

Why Test?

- Research and Development
- Selection of Raw Materials
- Process Development
- Product Testing
 - Compliance testing
 - End use performance
 - Lot to lot comparison
 - Defect detection
 - Advertising

Note: The expense of testing is not at all costly when compared to the cost of returned merchandise and dissatisfied customers!

Sources of Test Methods

- In House
- ASTM
- AATCC
- ISO
- Professional Organizations
- Federal Standards
- Others

Testing of Industrial & Technical Textiles vs. Traditional Textiles

- Performance properties such as strength, durability, and thermal resistance are more important for industrial textiles, and minimum requirements for these properties are generally higher than for apparel and household textiles.
- In general, tests for comfort and aesthetics are not as important for industrial textiles.
- Product specifications for industrial textiles may be based more on performance than on construction and appearance.
- For a given property to be measured, the same standard test procedures and equipment are used for both industrial and traditional textiles!

Examples of Standards

- Standard Test Methods
 - Specify procedure, apparatus, and conditions of tests.
- Standard Definitions or Nomenclature
 - Establish uniformly accepted meanings for terms.
- Performance Specifications
 - Means of judging product acceptability.

Typical Format of a Test Standard May Include:

- Introduction/Scope/Summary
- References and Terminology
- Apparatus and Materials
- Sampling and Preparation of Test Specimens
- Conditioning
- Procedure
- Calculations and Reporting
- Precision and Bias Statement

Sample Table from a Performance Specification:

ASTM D 4847: Standard Performance Specification for Woven Awning and Canopy Fabrics

Characteristic	Minimum Requirements	Test Method
Breaking Strength (load)	150 lbf, min	ASTM D5034
Yarn Slippage (1/4 in.)	15 lbf	ASTM D434*
Tear Strength	10 lbf	ASTM D1424
Dimensional Change	3% max	AATCC 135
Colorfastness		
-Burnt Gas Fumes-2 cycles	Class 4 (a)	AATCC 23
-Laundering		
Shade change after 1 cycle	Class 4 (a)	AATCC 61
-Crooking		AATCC 8, 116
Dry	Class 4 (b)	
Wet	Class 3	
-Light (160 AATCC SFU)	Class 4 (a)	AATCC 16
-Ozone - 1 cycle	Class 4 (a)	AATCC 129

*This method has been withdrawn. Use ASTM D1683 instead.

**ASTM D 4847: Standard Performance Specification
for Woven Awning and Canopy Fabrics (cont.)**

Characteristic	Minimum Requirements	Test Method
Water Resistance		AATCC 35
-2 ft	30 s shower	
-2 ft	2 min rain	
-3 ft	5 min storm	
Water Repellency		AATCC 22
Smooth Fabrics:		
Original	90 min	
After laundering	70 min	
Rough Fabrics:		
Original	80 min	
After laundering	70 min	
Flammability	pass	No Std. given

Notes:

- (a) AATCC Gray Scale for Color Change
(b) AATCC Chromatic Transference Scale

**Basic Statistical Applications
to Testing**

Obtaining Useful Results

- A test method is useful if it gives reproducible results which correlate with the parameter of interest to the user.
- Inter-laboratory correlation is important.
- Test results are characterized by their accuracy (mean value) and their precision (standard deviation)

Accuracy vs. Precision

Accurate, but not precise:



+ Actual or Standard Value; • Observed Values

Precise, but not accurate:



+ Actual or Standard Value; • Observed Values

Calculation of Variance and Standard Deviation

$$s^2 = [\sum (x - \bar{x})^2] / (n - 1)$$

where x = individual data values
 \bar{x} = mean value
 n = number of observations

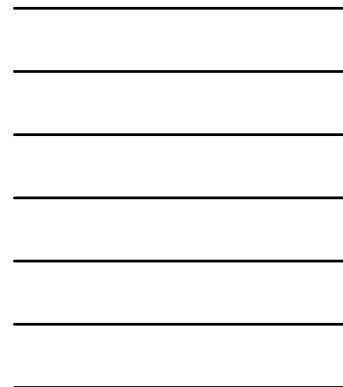
Sources of Experimental Error

- Systematic (Determinate) - Can Be Detected and Corrected
 - Improper Calibration
 - Wrong Test Method
 - Instrument Malfunction
 - Calculation Errors
 - Operator Technique
- Random (Indeterminate) - Cannot Be Eliminated
 - Judgement in Reading Scales
 - Instrumental Noise

A normal distribution curve is shown, centered at the mean \bar{x} . The horizontal axis is marked with standard deviation intervals: 1s, 2s, and 3s on the right side of the mean.

For a Normal Distribution:

- [illegible]



These analyses are based on calculations using the mean, standard deviation, and number of observations in a data set. A distribution similar to the normal distribution, called the t-distribution, is also utilized.

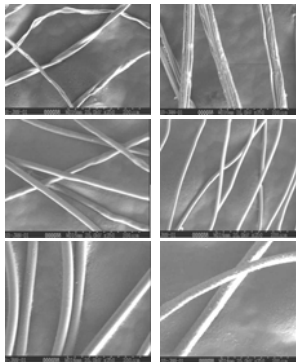
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Fiber Properties and Test Methods

Examples of Fiber Performance Properties

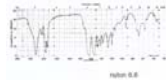
- Appearance and Identification (shape, birefringence)
- Color
- Crimp
- Fineness (linear density)
- Length and length distribution
- Luster
- Moisture regain
- Solubility and chemical resistance
- Specific gravity
- Tensile properties (strength, elongation, modulus)
- Thermal properties (T_g , T_m) and flammability

Can you identify the fibers below?



Identification of Fibers

- Qualitative: AATCC Test Method 20
- Quantitative: AATCC Test Method 20A
- ASTM D276



Identifying Characteristics of Fibers

- Absorbance of IR Radiation
- Appearance
 - Cross-Sectional View
 - Longitudinal View
- Reaction to Flame
- Birefringence
- Density
- Melting Point
- Solubility
- Staining



Crimp

- Crimp Frequency - ASTM D3937



- Crimp Amplitude - No Standard Method



Fineness or Linear Density

- Cotton Fibers
 - Micronaire - Function of both fineness and maturity - micrograms per inch
 - ASTM D5867 (HVI)
 - ASTM D1448 (Micronaire, Fibronaire)
- Synthetic Fibers
 - Linear Density - Denier, tex, decitex
 - ASTM D1577 (Direct Weighing or Vibroscope)



Moisture in Fibers

- Moisture Content
- Moisture Regain



CEM Smart System 5



Denver Moisture Analyzer

Test Methods:

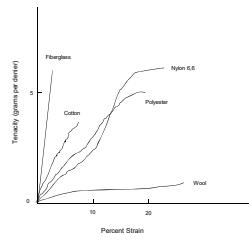
- ASTM D1776 (Conditioning)
- ASTM D629 – Section 9
- ASTM D2495 (Cotton – Oven Drying Method)

Tensile Properties: Strength (Tenacity) and Elongation

- Cotton Fibers
 - ASTM D5867 (HVI)
- All Other Fibers
 - ASTM D3822 (Single Fibers)



Typical Fiber Stress-Strain Curves



Thermal Properties of Fibers

- Non-thermoplastic Fibers (No Melting Point)
 - Natural Fibers
 - Synthetic Fibers Regenerated from Natural Materials, e.g., Rayon
 - Aramids
- Thermoplastic Fibers
 - Polyamides
 - Polyesters
 - Acrylics
 - Olefins
 - Acetates

Methods for Measuring Fiber Melting Point

- Fisher-Johns Melting Point Apparatus (See ASTM D276 or AATCC Test Method 20)

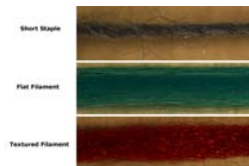


- Hot Stage Microscope
- Differential Scanning Calorimetry (DSC)



Yarn Properties and Test Methods

Yarn Examples



Spun Yarns	vs.	Flat Filament Yarns
<ul style="list-style-type: none">• Lower strength• Higher stretch• Higher bulk• Softer hand• Better absorbency• Higher pilling tendency		<ul style="list-style-type: none">• Higher strength• Lower stretch• Lower bulk• Stiffer hand• Lower absorbency• Lower pilling tendency

Yarn Performance Properties

- Coefficient of Friction
- Count
- Evenness
- Hairiness
- Tensile Strength and Elongation
- Twist

Yarn Methods

Coefficient of Friction

- ASTM D3108 (Yarn-to-Metal)



- ASTM D3412 (Yarn-to-Yarn)

Yarn Count

- Indirect – Hanks per pound
 - Cotton System: 1 Hank = 840 yd.
 - Worsted System: 1 Hank = 560 yd.
- Direct
 - Denier: grams per 9000 meters
 - Tex: grams per 1000 meters
 - Decitex: grams per 10,000 meters

Yarn Count Methods

- ASTM D1059 – Short Lengths
- ASTM D1907 – Skeins

Example Calculations of Yarn Count for a measured length of 1,000 m and mass of 0.0186 g.

Cotton Count:
$$\frac{(1,000 \text{ m})}{(0.0186 \text{ g})} \times \frac{(453.6 \text{ g})}{(\text{lb})} \times \frac{(1,000 \text{ yd})}{(\text{m})} \times \frac{(1 \text{ hank})}{(840 \text{ yd})} = 31.7 \text{ (hanks/lb)}$$

Denier:
$$(0.0186 \text{ g}/1,000 \text{ m}) \times 9000 = 167 \text{ (g/9000 m)}$$

Evenness and Hairiness

- ASTM D1425 – Capacitance Testers (%CV, Mass Diagram, Spectrogram, Hairiness Index)



Uster Tester 5 (UT5)

Tensile Strength

- ASTM D2256 (Single Strand)
- ASTM D1578 (Skeins)



MTS Q-TestV5



Uster Tensorapid

- Specialized Instruments



Uster Tensocjet

Twist – Measured for Ring Spun Yarns

- ASTM D1422 (Untwist-Retwist for single spun yarns)
- ASTM D1423 (Direct Counting)

Notes:

- Twist reported in turns per inch (tpi)
- Twist multiplier = $\text{tpi}(\text{yarn number})^{1/2}$
- Twist factor = turns per cm x $(\text{tex})^{1/2}$



Types of Spun Yarn:



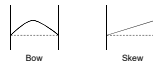
Fabric Properties and Test Methods

Important Fabric Properties

- Fabric Construction
- Fabric Appearance
 - Abrasion Resistance
 - Snagging and Pilling Resistance
 - Dimensional Stability
 - Wrinkle Recovery and Smoothness
 - Color Measurement and Evaluation
 - Colorfastness
 - Hand
- Fabric Performance
 - Comfort
 - Flammability and Thermal Resistance
 - Permeability (Air and Liquid)
 - Soil Release
 - Strength and Extensibility

Construction Test Methods

- ASTM D3776 - Fabric Weight
- ASTM D1777 - Fabric Thickness
- ASTM D3775 - Warp and Filling Count
- ASTM D1059 - Yarn Number
- ASTM D3882 - Bow and Skew



- AATCC Test Method 179 - Skewness after Home Laundering
- ASTM D8007 - Wale and Course Count (Weft Knits)

Abrasion Test Methods

- For Woven Fabrics:
- ASTM D3885 (Flexing and Abrasion)
 - ASTM D4157 (Oscillatory Cylinder)

- For Woven or Knitted Fabrics:
- ASTM D3884 (Rotary Platform)
 - ASTM D3886 (Inflated Diaphragm)
 - ASTM D4158 (Uniform Abrasion)
 - ASTM D4966 (Martindale)
 - AATCC 93 (Accelerator)
 - AATCC 119/120 (Frosting)

Possible Evaluation Criteria for Abrasion Testing

- Appearance (holes or broken yarns)
- Color Change
- Rupture of Specimen
- Strength Change
- Weight Change

Abrasion Testers for Woven Fabrics



Wyzenbeek

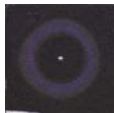


Flex and Abrasion

Abrasion Testers for All Fabrics



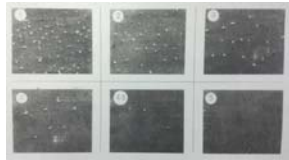
Taber Abraser



Martindale

Snag Resistance

- ASTM D3939 (Mace)
- ASTM D5362 (Bean Bag)



Pilling Resistance

- ASTM D3511 (Brush and Sponge)
- ASTM D3512 (Random Tumble)
- ASTM D3514 (Elastomeric Pad)
- ASTM D4970 (Martindale)



Pilling Testers



Random Tumble
Pilling Tester



Martindale

Effects of Laundering and Cleaning on Fabrics

- Dimensional Stability
 - AATCC 135 (Home Laundering)
 - AATCC 96 (Commercial Laundering)
 - AATCC 158 (Drycleaning)
- Wrinkle Recovery
 - AATCC 128 (Appearance Method)
 - AATCC 66 (Recovery Angle Method)
- Smoothness
 - AATCC 88B (Seams)
 - AATCC 88C (Crease Retention)
 - AATCC 124 (Fabric Smoothness)



AATCC Smoothness Appearance Replicas



Color in Textiles

- Color Matching
 - Instrumental Assessment
 - Visual Assessment
- Colorfastness Testing
 - AATCC Definition of **Colorfastness**: "the resistance of a material to change in any of its color characteristics, to transfer of its colorant(s) to adjacent materials, or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage, or use of the material."¹

¹Reference: Technical Manual of the American Association of Textile Chemists and Colorists

Instrumental Measurement of Color

- Standards
 - AATCC Evaluation Procedure 6 (Instrumental Color Measurement)
 - AATCC Evaluation Procedure 7 (Change in Color)
 - AATCC 110 (Whiteness)
 - ASTM E313 (Whiteness)
- General Procedure for Color Difference Measurement:
 - Measure reference specimen
 - Measure test specimen
 - Calculate color difference
- Report
 - Equipment used
 - Illuminant
 - Observer angle – 1964 10° or 1931 2°
 - Sample presentation

Standard Procedures for Visual Assessment of Colorfastness

- AATCC Evaluation Procedure 1 (Gray Scale for Color Change)
- AATCC Evaluation Procedure 2 (Gray Scale for Staining)
- AATCC Evaluation Procedure 8 (9-Step Chromatic Transference Scale)

Gray Scale for Color Change

- AATCC Evaluation Procedure 1
- Used to assess fading in original sample after exposure to test conditions of laundering, light, perspiration, heat, water, ozone, etc.
- Assign rating from 1 to 5
 - Grade 5
 - No change in original sample
 - 2 reference chips of neutral gray $Y = 12 \pm 1$
 - Color difference of the pair $\Delta E \approx 0 \pm 0.2$
 - Grades 4,3,2,1
 - Paired with Grade 5 chip
 - Geometric steps of color difference
 - Half-step Grades
 - Intermediates between the whole step pairs



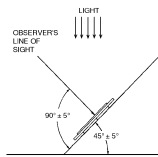
Gray Scale for Staining

- AATCC Evaluation Procedure 2
- Used to used to evaluate transfer of color from a dyed or printed fabric to a standard white fabric after test conditions of laundering, perspiration, water, crocking, etc. Can assess multifiber fabric or crock squares.
- Assign rating from 1 to 5
 - Grade 5
 - No change in original sample
 - 2 reference white chips $Y \geq 85$
 - Color difference of the pair $\Delta E \leq 0.2$
 - Grades 4,3,2,1
 - Paired with Grade 5 chip
 - Geometric steps of color difference
 - Half-step Grades
 - Intermediates between the whole step pairs



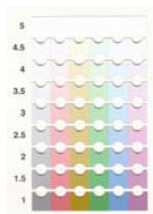
General Use of Gray Scales

- Position original and test specimen with sharp junction (no gap). Have specimens oriented consistently.
- Back all specimens uniformly.
- Align with scale pair.
- Use a Gray Mask with $Y = 53 \pm 1$. (For Gray Scale for Staining, select appropriate mask opening – multifiber, crock or general staining.)
- Angle of incident light is $45^\circ \pm 5^\circ$.
- Angle of viewing is $90^\circ \pm 5^\circ$.
- Assign grade from 1 to 5 (a grade of 0 is permissible).



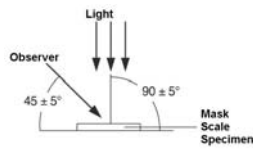
9-Step Chromatic Transference Scale

- AATCC Evaluation Procedure 8
- Used to used to evaluate transfer of color from a dyed or printed fabric to a standard white fabric after test conditions of laundering, perspiration, water, crocking, etc. Can assess multifiber fabric or crock squares.
- Assign rating from 1 to 5
 - 54 Color Chips
 - 5 Hues and neutral gray
 - 9 Rows
 - Circular hole between rows
 - White mask



General Use of 9-Step Scale

- Position test specimen.
 - Back all specimens uniformly.
 - Clean test material.
- Mask with white cardboard mask.
- Angle of incident light is $90^\circ \pm 5^\circ$.
- Angle of viewing is $45^\circ \pm 5^\circ$.
- Assign grade from 1 to 5 (a grade of 0 is permissible).



Methods for Evaluation of Colorfastness

- AATCC 6 – Acids and Alkalis
- AATCC 23 – Burnt Gas Fumes
- AATCC 8, 116 – Crocking
- AATCC 132 – Drycleaning
- AATCC 61 – Laundering (Accelerated)
- AATCC 16 – Light
- AATCC 172 – Non-Chlorine Bleach
- AATCC 164 – Oxides of Nitrogen
- AATCC 109, 129 – Ozone
- AATCC 15 – Perspiration
- AATCC 107 – Water



Colorimeters



Accelerated Laundering Machine



Xenon-Arc Fading Apparatus

Fabric Hand Test Methods

- ASTM D123, Annex A1
- AATCC Evaluation Procedure 5
- ASTM D1388 (Stiffness-Canilever)



- ASTM D4032 (Stiffness-Circular Bend)



- BS 5058 (Cusick Drape)



- Specialized Instruments
 - Kawabata System
 - Fabric Touch Tester (FTT)

Flammability

- ASTM D4391 – Definitions and Terminology
- ASTM D4723 – Index of Test Methods (numerous methods)
Examples:
 - ASTM D2863 (Limiting Oxygen Index)
 - ASTM D6413 (Textile Materials-Vertical Test)
 - CPSC 16 CFR 1610 (Wearing Apparel-45° test)
 - CPSC 16 CFR 1632 (Mattresses)

Air and Liquid Permeability

Air Permeability

- ASTM D737 (Frazier Air Permeability)

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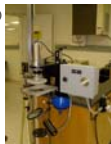
Water Repellency and Resistance

- AATCC 22 (Spray Test)
- AATCC 35 (Rain Test)
- AATCC 42 (Impact Penetration)
- AATCC 70 (Dynamic Absorption)
- AATCC 127 (Hydrostatic Pressure)

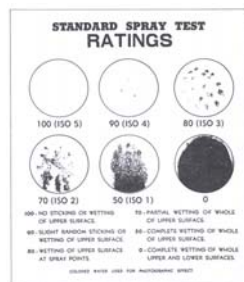
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Oil Repellency

- AATCC 118 (Oil Repellency)



Water Repellency Testing



Soil Release

- AATCC 130 – Soil Release: Oily Stain Release Method



- AATCC 121 – Carpet Soiling: Visual Rating Method
- ASTM D4265 – Stain Removal

Strength Testing

- Tensile (Woven Fabrics)
- Tear (Woven Fabrics)
- Burst (Knitted Fabrics)

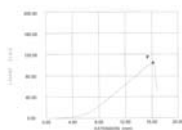


MTS Q-Test/5 Universal Testing Machine

Tensile Strength Methods

- ASTM D5034 (Grab Test)
- ASTM D5035 (Strip Test)
- ASTM D4964 (Elastic Fabrics)

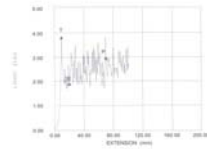
Load-Elongation Curve for Fabric Grab Test:



Tear Strength Methods

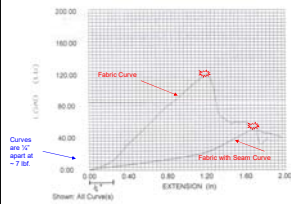
- ASTM D2261 (Tongue Tear)
- ASTM D1424 (Elmendorf)
- ASTM D5587 (Trapezoid Tear)

Load-Elongation Curve for Fabric Tongue Tear Test:



Seam Slippage Test Method

- ASTM D1683 (Seam Slippage and Efficiency)



Burst Strength Methods

- ASTM D3786 (Hydraulic or Pneumatic)
- ASTM D3787 (Ball Burst-CRT)
- ASTM D6797 (Ball Burst-CRE)



Mullen Burst Tester



TruBurst[®] Burst Tester



Ball Burst Tester

NC STATE UNIVERSITY

Questions?

Thank you for coming!

Zelig Textiles
Extension
