INTERNATIONAL STANDARD

ISO 9867

Second edition
2009-07-15

Textiles — Evaluation of the wrinkle recovery of fabrics — Appearance method

Textiles — Évaluation de la défroissabilité des étoffes — Méthode d'évaluation de l'aspect

Reference number
ISO 9867:2009(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 9867 was prepared by Technical Committee ISO/TC 38, *Textiles*, Subcommittee SC 2, *Cleansing, finishing and water resistance tests*.

This second edition cancels and replaces the first edition (ISO 9867:1991), which has been technically revised. Annex B (informative) has been added.

Textiles — Evaluation of the wrinkle recovery of fabrics — Appearance method

1 Scope

This International Standard describes a method for evaluating the appearance of textile fabrics after induced wrinkling. It is applicable to fabrics made from any fibre or combination of fibres.

NOTE A digital description of the ISO wrinkle replicas is given in Annex B.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 105-A03, *Textiles — Tests for colour fastness— Part A03: Grey scale for assessing staining*

ISO 139, *Textiles — Standard atmospheres for conditioning and testing*

3 Principle

A test specimen is wrinkled under specified atmospheric conditions in a wrinkling device under a pre-determined load for a prescribed period of time. The specimen is reconditioned in a standard atmosphere and evaluated for appearance by comparison with three-dimensional wrinkle recovery replicas.

4 Apparatus

4.1 Wrinkle tester [1] (see Figure 1).

4.2 Three-dimensional wrinkle recovery replicas [2] (see Figure 2).

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1) For details of the source of supply of wrinkle testers, apply to national standards institutions. The apparatus shown in Figure 1 is for illustrative purposes only. A suitable product is available from AATCC Technical Center, One Davis Drive, P.O. Box 12215, Research Triangle Park, North Carolina 27709-2215, USA; Tel: +1 919-549-8141; Fax: +1 919-549-8933; http://www.aatcc.org. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) Wrinkle Recovery Replica is the trade name of a product supplied by the American Association of Textile Chemists and Colorists. These replicas may be obtained from AATCC Technical Center, One Davis Drive, P.O. Box 12215, Research Triangle Park, North Carolina 27709-2215, USA; Tel: +1 919-549-8141; Fax: +1 919-549-8933; http://www.aatcc.org. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4.3 Lighting and evaluation area, in a darkened room, using the overhead lighting arrangement shown in Figure 3 and comprising the items described in 4.3.1 to 4.3.3.

The lamp dimensions should be chosen to extend beyond the overall surface of the test specimen and replicas, when used for the assessment.

4.3.1 Two cool white (CW) fluorescent lamps, without a baffle or glass, a minimum of 2 m in length each, placed side by side.

4.3.2 One white enamel reflector, without a baffle or glass.

4.3.3 One thick plywood viewing board, painted grey to match the No. 2 rating on the grey scale for assessing staining specified in ISO 105-A03.

The evaluation area shall be maintained under the conditions specified in Clause 5 b).

4.4 Clothes hangers with clips, to hang test specimens for conditioning and grading.

Figure 1 — Wrinkle tester

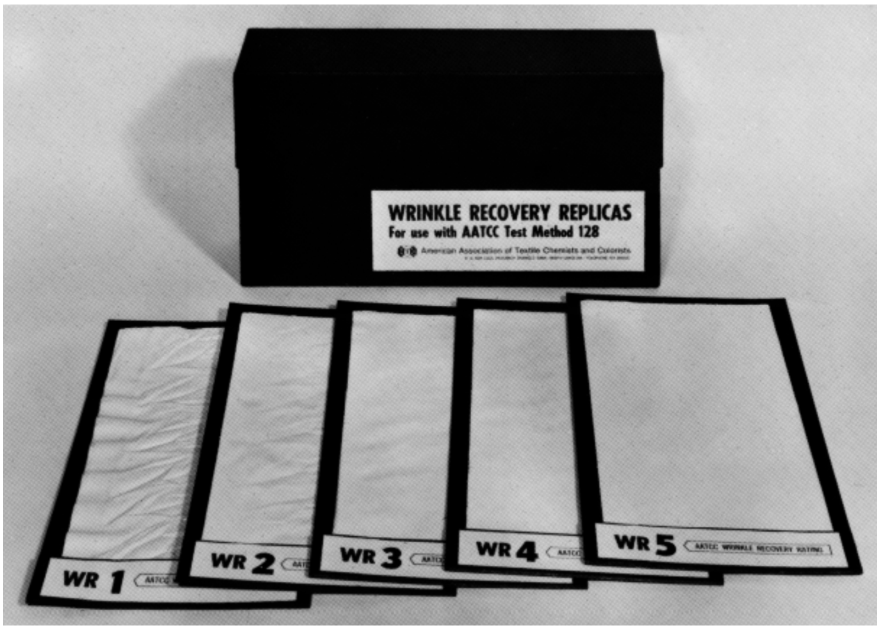
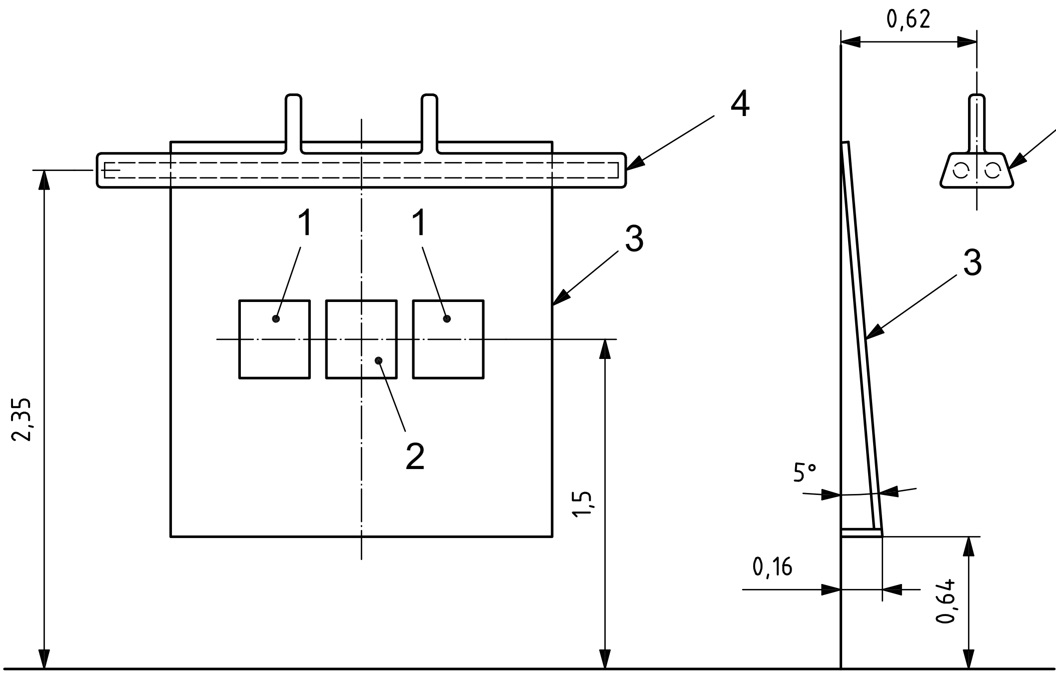


Figure 2 — Wrinkle recovery replicas

Dimensions in metres



Key

1 replica

2 test specimen

3 board for viewing

4 example of fluorescent lamp placement

Figure 3 — Lighting equipment for viewing test specimens

5 Atmospheres for conditioning and testing

Unless otherwise indicated, the following atmospheres, as specified in ISO 139, shall be used:

a) for preconditioning, an atmosphere having a relative humidity of 10 % or lower and a temperature of 50 °C or lower;

b) for conditioning and testing, an atmosphere having a relative humidity of (65 ± 4) % and a temperature of (20 ± 2) °C or (27 ± 2) °C;

c) for alternative standard atmospheres, see ISO 139.

6 Test specimens

6.1 Preparation

From the fabric to be tested, cut three specimens, each measuring 150 mm × 280 mm, and each with the long dimension running in the warp direction of a woven fabric or the wale direction of a knitted fabric. Identify each specimen along one edge of the face side.

Cut the specimens from an area of the fabric that is free from wrinkles. If any wrinkles are unavoidably present in the test specimens, press each specimen lightly with a steam iron before conditioning.

6.2 Conditioning

Precondition and then condition the test specimens in accordance with ISO 139 in the respective atmospheres specified in Clause 5.

7 Procedure

7.1 Raise the top flange of the wrinkle tester (4.1) and hold it in the top position with the locking pin.

7.2 Wrap one long edge (i.e. the 280 mm side) of a preconditioned and conditioned test specimen (see 6.2) around the top flange of the wrinkle tester, with the face side of the specimen on the outside, and clamp it in position using the steel spring and clamp provided. Arrange the ends of the specimen so that they are opposite the opening in the spring clamp.

7.3 Wrap the opposite long edge of the specimen around the bottom flange and clamp it as described in 7.2.

7.4 Adjust the specimen by pulling on its bottom edge so that it lies smooth without sagging between the top and bottom flanges.

7.5 Withdraw the locking pin and lower the top flange gently with one hand until it comes to rest.

7.6 Immediately place a total mass of 3 500 g on the top flange and record the time.

There may be differences in the weights supplied with different wrinkle testers. If necessary, add additional weights to the top flange to achieve a total mass of 3 500 g on the top flange.

7.7 After 20 min, remove the mass, the springs and the clamps. Raise the top flange and gently remove the specimen from the wrinkle tester so as not to distort any induced wrinkles.

7.8 With a minimum of handling, place the shorter edge (i.e. the 150 mm side) under the clips on the clothes hanger (4.4) and allow the specimen to hang vertically in the long direction.

7.9 After 24 h in the standard atmosphere [see Clause 5 b)], gently remove the hanger with the specimen and transfer it to the evaluation area (4.3).

8 Evaluation

8.1 Three trained observers shall rate each test specimen independently.

Since previous tests have proven that specimens change in appearance during the first few hours, it is important that accurate times be observed and that a minimum time elapse while the three observers are evaluating the specimens. Because of these changing conditions, the duration of recovery before rating for this method has been standardized at 24 h.

8.2 Mount the test specimen on the viewing board as illustrated in Figure 3, with the warp or wale direction vertical. Place three-dimensional wrinkle recovery replicas (4.2), one on each side of the test specimen, to facilitate comparative rating. Mount replicas 1, 3 or 5 on the left side and 2 or 4 on the right side.

The overhead fluorescent light shall be the only light source for the viewing board, and all other lights in the room shall be turned off.

It has been the experience of many observers that light reflected from the side walls near the viewing board can interfere with the rating results. It is recommended that the side walls be painted black, or that blackout curtains be mounted on either side of the viewing board, to eliminate reflective interference.

8.3 The observer shall stand directly in front of the specimen, 1,22 m away from the bottom front of the board.

NOTE It has been found that normal variations in the height of the observer above and below the arbitrary 1,50 m eye level have no significant effect on the rating given.

8.4 Assign the number of the replica which most closely matches the appearance of the test specimen (see Table 1).

NOTE A No. 5 rating is equivalent to the WR-5 replica and represents the smoothest appearance and best retention of the original appearance, while a No. 1 rating is equivalent to the WR-1 replica and represents the poorest appearance and poorest retention of the original appearance.

8.5 Similarly, the observer independently rates the other two test specimens. The other two observers proceed in the same manner, assigning ratings independently.

Table 1 — Fabric smoothness ratings

Rating No.	Fabric appearance
5	An appearance equivalent to the WR-5 replica
4	An appearance equivalent to the WR-4 replica
3	An appearance equivalent to the WR-3 replica
2	An appearance equivalent to the WR-2 replica
1	An appearance equivalent to or worse than the WR-1 replica

9 Expression of results

Calculate the average of the nine observations for each sample and express the results to the nearest half-rating.

NOTE Annex A gives a summary of the report of an international interlaboratory study on the wrinkle recovery of fabrics.

10 Test report

The test report shall include the following information:

a) a reference to this International Standard, i.e. ISO 9867:2009;

b) all details necessary for the identification of the sample tested;

c) the average of the nine observations made for each sample, to the nearest half-rating;

d) the conditioning atmosphere used for testing;

e) details of any deviation from the specified procedure.

Annex A
(informative)

Summary of an international interlaboratory study on wrinkle recovery of fabrics

In the spring of 1986, eleven laboratories agreed to participate in an interlaboratory trial to determine the reproducibility of this method. Data was received from nine of the laboratories: in Belgium, South Africa, Sweden, the United Kingdom and five laboratories in the United States.

The within-laboratory variability demonstrated in this study is negligible and, while there is more variability between laboratories, that variability is within statistical control. From the data presented, it can be concluded that this method of test does provide a test procedure which will allow laboratories to compare the wrinkle behaviour of fabrics in a reproducible manner.

NOTE The full study containing all raw data is available from the secretariat of ISO/TC 38/SC 2 (ANSI) upon request.

Annex B
(informative)

Digital description of the ISO wrinkle replicas

B.1 Introduction

This annex provides the digital description of 3-dimensional (3D) replicas. The data are not intended to be used to assess specimens. When assessing specimens, the 3D replicas are to be used.

B.2 Processes of measurement and analysis

B.2.1 A 3-dimensional scanning system was used to measure digital images of ISO wrinkle replicas as shown in Figure B.1. Specifications for the scanning system are given in Table B.1.

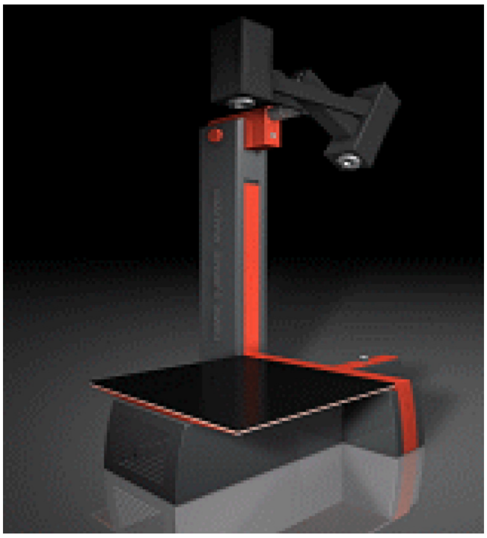


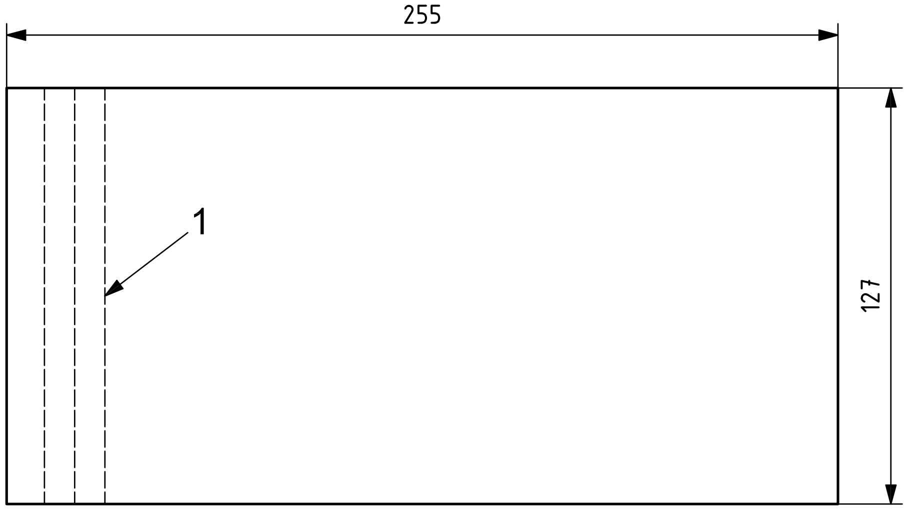
Figure B.1 — 3-Dimensional scanning system

Table B.1 — Specification of the 3-dimensional scanning system

Camera	1024 × 768 pixels, black and white (B/W)
Special pattern	Structural beam by halogen lamp
Adjustment of focus	Using the laser-point light source
Measurement time	Approximately 70 s to 80 s
Resolution	± 0,05 mm

B.2.2 The measuring area is shown in Figure B.2

Dimensions in millimetres

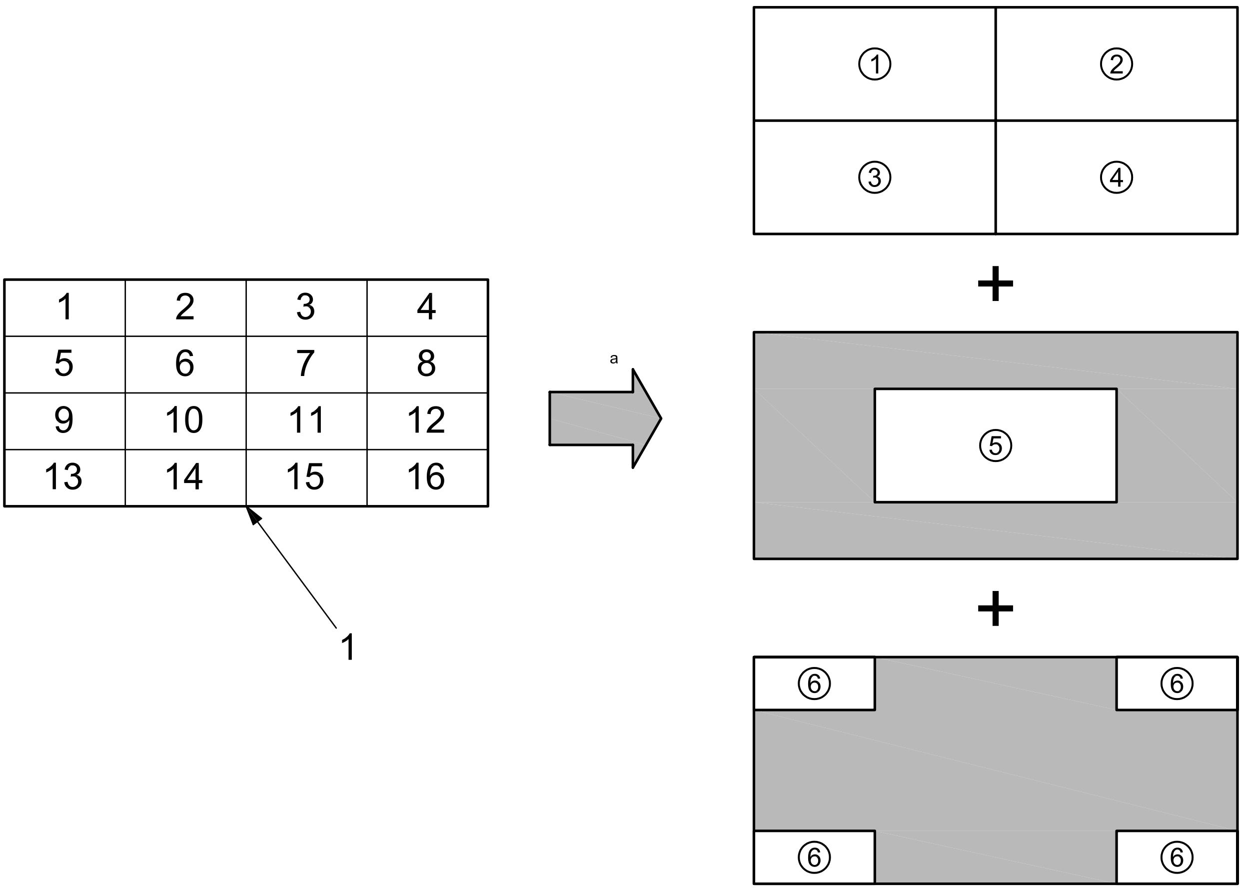


Key

1 measuring lines

Figure B.2 — Measuring area of wrinkle replica

B.2.3 The 3-dimensional measured images are separately stored as six regions to be divided intentionally for analysis. See Figure B.3.



Key

1 measuring area and number of sections

a 6 areas (① to ⑥).

Figure B.3 — Six regions for wrinkle replica analysis

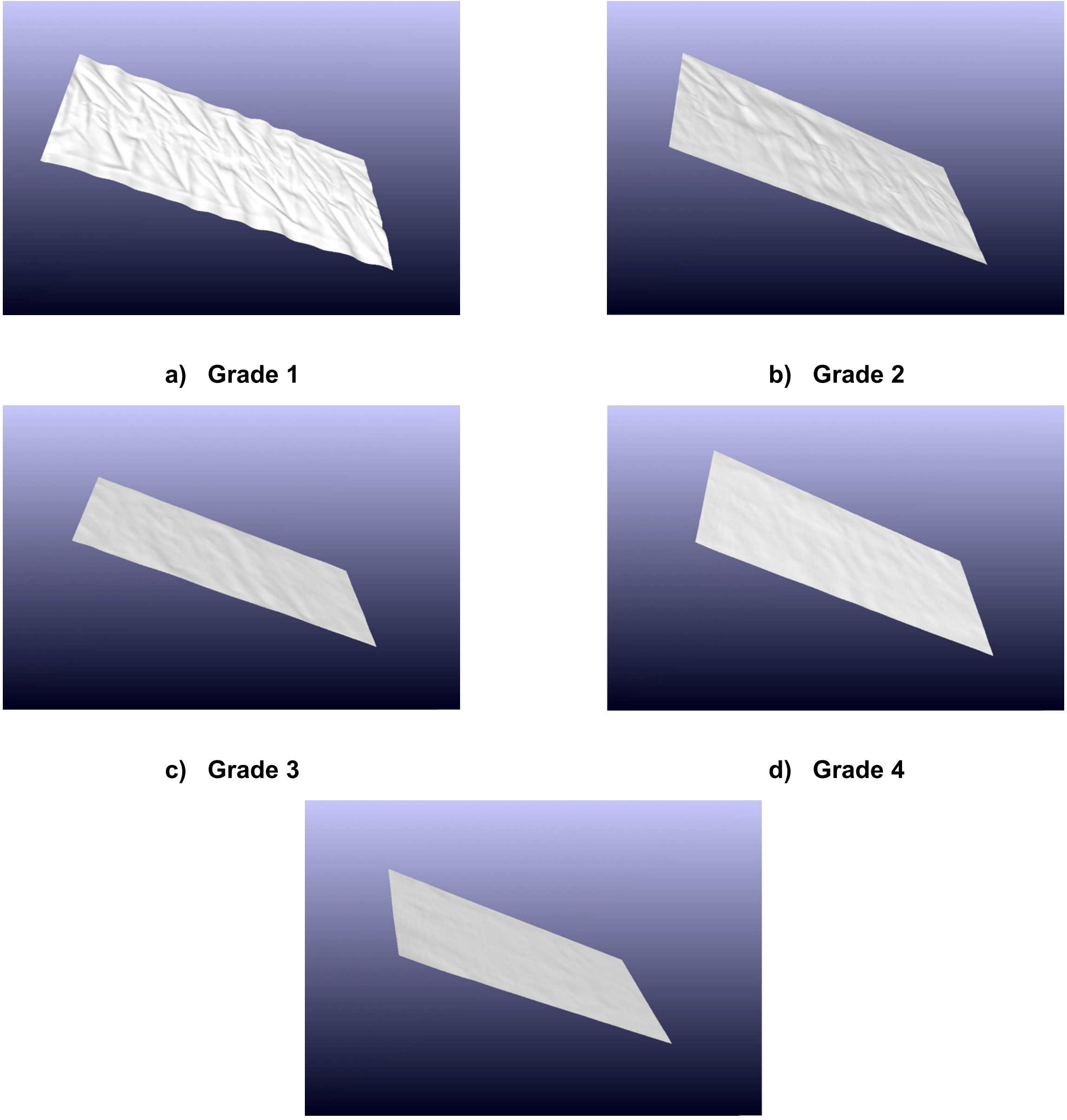
B.2.4 A geometric shape of each standard replica is measured using a 3-dimensional laser scanning system at an interval of 1 mm. The number of measuring points along each line is determined by the intervals.

To analyse the replicas, define six shape parameters that have an influence on the grade of replica. These parameters are mean values of heights, maximum values of heights, variation of heights, mean values of height frequency, maximum values of height frequency and variation of height frequency. For each region, six parameters can be obtained.

B.3 Analysis of wrinkle with 1 mm measurements

B.3.1 Measured images of wrinkle replicas

Figure B.4 shows measured images of wrinkle replicas using a 3-dimensional scanning system at intervals of 1 mm.



a) Grade 1

b) Grade 2

c) Grade 3

d) Grade 4

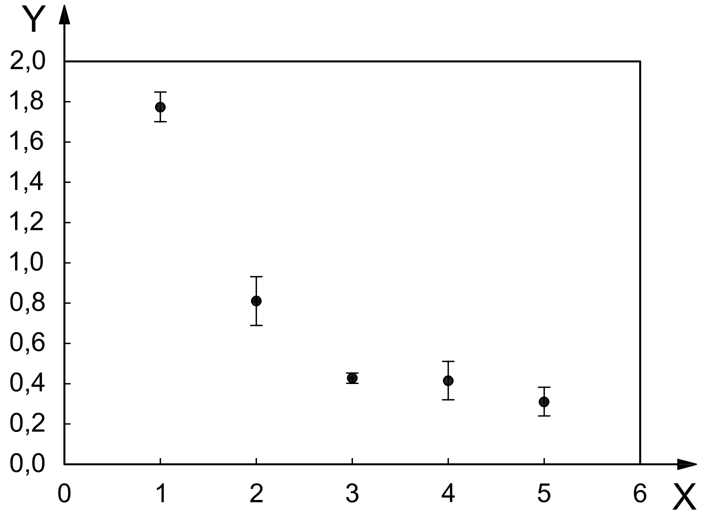
e) Grade 5

Figure B.4 — Measured images of wrinkle replicas

B.3.2 Analysis of parameters

B.3.2.1 Mean value of height ($\bar{h}$)

An Analysis Of Variance (ANOVA) test and Tukey's method were performed to confirm differences in this parameter between grades. From the results of the ANOVA test, the difference in grades was confirmed at the 95 % confidence level. The results of Tukey's method indicated no significant differences between grades 3 and 4 and between grades 4 and 5. The parameter is transformed to a logarithmic form to minimize this actual state. The transformed parameter is also analysed with the ANOVA test and Tukey's method. While differences in the transformed parameter between grades are again confirmed at the 95 % confidence level in the ANOVA test, the difference between grades 3 and 4 remains unconfirmed in the same conditions in Tukey's method. Figure B.5 presents the relationship between wrinkle grade and original mean value of height. Figure B.6 shows the relationship between wrinkle grade and transformed mean value of height.

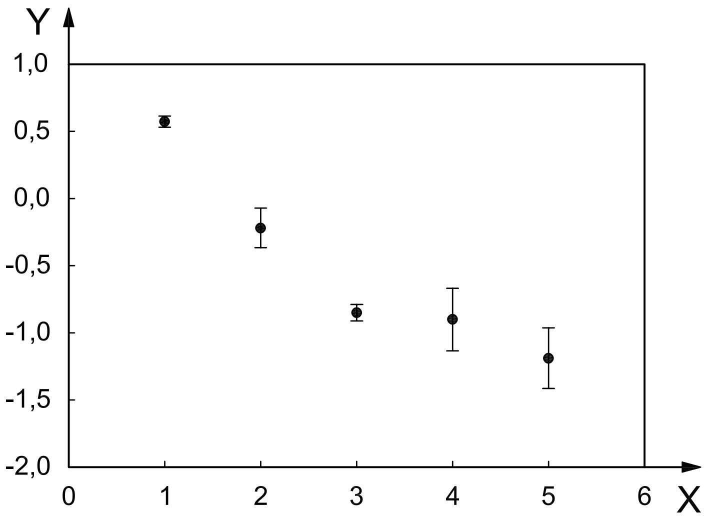


Key

X grade

Y $\bar{h}$

Figure B.5 — Relationship between grade and original $\bar{h}$



Key

X grade

Y ln($\bar{h}$)

Figure B.6 — Relationship between grade and transformed $\bar{h}$

A simple regression analysis is performed to verify the apparent linear relationship between grades of replicas and both the original and transformed mean value of height. From the results of this analysis, the R-squared value of the original data rises from 74,10 % to 84,40 % with the logarithmic transformed data, as given in Table B.2.

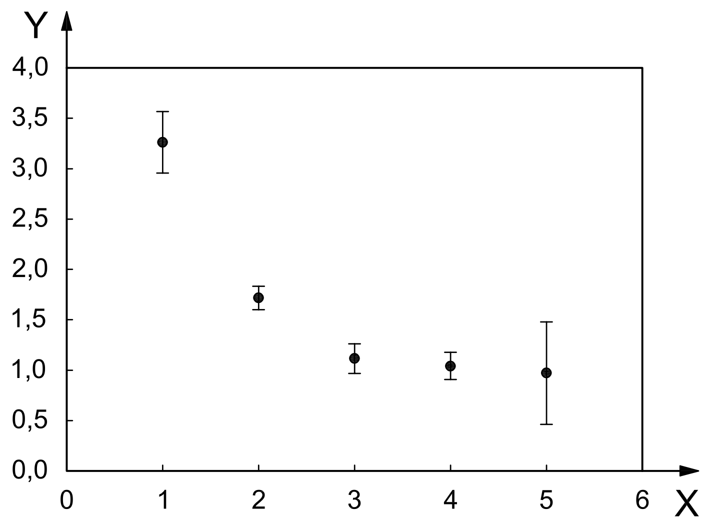
Table B.2 — Results of a simple regression analysis on $\bar{h}$

	Original data	Transformed data
Regression equation	Grade = 4,67 − 2,23 × $\bar{h}$	Grade = 1,96 − 2,01 × ln($\bar{h}$)
R-squared value	74,10 %	84,40 %

B.3.2.2 Maximum value of height (h_{max})

An ANOVA test and Tukey's method were performed to confirm any difference of this parameter between grades. While the difference was confirmed at the 95 % confidence level with the ANOVA test, grades 3 and 4, grades 3 and 5 and grades 4 and 5 were clearly not classified in a way comparable with Tukey's method. As with the mean value of height, the maximum value of height parameter was also transformed to a logarithmic form and analysed with the ANOVA test and Tukey's method. While the difference of the transformed maximum value of height between grades is confirmed at the 95 % confidence level in the ANOVA test, the differences between grades 3, 4 and 5 are still not confirmed at the 95 % confidence level with Tukey's method.

Figure B.7 shows the relationship between the wrinkle grade and the original maximum value of height. Figure B.8 shows the relationship between the wrinkle grade and the transformed maximum value of height.

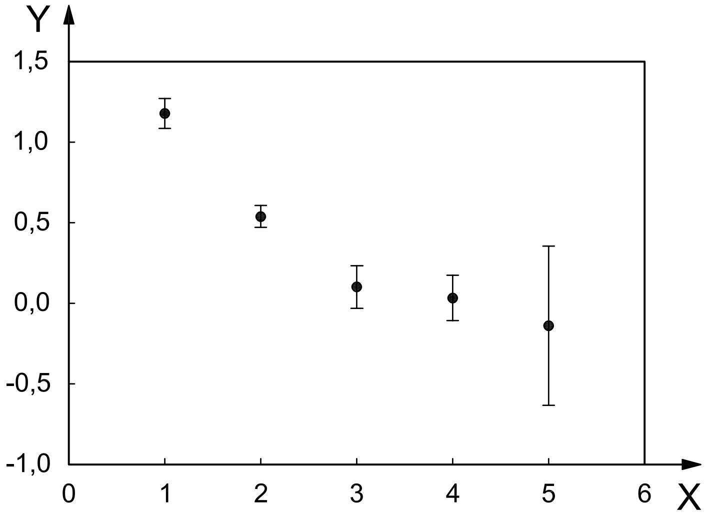


Key

X grade

Y h_{max}

Figure B.7 — Relationship between grade and original h_{max}



Key

X grade

Y $\ln(h_{max})$

Figure B.8 — Relationship between grade and transformed h_{max}

A simple regression analysis is performed to confirm the linear relationship between the grade of replicas and both the original and transformed maximum value of height. The results indicate that the R-squared value with the original data rises from 68,30 % to 72,00 % with the logarithmic transformed data, as given in Table B.3.

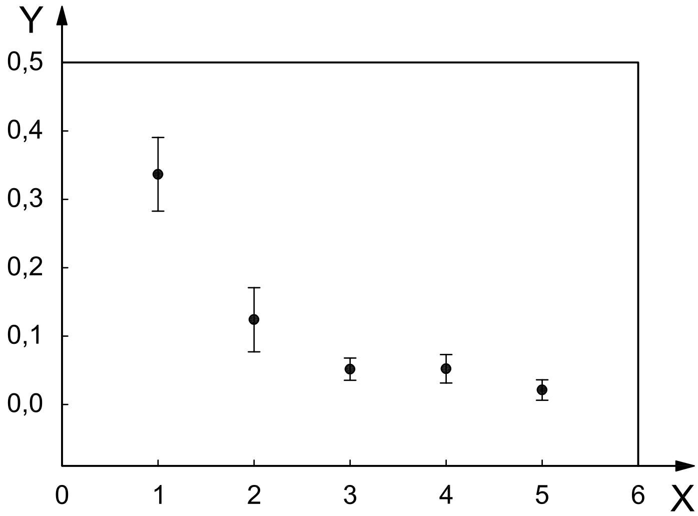
Table B.3 — Results of a simple regression analysis on h_{max}

	Original data	**Transformed data**
Regression equation	Grade = 5,10 − 1,30 × h_{max}	Grade = 3,79 − 2,29 × ln(h_{max})
R-squared value	68,30 %	72,00 %

B.3.2.3 Variation of height (h_{var})

The ANOVA test and Tukey's method were performed to confirm differences in the variation of height between grades.

While the difference between grades is confirmed at the 95 % confidence level with the ANOVA test, the difference between grades 3 and 4 and grades 4 and 5 is not confirmed at the 95 % confidence level with Tukey's method, as was the case with the mean value of height. Each value was also transformed to a logarithmic form, and similar analyses were conducted. While the ANOVA test with transformed data has results that are equivalent to the original data, the differences between grades 2 and 3 and grades 3 and 4 are still not confirmed at the 95 % confidence level with Tukey's method for the transformed data. Figure B.9 shows the relationship between the wrinkle grade and the original variation of height. Figure B.10 shows the relationship between the wrinkle grade and the transformed variation of height.

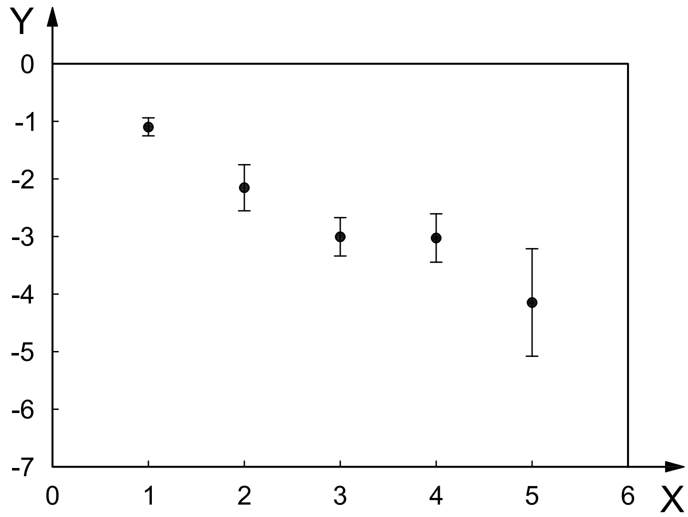


Key

X grade

Y h_{var}

Figure B.9 — Relationship between grade and original h_{var}



Key

X grade

Y In(h_{var})

Figure B.10 — Relationship between grade and transformed h_{var}

Both the original and transformed data were again analysed using simple regression analysis to verify the linear relationship between both grades and the variation of height. From the results, the R-squared value with the original data rises from 69,90 % to 77,40 % with the logarithmic transformed data, as given in Table B.4.

Table B.4 — Results of a simple regression analysis on h_{var}

	Original data	Transformed data
Regression equation	Grade = 4,16 − 9,90 × h_{var}	Grade = 0,017 − 1,11 × ln(h_{var})
R-squared value	69,60 %	77,40 %

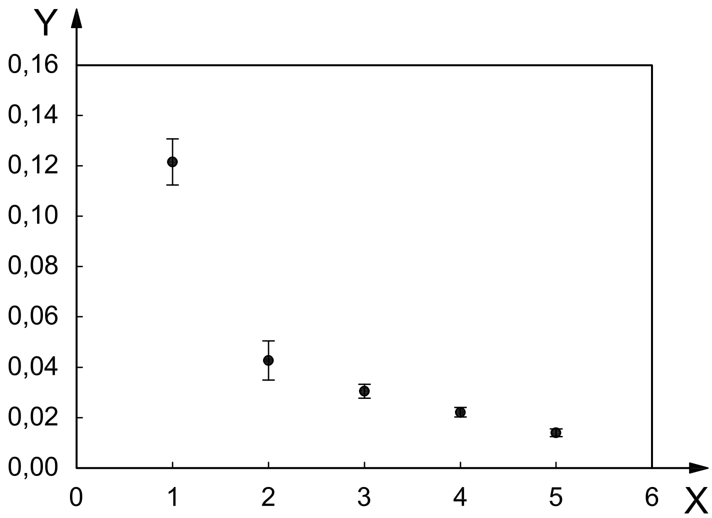
B.3.2.4 Mean value of height frequency ($d\bar{h}$)

The ANOVA test and Tukey's method were performed to confirm differences in the mean value of height frequency between grades.

While the difference between grades was confirmed at the 95 % confidence level with the ANOVA test, grades 3 and 4 and grades 4 and 5 are not classified at the 95 % confidence level with Tukey's method.

Each value was also transformed to its natural logarithmic form, and similar analyses were performed.

With the ANOVA test and Tukey's method, all grades with transformed data are clearly distinguished at the 95 % confidence level. Figure B.11 shows the relationship between the wrinkle grade and the original mean value of height frequency. Figure B.12 shows the relationship between the wrinkle grade and the transformed mean value of height frequency.

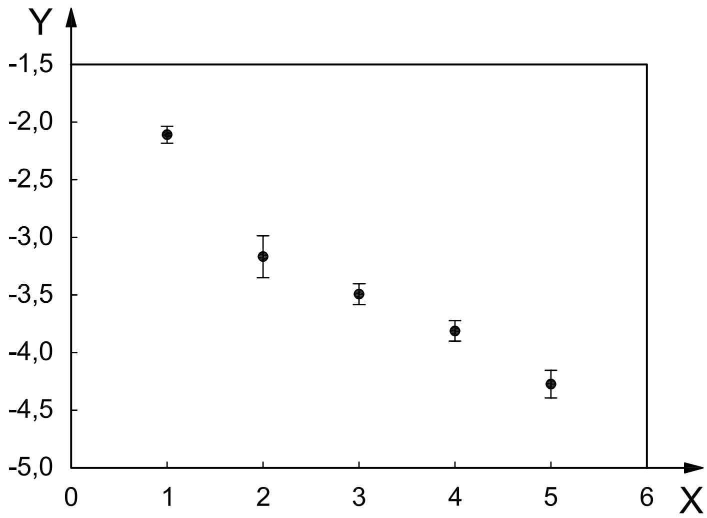


Key

X grade

Y $d\bar{h}$

Figure B.11 — Relationship between grade and original $d\bar{h}$



Key

X grade

Y $\ln(\mathrm{d}\bar{h})$

Figure B.12 — Relationship between grade and transformed $\mathrm{d}\bar{h}$

Both the original and transformed data were analysed with the simple regression analysis to verify the linear relationship between grades and the mean value of height frequency of both the original and transformed data.

From the results of this analysis, the R-squared value with the original data increases from 72,20 % to 91,10 % with the transformed data, as given in Table B.5.

Table B.5 — Results of a simple regression analysis on $\mathrm{d}\bar{h}$

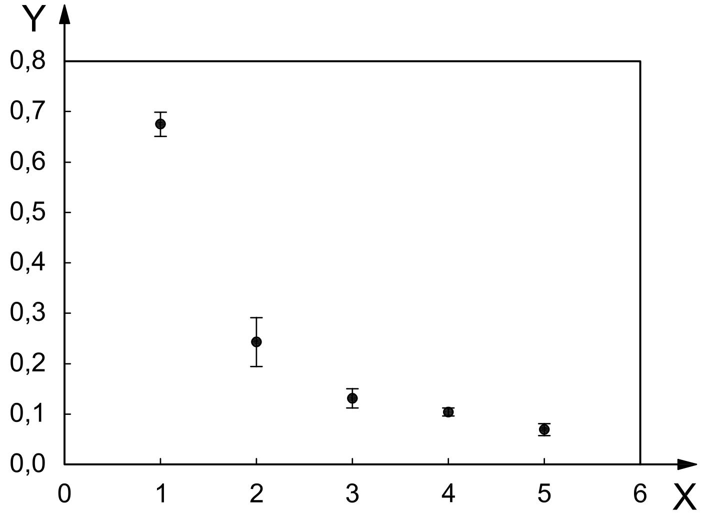
	Original data	**Transformed data**
Regression equation	Grade = 4,42 − 30,70 × $\mathrm{d}\bar{h}$	Grade = −3,18 − 1,83 × $\ln(\mathrm{d}\bar{h})$
R-squared value	72,20 %	91,10 %

B.3.2.5 Maximum value of height frequency ($\mathrm{d}\bar{h}_{max}$)

The ANOVA test and Tukey's method were performed to confirm the difference in the maximum value of height frequency between grades. While the difference between grades was confirmed at the 95 % confidence level with the ANOVA test, grades 3 and 4 and grades 4 and 5 are not distinguished at the 95 % confidence level with Tukey's method. Each value was transformed to a logarithmic form and an identical analysis was conducted.

While the difference between grades was confirmed at the 95 % confidence level with the ANOVA test, grades 3 and 4 were still not distinguished at the 95 % confidence level with Tukey's method.

Figure B.13 shows the relationship between the wrinkle grade and the original maximum value of height frequency. Figure B.14 shows the relationship between the wrinkle grade and the transformed maximum value of height frequency.

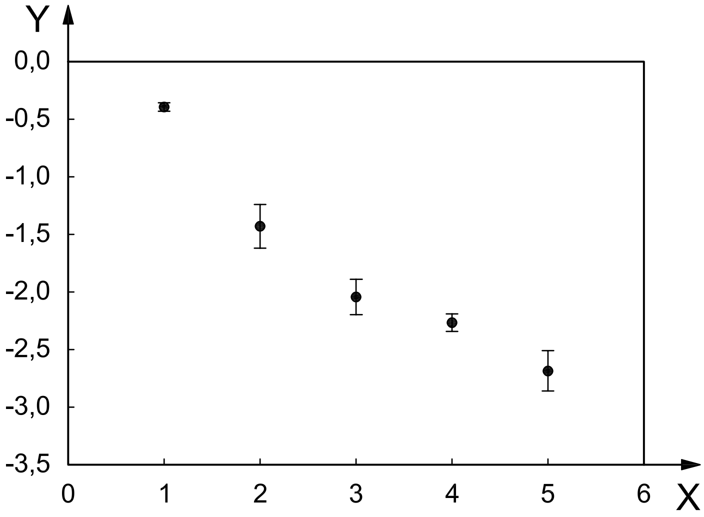


Key

X grade

Y dh_{max}

Figure B.13 — Relationship between grade and original dh_{max}



Key

X grade

Y ln(dh_{max})

Figure B.14 — Relationship between grade and transformed dh_{max}

Both the original and transformed data were also analysed with the simple regression analysis to verify the linear relationship between grades and the maximum value of height frequency of both the original and transformed data.

The results indicate that the R-squared value using the original data increases from 72,50 % to 90,40 % with the transformed data, as given in Table B.6.

Table B.6 — Results of a simple regression analysis on $\mathrm{d}h_{max}$

	Original data	**Transformed data**
Regression equation	Grade = 4,31 − 5,37 × $\mathrm{d}h_{max}$	Grade = 0,058 − 1,67 × ln($\mathrm{d}h_{max}$)
R-squared value	72,50 %	90,40 %

B.3.2.6 Variation of height frequency ($\mathrm{d}h_{var}$)

The variation value of height frequency between grades 4 and 5 is almost zero. Therefore, the relationship between this parameter and the grades could not be proven.

B.3.3 Multiple regression analysis

A multiple regression analysis was performed with the six parameters given in B.3.2 to produce an objective wrinkled-sample rating equation. The results are given in Table B.7. The R-squared value is 74,10 %, which suggests that this regression equation is valid at the 95 % confidence level. All the logarithmically transformed parameters were also analysed with the multiple regression analysis.

Table B.7 — Results of the multiple regression analysis

Multiple regression with the original data (R^2)	74,10 %
Multiple regression with the transformed data (R^2)	92,40 %

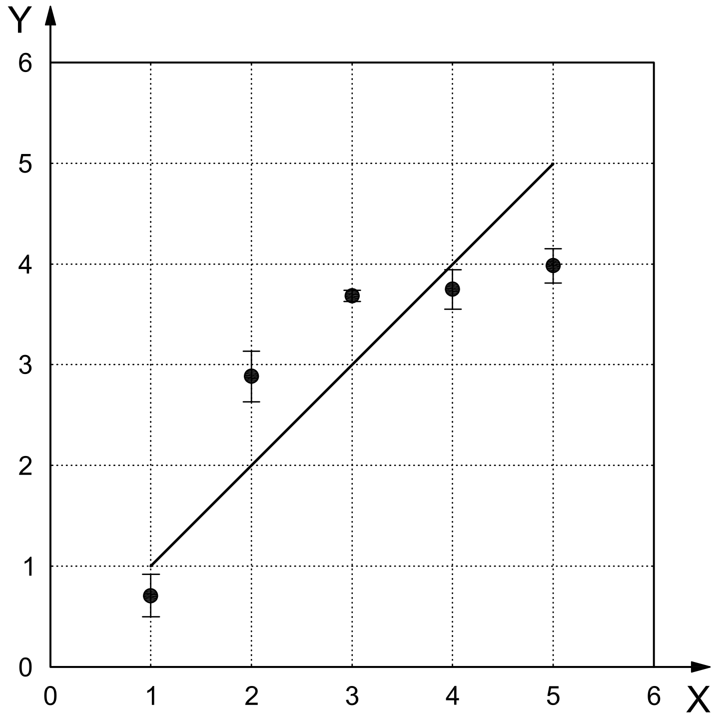
Using two regression equations with both original and transformed values, the subjective and objective grades were compared. A correlation analysis was performed to verify and compare these equations.

Table B.8 gives the correlation coefficients between the objective and subjective grades obtained from each equation. Figures B.15 and B.16 show the relationship between the subjective grade and objective wrinkle grade obtained from the regression equation.

The results indicate that the regression equation specifying the transformed parameters is more useful than that using the original data.

Table B.8 — Results of the correlation analysis

Regression with the original parameters	0,950
Regression with the logarithmic transformed parameters	0,974



Key

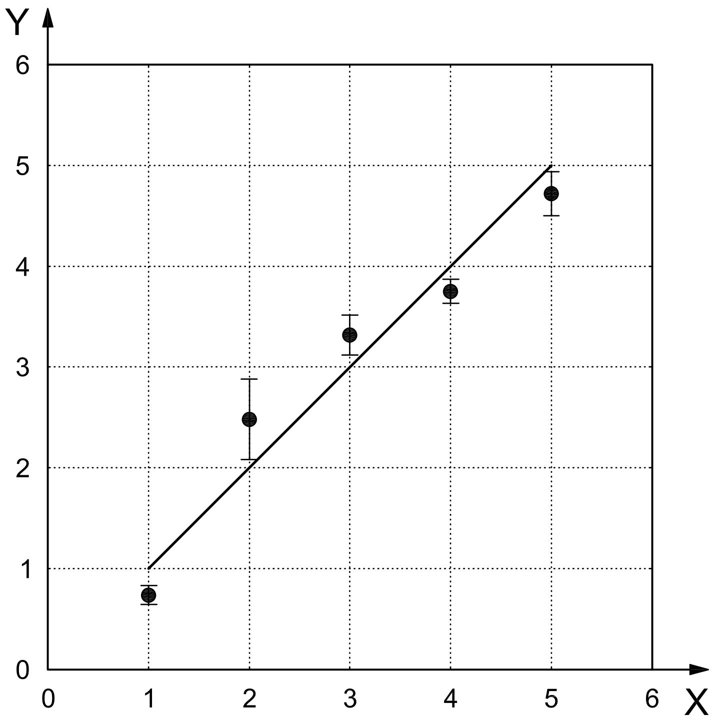
X subjective grade

Y original objective grade

— Y = X

● subjective grade vs the original objective grade

Figure B.15 — Relationship between subjective grade and objective grade with original data



Key

X subjective grade

Y transformed objective grade

— Y = X

● subjective grade vs transformed objective grade

Figure B.16 — Relationship between subjective grade and objective grade with transformed data

B.4 Conclusion

Six parameters of height and frequency distribution were determined from the images of replicas, and statistical analyses were performed. The ANOVA test results proved that these logarithmically transformed parameters have strong linearity with the grade of replicas. Multiple regression equations were obtained using these parameters. The results of this analysis indicated a strong linear relationship between the grades of replica and the parameters.

The multiple regression equation with the same parameters was also used to obtain an objective wrinkle grade. High correlations between the objective and subjective grades of wrinkle samples were proved. It can be conclusively confirmed that the current ISO wrinkle replicas are suitable for a subjective rating evaluation.

Bibliography

[1] AATCC TM 128, *Wrinkle Recovery of Fabrics: Appearance Method*

ICS 59.080.30

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