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Textiles - Test method for assessing the smoothness appearance of fabrics after laundering and drying: Infrared image analysis method

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Foreword

This standard is drafted in accordance with ISO (2024). Guidance on new work, ISO PUB100438. Geneva: International Organization for Standardization and GB/T 1.1-2020 Directives for standardization - Part 1: Rules for the structure and drafting of standardizing documents

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Textile Bioengineering and Informatics Society (TBIS)

Address: Market Square, Sandbach, Cheshire, England, CW11 1AT, UK
Email: admin@tbisociety.org
Website: www.tbisociety.org
Published in: United Kingdom

Textiles-Test method for assessing the smoothness appearance of fabrics after laundering and drying-Infrared image analysis method

Table of Contents

1 Scope

This document specifies the method principles, test equipment, test device, test results and test report of the retention capacity of the smoothness appearance of fabrics after laundering and drying procedures based on the infrared image analysis technology.

This document shall be primarily applicable to the laundering and drying procedures specified in GB/T 8629-2017 or GB/T 19981(all parts) but also applies to other laundering and drying procedures.

2 Normative References

The following referenced documents shall be indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest editions of the document of the normative documents (including all the amendments) are applicable to this document.

GB/T 6529-2008, *Textiles—Standard atmospheres for conditioning and testing*

GB/T 8629-2017, *Textiles—Domestic washing and drying procedures for textile testing*

GB/T 13769-2009, *Textiles—Test method for assessing the smoothness appearance of fabrics after cleansing*

GB/T 19981 (all parts), *Textiles—Professional care, drycleaning and wet cleaning of fabrics and garments*

3 Terms and Definitions

For purposes of this document the terms and definitions apply.

3.1 Image Acquisition

The process of capturing an image of a specimen or a smoothness appearance three-dimensional standard replica and converting the image information into digital information recognizable by the system.

3.2 Image Analysis

The process of analyzing and assessing the acquired image information using mathematical methods.

4 Method Principle

Infrared imaging technology is used to avoid the interference of colour patterns on the surface of multi-colour fabrics on the shadow information caused by wrinkles, improving the variety adaptability of image analysis technology in assessment of the smoothness appearance of the fabric after washing.

Note: Multi-colour fabrics in this document refer to fabrics with two or more colour rendering effects.

Image analysis technology is used to analyze the images of the specimen and the smoothness appearance three-dimensional standard replica in each grade and assessing the specimen as the grade of a certain smoothness appearance three-dimensional standard replica.

5 Devices

5.1 Laundering and Drying Device or Professional Caring Devices

In accordance with the provisions of GB/T 8629-2017 or GB/T 19981 (all parts), or in accordance with the agreement of the parties concerned.

5.2 Smoothness Appearance Three-Dimensional Standard Replicas

For the grade rating of the smoothness appearance (SA) shall be in the range of five grades from SA1, SA2, SA3, SA4 to SA5 in accordance with the provisions of GB/T 13769-2009, or according to the agreement of the parties concerned to use products with equivalent effect. Where SA5 grade corresponds to the standard sample SA-5, indicating the smoothest appearance and optimal retention of original smoothness. While, SA-1 grade corresponds to standard sample SA-1, indicating the least smooth appearance and poorest retention of original smoothness.

5.3 Image Acquisition Device

5.3.1 Light Source Box

5.3.1.1 The light source box shall be composed of three parts: a box body, a light source, and a sample stage (see Figure 1).

5.3.1.2 The box body shall be made of opaque material, which can block external light from entering the interior.

5.3.1.3 The sample stage shall be installed inside the box with a size of 400 mm×400 mm.

5.3.1.4 The light source shall be installed inside the box. Strip LED infrared light source shall be used. The length of the light source shall be within the range of 400 mm to 500 mm, the width shall be within the range of 20 mm to 30 mm, the rated luminous flux shall be greater than 15 lm, and the wavelength band of the light source shall be chosen from the range of 850 nm to 950 nm.

5.3.1.5 The number of light sources shall be two. The length direction of the light source shall be parallel to the two mutually orthogonal edges of the sample stage.

5.3.1.6 The horizontal distance between the light source and the center of the sample stage shall be400 mm, and the vertical distance shall be 100 mm.

5.3.2 Digital Camera

5.3.2.1 Using an area-array camera, the camera shall be capable of imaging in the light source box (5.3.1).

5.3.2.2 The camera shall be installed inside the light source box (5.3.1), directly above the sample stage, and its collection plane shall be parallel to the sample stage.

5.3.2.3 The installation height of the camera should be able to ensure that the camera can obtain the image of the entire sample stage.

5.3.2.4 The camera resolution shall provide a minimum of 300 × 300 pixels in the area stage located.

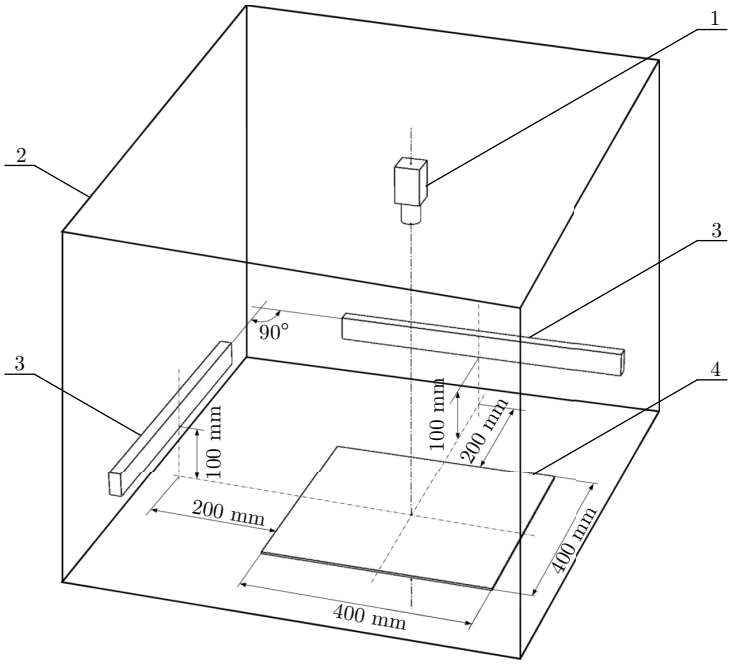
5.4 Image Analysis Device

5.4.1 Analysis

The device has the function to analyze the images acquired by the image acquisition device (5.3), including automatic calculation of image features and assessing the smoothness appearance of the specimen according to the feature similarity between the specimen and the smoothness appearance three-dimensional standard replica in each grade.

Example of mathematical calculation methods in the image analysis device and evaluation of their effectiveness can be referred to in Appendix B.

The assessment results of the smoothness appearance grade range from 1 grade to 5 grade. The results are accurate to the nearest 0.5 grade.



Key: 1—digital camera; 2—box body; 3—strip LED infrared light source; 4—sample stage.

Fig. 1: Image acquisition device diagram

5.4.2 Display

The device has the function of displaying the assessment results obtained by the analysis device (5.4.1) on the display screen.

6 Specimens

Specimens shall be prepared in accordance with the provisions of GB/T 13769-2009 by cutting parallel to the length direction of the fabric. Each specimen shall be measured 380 mm×380 mm. The edges of the specimens shall be cut into serrated or overlocked to prevent fraying. The number of specimens shall be three or nine pieces.

7 Test Procedure

7.1 Device Calibration

7.1.1 General Principles

To ensure the operational stability of the image analysis equipment (5.4), an equipment calibration shall be performed for the image acquisition device (5.3) and the image analysis device (5.4) in the following cases.

– when using the equipment for the first time.

– after a change in the settings of light box (5.3.1) or digital camera (5.3.2).

– after reaching the manufacturer's recommended calibration interval.

7.1.2 Placement of Smoothness Appearance Three-Dimensional Standard Replica

In accordance with the operating requirements of the image acquisition device (5.3), the smoothness appearance three-dimensional standard replica of each grade shall be naturally placed in the designated position.

7.1.3 Image Acquisition of Smoothness Appearance Three-Dimensional Standard Replica

In accordance with the operating requirements of the image acquisition device (5.3), the two light sources of the light source box (5.3.1) shall be turned on separately. The imaging device (5.3.2) shall be used to implement image acquisition. Two images of each smoothness appearance three-dimensional standard replica shall be acquired.

7.2 Specimen Laundering and Drying

Treat the samples in accordance with one of the laundering and drying procedures specified in GB/T 8629-2017 or GB/T 19981; or treat the samples with the laundering and drying procedures in accordance with the agreement of the parties concerned.

7.3 Specimen Conditioning

Condition the sample according to the standard atmosphere specified in GB/T 6529-2008 for a minimum of 4h and a maximum of 24h; or according to the agreement of the parties concerned, the sample shall be conditioned in accordance with the conditioning procedure agreed in the agreement.

7.4 Specimen Placement

In accordance with the operating requirements of the image acquisition device (5.3), the specimen shall be naturally placed in the designated position to avoid damage to the natural wrinkle appearance of its surface due to the placing operation.

7.5 Specimen Image Acquisition

In accordance with the operating requirements of the image acquisition device (5.3), the two light sources of the light source box (5.3.1) shall be turned on separately. The imaging device (5.3.2) shall be used to implement image acquisition. Two images of each smoothness appearance three-dimensional standard replica shall be acquired.

7.6 Smoothness Appearance Grade Rating

In accordance with the operating requirements of the image analysis device (5.4), the image analysis device shall be used to rate the smoothness appearance grade of the specimen based on the images of it.

8 Result Representation

Calculate the average value of the grades assessed for a group of samples. If the group size is three, round the average to the nearest 0.5 grade as the assessment result. If the group size is nine, round the average to the nearest 0.1 grade as the assessment result.

9 Test Report

The test report shall include the following:

a) Explain that the test is carried out in accordance with this document;

b) Specimens details;

c) Details of the laundering and drying procedures;

d) Details of the conditioning procedure;

e) The model of the used devices;

f) Report of the fabric smoothness appearance grade calculated according to Chapter 8;

g) Any details deviated from this document.

Annex A Calculation of image analysis

(Informative annex)

A.1 Principle

Using computer software to automatically calculate the characteristics of the infrared image of the fabric, based on the feature similarity between the specimen and each grade of smoothness appearance three-dimensional standard replica infrared image.

A.2 Program

A.2.1 Image Feature Calculation

A.2.1.1 General Principles

Calculate the signal intensity of wrinkles at different frequencies in the fabric image as features. Techniques such as Fourier transform, wavelet decomposition, Gabor filtering, and Gaussian

pyramid can be used to calculate the signal intensity of the wrinkles at different frequencies.

A.2.1.2 Fourier Image Feature Calculation

Scale the image to 300 pixels × 300 pixels.

Apply Fourier transform to the image to obtain the spectrogram of the image.

Calculate the signal strength at different frequencies by equation (A.1), retaining four decimal places:

$$a_n = \sum_{u=1}^{300} \sum_{v=1}^{300} A_{u,v} h_{u,v} \tag{A.1}$$

where

n — the dimensional number of the feature, which is an integer between 1 and N;

N — the dimension of the feature, which takes the value of 10;

A — the spectrogram of the image;

u, v — coordinates of the pixel points in the spectrogram;

h_n — the n^{th} ideal bandpass filter with a bandwidth of 15 pixels and a center radius of r_n, where $r_n = 20 + 15 \times n$.

A.2.2 Feature Similarity Calculation

A.2.2.1 General Principles

Models such as logistic regression, support vector machine, and random forest can be used to calculate the similarity between fabric image features and smoothness appearance three-dimensional standard replica in each grade.

The calculation of the similarity model relies on the selection of the weights of the features. But the limited and discontinuous grades of the smoothness appearance three-dimensional standard replicas make it difficult to provide sufficient reference for the selection of weights. At least 20 fabric samples of each grade shall be collect as training samples, and the grades of these training samples are evaluated with reference to the method specified in GB/T 13769-2009.

A.2.2.2 Logistic Regression

The similarity between the fabric image features and the image features of smoothness appearance three-dimensional standard replicas in each grade is calculated by equation (A.2), retaining four decimal places:

$$y = \frac{1}{1 + \mathrm{e}^{-\sum_{n=1}^{N} \omega_n (a_n - b_n) + c}} \tag{A.2}$$

where

n — the dimensional number of the feature, which is an integer between 1 and N;

N — the dimension of the feature, which takes the value of 10

a — fabric image features;

b — image features of the smoothness appearance three-dimensional standard replica;

ω, c — Feature weights and constant terms, which are calculated by maximizing the likelihood function of the similarity estimate of all training samples to the smoothness appearance three-dimensional standard replicas in each grade.

A.2.3 Effectiveness Evaluation

For the image assessment results of the same specimen, the error between the assessment results of the method specified in GB/T 13769-2009 should be better than the following statistical distribution.

The grade error is 0:80%

The grade error is 0.5:10%

The grade error is 1:10%