Designation: D1683/D1683M − 17

Standard Test Method for Failure in Sewn Seams of Woven Fabrics[1]

This standard is issued under the fixed designation D1683/D1683M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

The structural integrity of textile products made of woven fabrics is dependent on how well the pieces that are cut from rolls of fabric have been joined together. To measure this integrity requires understanding the inter-relationship between two distinct test methods.

(a) The first evaluation is done by testing fabric using Test Method D5034. This standard is used to measure the resistance of a woven fabric to rupture in the warp direction and, the filling yarn direction. The test method measures the force needed to rupture the fabric causing the destruction of the fabric and the loss of its structural integrity. This loss of structural integrity causes yarn slippage, that is, the displacement and change of yarn spacing causing an irreversible fabric failure.

(b) Before completing the second evaluation, an analysis and determination of the anticipated failure mode needs to be completed by the fabric weaver or textile product manufacturer. While the failure mode for a woven fabric textile product sewn seam can demonstrate various and distinct levels, it is imperative to have agreement and understanding about the expected performance or service life of the end use product. Is the seam engineering used to build the textile product intended to perform for a "single incident" discarded and replaced, or is the end use product designed and engineered to be subjected to regular care and maintenance to include repairs?

(c) The second evaluation is done by using this test method, D1683/D1683M, to test fabric sections that have been cut and then sewn together using procedures that select a specific combination of sewing thread, stitch type, seam type, and stitch density. These are the seam engineering variables that determine which of the following outcomes can occur: *(1)* the fabric, at a force similar to that when tested using Test Method D5034, will rupture adjacent to the stitch line causing the destruction and loss of fabric integrity, and the failure of the textile structure; *(2)* the sewing thread used in the specific stitch configuration will rupture, at a force less than 85 % of the fabric break strength, such that the fabric integrity will be sufficient to enable repair of the textile structure along the same axis.

1. Scope

1.1 This test method measures the sewn seam strength in woven fabrics by applying a force perpendicular to the sewn seams.

1.1.1 The axis perpendicular to the sewn seam can represent either the warp yarn axis or filling yarn axis, the same axis tested when using grab Test Method D5034.

1.1.1.1 This test method is applicable to sewn seams obtained from a previously sewn article or seams sewn with fabric samples using one of two specific seam assemblies as shown in Table 1.

1.2 This test method is used when the maximum breaking force measurement to rupture of a woven fabric sewn seam is required.

1.2.1 This test method is used when the seam efficiency measurement of a woven fabric sewn seam is required.

1.2.2 This test method is used to identify the sewn seam strength threshold at which the failure of the stitching occurs, without damage to the fabric, so that the textile product can be repaired.

1.2.3 This test method is used to identify the force at which seam strength results in slippage and displacement of warp yarns, filling yarns, or any combination of these yarns.

1.3 This test method does not predict actual wear performance of a seam.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

[1] This test method is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.54 on Subassemblies.

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TABLE 1 Standard/Default Seam Assembly Specification[A]

Fabric Mass: ≤ 4 oz/yd² [130 g/m²]		
	Procedure A	Procedure B
Mass	up to 4 oz/yd² [130 g ⁄m²]	up to 4 oz/yd² [130 g ⁄m²]
Seam allowance	13 mm [0.5 in.]	13 mm [0.5 in.]
Needle:		
Size	Metric 90 [0.036 in.]	Metric 90 [0.036 in.]
Finish	chrome	chrome
Point	thin ball (No. 1/No. 23)	thin ball (No. 1/No. 23)
Sewing thread size:		
Spun Polyester	Tex 40	Tex 40
Polyester-Core	Tex 40	Tex 40
Seam Type	Ssa-1	Ssa-1
Stitch Type	301	401
Stitch Density	4.7 ± ½ stitches per centimetre [12 ± ½ stitches per inch]	4.7 ± ½ stitches per centimetre [12 ± ½ stitches per inch]
Fabric Mass: ≥ 4 oz/yd² [130 g/m²] ≤ 8 oz/yd² [270 g/m²]		
	Procedure A	Procedure B
Mass	4 oz/yd² [130 g/m²] up to 8 oz/yd² 270 g/m²	4 oz/yd² [130 g/m²] up to 270 g/m² [8 oz/yd²]
Seam Allowance	13 mm [0.5 in.]	13 mm [0.5 in.]
Needle:		
Size	Metric 110 [0.044 in.]	Metric 110 [0.044 in.]
Finish	chrome	chrome
Point	ball	ball
Sewing Thread:		
Spun Polyester	Tex 60	Tex 60
Polyester-Core	Tex 60	Tex 60
Seam type	SSa-1	SSa-1
Stitch type	301	401
Stitch density	3.1 ± ½ stitches per centimetre [8 ± ½ stitches per inch]	3.1 ± ½ stitches per centimetre [8.5 ± ½ stitches per inch]
Fabric Mass: ≥ 8 oz/yd² [270 g/m²] ≤ 12 oz/yd² [405 g/m²]		
Mass	8 oz/yd² [270 g/m²] up to 12 oz/yd² [405 g/m²]	8 oz/yd² [270 g/m²] up to 12 oz/yd² [405 g/m²]
Seam allowance	13 mm [0.5 in.]	13 mm [0.5 in.]
Needle:		
Size	Metric 120	Metric 120
Finish	chrome	chrome
Point	ball	ball
Sewing thread size:		
Spun Polyester	Tex 80	Tex 80
Polyester-Core	Tex 80	Tex 80
Seam type	Ssa-1	SSa-1
Stitch type	301	401
Stitch density	3.1 ± ½ stitches per centimetre [8 ± ½ stitches per inch]	3.1 ± ½ stitches per centimetre [8.5 ± ½ stitches per inch]

[A] A complete description of seam types and stitch types can be found in Practice D6193.

NOTE 1—When the performance of a woven textile structure requires data to indicate the maximum seam strength that will result in the failure of fabric on either side of seam, the standard seam can be changed to use the Lapped seam type construction with two or more rows of stitching: Lsc-2; Lsc-3; Lsc-4; and the maximum number of stitches per inch that can be used. (See Practice D6193.)

responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D76 Specification for Tensile Testing Machines for Textiles
D123 Terminology Relating to Textiles
D1776 Practice for Conditioning and Testing Textiles
D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
D6193 Practice for Stitches and Seams
D7722 Terminology Relating to Industrial Textile Stitches and Seams
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3. Terminology

3.1 *Definitions:*

3.2 The following terms are relevant to this standard: needle damage; seam allowance; seam assembly; seam efficiency; seam engineering; seam failure; seam slippage; seam type; sewn seam; sewn seam strength; slippage; standard seam; stitch; stitch density; stitch gage; stitch type; yarn slippage.

3.3 For terminology related to seams and stitched, see Terminology D7722.

3.4 For definitions of other textile terms used in this test method, refer to Terminology D123.

4. Summary of Test Method

4.1 Sewn fabric sections are placed in a test machine so that an applied force, perpendicular to the stitching, can be exerted until one of the following phenomena occur:

4.1.1 Failure of sewing thread stitchline without damage to fabric (sewn seam strength) (seam efficiency).

4.1.2 Failure caused by a force sufficient to stress the sewn seam and displace one or more fabric yarns from their original position so as to cause fabric failure due to difference in alignment, spacing, or both.

5. Significance and Use

5.1 The manufacturing of textile products uses seam engineering to determine the best combination of sewing thread, stitch type, seam type, and stitch density to construct the end use structure. These four seam engineering variables contribute to a textile product being able to achieve the maximum sewn seam strength performance and structural integrity when cut pieces of fabric are joined together.

5.1.1 It is known that for some textile structures the seam engineering variables are selected to meet a "one time performance requirement." This means that following the "single incident" during which the maximum performance potential or capability of the textile structure has been met, it is expected to be discarded and replaced with another "new" unit. For example: an inflatable restraint in an automobile. Once deployed, it must be replaced; it cannot be re-used. Likewise, there are other textile structures, intended to be used multiple times, while also being subjected to various care and maintenance regimens.

5.1.2 This test method enables the fabric producer of woven fabrics, the textile producer, and other users of the test method to determine which seam engineering choices can be made relative to: sewing thread tex size; seam type; stitch type; and stitch density to determine the potential outcomes that can occur when a particular woven fabric is used:

(a) What is the maximum force at which sewn seam strength failure will enable products made with this fabric to be repaired?

(b) What is the highest seam efficiency percentage attained?

(c) What is the maximum force at which the sewn seam strength results in seam slippage that can cause yarn slippage, yarn displacement and fabric failure?

5.1.2.1 The maximum force at which sewn seam strength or the highest seam efficiency retained demonstrate failure of the stitching without causing the displacement of one or more fabric yarns from their original position mean that the product can be repaired. When the failure results in displacement of yarns, the textile product will need to be replaced.

5.1.3 The procedures used in this test method represent two primary seam engineering techniques identified in Practice D6193 and used to manufacture products made of woven textile fabrics.

5.1.4 In case of dispute arising from differences in reported test results when using this test method for acceptance testing of commercial shipments, the purchaser and the supplier should perform comparative tests to determine if there is a statistical bias between their laboratories. Competent statistical assistance is recommended for the investigation of bias. As a minimum, the two parties should take a group of test specimens from the same lot of fabric to be evaluated, which utilize a like seam assembly (or standard seam assembly). The test specimens should then be randomly assigned in equal numbers to each laboratory for testing. If a bias is found, either its cause must be determined and corrected, or the purchaser and supplier must agree to interpret future test results in light of the known bias.

5.2 This test method can be used to determine the sewn seam strength and sewn seam efficiency of a specified seam assembly with each fabric. Because sewn seam strength and sewn seam efficiency varies with each fabric, both of the standard seam assemblies, noted in Table 1, should be used when comparing the seam strength of different fabrics. Table 1 lists the default seam assembly specifications to be used for fabrics made with fine, medium and heavy count yarns. If a determination cannot be made as to which seam is the best suited for a particular fabric, all should be evaluated.

5.3 Seams prepared for this test method should be made by competent factory sewing operators familiar with the potential for damage to the integrity of the sewn seam when stitching is improperly done.

5.3.1 If competent factory sewing operators are not accessible, a laboratory technician familiar with the potential for damage of an improperly sewn seam may prepare the seamed test specimens. It is imperative for purchaser/supplier to understand the impact an improperly sewn seam will have on test results.

5.4 This test method is applicable whenever a determination of sewn seam strength is required. The breaking force of the seam and fabric will permit estimation of seam efficiency. This test method can be used as an aid for estimating seam strength for any given fabric.

5.5 Seam engineering techniques for specific fabric types can also be determined by utilizing this test method.

5.6 This test method can be used to determine when the sewn seam is affected by seam slippage. While the ultimate consequence of this phenomenon is rupture, seam slippage greater than either the values stated in customer specifications, or as agreed upon by purchaser/supplier may severely reduce the integrity such that the product cannot be used for its intended purpose.

6. Apparatus

6.1 *Tensile Testing Machine,* as used in Test Method D5034 conforming to Specification D76, and preferably a constant-rate-of-extension (CRE) type of machine capable of jaw separation rate of 305 ± 10 mm/min [12.0 ± 0.5 in./min] and an interfaced computer response to record the force-extension curve. When a CRE type of machine is not used, a constant-rate-of traverse (CRT) type of machine may be used. (See Note 1.)

NOTE 1—In cases of dispute a constant-rate-of-extension (CRE) type machine should be used to referee testing. Because of the biases between test results for these types of tensile testing machine, report the name, type and date of calibration of the machine used.

6.1.1 At least one clamp should be supported by a free swivel or universal joint to allow the clamp to rotate in the plane of the fabric.

6.1.2 *Back Jaw,* faces measuring 25 ± 1 mm [1 ± 0.04 in.], parallel to direction of force application by not less than 50 ± 1 mm [2 ± 0.04 in.] perpendicular to direction of force application.

6.1.2.1 Front (or top) faces measuring 25 ± 1 by 50 ± 1 mm [1.0 ± 0.04 by 2.0 ± 0.04 in.] will not necessarily give the same value as 25 ± 1 by 25 ± 1 mm [1.0 ± 0.04 by 1.0 ± 0.04 in.] faces. For many materials, the former are preferable because of the larger gripping area which tends to reduce slippage. While both sizes of gripping surface are permitted, the face sizes used must be the same for all samples in the test and must be recorded in the report.

6.1.3 *Front Jaw,* faces measuring 25 ± 1 by 25 ± 1 mm [1 ± 0.04 by 1 ± 0.04 in.].

6.2 *Sewing Machine,* with any necessary accessories capable of handling the test fabric and forming the required seam(s) and stitch types.

6.3 *Sewing Threads,* to be either of required type, materials, and tex size as determined by purchaser and supplier, or of the type, materials, and tex size specified for standard seams in Table 1.

6.4 *Dividers,* one pair.

6.5 *Metal Rule,* graduated in 1-mm [0.03125-in.] subdivisions.

7. Sampling Manufactured Items

7.1 Specimens can be taken from either previously sewn seam or from structures made with sewn seams as noted in Table 1, or using a seam assembly as agreed to between purchaser and supplier.

7.2 *Lot Sample for Manufactured Items*—As a lot sample for acceptance testing, take at random, the number of shipping units of manufactured items containing sewn seams as directed in a material specification or other agreement between the purchaser and the supplier.

7.2.1 An adequate specification or other agreement between the purchaser and supplier requires taking into account the variability between cartons of previously manufactured items or rolls of fabric from which sewn seam will be prepared; and between specimens from a carton of manufactured items or prepared constructions to produce a sampling plan with a meaningful producer's risk and consumer's risk, while at the same time providing acceptable quality and limited quality levels.

7.3 *Laboratory Sample for Manufactured Items*—Take sufficient manufactured items from each carton of a lot sample as to provide adequate laboratory samples and adequate specimens for each assembly being evaluated. If more than one type of seam assembly exists in the laboratory samples, the choice of seam assembly to be evaluated must be agreed upon by the purchaser and supplier.

7.4 *Test Specimens from Manufactured Items*—Cut five test specimens for each specified seam assembly in each of the warp and fill directions (where applicable) from the specified manufactured item(s) in the laboratory sample. Cut each specimen to a total length of 350 ± 3 mm [14 ± 0.1 in.] perpendicular to the proposed seam, with 250 ± 3 mm [10 ± 0.1 in.] on one side of the seam and 100 ± 3 mm [4 ± 0.1 in.] on the opposite site of the seam, and a width of 100 ± 3 mm [4 ± 0.1 in.] parallel to the stitch line(s) of the seam. (See Fig. 1.) If the required number of specimens cannot be cut from each laboratory sampling unit or if there is more than one seam in the laboratory sampling units, modify the sampling plan as agreed between the supplier and purchaser.

7.4.1 When the specimen length of 350 ± 3 mm [14 ± 0.1 in.] is not attainable so as to provide sufficient length of fabric perpendicular to the seam, to allow adequate seam strength testing and fabric strength testing, a modification must be agreed to between purchaser and supplier. A comparison of the fabric break strength as determined by Test Method D5034, of the two fabric swatches used in the seaming to the sewn strength of the seam assembly is required to produce a value indicative of the seam efficiency.

8. Sampling of Seams Prepared from Fabric

8.1 *Lot Sample for Fabric*—As a lot sample for acceptance testing, take at random the number of rolls of fabric directed in an applicable material specification or other agreement between the purchaser and supplier.

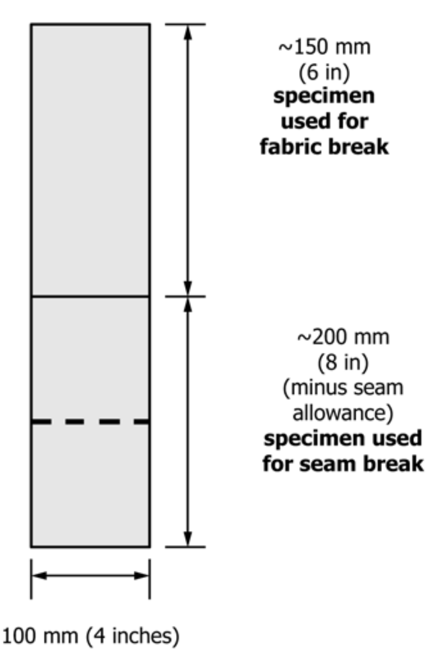


FIG. 1 Seamed Specimen Removed from Manufactured Item

8.2 *Laboratory Sample for Fabric*—After discarding 1 ± 0.1 m [1 ± 0.1 yd] from the outside roll, take a swatch 3 ± 0.1 m [3 ± 0.1 yd] in length and the full width of the fabric to construct an adequate quantity of the seam assembly, which is to be evaluated.

8.2.1 *Specimen Preparation*—As a source of test specimens, cut five specimens 350 ± 3 mm [14 ± 0.1 in.] by 100 ± 3 mm [4 ± 0.1 in.] with their long dimensions parallel either to the warp (machine) direction or to the filling (cross) direction, or cut specimens for testing from both directions if required. (See Fig. 2.) Preferably specimens for a given fabric direction should be spaced along a diagonal of the fabric to allow for representation of different warp and filling yarns, or machine and cross direction areas, in each specimen. When possible, filling specimens should contain yarn from widely separated filling areas. Unless otherwise specified, take specimens no nearer to the selvage, or edge of the fabric, than one tenth of the width of the fabric. Depending on the direction in which seam strength is to be tested, sew swatch as follows:

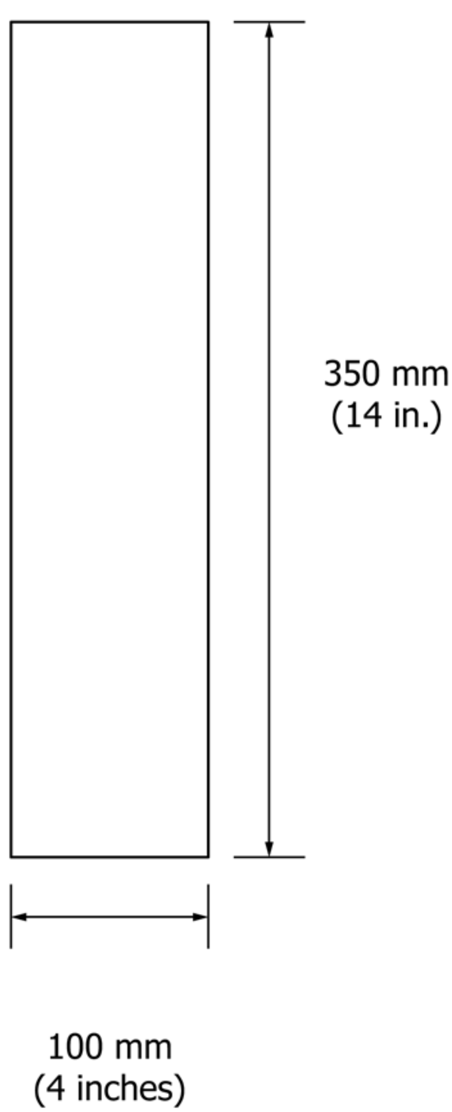


FIG. 2 Cut Specimen Dimension from Fabric

8.2.2 Fold the specimen 100 ± 3 mm [4 ± 0.1 in.] from one end with the fold parallel to the short direction of the fabric. Sew a seam as agreed upon by purchaser and supplier. (See Fig. 3.)

8.2.2.1 In the absence of an agreement on the construction of a seam assembly, prepare a standard seam using the specifications from Table 1. These seam assembly specifications are categorized by fabric weight, as shown in Table 1. These default seam assemblies are to be used when production seams are not available, or specified.

8.2.3 After seaming, cut the fold open. The test specimen should contain a seam approximately 100 ± 3 mm [4 ± 0.1 in.] from one end. Each test specimen will contain sufficient material for one seamed and one fabric test. (See Fig. 1.)

8.2.3.1 Yarns parallel to direction of force, and perpendicular to the seam, when tested, indicate seam strength test direction.

8.2.3.2 When preparing sewn seams to be evaluated for failure, it is suggested that distinct colors of sewing thread be used to easily identify warp direction ruptures and filling direction ruptures.

8.3 Modifications to seam sample preparation are detailed in Annex A1 and Annex A2. These modifications can be used when a determination is made about the acceptable failure mode for the textile structure. Will the failure mode be measured as a single incident or is the structure expected to be repaired?

8.3.1 Changes to be made in tex size of sewing thread, seam type, and stitch density are explained and calculations shown.

8.3.2 The determination of an acceptable failure mode – either a single incident or a textile structure able to be repaired, is a determination that can be made by either fabric weaver or textile structure producer.

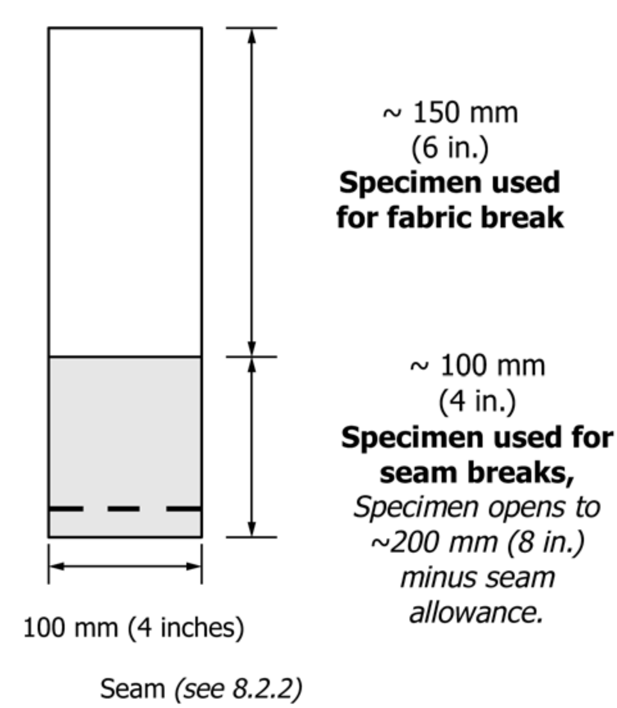


FIG. 3 Seamed Specimen Dimensions Prepared from Fabric

9. Conditioning

9.1 Condition the specimens by bringing them from the dry side to approximate moisture equilibrium for testing in the standard atmosphere for testing textiles as directed in Practice D1776. Equilibrium is considered to have been reached when the increase in mass of the specimen in successive weighings made at intervals of not less than 2 ± 0.1 h does not exceed 0.1 % of the mass of the specimen.

10. Procedure

10.1 *Seam Strength Procedure A:*

10.1.1 This procedure is used to measure when the stress created by a specific sewn seam can result in the displacement of one or more fabric yarns from their original position so as to cause differences in alignment, spacing, or both.

10.1.2 Using the reported grab break strength results when fabric is tested using Test Method D5034, calculate the 85 % seam efficiency in both the warp yarn direction and filling yarn direction.

10.1.2.1 Multiply the reported grab break strength results, starting at 85 % and continue to 70 % by increments of 5 %. These results can be used to estimate sewn seam strength and sewn seam efficiency percentages using a default seam engineering combination of sewing thread, stitch type, seam type and stitch density detailed in Table 1, Procedure A or the modifications detailed in Annex A1 and Annex A2.

10.1.3 Test five specimens in both directions, perpendicular to warp yarns and perpendicular to filling yarns, to determine if the standard seam used in this procedure will result in the displacement of one or more fabric yarns from their original position and cause a difference in alignment, spacing, or both. When this failure mode occurs, continue testing after modifying one of the following:

10.1.3.1 Change either the sewing thread tex size or stitch density and complete calculation in either Annex A1 or Annex A2 to include using either a single row or multiple rows of stitching, and test five specimens in both directions perpendicular to warp yarns and perpendicular to filling yarns to determine if failure results in the displacement of one or more fabric yarns. Report these changes.

10.1.4 Report when the failure mode is a rupture of the stitching without causing any displacement of fabric yarns or difference in alignment.

10.1.4.1 Compare the results to the estimated seam strength calculated in 10.1.2.

10.1.5 Report the seam efficiency percentage at which the sewn seam rupture occurs without causing yarn displacement of one or more fabric yarns.

10.2 *Seam Strength Test Procedure B:*

10.2.1 This procedure is used to measure when the stress created by a specific sewn seam can result in the displacement of one or more fabric yarns from their original position so as to cause differences in alignment, spacing, or both.

10.2.2 Using the reported grab break strength results when fabric is tested using Test Method D5034, calculate the 85 % seam efficiency in both the warp yarn direction and filling yarn direction.

10.2.2.1 Multiply the reported grab break strength results, starting at 85 % and continue to 70 % by increments of 5 %. These results can be used to estimate sewn strength and sewn seam efficiency percentages using default seam engineering combination of sewing thread, stitch type, seam type and stitch density detailed in Table 1, Procedure B or the modifications detailed in Annex A1 and Annex A2.

10.2.3 Test five specimens in both directions, perpendicular to warp yarns and perpendicular to filling yarns, to determine if the standard seam used in this procedure will result in the displacement of one or more fabric yarns from their original position and cause a difference in alignment, spacing, or both. When this failure mode occurs, continue testing after modifying one of the following:

10.2.3.1 Change either the sewing thread tex size or stitch density, complete the calculation in either Annex A1 or Annex A2 to include using either a single row or multiple rows of stitching, and test five specimens in both directions perpendicular to warp yarns and perpendicular to filling yarns to determine if failure results in the displacement of one or more fabric yarns. Report these changes.

10.2.4 Report when the failure mode is a rupture of the stitching without causing any displacement of fabric yarns or difference in alignment.

10.2.4.1 Compare the results to the estimated seam strength calculated in 10.2.2.

10.2.5 Report the seam efficiency percentage at which the sewn seam rupture occurs without causing yarn displacement of one or more fabric yarns.

10.3 *All Sewn Seam Samples*—Specimens are cut from samples to achieve specimen size shown in Fig. 4.

10.3.1 Determine the stitch density by counting the stitches per centimetre [stitches per inch].

10.3.2 With the fabric in the open front position (as shown in Fig. 4) place the specimen into the clamp with the seam line centrally located between the clamp faces and perpendicular to the pulling force.

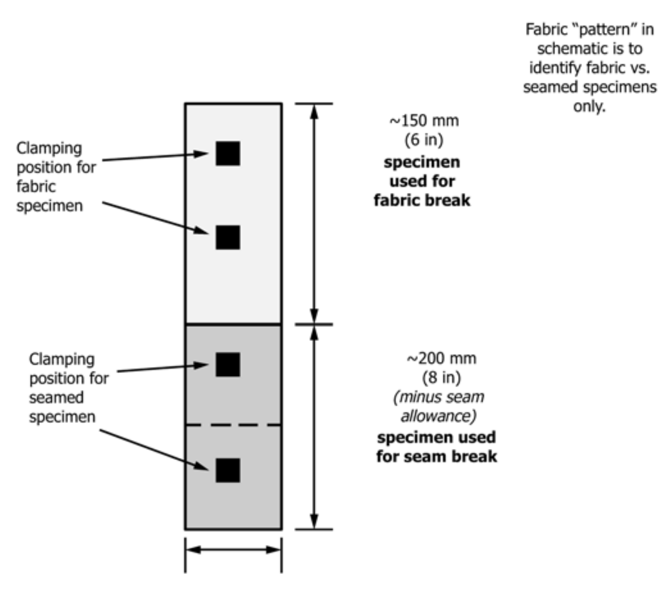


FIG. 4 Seamed Specimen Removed from Manufactured Item

10.4 *Fabrics Tested Using Modified Grab Break (see Annex A2):*

10.4.1 Fabrics tested using the modified grab break procedure demonstrate higher grab break strength.

10.4.1.1 Annex A2 provides additional data that can be used to select sewing thread having break strength needed to reach the higher seam strength needed to evaluate these fabrics. Sewn seam strength achieved with these higher grab break strength fabrics require using sewing threads made of high performance fibers to meet the traditional seam efficiency ratios of 80 – 85 %.

10.4.1.2 Purchaser and supplier should agree on either the sewn seam strength or the sewn seam efficiency needed for the textile structure subsequent to evaluation of results using this test method.

10.5 To aid in placing specimens into the testing machine, it is recommended to draw vertical alignment guides perpendicular to the stitch line 40 ± 3 mm [1.5 ± 0.1 in.] from both edges. For matched top and bottom jaws of equal width, measuring from the edge to perpendicular lines drawn on the specimen can ensure proper placement in the clamps. (See Fig. 5.)

10.6 *Machine Set-up Conditions*—Adjust the distance between the clamps at the start of the test at 75 ± 3 mm [3 ± 0.1 in.]. (See Fig. 5.) Select the force range of testing machine so that break occurs between 10 and 90 % of full-scale force.

10.7 *Sewn Seam Strength and Seam Slippage*—To calculate seam slippage, the load versus displacement curve for the sewn seam must be compared to the load versus displacement curve for the fabric. (See Fig. 6.)

10.7.1 Computerized software programs are available from various tensile testing equipment manufacturers. Although these programs are available to testing facilities, it is imperative that the laboratory operators/technicians fully understand the test parameters used in the calculations for both sewn seam strength and seam slippage.

10.7.2 During application of the force to the sewn seam specimen, observe and record whether the seam rupture is caused by *(1)* fabric yarn rupture, *(2)* sewing thread rupture, *(3)* sewn seam yarn slippage, or *(4)* a combination of two or more of the foregoing.

10.7.3 For measurement of seam elongation, prepare a force-elongation chart, having the curve set separated for each specimen and the starting point on a zero ordinate and corresponding abscissa.

10.7.4 Ensure that no clamp slippage occurs during the test. There are several options available to check for clamp slippage, an example of which follows: Distinction between clamp slippage and fabric slippage within the specimen can be

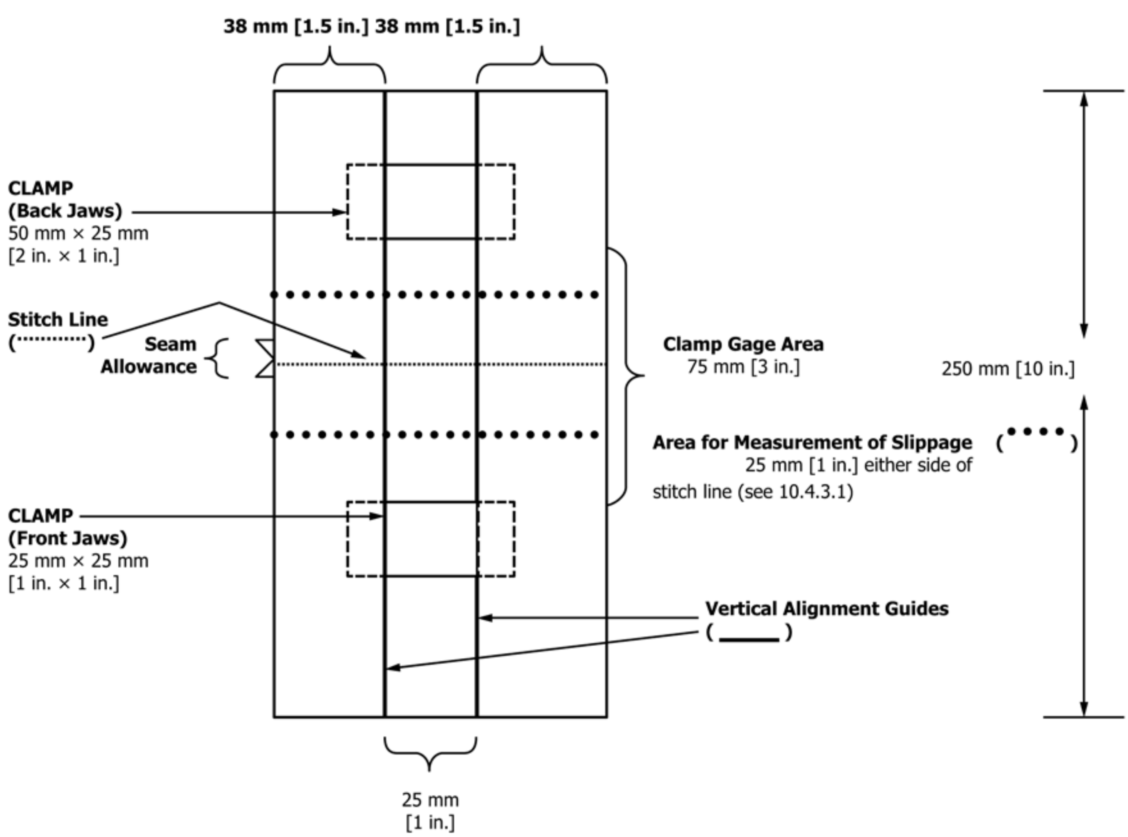
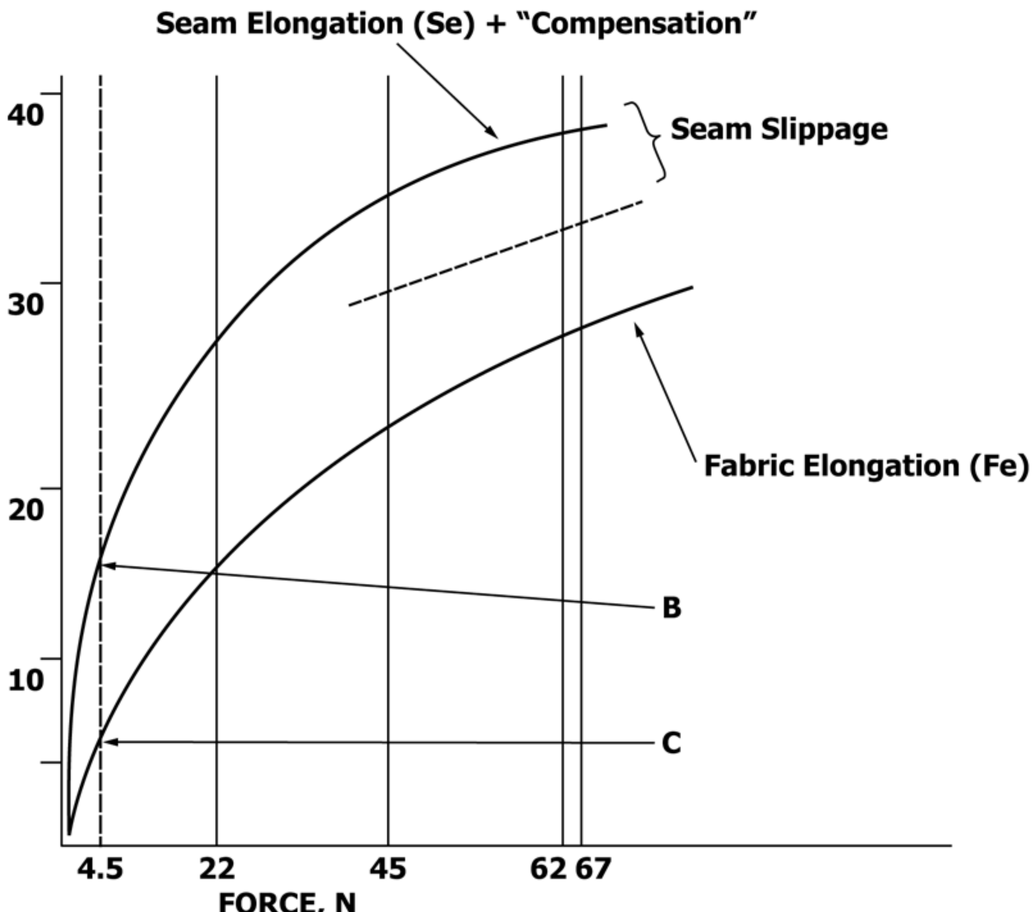


FIG. 5 Seamed Specimen Placement in Clamps



Elongation	**Force**
25 mm = 1 in. (0.984 in.)	**4.5 N = 1 lbf (1.01 lbf)**
50 mm = 2 in. (1.967 in.)	**22 N = 5 lbf (4.95 lbf)**
1 inch = 25 mm (25.4 mm)	**45 N = 10 lbf (10.12 lbf)**
2 inch = 50 mm (50.84 mm)	**62 N = 14 lbf (13.94 lbf)**
	67 N = 15 lbf (15.06 lbf)

FIG. 6 Seam Slippage Chart

determined by measuring the elongation of the intermediate space between the upper and lower limits of the clamp gauge area. (See Fig. 5.)

10.7.4.1 Measure two points 25 ± 3 mm [1.0 ± 0.1 in.] both above and below stitch line and *(1)* draw parallel lines, *(2)* attach a device which measures elongation either mechanically or electronically, and *(3)* record the change in length between these two lines.

10.7.5 Note the actual time of break for the first three specimens. If the time of break for these specimens is within 20 ± 3 s, do not determine the time of break for the remaining specimens and do not report the average time of break. If the time of break for the first three specimens is outside 20 ± 3 s, determine the time of break for each specimen and report the average time of break.

10.7.5.1 If the average of the three tests meets the time criterion set up, these observations shall be part of the number of tests. Record and report separately the test results in either warp or filling directions.

10.8 *Elongation of Base Fabric:*

10.8.1 To determine the elongation of the fabric of a previously manufactured item, use the remainder of fabric specimen, perpendicular to the seam not utilized in sewn seam strength testing (see Fig. 1, Fig. 3, or Fig. 4), and test as indicated in Test Method D5034. The pen of the recording device must be placed on the same zero ordinate and abscissa as used to test the corresponding sewn seam.

10.9 *Discarding Data*—Causes for failure which yield breaking force values that are significantly below average include, but are not limited to *(1)* specimen slippage in jaws, *(2)* breaks at the edge of (or in) the jaws, and *(3)* faulty operation of test equipment. The decision to discard the results of any failing specimen must be agreed to between purchaser and supplier. In the absence of any such agreement, these specimens and results shall be retained.

10.9.1 Any decision to discard the results of a breaking force test shall be based on observation of the specimen during the test. When a determination is significantly below the average for the set of specimens and there is physical evidence that the specimen was damaged, or that the test was carried out improperly, disregard the test determination and test another specimen. The reason for disregarding this determination must be reported.

10.9.2 When a fabric manifests any slippage in the jaws, or if the specimens break at a point within 5 ± 1 mm [0.2 ± 0.04 in.] of the edge of the jaw, then *(1)* the jaws may be padded, *(2)* the fabric may be coated under the jaw face area, or *(3)* the surface of the jaw face may be modified. If any of these modifications are used, state so in the report.

11. Calculation

11.1 *Sewn Seam Strength*—Calculate the maximum sewn seam strength of individual specimens having a like seam assembly; that is, maximum force in Newtons rupture as read directly from the testing instrument using Eq 1.

11.2 *Seam Efficiency*—Determine percent seam efficiency using Eq 1:

$$E = 100\, S_s / F_b \tag{1}$$

where:

E = seam efficiency, %,
S_s = sewn seam strength, N [lbf], and
F_b = fabric breaking force, N [lbf].

11.3 *Measurement of Seam Slippage*—To measure 6 ± 1-mm [0.25 ± 0.04-in.] seam slippage, set the dividers at one quarter the distance of chart travel for 25 ± 3 mm [1 ± 0.1 in.] of jaw travel. Recorders may exhibit distinct ratios of actual magnification. (See Fig. 6.)

NOTE 2—While a 6 mm seam opening is typically used to compute the force required to create seam failure due to slippage, for certain combinations of fabrics and seams, a value lower than 6 mm may be used. If an alternate size seam opening is utilized, it should be reported.

11.3.1 To this setting, add the compensation, the distance between the force-elongation curves of the sewn specimens at the 4.5-N [1-lbf] ordinate (point B,C, Fig. 6).

11.3.1.1 The 4.5 N [1 lbf] is the standard force at which the initial compensation (elongation difference) is recorded between the paired seam and fabric seams. While certain stitch configurations do not demonstrate elongation, others are specifically configured to allow for elongation before stress-to-rupture occurs. The 4.5 N [1 lbf] is intended to be a constant for evaluating all sewn seam strength specimens.

11.3.2 With the dividers set as in 11.3, follow the force-elongation curve for the fabric with one point of the divider until the other point of the divider meets the force-elongation curve of the sewn seam and both points rest on the same ordinate.

11.3.3 Record the force in newtons [pounds-force] to the nearest 2 ± 0.1 N [0.5 ± 0.02 lbf] at this ordinate.

11.3.4 Subtract the 4.5 ± 0.01-N [1± 0.02-lbf] compensation and record the result as resistance to seam slippage.

11.3.5 Repeat this procedure for the additional sewn seam specimens.

12. Report

12.1 State that the tests were performed in accordance with ASTM D1683. Describe the material or product being sampled and the method of sampling used.

12.2 Report all of the following items for the sewn seams tested:

12.2.1 Sewn seam strength in newtons [pounds-force] for each specimen tested using Procedure A and Procedure B or the modification in Annexes Annex A1 and Annex A2 and the average of the results.

12.2.1.1 Report at which force the failure is caused by the rupture of the stitching without causing a displacement of fabric yarns.

12.2.2 Seam efficiency using Eq 1 for each specimen,

12.2.3 Force required to effect seam slippage of 6 mm. If a different value is used to compute slippage, such as determined by specification or agreed upon by purchaser and supplier, or if the seam ruptures prior to the specified value, then that value should be reported.

12.2.3.1 Indicate type of failure: for example, rupture characterized by fabric break or thread break, or slippage, or if force to break exceeds capacity of testing machine,

12.2.4 Time to break as discussed in 10.7.5,

12.2.5 If requested, the standard deviation, coefficient of variation, or both, of any of the properties,

12.2.6 Number of specimens tested in each direction,

12.2.7 Type and size of jaw faces (clamp design) used,

12.2.8 Type of padding used in jaws, modification of specimens gripped in the jaws, or modification of jaw faces, if used,

12.2.9 If requested, the make and model of testing machine and full scale load range used for testing and date of calibration, and

12.2.10 Any modification of procedure.

13. Precision and Bias

13.1 The precision of this test method is based on an intra-laboratory study of ASTM D1683, Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics, conducted in 2014. Two operators in a single laboratory participated in this study, testing two unique fabrics on different days. Every "test result" represents an individual determination. Both operators reported five replicate test results for each test and material. Except for the use of only two operators, Practice E691 was followed for the design and analysis of the data; the details are given in an ASTM research report.[3]

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D13-1145. Contact ASTM Customer Service at service@astm.org.

13.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

13.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.1.2 Repeatability limits are listed in Tables 2-13.

13.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

13.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.2.2 Reproducibility limits cannot be accurately estimated when data are submitted by fewer than six participating laboratories.

13.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

13.1.4 Any judgment in accordance with 13.1.1 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting replicate results essentially guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. Consider the repeatability limit as a general guide, and the associated probability of 95 % as only a rough indicator of what can be expected.

13.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

TABLE 2 Warp – Fabric Strength (N)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	551.34	18.36	51.40
Viscose	297.31	8.36	23.42

[A] The average of the operators' calculated averages.

TABLE 3 Warp – Sewn Seam Strength (N)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	411.70	14.51	40.62
Viscose	182.67	8.03	22.48

[A] The average of the operators' calculated averages.

TABLE 4 Warp – Seam Efficiency (%)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	74.74	3.45	9.66
Viscose	61.48	3.32	9.29

[A] The average of the operators' calculated averages.

TABLE 5 Warp – Fabric Time-to-Break (s)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	2.0	0.0	0.0
Viscose	2.9	0.3	0.9

[A] The average of the operators' calculated averages.

TABLE 6 Warp – Seam Time-to-Break (s)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	4.0	0.5	1.4
Viscose	4.1	0.3	0.9

[A] The average of the operators' calculated averages.

TABLE 7 Warp – Seam Slippage Force (N) @ 3 mm

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	155.61	43.94	123.02
Viscose	147.14	18.93	52.99

[A] The average of the operators' calculated averages.

13.3 The precision statement was determined through statistical examination of 240 results, from two operators, on two different fabric types.

14. Keywords

14.1 seam efficiency; seam slippage; sewn seam; sewn seam strength; yarn slippage; woven fabric

TABLE 8 Filling – Fabric Strength (N)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	272.24	8.38	23.46
Viscose	287.96	12.59	35.24

[A] The average of the operators' calculated averages.

TABLE 9 Filling – Sewn Seam Strength (N)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	260.20	7.27	20.34
Viscose	171.16	12.07	33.79

[A] The average of the operators' calculated averages.

TABLE 10 Filling – Seam Efficiency (%)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	95.55	3.93	11.00
Viscose	59.46	4.19	11.72

[A] The average of the operators' calculated averages.

TABLE 11 Filling – Fabric Time-to-Break (S)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	2.0	0.0	0.0
Viscose	3.1	0.3	0.9

[A] The average of the operators' calculated averages.

TABLE 12 Filling – Seam Time-to-Break (S)

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	4.1	0.5	1.4
Viscose	4.4	0.5	1.5

[A] The average of the operators' calculated averages.

TABLE 13 Filling – Seam Slippage Force (N) @ 3 mm

	Average[A] $\bar{x}$	Repeatability Standard Deviation	Repeatability Limit
Cotton	163.53	14.42	40.38
Viscose	152.70	16.86	47.20

[A] The average of the operators' calculated averages.

ANNEXES

A1. CALCULATION OF SEWN SEAM STRENGTH ESTIMATES

(Mandatory Information)

A1.1 The following information details how sewn seam strength estimates are calculated when stitched using either a 301 Lockstitch or a 401 Chainstitch.

A1.2 Estimated sewn seam strength for a 301 Lockstitch or a 401 Chainstitch is determined by using the following data:

(a) Determine break strength average of the tex size selected for the needle (top) thread and the tex size selected for the bottom thread. When using a 301 Lockstitch, tex size for top thread and bottom thread must be the same.

(b) Multiply average break strength *(a)* by stitch density used to construct the textile product.

(c) Multiply this result *(b)* by the Stitch Factor Multiplier – For the 301 Lockstitch the stitch factor multiplier is 1.5; for the 401 Chainstitch, the stitch factor multiplier is 1.6.

(d) Rows of stitches used for a specific seam configuration shown in Practice D6193.

(e) Result is the estimated seam strength achieved using this specific tex size of sewing thread and this specific stitch density.

A1.3 Examples are given in Tables A1.1-A1.3.

TABLE A1.1 Stitch Type: 301 Lockstitch

Nominal Break Strength Average of Sewing Thread (Same Tex Size Needle/Bobbin)	x	Stitch Density	x	301 Lockstitch Multiplier (1.5)	x Rows of Stitches	=	Estimated Sewn Seam Strength
Example 1: 13 N [3 lbf]	x	8 spi	x	1.5	x 2	=	320 N [72 lbf]
Example 2: 22 N [5 lbf]	x	8 spi	x	1.5	x 1	=	265 N [60 lbf]
(a)		*(b)*		*(c)*	*(d)*		*(e)*

TABLE A1.2 Stitch Type: 401 Chainstitch (Same Tex Size Needle/Looper Thread)

Nominal Break Strength Average of Sewing Thread (Same Tex Size Needle/Looper)	x	Stitch Density	x	401 Chainstitch Multiplier (1.6)	x Rows of Stitches	=	Estimated Sewn Seam Strength
Example 1: 22 N [5 lbf]	x	10 spi	x	1.6	x 2	=	712 N [160 lbf]
Example 2: 31 N [7 lbf]	x	10 spi	x	1.6	x 1	=	498 N [112 lbf]
(a)		*(b)*		*(c)*	*(d)*		*(e)*

TABLE A1.3 Stitch Type: 401 Chainstitch (Lower Tex Size Looper Thread)

Nominal Break Strength Average of Sewing Thread (Lower Tex Size Looper)	x	Stitch Density	x	401 Chainstitch Multiplier (1.6)	x Rows of Stitches	=	Estimated Sewn Seam Strength
Example 1: 22 N + 13 N=18 N [5 lbf + 3 lbf = 4 lbf] Avg	x	10 spi	x	1.6	x 2	=	569 N [128 lbf]
Example 2: 31 N + 22 N=27N [7 lbf + 5 lbf = 6 lbf] Avg	x	10 spi	x	1.6	x 1	=	427 N [96 lbf]
(a)		*(b)*		*(c)*	*(d)*		*(e)*

A2. CALCULATION FOR MAKING DETERMINATON OF SEWING THREAD BREAK STRENGTH FOR TEXTILE STRUCTURES

A2.1 When making a determination about the sewing thread break strength that can be used to make a textile structure, the following calculation can be completed after learning the grab break strength data using Test Method D5034.

(a) Grab break strength data.

(b) Multiply grab break data by .85 and continue to .65 in increments of 5 % to determine different estimated seam efficiency thresholds.

(c) Using these estimated seam efficiency thresholds, determine the stitch type and stitch multiplier to be used for calculations.

(d) Divide by appropriate stitch multiplier for 301 Lockstitch (1.5) for 401 Chainstitch (1.6).

(e) Divide quotient by the stitch density per inch to be used.

(f) Divide the stitch density quotient by the number of rows to be used in construction.

(g) Result will indicate the nominal break strength of sewing thread to be used.

A2.2 *Example 1:* See Table A2.1 and Table A2.2.

A2.2.1 *(a)* Grab Break Strength = 734 N [165 lbf],

A2.2.2 *(b)* Seam Efficiency = 85 %,

A2.2.3 *(c)* Estimated Sewn Seam Strength = 624 N [140 lbf].

TABLE A2.1 Using a 301 Lockstitch

Estimated Sewn Seam Strength	÷	301 Lockstitch Multiplier (1.5)	÷	Stitch Density	÷ Rows of Stitch	=	Nominal Break Strength of Sewing Thread
624 N [140 lbf]	÷	1.5	÷	9 spi	÷2	=	22 N [5 lbf]
624 N [140 lbf]	÷	1.5	÷	10 spi	÷2	=	22 N [5 lbf]
(c)		*(d)*		*(e)*	*(f)*		*(g)*

TABLE A2.2 Using a 401 Chainstitch

Estimated Sewn Seam Strength	÷	401 Chainstitch Multiplier (1.6)	÷	Stitch Density	÷ Rows of Stitch	=	Nominal Break Strength of Sewing Thread
624 N [140 lbf]	÷	1.6	÷	8 spi	÷2	=	27 N [6 lbf]
624 N [140 lbf]	÷	1.6	÷	11 spi	÷2	=	18 N [4 lbf]
(c)		*(d)*		*(e)*	*(f)*		*(g)*

A2.3 When high strength fabrics are tested using the Modified Grab Break Method Procedure of Test Method D5034, the nominal break strength of the sewing thread which can be used to achieve the highest seam strength and sewn seam efficiency threshold can be determined by using the following data:

(a) Modified Grab Break Strength (MGBS).

(b) Multiply the MGBS starting at 85 % and continue to 65 %, by increments of 5 %, to determine the estimated sewn seam strength.

(c) Using these estimated seam efficiency thresholds, determine the stitch type and stitch multiplier to be used for calculations.

(d) Divide by appropriate stitch multiplier for 301 Lockstitch (1.5) for 401 Chainstitch (1.6).

(e) Divide quotient by the stitch density per inch to be used.

(f) Divide the stitch density quotient by the number of rows to be used in construction.

(g) Result will indicate the nominal break strength of sewing thread to be used.

A2.4 *Example 1:* See Table A2.3 and Table A2.4.

A2.4.1 *(a)* Modified Grab Break Strength = 1067 N [240 lbf],

A2.4.2 *(b)* Seam Efficiency = 80 %,

TABLE A2.3 Using a 301 Lockstitch

Estimated Sewn Seam Strength	÷	301 Lockstitch Multiplier (1.5)	÷	Stitch Density	÷ Rows of Stitch	=	Nominal Break Strength of Sewing Thread
854 N [192 lbf]	÷	1.5	÷	11 spi	÷2	=	27 N [6 lbf]
854 N [192 lbf]	÷	1.5	÷	8 spi	÷2	=	35 N [8 lbf]
(c)		*(d)*		*(e)*	*(f)*		*(g)*

TABLE A2.4 Using a 401 Chainstitch

Estimated Sewn Seam Strength	÷	401 Chainstitch Multiplier (1.6)	÷	Stitch Density	÷ Rows of Stitch	=	Nominal Break Strength of Sewing Thread
854 N [192 lbf]	÷	1.6	÷	10 spi	÷2	=	27 N [6 lbf]
854 N [192 lbf]	÷	1.6	÷	8 spi	÷2	=	35 N [8 lbf]
(c)		*(d)*		*(e)*	*(f)*		*(g)*

A2.4.3 *(c)* Estimated Sewn Seam Strength = 854 N [192 lbf].

A2.5 *Example 2:* See Table A2.5 and Table A2.6.

A2.5.1 *(a)* Modified Grab Break Strength = 1712 N [385 lbf],

TABLE A2.5 Using a 301 Lockstitch

Estimated Sewn Seam Strength	÷	301 Lockstitch Multiplier (1.5)	÷	Stitch Density	÷ Rows of Stitch	=	Nominal Break Strength of Sewing Thread
1112 N [250 lbf]	÷	1.5	÷	10 spi	÷2	=	35 N [8 lbf]
1112 N [250 lbf]	÷	1.5	÷	8 spi	÷2	=	45 N [10 lbf]
(c)		*(d)*		*(e)*	*(f)*		*(g)*

TABLE A2.6 Using a 401 Chainstitch

Estimated Sewn Seam Strength	÷	401 Chainstitch Multiplier (1.6)	÷	Stitch Density	÷ Rows of Stitch	=	Nominal Break Strength of Sewing Thread
1112 N [250 lbf]	÷	1.6	÷	10 spi	÷2	=	35 N [8 lbf]
1112 N [250 lbf]	÷	1.6	÷	8 spi	÷2	=	45 N [10 lbf]
(c)		*(d)*		*(e)*	*(f)*		*(g)*

A2.5.2 *(b)* Seam Efficiency = 65 %,

A2.5.3 *(c)* Estimated Sewn Seam Strength = 1112 N [250 lbf].

A3. SEWN SEAM INFORMATION

A3.1 Fabric #1—100 % Cotton 3/1 twill; 225 g/m^2 provided by James Heal Ltd.

A3.1.1 Seam type SSa-1, stitch type 301/12 spi, listed in Table 1, "Standard/Default Seam Assembly Specification" Section Fabric Mass up to 4 oz/yd^2 (130 g/m^2) using 80 tex thread. These samples were sewn with needle 90 and not needle 110 as identified in the table.

A3.2 Fabric #2—100 % Viscose plain weave, 125 g/m^2 provided by James Heal Ltd.

A3.2.1 Seam type SSa-1, stitch type 301 listed in Table 1, "Standard/Default Seam Assembly Specification" Section Fabric Mass >4 oz/yd^2 (130 g/m^2) ≤8 oz/yd^2 (270 g/m^2) Procedure "B" using 60 tex thread and needle 110. These samples were sewn using 8 spi and not 12 spi as identified in the table.

A4. SPECIMEN PREPARATION

A4.1 As a source of test specimens, cut five specimens 350 ± 3 mm [14 ± 0.1 in.] by 100 ± 3 mm [4 ± 0.1 in.] with their long dimensions parallel either to the warp (machine) direction or to the filling (cross) direction, or cut specimens for testing from both directions if required. (See Fig. 2.) Preferably specimens for a given fabric direction should be spaced along a diagonal of the fabric to allow for representation of different warp and filling yarns, or machine and cross direction areas, in each specimen. When possible, filling specimens should contain yarn from widely separated filling areas. Unless otherwise specified, take specimens no nearer to the selvage, or edge of the fabric, than one tenth of the width of the fabric. Depending on the direction in which seam strength is to be tested, sew swatch as follows:

A4.2 Fold the specimen 100 ± 3 mm [4 ± 0.1 in.] from one end with the fold parallel to the short direction of the fabric. Sew a seam as agreed upon by purchaser and supplier. (See Fig. 3.)

A4.2.1 In the absence of an agreement on the construction of a seam assembly, prepare a standard seam using the specifications from Table 1. These seam assembly specifications are categorized by fabric weight, as shown in Table 1. These default seam assemblies are to be used when production seams are not available, or specified.

A4.3 After seaming, cut the fold open. The test specimen should contain a seam approximately 100 ± 3 mm [4 ± 0.1 in.] from one end. Each test specimen will contain sufficient material for one seamed and one fabric test. (See Fig. 1.)

A4.3.1 Yarns parallel to direction of force, and perpendicular to the seam, when tested, indicate seam strength test direction.

A4.3.2 When preparing sewn seams to be evaluated for failure, it is suggested that distinct colors of sewing thread be used to easily identify warp direction ruptures and filling direction ruptures.