TEST METHOD FOR EXTENSION FORCE TESTING

OF PARTIALLY ORIENTED FILAMENT YARN

1. SCOPE

1.1 This method covers the measurement of extension force of partially oriented filament yarn.

1.2 The method provides a rapid, precise estimate of the yarn orientation, by means of continuous drawing of the yarn while running between pairs of drafting rolls of different surface speeds.

1.3 The method applies to partially oriented filament yarns with deniers less than 300, but can be used for higher deniers if test condition changes are considered. (See APPENDIX I)

2. APPLICABLE DOCUMENTS

2.1 ASTM Standards

D123 Definitions of Terms Relative to Textiles

D1776 Recommended Practice for Sampling Yarn for Testing.

D2258 Recommended Practice for Sampling Yarn for testing.

3. TERMINOLOGY

3.1 Extension, n. - An increase in length of a specimen.

3.2 Extension Force, n. - The force required to draw a yarn to a given extension under given conditions.

3.3 Partially oriented yarn, n. - Filament yarns in which the draw ratio is less than normal resulting in only partial longitudinal orientation of the polymer molecules.

4. SUMMARY OF METHOD

4.1 Partially oriented filament yarn withdrawn from a package is pretensioned, heated, and drawn on an instrument under conditions similar to those used in the draw-texturing process. A tension measuring head senses the force required to draw the running yarn to a specified amount of its original length under given conditions.

5. SIGNIFICANCE AND USE

5.1 The extension force of synthetic filament yarns is related to the alignment of the molecules in the yarn, which influences the yarn processing behavior. Knowledge of this property of partially oriented yarn is useful to determine processing conditions.

6. APPARATUS

6.1 The following description of an extension force measuring instrument's operation is intended for general information and refers to Figure 1. The test is performed on the running threadline, with the yarn strung along a series of tensioning devices, guides and draw rolls between the supply package and the take-up mechanism. The filament strand should first run through the thread tensioner and then around the supply godet, which should be paired with a laying roll to position individual wraps. The yarn then runs over the compensating roll, to which the pretensioning weight is applied. The next stage in the yarn path is designed to draw the yarn at a constant draw ratio. This can be accomplished in several ways such as stepped godet rolls or variable speed rolls with the same diameter. During the draw step the yarn runs through a non-contact heater tube, around the load cell roller, and back alongside the heater. The tension measuring head is attached to the load cell roller and sends the force measurement to the chart recorder or some other data collecting device such as a microprocessor. After leaving the draw stage the yarn runs to either a windup or waste aspirator.

6.2 The godet rolls/draw rolls and measuring heads required for specific tests will have to be determined.

7. SAMPLING

7.1 Extension force testing should be performed on specimens of yarn in package form. Surface yarn should be removed from the outside of each package immediately before the test is run to remove damaged or distorted yarn.

7.2 The recommended minimum length of yarn necessary for a precise test of polyester and nylon is 50 meters. For polypropylene the recommended minimum length is 100 meters. Consecutive lengths of yarn on a given package may be tested to increase the accuracy of the results.

8. CONDITIONING

8.1 Bring specimens in package form to moisture equilibrium for testing in the standard atmosphere for testing textiles (70 +- 2 F degrees and 65 +- 2 percent relative humidity), in accordance with ASTM Practice D1776. When a specimen has been exposed to conditions other than the standard atmosphere for testing textiles, the minimum conditioning time is 24 hours. The recommended time for conditioning, particularly where the specimen has been exposed to outdoor conditions, is 48 hours.

9. PROCEDURE

9.1 Optimum test conditions must be mutally established for direct comparison between users.

9.2 For conditions other than those listed in 9.4, see APPENDIX I for test conditions optimization.

9.3 The conditions described below are for a 76.2cm non-contact heater tube for testing deniers less than 300.

9.4.1 Suggested test conditions:

Polymer Type	Pretension gm/Den.	Speed m\min.	Heat C°	Draw Ratio
Polyester	.10	50	150	1.60
Nylon	.10	50	150	1.40
Polypropylene	.15	100	140	1.60

9.4.2 Calibrate the instrument for Extension Force Testing as specified by manufacturer. Certified control packages should be tested and evaluated using statistical procedures to insure calibration.

9.4.3 Conduct all testing under standard lab conditions of temperature and humidity for textile labs. These conditions are 65 ± 2% relative humidity and 70 ± 2 degrees F temperature.

9.5 Set heater temperature and allow one hour for the temperature to stabilize.

9.6 Set yarn test speed.

9.7 Set yarn pretension.

9.8 Test each yarn sample for a minimum of 1 minute.

10. CALCULATION

10.1 The extension force of a given sample can be estimated by determining the average center line at specified intervals along a chart recording or more accurately and precisely by electronic integration of the detector signal to give an average value and a Coefficient of variation for the length of yarn tested.

11. REPORT

11.1 State that the test has or has not been performed as directed in ASTM Method D _____ and report the following information:

11.2 Lot number, individual package identification, denier, and number of filaments of feed yarn.

11.3 Sampling protocol (number of packages tested, number of tests per package).

11.4 Conditions of the test (temperature and relative humidity if different from the standard atmosphere, test time, test day, analyst identification

11.5 Average extension force and coefficient of variation for each individual test.

11.6 Average of average extension force values for all tests of a single sample.

11.7 Average of average extension force values for all packages tested.

12. PRECISION AND ACCURACY

12.1 The lack of an absolute standard for this test makes it impossible to give an exact value for the precision and accuracy of this method. The problem of determining the quality of the test is further compounded by the fact that it is not possible to test the same length of yarn twice. It has been found that test precision (the standard deviation for repeated tests under identical conditions for consecutive lengths of yarn from the same package using electronic signal integration) is approximately 1.0% coefficient of variation for the length of yarn tested.

APPENDIX I

OPTIMIZATION OF EXTENSION FORCE TEST CONDITIONS FOR PARTIALLY ORIENTED YARN

Selection of test conditions, i.e. yarn speed, heater temperature and draw ratio, that will assure data reproducibility for extension force testing, is as follows:

1. Select a draw ratio (DR) based on the ratio of raw yarn denier to textured yarn denier.

$$DR = \frac{\text{Raw Yarn Denier}}{\text{Textured Yarn Denier}}$$

   Note 1 - If data is used from this test procedure for yarn comparisons, the same draw ratio must be used on all yarns tested.

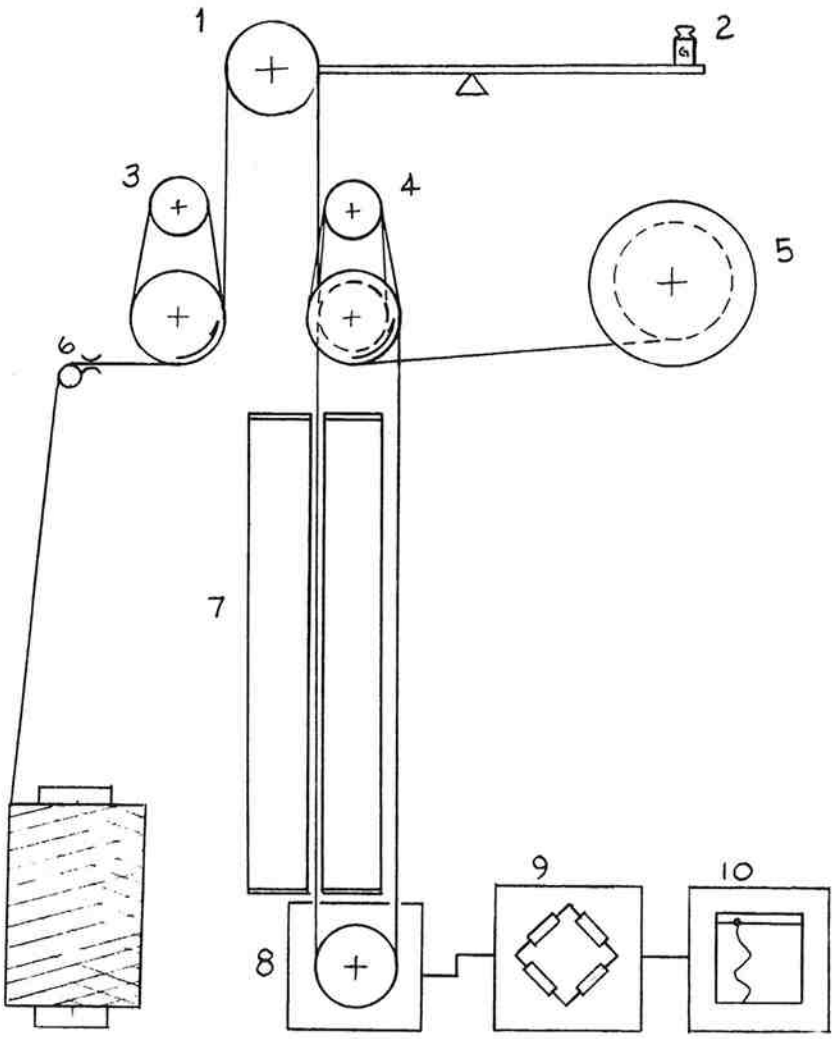
2. Select a speed and temperature setting that assures an effective yarn temperature that exceeds the glass transition temperature (Tg°) of the yarn being tested. This condition provides the most stable results for extension force testing for partially oriented yarn.

3. To select a speed and temperature combination, develop a series of extension force vs. speed plots at increasing heater temperature settings. Select test heater temperatures and speed combinations that assure maximum test precision as shown in Figure 2, which is the flat portion of the curve.

   Note 2 - These curves were developed from data representing polyester POY in the denier range of 200 to 300. Curves for Nylon and Polypropylene are not shown, but can be established in a similar manner.

4. The fiber producer should be a good source for test conditions which provide the most stable test results for extension force testing.

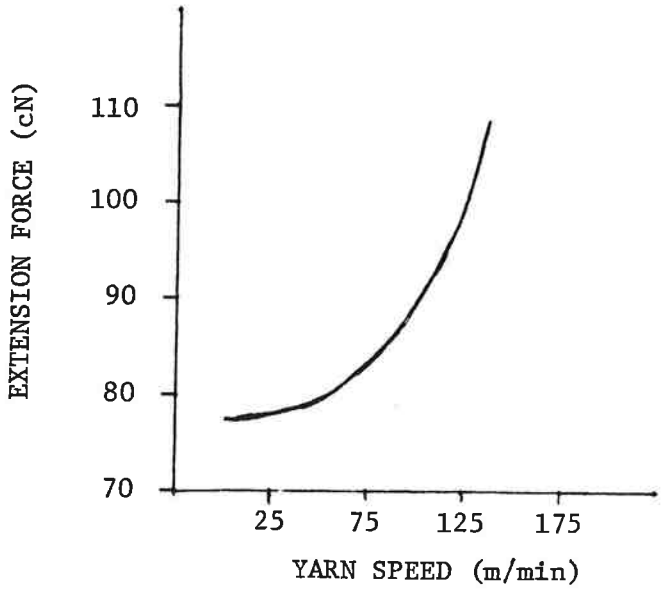
FIGURE I



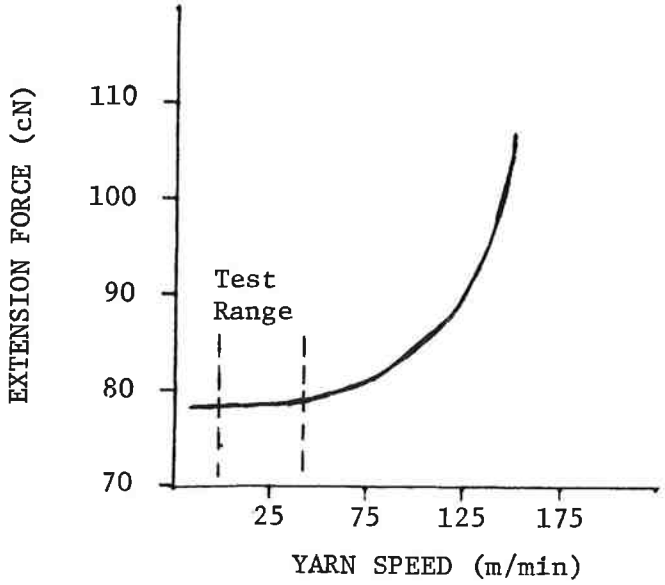
1. Compensating Roll
2. Pretension Weight
3. Supply Godet with Laying Roll
4. Stepped Godet (Draw Roll)
5. Thread Take-up (Aspirator)
6. Thread Tensioner
7. Non-Contact Heater Tube
8. Load Cell with Measuring Roll
9. Measuring Bridge
10. Chart Recorder (Microprocessor)

FIGURE 2: TEMPERATURE AND SPEED EFFECTS ON EXTENSION FORCE

HEATER TEMP. AT 125°C



HEATER TEMP. at 150°C



HEATER TEMP. AT 175°C