In one group of tests with the medium grit liner the strength loss increased as the speed increased. The increase in speed affected the strength loss in the other two groups but not in a successive manner.

V. RECOMMENDATIONS FOR FURTHER STUDY

The main recommendation is to use the selected accelerated abrasion test using the Accelerotor on the cotton sheetings in Phase II of the Southern Regional Research Project in order to predict fabric serviceability. The following procedure is recommended:

Specimen Preparation

1. Cut the five and one quarter inch square from the specified sheetings with pinking shears.

2. Apply a thin coat of prepared Vulcanol AL-100-5S adhesive to each edge on one side of the specimen.

3. Allow the adhesive to dry thoroughly.

4. Condition the specimen at 65 $\pm$ 2 per cent relative humidity and 70 $\pm$ 2 degrees F. for a minimum of four hours before testing.

Adjustment and Preparation of the Accelerotor

1. Equip the Accelerotor with the selected rotor (the S-shaped rotor).

2. Insert the collar prepared with the abrasive liner number 180.

3. Use the neon lamp to check the accuracy of the Tachometer and make an adjustment if necessary.

4. Use a 4 1/2" x 4 1/2" prepared specimen of 80 x 80 finish free cotton to break in the abrasive liner. Follow these directions:
   a. Close the door before starting the machine.
   b. Start the Accelerotor and maintain a speed of 3000 r.p.m. for 12 minutes.
   c. Stop the Accelerotor upon completion of the test; open the door and remove the specimen. The detritus is brushed from the abrasive liner.

The Accelerated Abrasion Test Using the Accelerotor

1. Weigh the conditioned specimen on the Torsion Balance. Record the weight in grams.

2. Crumple the test specimen and place it in the path of the rotor. Close the door.

3. Start the Accelerotor and maintain the speed of 5000 r.p.m. for eight minutes.

4. Stop the Accelerotor and take out the specimen. Shake the spe-

cimen free of detritus. Brush the detritus from the Accelerotor.

5. Recondition the specimen for a minimum of four hours.

6. Re-weigh the conditioned specimen.

7. Use the Mullen Tester to determine the bursting strength of the specimen. Record the strength in pounds.

Other Recommendations for Further Study:

1. The experimentation with the adhesive and drying methods. It is possible that thinning of Ubabond H-511 adhesive with a substance such as ethanol would facilitate drying of the adhesive and enable it to be used in sample preparation with better results.

2. The use of a different rotor.

3. Further investigation to give the accelerated abrasion test greater reliability.

4. The use of other variable combinations.

5. The more extensive use of the weight loss method of evaluation.

6. The development of an automatic time control for the machine.

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APPENDIX

APPENDIX A

FIBER DATA

(composite of top, middle and bottom of samples), second set of classers samples, bales of Stardel 624235, Magnolia 567063, Magnolia EBU-52-941817, Magnolia EBU-43-948243.

Data from Louisiana

	Micronaire Reading	U.H.M Length Inches	Pressley "O" Gauge Index	Stelometer -" /8" Gauge Grams/tex	Stelometer -" /8" Gauge % Elongation
1. Stardel 624235					
L.S.U. 2nd Samples	4.64	1.06	8.79	19.1	6.6
L.S.U. 1st Sample	4.63	1.04	8.73	20.8	6.3
SURDD 1st Sample	4.78	1.06	8.48	20.4	6.8
2. Magnolia 567063					
L.S.U. 2nd Samples	4.06	1.00	8.51	18.8	6.2
L.S.U. 1st Sample	4.14	1.00	9.09	19.5	6.1
SURDD 1st Sample	4.26	.97	8.32	19.5	6.8
3. Magnolia-EBU-52-941817					
L.S.U. 2nd Samples	3.99	1.04	7.31	17.8	10.3
L.S.U. 1st Sample	4.00	1.04	7.48	18.1	10.0
SURDD 1st Sample	4.10	1.03	7.13	19.2	10.0
4. Magnolia EBU-43-948243					
L.S.U. 2nd Samples	4.27	1.04	7.24	17.4	10.1
L.S.U. 1st Sample	4.38	1.02	7.49	19.6	10.1
SURDD 1st Sample	4.50	1.03	7.24	18.7	9.6

This thesis typed by Marie E. Teague.