DEPARTMENT OF COMMERCE

BUREAU OF STANDARDS

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TESTING OF TEXTILE MATERIALS

CONTENTS

I. INTRODUCTION

The textile industry is one of the greatest of the manufacturing activities of the United States. Large quantities of raw wool, cotton, silk, jute, and many other kinds of fiber are continually

being converted into various forms of finished product. These products are the basis of commercial transactions both in domestic and foreign markets, involving large sums of money and indirectly affecting every individual consumer. While supply and demand affect their money value, the quality and kind of the raw material and the process and care used in manufacturing determine to a considerable extent their economic value. It is therefore desirable, both for the raw materials and for the finished goods produced from them, to have methods of testing which may be easily applied and which will furnish a reliable means for reaching harmonious agreements between producer, distributor, and consumer. Experience in the use of any material will show the characteristics which affect the suitability of that material for a certain purpose and the service which it may be expected to render. Having determined these characteristics, methods should be developed to measure them which will serve as a guide to both manufacturer and purchaser to assist them in determining in what degree they have been secured in individual cases.

The accurate description of the material and quality required, supplemented by an indication of the conditions and methods of test by which they are to be determined, forms a specification by means of which it should be possible for the buyer and seller to reach an agreement. For some materials, like products of iron and steel, cement, and other structural materials, there have, in recent years, been developed through the cooperation of producers, consumers, and engineering societies standard specifications and standard methods of testing. For textile materials no such standardization has been undertaken, and the industry is dependent very largely upon the units and methods of measurement as carried out by various manufacturers and individuals.

The study of the physical and chemical properties of textile material by means of laboratory tests has been carried on in this country in a more or less desultory fashion for a great many years. The recent development of more systematic and greatly improved methods of testing has, however, given the results obtained much more significance than formerly.

The present general interest in the establishment of standardized and better methods of testing has resulted in the introduction of testing apparatus in textile institutions, public testing laboratories, stores, and mills.

In England, France, Germany, Austria, Italy, and Japan testing has been utilized with excellent results.

Large numbers of samples for investigation are being submitted to this Bureau not only by the Government departments but also by manufacturers, dealers, and other concerns and individuals. The fact that this work is rapidly increasing is good evidence of the value of the information received.

The Bureau will gladly cooperate with institutions, investigators, manufacturers, and consumers not only in the development of methods of testing and standardization, but also in furnishing information in its possession concerning methods of testing and the interpretation of results. It will be pleased to help in the design and construction of special testing apparatus. It is the object of this circular to outline the scope of work which is being undertaken by the Bureau and the range of fees for tests performed. It is the policy of the Bureau to do testing only for the Government departments, and for the public, when facilities are not provided elsewhere, in order that the Bureau's efforts may be chiefly devoted to investigational work leading to the establishment of better specifications for textiles and of better methods of testing.

II. GENERAL INFORMATION

All weighings and other physical determinations will be made upon instruments which have been carefully adjusted and calibrated, and will be performed in an atmosphere of 65 per cent relative humidity at 21° C (70° F) temperature,[1] if not otherwise specified.

If desired, tests for weight, yarn number, and tensile strength will be made at bone-dry condition, i. e., after the test specimens have been kept at a temperature of 105° C (221° F) for two hours.

Tests will be made upon all kinds of textile materials. In general, these materials may be classified as (*a*) raw and unspun fibers; (*b*) yarn, thread, twine, and rope; (*c*) fabric.

III. RAW AND UNSPUN FIBERS

Whether the sample is composed of one or more than one variety of fiber, tests will be made to determine (1) identity of fiber or fibers present; (2) percentage moisture or "regain" under any specified atmospheric condition within the Bureau's range of temperature and humidity; (3) the percentage of oil, grease, or other foreign matter present.

[1] These conditions are adopted temporarily, as they represent approximately the average of the standards of various European testing houses.

1. IDENTITY OF FIBER OR FIBERS

This is ordinarily determined by careful inspection and by the use of the microscope and staining agents, but other methods may be adopted from time to time after their accuracy and reliability has been definitely established. The Bureau has on hand a collection of commercial fibers and, if found necessary, these may be used for comparison. To determine the percentage fiber composition of a mixture, the segregation and chemical methods outlined on page 11 are followed.

2. PERCENTAGE OF MOISTURE AND REGAIN

Moisture.—All textile fibers normally contain moisture, the amount varying according to the surrounding atmosphere. Since the physical properties of the material are affected by this moisture, it is extremely necessary for uniformity in testing that some condition of humidity and temperature should be recognized as standard.

The material being tested is conditioned—that is, exposed for a certain length of time to the standard atmosphere—(p. 3) and weighed. It is then dried in an oven and reweighed. The time and temperature required for proper drying depends upon the variety of material under consideration. From the difference between weights, the percentage of moisture present is ascertained, employing the air-dry weight as a basis of calculation.

Regain.—A sample of textile material which has been made bone-dry will, if placed in the above-mentioned standard atmosphere, absorb a certain quantity of moisture. This increase is known as the "regain weight." From this is figured the "percentage regain," the bone-dry weight being used as a basis of calculation.

Under similar atmospheric conditions, wool, cotton, silk, linen, jute, hemp, etc., will absorb percentages of moisture which vary somewhat with the sample, to a considerable extent with the grade and source of the fiber, and widely with the kind of fiber.

3. DETERMINATION OF OIL OR GREASE

The method of procedure is to weigh the sample after exposure to standard atmospheric conditions, extract with ether, benzene, or other solvents, expose the fibers and the extract to the standard atmosphere, and weigh both.

The percentage of oil or grease is ascertained either from the weight of the extract or from the difference between the weights of the material before and after extraction. In some cases fibers will absorb more moisture with large quantities of oil present than with small amounts. This has been noted in some instances when experimenting with scoured wool. Therefore, perhaps, a more reliable procedure is to make all weighings on a bone-dry basis if there appears to be much oil in the sample.

IV. YARN, THREAD, AND TWINE

The important tests include the determination of (1) length; (2) tensile strength and load-stretch relation; (3) yarn number or "count"; (4) dry weight; (5) twist; (6) percentage of loading, sizing, or coloring material; (7) percentage fiber composition.

1. LENGTH

The length test is made from the skein, cop, bobbin, spool, ball, or other form by means of a yarn reel.

2. TENSILE STRENGTH AND LOAD-STRETCH RELATIONS

Determination of tensile strength and load-stretch relations may be made by tests upon single strands or, if desired, upon skeins which have been wound upon a 54-inch reel.

The instruments employed in these tests are of the dead-weight type. The pendulums are suspended upon knife-edges, and stress is uniformly applied either by motor or by water pressure. They are carefully calibrated, and any necessary correction is made after the tests have been performed.

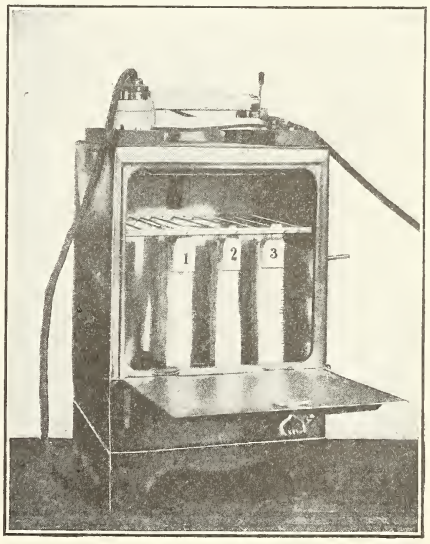

FIG. 1.—*Oven for drying test specimens*

All tests will be performed under standard atmospheric conditions and the yarn or twine being tested will be wound at least three times around a three-quarter-inch drum and securely held at either end, as shown in Fig. 2. The testing length between center of drums will be 6 inches and the pulling jaw will travel at a rate of 12 inches per minute.

Unless otherwise requested, results will be reported as the average of 10 tests for the single-strand determination, or the average of 5 tests for the skein determination.

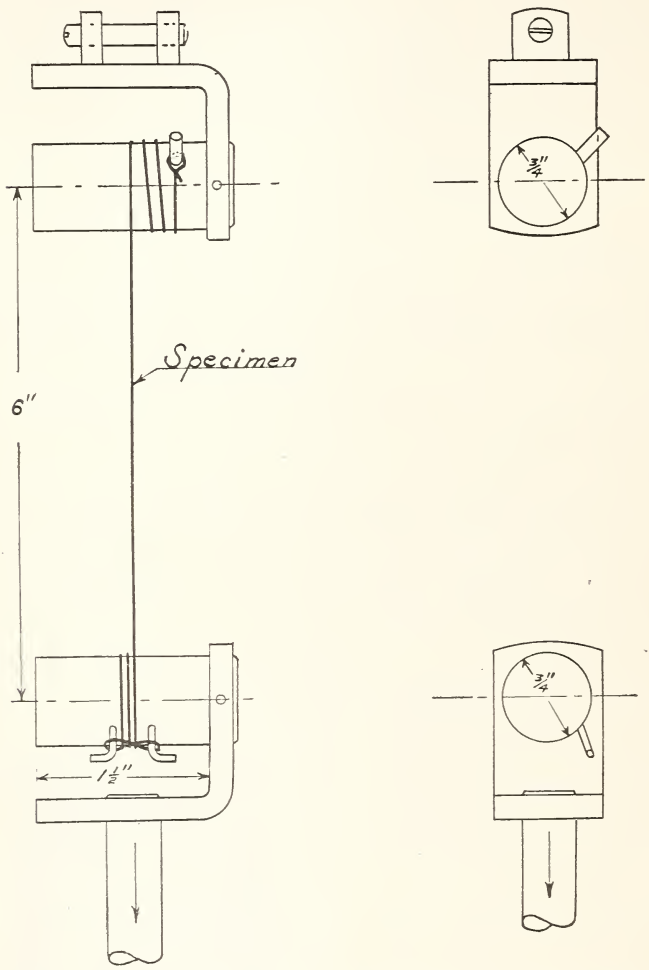

FIG. 2.—*Drums used in determining the tensile strength of twine*

3. YARN NUMBER OR "COUNT"

The yarn number—that is, the relation between weight and length as expressed by the use of arbitrary commercial standards—is a fundamental basis for textile calculation. (See p. 11.)

In testing for yarn number, four different results may be obtained by employing the following methods of weight determination:

1. Determination of the weight of the sample as received.

2. Determination of the weight of the sample after it has been exposed to a specified atmosphere.

3. Determination of the weight of the sample after all moisture has been driven out (i. e., the "bone-dry" weight).

4. Determination of the "regain" weight.

Tests made for number upon yarn as received will give results which vary in accordance with the condition of the sample submitted. If the sample is in a very dry state, the resultant yarn number will be greater, or if submitted in a very damp state the resultant yarn number will be less than if it were in accordance with normal conditions. The sample will not represent the bulk from which it was drawn unless it has been packed in an air-tight receptacle, as otherwise variation in weight will occur during transit according to the changing atmospheric conditions.

4. DRY WEIGHT

Bone-dry weighings are made in the oven shown in Fig. 3. The temperature of this oven is automatically maintained at the desired unit by a differential thermostat. A motor-driven fan circulates the atmosphere in the oven to insure uniformity of heat distribution. The sample to be weighed is placed in one of 10 small baskets carried by a chain. This chain may be turned by a wheel outside the oven, bringing each basket successively into such a position that it may be transferred to a hook suspended from one end of the balance beam by means of another hook operated from the outside of the oven. In this way 10 samples may be dried simultaneously and weighed without any opening of the oven doors after the samples have been introduced.

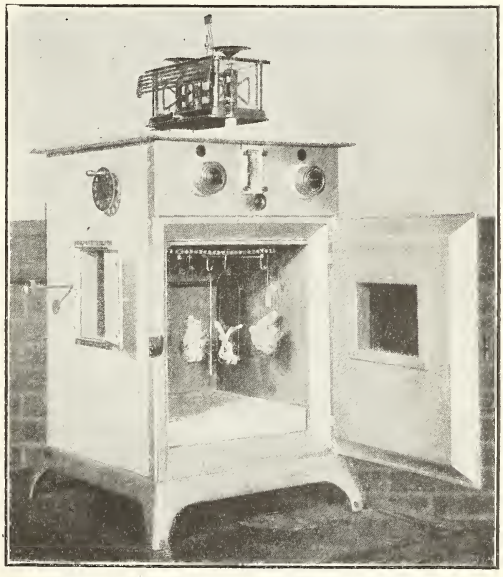

FIG. 3.—*Oven for making dry weighings*

5. TWIST

Yarn, thread, and twine necessarily contain more or less twist, the amount influencing the strength of the material and its adaptability for various uses.

In all determinations of the number of turns per inch 10 tests will be made, and the average of these will be reported, unless otherwise requested. The length of the specimen examined will be determined by the length of staple and such other considerations as the individual case may present. In the case of ply or folded material each test will be made on a 10-inch specimen, thus giving a result representing the average of 100 inches of yarn.

An instrument, specially designed for the purpose, is used in making these determinations. The specimen is held by two clamps. One of these is connected to a dial which may be turned to remove the twist from the specimen. The change in position of the dial shows the number of turns that have been given to the clamp, and therefore after all twist has been removed will show the number of turns originally present in the specimen. The other clamp is adjustable along a graduated bar, thus enabling the length of the specimen to be quickly and accurately regulated. A small spring attached to this clamp provides a uniform tension in the specimen, and an indicator carried by the spring shows the amount of elongation incident to the removal of the twist. The latter is only valuable in special cases and will not be reported unless requested.

If requested, the Bureau will report the individual results of twist tests as well as the average. The regularity of the twist will often give additional information regarding the quality of the material.

6. LOADING, SIZING, AND COLORING MATERIAL

The practice of adding to the weight of silk and to a less extent of cotton and other fibers during dyeing and finishing is very common, and it is frequently necessary to ascertain the amount of fiber present and the amount and kind of the weighting.

After weighing the sample to be tested in the standard atmosphere the necessary treatment for the elimination of the nonfibrous matter is performed. It is then weighed again under standard atmospheric conditions and the percentage of loss is computed from the difference between these two weights. In some instances, depending upon the character of the loading, all weighings are made with the sample in bone-dry instead of air-dry condition.

7. PERCENTAGE FIBER COMPOSITION

SEGREGATION METHOD.—The specimen under test is exposed to the standard atmosphere and weighed. Each yarn is then carefully untwisted; the fibers of each different kind are placed in a separate pile in the standard atmosphere and weighed after proper exposure.

CHEMICAL METHOD.—The sample is weighed in the standard atmosphere and then the proper chemical procedure is followed, according to the constituent fibers present.

V. FABRICS

The following are some of the determinations made upon fabrics: (1) Weight, (2) tensile strength and load-stretch relations, (3) percentage fiber composition, (4) thread count, (5) yarn number or size, (6) folding endurance, (7) action of light on colors.

1. WEIGHT

Unless otherwise specified, weighings will be made in the standard atmosphere, and the results will be reported as ounces per square yard. They will also be reported, if desired, according to one of the following:

1. Grams per square meter.
2. Ounces per linear yard.
3. Yards per pound.

2. TENSILE STRENGTH AND LOAD-STRETCH RELATIONS

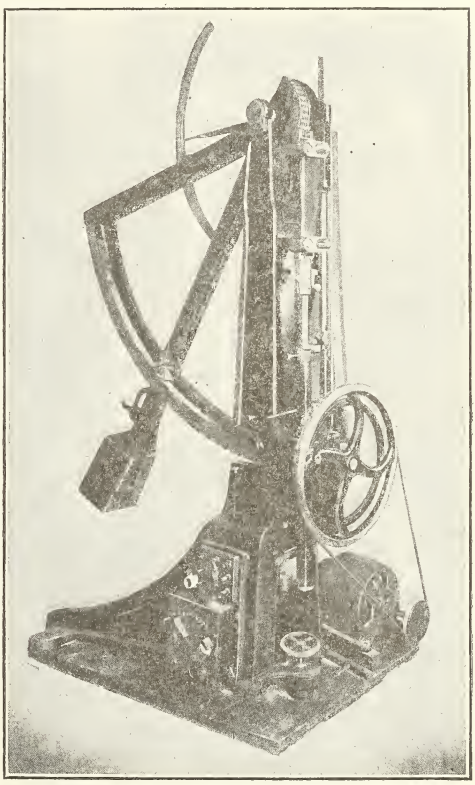

FIG. 4.—*Tensile-strength testing machine*

Test pieces are prepared by cutting samples 8 inches long and 1¼ inches wide and then pulling out threads from both sides until the standard width of 1 inch is reached.

The Bureau is prepared to make tensile strength tests by either of two common methods: (*a*) Test specimens are exposed to an

atmosphere having 65 per cent relative humidity at 21° C (70° F) temperature and are then tested in this atmosphere; (*b*) test specimens are subjected to a temperature of 105° C (221° F) for two hours, Fig. 4, and the breaking stress is determined with the moisture eliminated. In the latter case the test specimens are broken while hot and within 30 seconds after being removed from oven. If requested, any other available condition will be used.

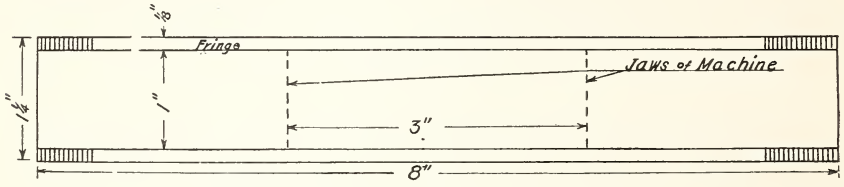

FIG. 5.—*Form of test specimen for cotton fabric*

Five test specimens each from warp and filling directions are taken from various parts of the sample. The usual length of the test specimen between the jaws or clamps of the testing machine is 3 inches for cotton fabric and 6 inches for wool, silk, linen, or jute fabric. The pulling jaw or clamp travels at a uniform rate of 12 inches per minute. The Bureau is equipped to make tests upon all fabrics breaking at less than 2200 pounds stress. The

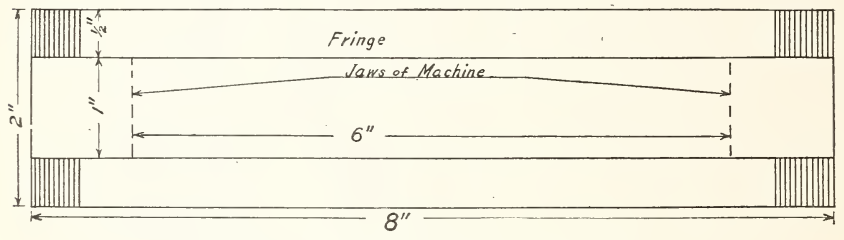

FIG. 6.—*Form of test specimen for wool fabric*

average results of tests are reported separately for warp and filling.

The sample of fabric for test should be 18 inches long, if the cloth is 25 inches or more in width; but if less than 24 inches wide, then a 36-inch length should be furnished.

3. PERCENTAGE FIBER COMPOSITION

If only one fiber is present, it is ascertained as outlined under "Identity of fiber or fibers," page 4.

When composed of more than one variety of fiber, the following is an explanation of the usual methods of procedure:

SEGREGATION METHOD.—Each warp yarn is carefully untwisted, the different varieties of fiber (cotton, wool, silk, linen, jute, etc.) found are placed in separate piles in the standard atmosphere and weighed. If any difficulty is experienced in identifying the composition of any pile, a chemical test combined with a microscopical examination is made. The same procedure is followed for the filling yarns.

CHEMICAL METHOD.—For the ordinary determination a test specimen of about 4 square inches, or one or two repeats of the pattern, is weighed in the standard atmosphere. It is then treated with the proper chemical or chemicals, neutralized, washed with distilled water, dried, weighed, etc., in accordance with the procedure considered correct. In this way one constituent is eliminated at a time and the percentages are obtained by simple calculation. A long series of tests is sometimes necessary, and this can not be outlined because each fabric must be analyzed according to its fiber composition.

4. METHOD OF COUNTING THREADS

An instrument called a "thread counter" is generally employed to ascertain the threads per centimeter or per inch. The "counter" carries a pointer which may be moved along a horizontal bar by means of a turnscrew. Directly above the pointer and moving with it is a low-power magnifying eyepiece through which each thread can be distinctly seen and readily counted. Under the pointer and resting upon the fabric under observation is a stationary piece of flat steel which is graduated to read to one-fourth inch divisions and to 0.5 cm divisions. It is therefore a comparatively simple matter to count the threads of most fabrics. If the number can not be determined by this instrument, the threads in a measured distance are pulled out by hand and counted. This test is also often made with light transmitted through the fabric. The results of analysis, unless otherwise specified, will be reported as the number of threads per inch.

5. YARN NUMBER OR SIZE OF YARN IN FABRIC

The terms "yarn number" and "size" are commonly used to indicate the length of yarn per unit weight.

There are many systems of yarn numbering in use. These are, for the most part, based upon arbitrary quantities, which differ according to the kind of material, the locality, or often the preference of the individual. Samples submitted to the Bureau

for this determination should therefore be accompanied by a statement of the particular system it is desired to use. Otherwise the report will be made in terms of the system which it is thought will be desired.

The method of determining the yarn number is the same as given for yarn, thread, and twine (p. 5).

6. FOLDING ENDURANCE

Some materials are subjected in actual use to a considerable amount of folding. In such cases folding endurance tests will show to what extent they may be expected to resist deterioration from this cause.

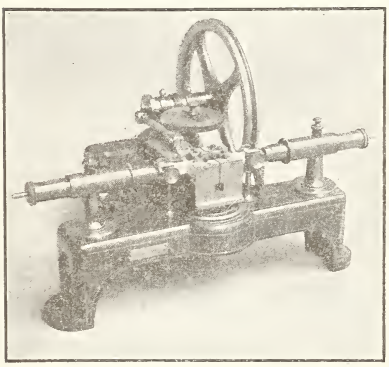

FIG. 7.—*Folding machine*

The folding test is made upon a specially constructed machine which registers the number of alternate folds the specimen endures before breaking under a given constant tension. The determination is made in the standard atmosphere upon a test strip 15 mm (19/32 inch) wide and 95 mm (3¾ inches) long. The number of double folds [2] made before rupture occurs is reported. A constant tension of 1000 g (35 ounces avoirdupois) is applied during the folding operation and the double folds are made at a rate of 200 per minute.

7. ACTION OF LIGHT ON COLORS

The permanency of the coloring material of certain fabrics when exposed to the action of sunlight is a matter of considerable importance.

Test strips of cloth are fastened to a board, one half of each strip being covered and the other half exposed to direct sunlight. After various intervals the sample is examined to observe what change has occurred in the exposed portion.

The result of tests of light action after any specified exposure will be reported as follows: (1) None; (2) slight (lighter or darker); (3) medium (lighter or darker); (4) decided (lighter or darker).

[2] By a double fold is meant that the sample is folded flat upon itself, then opened and folded at the same point upon itself in the reverse direction.

VI. GENERAL INSTRUCTIONS REGARDING APPLICATIONS FOR TESTS

1. APPLICATIONS FOR TEST

All articles submitted for test should be accompanied by a written request. This request should enumerate the material or materials, giving an identification mark, and should state explicitly the nature of the testing desired. When the test is one regularly provided for in the appended schedule, the fee may be computed in advance and should be sent with the request for the test at the time the material is shipped. When an article or material is sent simply for test without definite instructions the Bureau will, when practicable, decide upon the nature of the test without correspondence.

2. SPECIAL TESTS

The Bureau will gladly cooperate with scientific investigators, manufacturers of apparatus, and others who need higher precision than is provided in the regular tests, as far as the regular work of the Bureau will permit. Kinds of tests not at present provided for may be undertaken if the work is important and the facilities and time are available. Approved tests not provided for in the regular schedules will be considered special, and a special fee will be charged for them. The test should be arranged for by correspondence before shipment of the material. The application should state fully the need for the test, and the precision required, The special fee charged will depend chiefly upon the time consumed and the amount of alteration required in the regular testing apparatus. An estimate of the fee will be given when possible.

3. IDENTIFICATION MARKS

All packages should be plainly marked with the shipper's name and address and a list of the contents. Each separate piece or sample of material should be provided with an identification mark or number. The identification mark should also be given in the application for the test.

4. SHIPPING DIRECTIONS

Apparatus or test specimens should be securely packed in cases or packages which will not be broken in transportation and which may be used in returning them to the owner. The shipment in both directions is at the applicant's expense and risk. The tops of boxes should be put on with screws, as the jar due to nailing and the subsequent opening is liable to cause damage. The tops

of the shipping boxes should have the return or forwarding address on the underside. Transportation charges are payable by the party requesting the test. The charges for shipment to the Bureau must be prepaid, and, unless otherwise arranged, articles will be returned "charges collect."

5. ADDRESS

Material submitted for test, as well as all correspondence, should be addressed simply "Bureau of Standards, Washington, D. C."

6. REMITTANCES

Fees in accordance with the appended schedules should be sent when the material or apparatus is shipped, or promptly upon receipt of bill. Certificates are not given, nor is material returned, until the fees due thereon have been received. Remittances may be made by money order or by check drawn to the order of the "Bureau of Standards."

VII. FEES

The following schedule of fees for testing textile material will be followed in general from the date of issuance of this revised circular. The Bureau reserves the right, however, to make extra charges for any tests presenting unusual difficulties or to make changes in the schedule without notice.

1. Schedule 200.—RAW AND UNSPUN FIBERS

(*a*) Identification of fiber (if composed of one fiber only)	$2.00
(*b*) Identification of a mixture of fibers	$3.00–5.00
(*c*) Quantitative determination of a mixture	3.00–10.00
(*d*) Quantitative determination of moisture	2.00
(*e*) Determination of the percentage of oil or grease	3.00

2. Schedule 201.—YARN, THREAD, AND TWINE

(*a*) Measuring of skeins, cops, bobbins, spools, or balls (average of two tests), one sample:	
(1) Lengths up to 1000 yards	1.50
(2) Lengths over 1000 yards	2.00
(*b*) Tensile strength determination (average of 10 tests), one sample:	
(1) Breaking stresses from 0 to 1 kg (2.2 pounds)	1.00
(2) Breaking stresses from 1 kg (2.2 pounds) to 50 kg (110 pounds)	1.50
(3) Breaking stresses from 50 kg (110 pounds) to 1000 kg (2200 pounds	2.00
(*c*) Load-stretch relation (average of 3 tests), one sample:	
(1) Determined at breaking stress of specimen	2.00
(2) Determined under a specified stress	2.00
(*d*) Twist determination (average of 10 tests), one sample:	
(1) Single or one-ply strand	2.00
(2) Folded or ply yarn	1.50

(*e*) Determination of yarn number (average of five tests), one sample..... $2. 00
(*f*) Identification of fiber (if composed of one fiber only)..... 2. 00
(*g*) Identification of a mixture of fibers..... $3. 00–5. 00
(*h*) Percentage fiber composition, one sample:
(1) If composed of two fibers only..... 3. 00
(2) If composed of more than two fibers..... 4. 00–6. 00

3. Schedule 202.—FABRIC

(*a*) Weight, one sample..... 1. 00
(*b*) Tensile strength determination (average of five tests upon warp and filling, respectively), one sample..... 3. 00
(*c*) Load-stretch relation (average of two tests upon warp and filling, respectively), one sample:
(1) Determined at breaking stress of specimen..... 3. 00
(2) Determined under a specified stress..... 3. 00
(*d*) Fiber composition (percentage composition of warp, filling, and of whole fabric), one sample:
(1) If composed of two fibers only..... 3. 00
(2) If composed of more than two fibers..... 4. 00–6. 00
(3) Quantitative determination of warp or filling yarns, one sample (same as for Schedule 201*h*).
(*e*) Threads per inch (average of 10 tests both in warp and filling directions), one sample..... 1. 00
(*f*) Determination of yarn number, one sample:
(1) Yarn number of warp..... 3. 00
(2) Yarn number of filling..... 3. 00
(3) Average yarn number of whole fabric..... 3. 00
(*g*) Folding determination, one sample:
(1) Testing less than 1000 double folds..... 3. 00
(2) Testing between 1000 and 10 000 double folds..... 4. 00
(3) Testing between 10 000 and 100 000 double folds..... 5. 00
(4) Testing more than 100 000 double folds..... 6. 00
(*h*) Quantitative determination of starch, one sample..... 3. 00
(*i*) Quantitative determination of moisture, one sample..... 3. 00
(*j*) Action of light on colors, one sample..... 3. 00
(*k*) Action of weather on colors, comparison of two samples..... 3. 00
(*l*) Action of weather upon the tensile strength, one sample..... 5. 00
(*m*) Fastness to washing, one sample..... 3. 00
(*n*) Determination of thickness, one sample..... 1. 00

S. W. Stratton,
Director.

Approved:
William C. Redfield,
Secretary.

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