

# Lightfastness Testing of Textiles

## 纺织品的日晒色牢度测试

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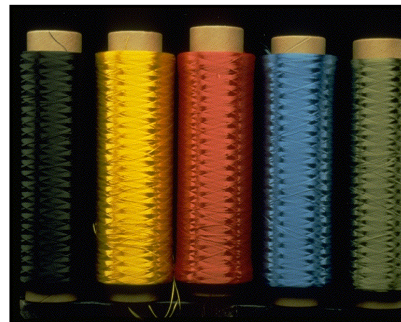
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# What is lightfastness of textiles?

## 什么是纺织品的日晒色牢度？

- Ability of a textile to resist color change due to exposure to light
- 纺织品抵抗光照引起的颜色变化的能力
- Lightfastness is specific to a particular dye and varies greatly.
- 不同染料的耐光性是不同的，存在很大差异
  - Lightfastness depends on the structure of dye 取决于染料的结构
  - Varies greatly from dye to dye 不同的染料差异很大
  - Reactive dye and Vat dye 活性染料和还原染料



# Lightstability vs. Weathering 耐光性vs.老化

- Lightfastness (lightstability) 耐光性 (光稳定性)
  - Less durable materials, limited outdoor exposure
  - 较不耐用的材料 · 几乎没有户外曝晒
  - Many tests look only for rapid color degradation
  - 许多测试只关注快速的褪色
- Weathering 老化
  - outdoor, durable materials 户外曝晒 · 耐用材料
  - Long term fading and fiber degradation 长时间褪色 · 纤维降解

# Colorfastness to Light 耐光色牢度

- Exposure to light radiation, temperature and humidity affects the fading / color change performance of a colored textile material
- 暴露于光，温度和湿度下，会影响有色纺织材料的褪色/变色性能
- Changes are initiated due to photo-chemical processes of absorbed ultraviolet and visible radiation and the interactions with temperature and humidity.
- 变化是由吸收的紫外线和可见光的光化学过程，以及与温度和湿度的相互作用引起的

# Wide range of lightfastness 耐光性差异很大



- One hat is new; the other was worn all summer in a hot environment
- The dyed thread in the “Q” remained lightfast; the rest of the hat faded

# Standard reference materials for lightfastness testing 耐光性测试的标准参照材料

Blue wool 蓝色羊毛标样

Red azoic and purple cloth 湿度控制标样和温度控制标样

# Standard Reference Materials 标准参照材料

Material recognized by a standards organization as having well-understood weathering performance that is repeatable under identical conditions

标准组织认可的具有良好耐候性能的材料，在相同条件下可重复使用

- AATCC Blue Wool
- ISO Blue Wool
- DIN Blue Wool
- JIS Blue Wool
- ISO Red Azotic Cloth





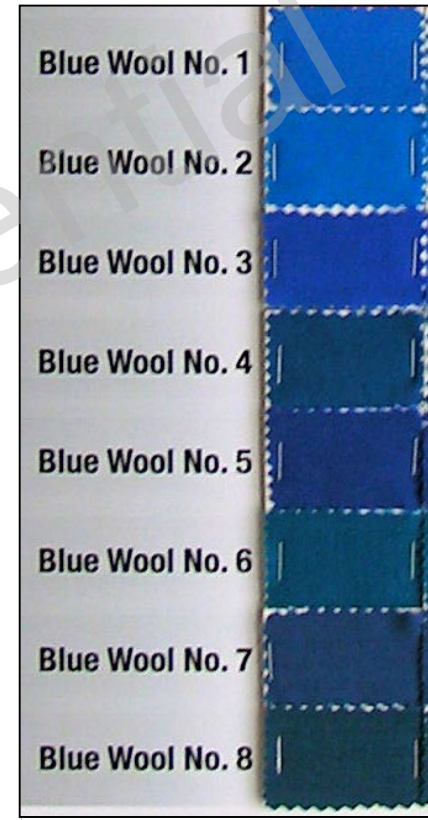
# Blue Wools 蓝色羊毛标样

- Set duration of exposure 设置试验时间
- Evaluate color fading 评估试样褪色
- Verify chamber test conditions 验证试验箱
- Improve repeatability and reproducibility
- 提高重复性和再现性
- Use predates modern chamber controls and instrumental color evaluations
- 较早使用



# ISO Blue Wool

- Numerically designated 1-8
- Increased light stability as numbers increase
- Used for comparison to evaluate specimens
- Used to set test duration
- Each blue wool made from a different dye
- Blue wools do not start out with identical colors



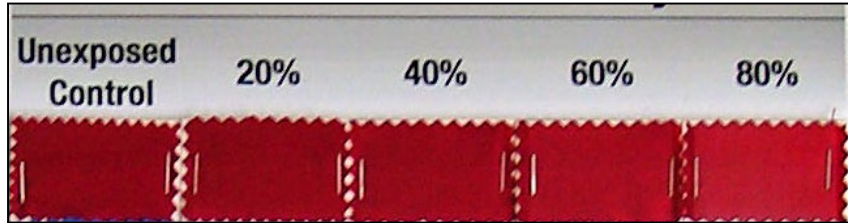
# AATCC Blue Wool

- Numbered L2 to L9
- Blend of durable and non-durable dye
- Each successive number requires twice exposure to fade an equivalent amount
- L2 is most common



# Other Standard Reference Materials

## ISO Red Azoic Cloth



Fading based on relative humidity

## AATCC Purple Cloth (Xenon Reference Fabric)



Fading based on temperature

# Evaluations for lightfastness testing

## 耐光性测试的评估

Colorimeter 色差计

Grey scale 灰色样卡

Blue wool comparison 与蓝色羊毛标样进行比较

# ISO Blue Wool for Evaluation

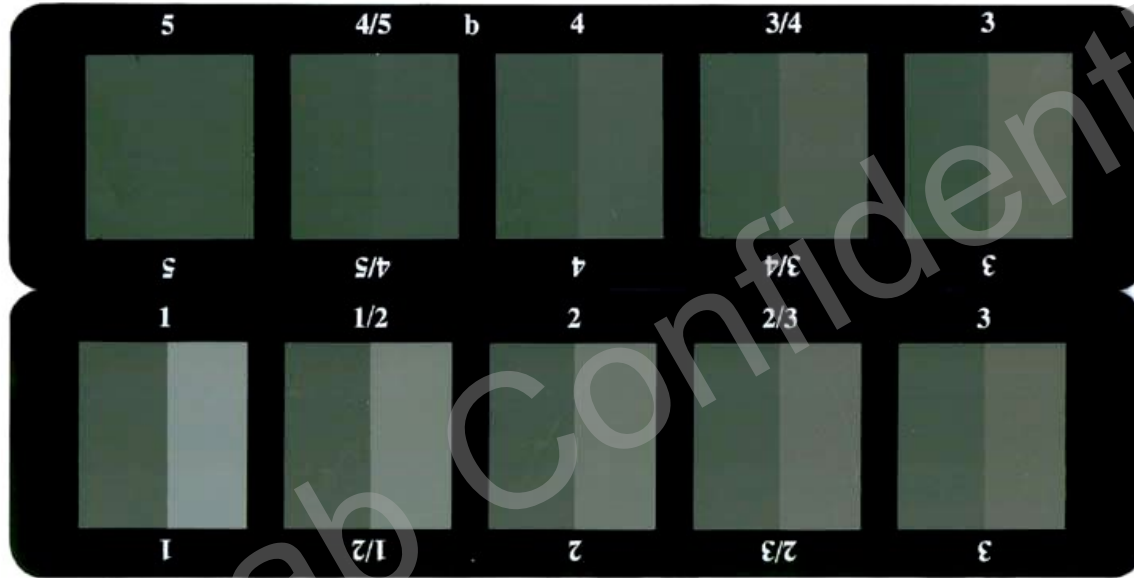


Specimen

Blue Wool

Fastness grade	Degree of fading	Light fastness
Grade 8	None	Outstanding
Grade 7	Very, very slight	Excellent
Grade 6	Slight	Very good
Grade 5	Moderate	Good
Grade 4	Appreciable	Moderate
Grade 3	Significant	Fair
Grade 2	Extensive	Poor
Grade 1	Very extensive	Very poor

# ISO Grey Scale for evaluation



- Used for visual evaluations
- Along with blue wools used to time tests
- Color gray scales different from staining gray scales

# Lightfastness major test standards

## 耐光性测试主要的标准

ISO 105-B02

AATCC TM 16

ISO 105-B series and others



# Products and Test Standards 产品与测试标准

Product	Test type	Major test standards
Apparel and Design Fabrics	Lightfastness	<ul style="list-style-type: none"><li>• ISO 105-B02</li><li>• ISO 105-B04 (like B02 but with water)</li><li>• AATCC TM 16 (Option 3)</li><li>• Other derivatives like Marks &amp; Spencer</li></ul>
Automotive and high-temp	Lightfastness	<ul style="list-style-type: none"><li>• ISO 105-B06</li><li>• VDA (DIN) 75202</li><li>• SAE J2412</li><li>• IUF 402 – Int'l Union of Leather Technologists and Chemists Societies</li></ul>
Outdoor and Industrial Textiles	Weathering	<ul style="list-style-type: none"><li>• AATCC TM 169 (xenon)</li><li>• AATCC TM 186 (fluorescent UV)</li><li>• ISO 105-B03 (outdoor)</li></ul>

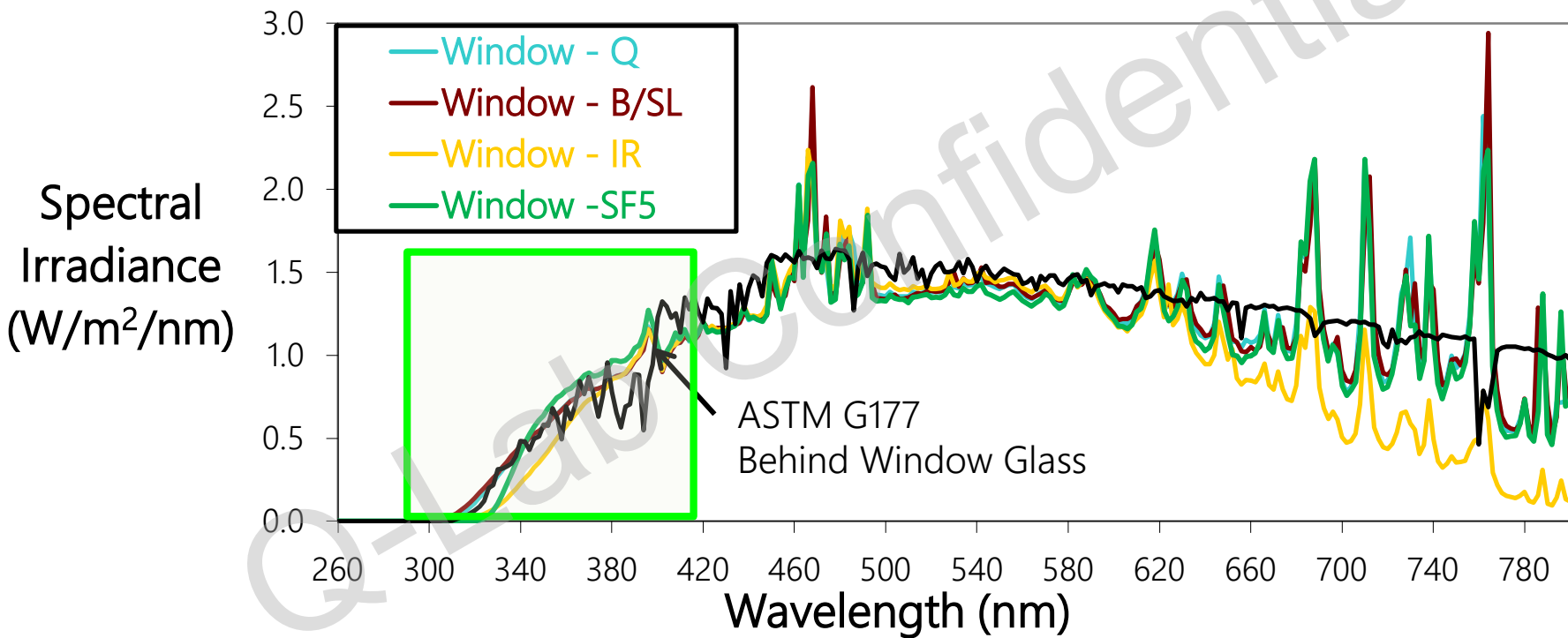
# Textile Lightfastness Exposure 纺织品耐光性测试

## Methods for Xenon arc 氙灯试验方法

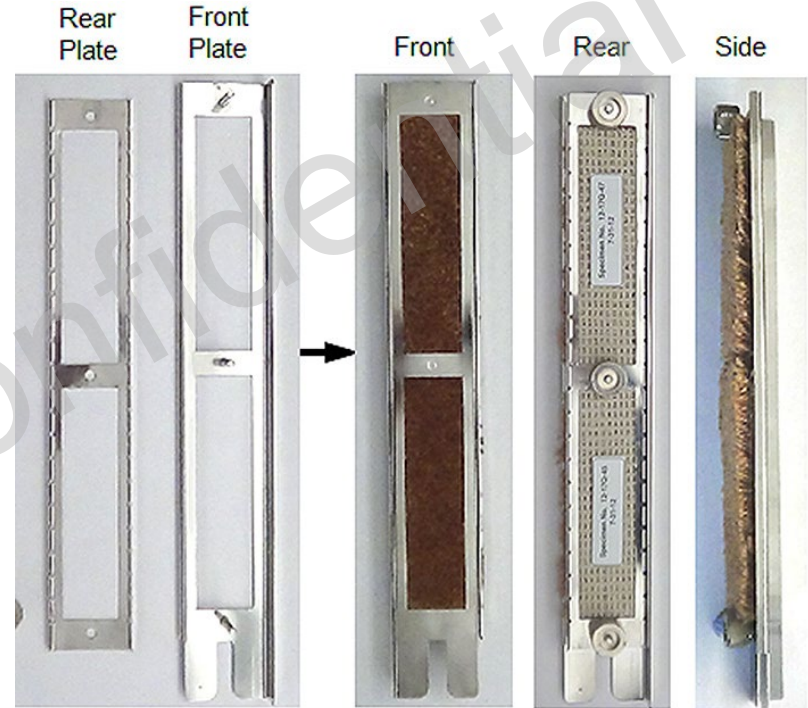
- Xenon arc light source and “Window” glass optical filtration
- Specimen mounting
- Blue wools and gray scales are used
  - Set duration of test
  - Evaluate exposed specimens

# Light source for textile testing 纺织品测试的光源

## Xenon Arc with Window Filters 配备窗玻璃过滤片的氙灯



# Open-Backed Specimen Holders 镂空样品架



Open Back Holder Components

Mounted Specimen

# Solid-Backed Specimen Holders 实心样品架

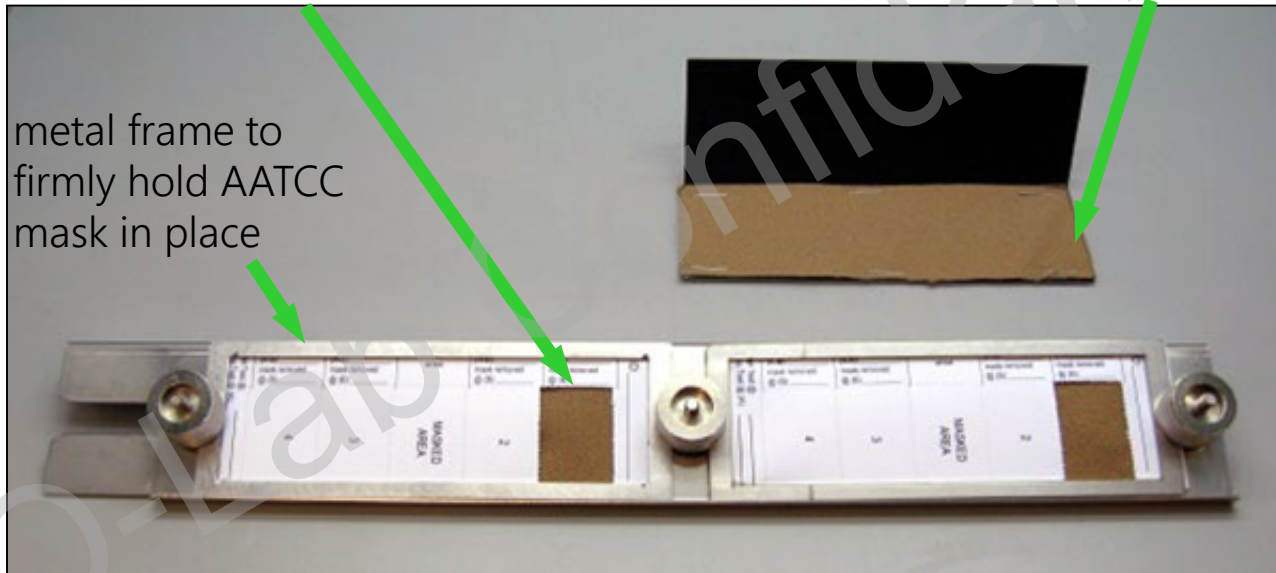


Sample holder with optional center nut for mounting 2 smaller samples.

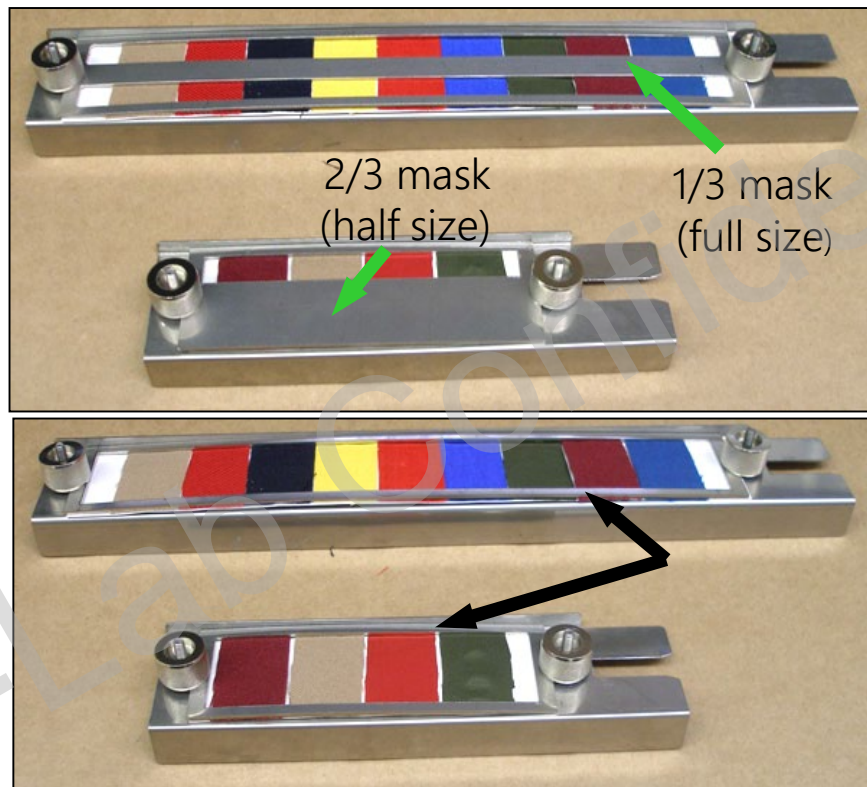
# Textile Masking 纺织品遮盖物

AATCC mask mounted in specimen holder with one section removed

Textile specimen stapled inside AATCC mask



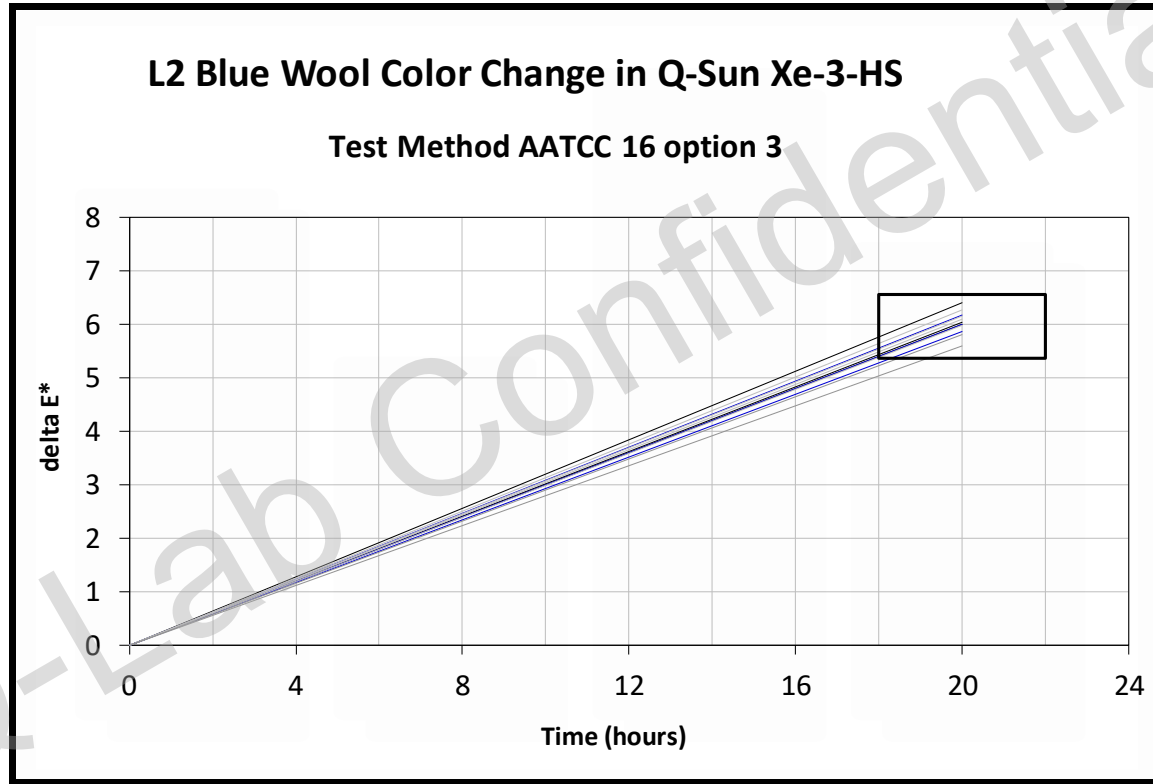
# Textile Masking 纺织品遮盖物



ISO 105-B02

- 1/4, 1/2, 3/4
- 1/3, 2/3

# Timing lightfastness tests with Blue Wool





# ISO 105-B02

The world's most common lightfastness test for textiles

# ISO 105-B02 Exposure Cycle

## “Normal Conditions” 通常条件

- Irradiance Controlled at  $1.10 \text{ W/m}^2/\text{nm}$  @ 420nm;
  - Window Glass IR Filter
  - Filters must be changed at regular intervals
- Continuous Light only @ 47 °C IBP Temperature
- 39 °C Chamber Air Temperature \*
- 40% Relative Humidity \*

*\*Method to determine value is complicated; these values are commonly used*

# Methods in ISO 105-B02

Method	Reference Material		Duration
	Material	Purpose	
1	Blue Wool 1-8	Evaluation	Specimen reaches Grey Scale 3
2	Blue Wool 1-8	Duration, Evaluation	Most resistant specimen reaches Grey Scale 3 OR Blue Wool 7 reaches Grey Scale 4
3	Single Blue Wool	Duration, Evaluation	Blue wool reaches Grey Scale 3
4	Known specimen	Duration, Evaluation	Reference material reaches Grey Scale 3
5	None	N/A	Specific radiant dosage measured

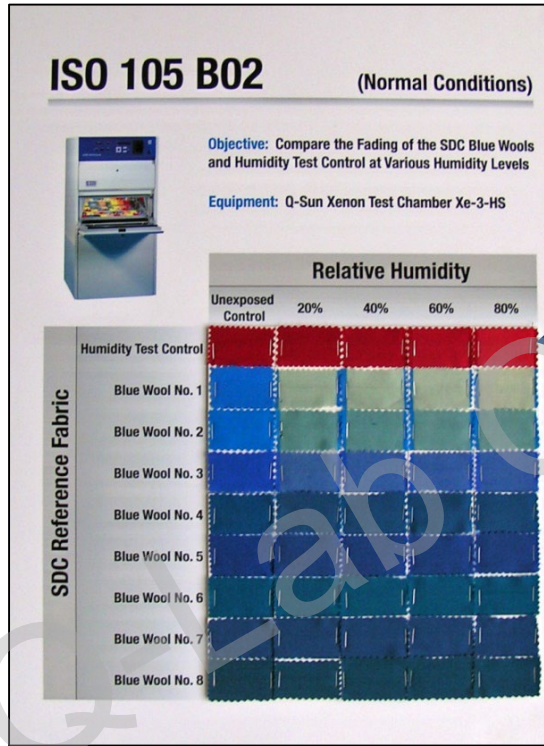
*Different exposure conditions used for different testing goals*

# Methods in ISO 105-B02

Method	Description
1	Most exact and time-consuming test, used for R&D
2	Comparison of multiple lots of a material
3	Quality control testing of known materials
4	Lower-resolution comparison test to reference lot
5	Standardized test to prescribed dosage

*Different exposure conditions used for different testing goals*

# ISO 105-B02: Standard reference materials



Red azoic dye

Blue Wool 1-8

# ISO 105-B02

## Test Protocol 测试方案

- **Duration** determined by comparing blue wool or specimen to gray scale (Depending on Method)
- **Evaluation** - exposed specimens are graded against the 8 blue wools
- Alternative Methods use 2 blue wools in a pass/fail test, agreed upon reference without blue wool, or radiant energy

# Test Duration and Evaluations 测试时间与评估

- ISO 105-B02 contains several options for setting the duration and rating specimens
- ISO 105-B02中有几种设置测试时间及评估试样等级的方法
- Example: Expose several specimens and complete set of blue wools
- 示例：曝晒几个试样及一整套蓝色羊毛标样
  - Run until blue wool #1 fades to gray scale 4—specimens that have faded to gray scale 4 are rated as “1”
  - Run again until blue wool #2 fades to gray scale 4—specimens that have faded to gray scale 4 are rated as “2”
  - And so on (2 and 4 are common apparel specifications)

# AATCC TM 16

American Association of Textile Chemist and Colorists



# Options in AATCC TM 16

Method	Description
1	Enclosed carbon arc, continuous light
2	Enclosed carbon arc, light/dark cyclic
3	Xenon arc, continuous light
4	Xenon arc, light/dark cyclic
5	Xenon, continuous light, higher irradiance, lower temperature

*Different exposure conditions used for different testing goals*

# AATCC TM 16 Option 3 and ISO 105-B02

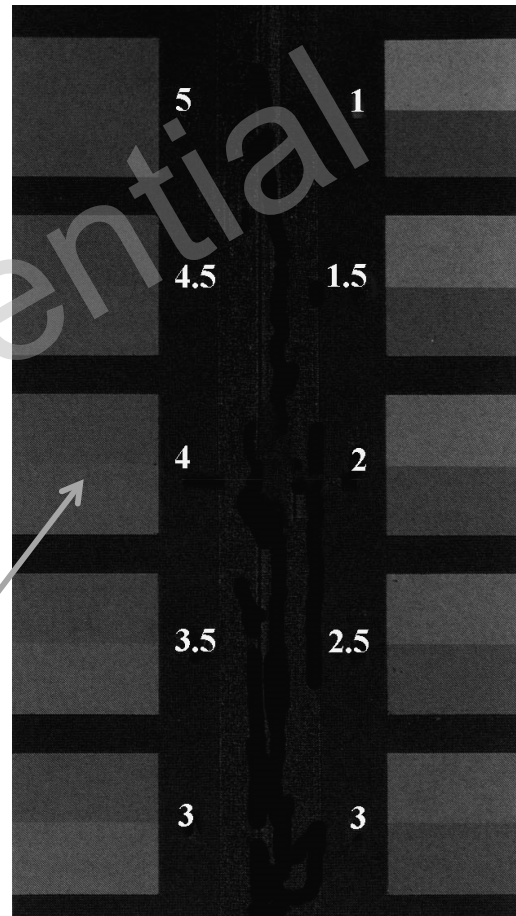
## Exposure conditions comparison

Parameter	AATCC	ISO 105-B02
Light source	Xenon arc	Xenon Arc
Irradiance (W/m <sup>2</sup> /nm @420nm)	1.10	1.10
BP temp (°C)	63	47
Chamber air temp (°C)	43	39
RH (%)	30	40
Optical Filter	Window B/SL	Window-IR

# Assessment of AATCC 16

- Compare contrast on specimens to the Grey Scale steps for Assessing change of color
- Grade specimen to corresponding Grey Scale step

*L4 blue wool should fade to contrast 4 after 85 kJ of energy at 420 nm*



# AATCC fading unit (AFU)

- Duration of the exposure determined by a specified amount of AATCC Fading Units (AFU), or radiant energy ( $\text{kJ}/\text{m}^2$ )
- 由指定数量的AATCC褪色单位(AFU) · 或辐照量( $\text{kJ}/\text{m}^2$ )来确定曝晒时间
- A specific amount of exposure made under the conditions specified in various test methods.
- 不同试样方法 · 曝晒时间不同
- One AFU is 1/20th of the light exposure required to produce a color change equal to step 4 on the Gray Scale using L4 of AATCC.
- 一个AFU是AATCC蓝色羊毛标样L4的颜色变化达到灰色样卡4级所需光照的二十分之一

# AFU Equivalence AFU等价

- Table II provided in AATCC TM 16
- L2 Blue wool also includes suggested color change when exposed to 20 AFU
- Each AFU is roughly 1 hour of TM 16 Option 3

Table II—AATCC Fading Unit and Light Exposure Equivalents for AATCC Blue Wool Lightfastness Standards (see 32.18)<sup>a</sup>

AATCC Blue Wool Lightfastness Standard	AATCC Fading Units	Xenon Only kJ/(m <sup>2</sup> nm) @ 420 nm	Xenon Only kJ/(m <sup>2</sup> nm) 300-400 nm
L2	5	21	864
L3	10	43	1728
L4	20	85 <sup>b</sup>	3456
L5	40	170	6912
L6	80	340 <sup>b</sup>	13824
L7	160	680	27648
L8	320	1360	55296
L9	640	2720	110592

<sup>a</sup> For color change of  $1.7 \pm 0.3$  CIELAB units or Step 4 on the AATCC Gray Scale for Color Change.

<sup>b</sup> Verified by experiment using Daylight Behind Glass and Xenon-Arc, Continuous Light. All other values are calculated (see 32.18).

# ISO 105-B series

Advances in performance-based textile lightfastness standards

# ISO 105-B Series

Commonly known, well-understood, successful tools for textile testing

常用，易懂，成功的纺织品测试工具



# Different materials require different test methods



Textiles are becoming more high-tech ...  
but the test methods are still the same.



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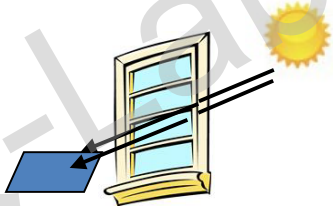
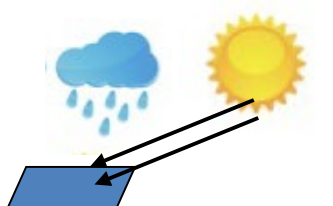
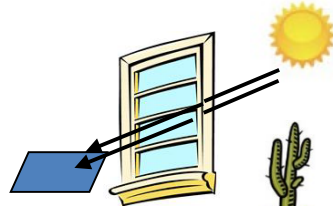
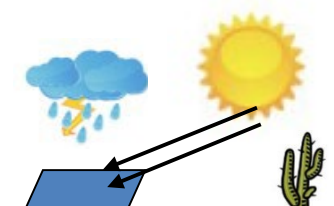
2013

- Are existing test methods still suitable to cover all aspects of modern textile testing?
- Do we need a new test method?
- Do we need new test equipment?



# ISO 105-B02, -B04, -B06 & -B10

## A variety of test protocols

Aspect	B02	B04	B06	B10
Environment	Indoor	Outdoor	Indoor	Outdoor
Irradiance (W/m <sup>2</sup> TUV)	42	42	45	60
Cut-on wavelength (nm)	315	300	310	290
UV light	Low	Medium	Low	High
IR light	Suppressed	Suppressed	High	High
Water cycle	Dry only	Cyclic dry/spray	Dry only	Cyclic dry/spray option
Graphic				

# ISO 105-B02 and -B04

## Do not cover all aspects of Outdoor Textiles & blends

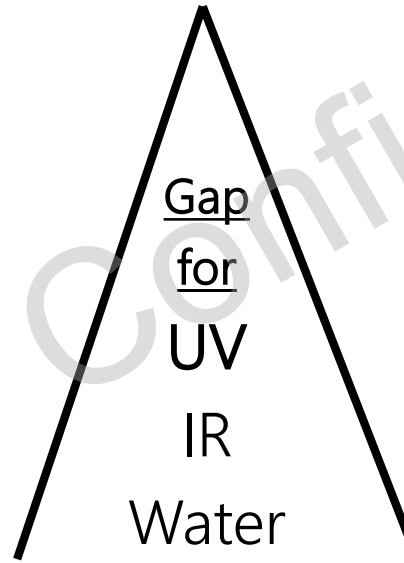
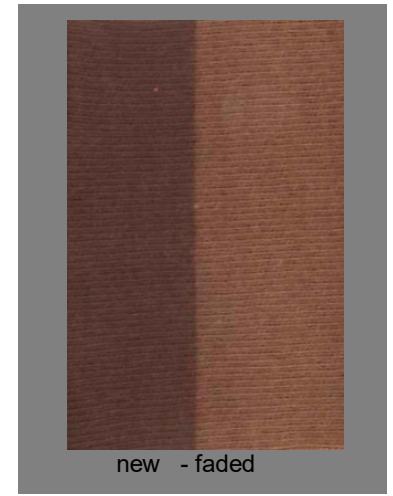
ISO 105-B02

Target group: Color Fading of textiles



ISO 105-B04

Target groups: Color Fading of textiles and material aging



Target group: Outdoor/functional wear

Accelerated testing of fibre blends (natural/synthetics)

# Future developments for ISO 105-B

- ISO 105-B10 offers several new accelerated weathering methods
  - Higher temperatures and increased amount of UV-radiation
  - allows higher acceleration level
  - Once thought to replace B04, instead will be better distinguished
- B02, B04, B06, and B10 are now performance-based standards
  - Hardware-based standards exclude new techniques/innovation
  - Hardware-based standards are ineffective and not flexible for update
  - Performance-based standards are open for innovation
  - Performance-based standards strictly define requirements, but do not describe a specific machine or technique

# A choice of xenon tester



Modern textile test methods ISO-B02, B04, B06, and B10 are *performance-based* standards, open to flatbed and rotating rack testing devices:

- An important change after 60 years of hardware exclusivity
- All test parameters are the same regardless of apparatus
- Performance conditions and reference materials can both be used to validate test equipment

*This means more choices for users and more freedom to innovate!*

# Summary – Lightfastness testing of textiles



- Lightfastness of textiles is their resistance to color fade under sunlight- especially UV light – and heat
- Accelerated weathering testing of textiles can be performed in xenon arc weathering testers
- Standard reference materials are used to validate tester performance and to evaluate material lightfastness
- Major test protocols include ISO 105-B02 and AATCC TM 16
- Modern test standards are nearly all performance-based instead of hardware-based

# Thank you for your attention!

## Questions?

Send your inquiry to:  
[ssun@q-lab.com](mailto:ssun@q-lab.com)

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