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**BUREAU OF INDIAN STANDARDS**

**AGENDA**

**First Working Group Meeting for "Preparation of Working draft for Smoothness test for fabrics" under TXD 01, Physical Methods of Test Sectional Committee**

| Date/Day | Time | Venue |
|---|---|---|
| 08 November 2024 (Friday) | 1100 hr | Through Video Conferencing |

**CONVENER**: Dr M. S. Parmar **MEMBER SECRETARY**: Shri Amit Kumar Pandey

**ITEM 0 WELCOME AND INTRODUCTORY REMARKS BY THE CONVENER**

**ITEM 1 COMPOSITION OF WORKING GROUP TXD 01/WG 01**

**1.1** The composition of the working group is given as follows:

i) Dr M. S. Parmar, NITRA, Ghaziabad (*Convener*)
ii) Dr Sanjeev Shukla, NITRA, Ghaziabad
iii) Dr T. Senthilkumar, ICAR-CIRCOT, Mumbai
iv) Dr A. Arputharaj, ICAR-CIRCOT, Mumbai
v) Ms Seema Patel, WRA, Thane
vi) Shri Mayur Basuk, WRA, Thane
vii) Shri Amit Kumar Pandey, Member Secretary (Textiles)

**ITEM 2 PREPARATION OF WORKING DRAFT FOR SMOOTHNESS TEST FOR FABRICS**

**2.1** In the 27$^{th}$ meeting of TXD 01, the committee had scrutinized the proposal received for formulation of Indian Standard on "Test method for smoothness characteristics for fabrics". After detailed deliberations, the committee decided to constituted a working group to prepare the working draft for Smoothness test for fabrics under the convenorship of Dr M. S. Parmar based on his expertise in the relevant field.

**2.1.1** The proposal received from NITRA, Ghaziabad for formulation of Indian Standard on "Test method for smoothness characteristics for fabrics" is given in **Annex 1 (Pages 2 to 4)**. A working draft prepared by BIS in consultation with Dr M.S. Parmar, NITRA, Ghaziabad is given in **Annex 2 (Pages 5 to 15)**. A comparative data of the Smoothness results received from Smoothness tester developed by NITRA, Ghaziabad and surface roughness results received from KAWABATA EVALUATION SYSTEM KES-FB-4 is given in **Annex 3 (Pages 16 to 19)**. The test reports of specimens tested on Smoothness tester developed by NITRA as received from NITRA, Ghaziabad is given in **Annex 4 (Pages 20 to 21**).

**2.1.2** The Working Group may **DELIBERATE** and **DECIDE**.

**Annex 1**

( *Item* 2.1.1 )

**PROFORMA FOR PROPOSING NEW SUBJECTS FOR NATIONAL STANDARDIZATION**

| | | |
|---|---|---|
| 1 | Proposer Name & Complete Contact Details including Phone no and Email ID. | Dr. M.S.Parmar, NITRA, Sector-23, Rajnagar, Ghaziabad-201002, U.P, 0120-2783586, drmsparmar@nitratextile.org, mail@nitratextile.org |
| 2 | Proposed Title of the standard (Indicate whether the standard required is for product specification/methods of test/code of practice and define the subject in brief) | **Title: Method for determination of smoothness characteristics of fabric (sheet form) -Test method**<br><br>This test method provides the scope of quantification of smoothness property of fabric using an indigenously developed cost-effective smoothness tester. The data generated by this instrument shall help the finishers to take appropriate decision to alter the recipe or process to meet the required smoothness characteristics of the fabric. |
| 3 | Scope of the proposed standard (Define the limits to be considered) | 1.1 This standard prescribes a method for determination of smoothness behavior of fabrics including woven, knitted and sheet form.<br>1.2 This test standard also specified the type of apparatus to be used for the determination smoothness behavior of fabric.<br>1.3 This test method may not appropriate for materials that demonstrate extensive compressive properties or having pile structure. |
| 4 | Purpose and Justification | Fabric smoothness-roughness has been considered as one of the most important factors of clothing comfort. It is also a significant factor in consumer buying decision. Fabric smoothness behaviour is influenced by many factors like weave particular, yarn characteristics finishing treatments etc. These all factors may increase or decrease the fabric surface friction behavior, which ultimately influence fabric surface smoothness property. Fabric friction, which is defined as the resistance to motion, can be detected when a fabric is rubbed mechanically against itself or tactually between the finger and thumb. Friction is considered to be one property of cloth which has considerable importance in the fields of both technological and subjective assessment. |

| | | |
|---|---|---|
| | | Subjective assessment which specifies the fabric handle, is undoubtedly influenced by the static and dynamic friction between the cloth surface and the thumb or finger, although other properties are also involved in the assessment. The human finger is a sensitive instrument capable of detecting small differences in the frictional behavior of fabrics.<br><br>Objective measurement of the frictional properties of fabrics helps in clear communication and the optimization of a particular process. It is well known that there are always disputes between buyer and manufacturer regarding feel of fabric as there is no cost-effective quantitative method is available which can spell out the feel of the particular fabric.<br><br>This test method provides the scope of quantification of smoothness property of fabric using an indigenously developed cost-effective smoothness tester. The data generated by this instrument shall help the finishers to take appropriate decision to alter the recipe or process to meet the required smoothness characteristics of the fabric. |
| 5 | Likely users of standards and their inputs | Textile Finishers, Garment and textile Exporter, defence textile supplier, Kids wear manufacturers |
| 6 | Any related standard/series of standard/system standard required to make this subject standard complete | NA |
| 7 | When the final Standard would be required *( any time limit)* | Within 3 months |
| 8 | Any specific problem being faced without this standard | As there is no test standard is available, fabric feel/smoothness is not being given. Even in the BIS standards on fabrics, this property is shown in the limitation of the scope. |
| 9 | Bearing with Govt legislation regulation, etc | NA |
| 10 | Name and address of manufacturers/implementing industries/purchasing organization/component supplier/raw material supplier, if any | The instrument used in the smoothness testing is developed by NITRA under the Ministry of Textiles, Govt of India, sponsored project |
| 11 | Status of the industry in the country | NA |
| 12 | Availability of test facilities in the country | Not available as this is first time developed in India. |
| 13 | Whether related to variety reduction, export, health, safety consumer protection, mass consumption, energy conservation, technology transfer, technology upgradation | It is related to Textile and garment export. It is also related to technology transfer. |

| | | |
|---|---|---|
| | protection of environment & other national priorities. | |
| 14 | Relevant supportive document/*other national/international standards, company standard, technical & research papers, etc* if any *(Please give reference or attach a copy)* | Attaching conference paper presented in Functional Textiles & Clothing, 9-12 Feb 2018, IIT, New Delhi, India |
| 15 | R&D work done in India | The work is done at NITRA, Ghaziabad |
| 16 | Any foreign collaboration (give details) | No |
| 17 | Liaison with any organisation(s) | Tested sample of various Textile Industries |
| 18 | Preparatory work:<br>a) whether draft attached<br>b) whether outline attached and draft can be prepared<br>c) no draft possible, if so, why ? | Draft is attached |
| 19 | Whether this project can be funded by your organization or can it be sponsored by industry/ association/professional bodies/ministry? If yes, to what extent? | It is funded by Ministry of Textiles, Govt of India. 50% grant given by Ministry of Textiles, Govt of India and rest by NITRA |
| 20 | Whether your organisation would be interested to opt for BIS Standard Mark once the standard is published? | Yes |
| Signature: | | |

*Note:*

*i) It is desirable that information is provided by the proposer for all items of the proforma; in any case information against item 1 to 5 must be provided.*

*ii) Write `NA' wherever not applicable.*

*iii) Add separate sheet to elaborate.*

**Annex 2**
( *Item* 2.1.1 )

**Preliminary Draft**

**भारतीय मानक ब्यूरो**

**BUREAU OF INDIAN STANDRADS**

*Draft For Comments Only* Doc: TXD 01 (xxxxx)P
xxxx 2024

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*भारतीय मानक* मसौदा

# वस्त्रादि — कपड़ों की स्मूथनेस विशेषताएं — परीक्षण पद्धतियाँ

Draft *Indian Standard*

# TEXTILES — SMOOTHNESS CHARACTERISTICS OF FABRIC — METHODS OF TEST

ICS 59.080.30

| | |
|---|---|
| Physical Methods of Test Sectional Committee<br>TXD 01 | Last date for receipt of comments<br>xx xxx 2024 |

FOREWORD

**(***Formal clauses will be added later***)**

Fabric smoothness-roughness has been considered as one of the most important factors of clothing comfort. Fabric smoothness behavior is influenced by many factors like weave particular, yarn characteristics, finishing treatments etc. These all factors may increase or decrease the fabric surface friction behavior, which ultimately influence fabric surface smoothness property. Fabric friction, which is defined as the resistance to motion, can be detected when a fabric is rubbed mechanically against itself or tactually between the finger and thumb. Friction is considered to be one property of cloth which has considerable importance in the fields of both technological and subjective assessment.

Subjective assessment of fabric handle is strongly influenced by the static and dynamic friction between the cloth surface and the thumb or finger, although other properties also play a role. The human finger, highly sensitive, can detect small differences in fabric frictional behavior, yet disputes often arise between buyers and manufacturers over the 'feel' of fabric. This is due to the lack of a cost-effective quantitative method that can accurately represent

the tactile properties. Objective measurement of fabric friction properties would facilitate clearer communication and help optimize specific processes.

This test method provides the scope of quantification of smoothness property of fabric using an indigenously developed smoothness tester. The data generated by this instrument will help the finishers to take appropriate decision to alter the recipe or process to meet the required smoothness characteristics of the fabric.

The procedures for calibration of Smoothness tester developed by NITRA is given in Annex A. The test results of smoothness characteristics of cotton fabric at various processing stages are given in Annex C for information only.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.

Draft *Indian Standard*

# TEXTILES — SMOOTHNESS CHARACTERISTICS OF FABRIC — METHODS OF TEST

## 1 SCOPE

**1.1** This standard prescribes a test method for determination of smoothness characteristics of fabrics including woven and knitted.

**1.2** The test method prescribed in this standard may not be appropriate for fabrics that exhibits extensive compressive properties or have pile structure.

## 2 REFERENCES

The Indian Standards given below contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

| *IS No.* | *Title* |
|---|---|
| IS 196 : 2024 | Atmospheric Conditions for Testing (*first revision*) |
| IS 6359 : 2023 | Method for conditioning of Textiles (*first revision*) |
| IS 6489 (Part 1): 2011 | Textiles - Tear properties of Fabrics Part 1- Determination of Tear Force using ballistic pendulum method (Elmendorf) |

## 3 TERMS AND DEFINITIONS

For the purposes of this standard, the following definitions shall apply.

**3.1 Time Required in Stopping Pendulum** — It is a time in milliseconds taken by the pendulum assembly to stop on the arc type platform.

**3.2 Smoothness Grading** — The time required to stop pendulum is converted into grading. The smoothness grading is given in 1 to 5 scales. Smoothness grade-1 means fabric surface is very rough (smoothness is very poor), smoothness grade-5 means fabric smoothness is excellent. Complete grading system for smoothness characteristics of woven and knitted fabric is given in Table 1 and Table 2 respectively.

## 4 PRINCIPLE

This test method is based on the pendulum principle. In this method, a constant weight is subjected to swing too and fro as a pendulum on the test specimen and the time taken in stopping the weight due to reduction in the amplitude of the swing with surface friction is

measured. Higher the surface friction of the test specimen, lesser will be the time taken in stopping the weight and vice versa. The time taken in stopping the weight is then corelated with the grading system given in Table 1 and Table 2 for determining the smoothness characteristics of fabric. A typical illustration of working principle of the test method is given in Figure 1.

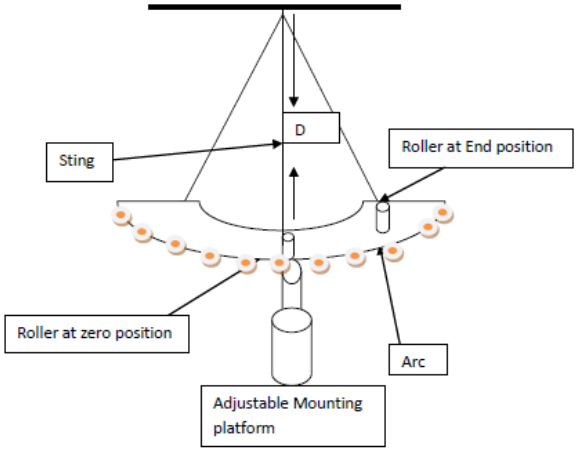



FIG.1 A TYPICAL ILLUSTRATION OF WORKING PRINCIPLE

## 5 SAMPLING

**5.1** Select samples either in accordance with the procedure laid down in the material specification for the fabric or agreed between the interested parties.

**5.2** In the absence of an appropriate material specification, an example of a suitable sampling procedure given in Annex B may be followed.

## 6 PREPARATION OF TEST SPECIMEN

**6.1** Take the sample to be tested for smoothness characteristics and iron it so that there shall not be any crease/wrinkle.

**6.2** Cut at least 10 specimens each from lengthwise (warp wise or course wise) and widthwise (weft wise or wale wise) with dimensions 10 cm x 20 cm respectively.

NOTE - Utmost care shall be made while cutting specimen from the sample. Sample shall be cut straight keeping in mind warp or course and weft or wale lines.

## 7 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

Prior to test, the specimens shall be conditioned to moisture equilibrium in the standard atmosphere of (65 ± 2) percent relative humidity and 27 °C ± 2 °C temperature from dry side as laid down in IS 6359 and the test shall be carried out in the standard atmosphere (*See also* IS 196). It is recommended that samples be conditioned for at least 24 h in the relaxed state.

## 8 APPARATUS

### 8.1 Fabric Smoothness tester

The smoothness tester should include three chambers namely top, middle and bottom chamber which comprises of the following:

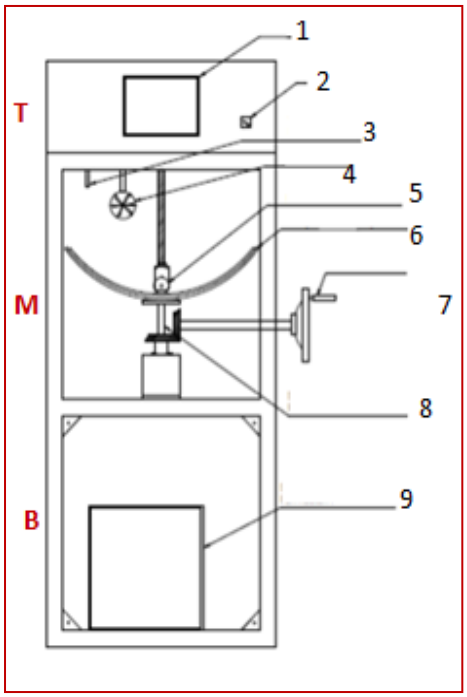
**8.1.1 Top chamber (T) -** This chamber accommodates display unit, on/off switch, geared motor with electromagnetic clutch, press button to actuate pendulum, rotor encoder in order to measure angle/amplitude and programmable logic controller (PLC) to control various parameters such as humidity, temperature etc. The display unit reflects information pertaining to humidity, amplitude, time of completion of cycle, air velocity etc. The on/off switch is provided to switch on or off the said apparatus. The geared motor with electromagnetic clutch controls oscillation of the roller hanging from the roof of the middle chamber with a rod.

The roller hanging from the roof by means of rod causes whole assembly to oscillate about the equilibrium position by swinging back and forth. This oscillation takes place with the help of geared motor. The electromagnetic clutch play role to shift the roller assembly at the maximum angle on one side. When this roller assembly attains the maximum angle, it is released by means of a release button. Upon release of the assembly, it starts oscillating about the equilibrium position swinging back and forth. Said rotary encoder is provided to measure angle/amplitude of the roller assembly.

**8.1.2 The middle chamber (M)** embodies temperature and humidity sensor, Anemometer, revolving roller assembly, Arc type sample holder and screw arrangement and height adjustment.

**8.1.3 Bottom chamber (B):** This chamber houses steam generator to generate steam for changing humidity. Beside the above three chambers, an air conditioning unit is also employed with the apparatus to maintain required temperature in the course of the testing.

> **NOTE** — The schematic diagram of Fabric smoothness tester developed by NITRA (Northern Textile Research Association), Ghaziabad, U.P, India. is shown in Figure 2.




Keys:

1. Display unit
2. Switches
3. Temperature and Humidity sensor
4. Anemometer
5. Revolving roller assembly
6. Arc type specimen holder
7. Screw arrangement
8. Height adjustment
9. Steam Generator

FIG. 2 SCHEMATIC DIAGRAM OF FABRIC SMOOTHNESS TESTER DEVELOPED BY NITRA

## 9 PROCEDURE

**9.1** First of all Pendulum assembly is moved upward to ensure that it is not touching the arc type platform, which also acts as specimen holding device and having sufficient distance from arc type platform so that the test specimen can be mounted easily on the platform using specimen holder.

**9.2** Mount the specimen on the arc type platform using specimen holder ensuring that there shall not be any crease/fold/wrinkle on the specimen.

**9.3** Lower the pendulum assembly slowly using load cell adjustment wheel so that it touches the specimen. Apply required load on the specimen using load cell. The recommended load shall be 400 ± 20 grams.

**9.4** For knitted fabric or samples having high extensibility, instead of using sample holder, use 51 ± 1 mm width binder clip on all four sides of the fabric specimen with total load 400 ± 20 grams (per side per clip having hanging weight, shall be 100 g including clip weight).

**9.5** Push the start button so that the pendulum device starts swinging to and fro on the arc type platform. After pushing the start button, time measuring device also start simultaneously. It measures time in milliseconds. Note down the reading. Repeat this procedure for all the specimens. Take average of all 10 readings of each side. Convert it into grading as per given in **Table 1** and **Table 2**.

NOTE- If any of the reading deviate from $\bar{x} \pm 3\sigma$, then the same shall be discarded and fresh sample shall be taken for further testing.

**Table 1 Smoothness Grading Table for Woven Fabric**

( *Clauses* 3.2, 9.5, 10 )

| **Sl No.** (1) | **Time (millisec) to stop pendulum** (2) | **Smoothness grade** (3) |
|---|---|---|
| i) | Up to 400 | Grade 1 (Very poor) |
| ii) | 401 to 500 | Grade 2 (Poor) |
| iii) | 501 to 600 | Grade 3 (Good) |
| iv) | 601 to 700 | Grade 4 (Very good) |
| v) | > 701 | Grade 5 (Excellent) |

**Table 2 Smoothness Grading Table for Knitted Fabric**

( *Clauses* 3.2, 9.5, 10 )

| **Sl No.** (1) | **Time (millisec) to stop pendulum** (2) | **Smoothness grade** (3) |
|---|---|---|
| i) | Up to 300 | Grade 1 (Very poor) |
| ii) | 301 to 400 | Grade 2 (Poor) |
| iii) | 401 to 500 | Grade 3 (Good) |
| iv) | 501 to 600 | Grade 4 (Very good) |
| v) | > 601 | Grade 5 (Excellent) |

## 10 CALCULATION

The calculation of smoothness characteristics are based on mean of at least 10 test specimen readings, each side (lengthwise and widthwise) of time taken to stop pendulum device in milliseconds.

The mean value of these reading is converted into smoothness grading as per Table 1 and Table 2.

## 11 TEST RESULTS

The test report shall include the following information:

a) Type of sample i.e. woven or knitted
b) Side of surface taken for test
c) Number of test specimens and if needed, number of tests rejected with reasons.
d) Mean of 10 readings of specimen for time taken to stop pendulum device in milliseconds in lengthwise and widthwise.
e) the coefficient of variation of time taken to stop pendulum device, in percentage.
f) Grading of smoothness (Specimen - lengthwise and widthwise).
g) Any deviation from the test procedure

**ANNEX A**

( Foreword )

## ADJUSTMENTS AND CALIBRATION OF FABRIC SMOOTHNESS TESTER

**A-1** With the pendulum in the raised position, starting position, check the alignment of the arc type platform. For this purpose, lower the pendulum device in such a way that the wheel provided at lower end start touching the center position of arc type platform. At this position the weight impose on the center position of arc type platform shall be 0.4 kg using load cell. Now move this whole pendulum assembly on the arc type platform by hand and note down the readings of weight displayed on the displayed unit. Change in reading at any place shall not be more than ± 20 grams than the center position. If change in reading is more than ± 20 grams, adjust the platform.

**A-2** The metallic wheel provided at the end of the pendulum device shall be smooth, scratch free and free to move. To check its proper working, a polyester transparent film of same size of arch type platform shall be taken and fix over the platform using tapes. Tape shall not be put in middle part of the film otherwise movement of wheel may hinder and true reading of smoothness of film may not reflect. Push the start button so that the pendulum device starts swinging to and fro on the arc type platform. Measure the total time taken by the pendulum device to stop. Note down the reading. Repeat this procedure 10 times on the same polyester transparent film. Take average of all 10 readings. If any of the individual value deviate from the mean by ± 20 %, the complete set of values shall be discarded and fresh reading on a new polyester transparent film shall be taken. This average of the 10 readings in millisec shall be 2600 ± 5%. The above procedure shall be followed for any subsequently working on the apparatus.

NOTES –

**1** This is an important part of the apparatus which actually touch the specimen and move on the specimen. If some scratches are found then it may be electroplated, to have a smooth and clear surface.

**2** Oddy overhead projector polyester film of 100 micron shall be used for the verification of the apparatus.

**A-3** The levelness of the apparatus is essential. Movement of the instrument during the swinging of the pendulum device is significant source of error. Securely anchor the apparatus so that it is sufficiently rigid and that there shall not be perceptible movement of the apparatus during the swing of the pendulum device. Adjust the apparatus accordingly to the built-in level.

**A-4** Whole assembly shall be placed in the closed chamber so there shall not be any effect of air current.

## ANNEX B

( *Clause* 5.2, Foreword )

## RECOMMENDATORY SAMPLING PROCEDURE

**B-1 Bulk sampling (Number of pieces taken from shipment or lot)**

Take at random from the shipment or lot the appropriate number of pieces shown in the table 3. Ensure that no piece shall show signs of damage or dampness incurred during transit is included in the bulk sample.

**Table 3 Bulk Sampling**

( *Clause* B-1 )

| Sl No. | Number of pieces in shipment or lot | Number of pieces comprising bulk sample, *Min.* |
|---|---|---|
| (1) | (2) | (3) |
| i) | 3 or less | 1 |
| ii) | 4 to 10 | 2 |
| iii) | 11 to 30 | 3 |
| iv) | 31 to 75 | 4 |
| v) | 76 or more | 5 |

**B-2 Number of laboratory samples**

From each piece in the bulk sample, if it is a fabric roll, cut (from a position taken at random but at least 3 meters from the end piece) a laboratory sample of length at least 1/2 meter and full width. Ensure that areas that are creased or that have a visible fault, or faults, are not included in the laboratory sample.

If the test is carried out on a garment, at least three garments from same lot shall be taken and specimen is cut from all the three garment samples.

## ANNEX C

( *Foreword* )

## EXAMPLE FOR TESTING FABRIC SAMPLES

**C.1** To further explain testing procedure, an example of cotton fabric is taken over here. For the study, 100% cotton grey fabric was desized, singed, scoured, bleached and mercerized in the mill using standard recipe. The mercerized fabric sample was given various finishing treatments. All these samples were evaluated for smoothness characteristics using NITRA-Fabric smoothness tester. The results are shown in Table-4 and Table-5 with smoothness grade.

**Table 4 Smoothness Behavior of Cotton Fabric at Various Stages of Wet Processing**

| Sl. No. | Time required to stop pendulum, millisecond | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Gray | | Singed | | Desized | | Scoured | | Bleached | | Mercerized | |
| | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt |
| i) | 470 | 420 | 419 | 411 | 519 | 449 | 448 | 439 | 432 | 439 | 599 | 559 |
| ii) | 486 | 434 | 429 | 419 | 519 | 419 | 439 | 440 | 418 | 438 | 539 | 569 |
| iii) | 488 | 428 | 439 | 418 | 518 | 459 | 439 | 438 | 428 | 420 | 599 | 559 |
| iv) | 447 | 430 | 418 | 429 | 528 | 479 | 440 | 448 | 438 | 428 | 589 | 569 |
| v) | 445 | 440 | 399 | 420 | 529 | 418 | 438 | 439 | 418 | 438 | 560 | 611 |
| vi) | 466 | 430 | 399 | 419 | 519 | 478 | 436 | 449 | 448 | 439 | 539 | 559 |
| vii) | 454 | 434 | 418 | 419 | 519 | 479 | 432 | 448 | 438 | 429 | 500 | 558 |
| viii) | 442 | 442 | 419 | 429 | 522 | 479 | 441 | 438 | 438 | 428 | 579 | 559 |
| ix) | 439 | 438 | 420 | 428 | 519 | 479 | 439 | 449 | 429 | 439 | 500 | 499 |
| x) | 447 | 444 | 429 | 418 | 528 | 468 | 438 | 448 | 419 | 439 | 499 | 499 |
| **Mean** | **458** | **434** | **419** | **421** | **522** | **460** | **439** | **444** | **430** | **434** | **550** | **554** |
| **Grade** | **2** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |

Wp: Waprwise, Wt: Weftwise

**Table 5 Smoothness behaviour after treatment of mercerized cotton fabric**

| Sl.No | Time required to stop pendulum, millisecond | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Treatment-1 | | Treatement-2 | | Treatment-3 | | Treatment-4 | |
| | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt |
| i) | 610 | 602 | 650 | 646 | 710 | 701 | 740 | 680 |
| ii) | 620 | 621 | 652 | 642 | 1720 | 706 | 734 | 688 |
| iii) | 622 | 608 | 640 | 638 | 1725 | 690 | 729 | 690 |
| iv) | 625 | 610 | 642 | 635 | 702 | 698 | 720 | 680 |
| v) | 605 | 615 | 647 | 632 | 704 | 692 | 724 | 682 |
| vi) | 610 | 616 | 646 | 630 | 710 | 696 | 725 | 698 |
| vii) | 609 | 618 | 647 | 640 | 722 | 697 | 722 | 690 |
| viii) | 606 | 610 | 652 | 645 | 710 | 694 | 718 | 675 |
| ix) | 620 | 611 | 654 | 633 | 715 | 699 | 732 | 680 |
| x) | 623 | 612 | 640 | 638 | 716 | 695 | 730 | 682 |
| Mean | **615** | **612** | **647** | **638** | **713** | **697** | **727** | **685** |
| Grade | 4 | 4 | 4 | 4 | 5 | 4 | 5 | 4 |

Wp: Waprwise, Wt: Weftwise

## Annex 3

(*Clause* 2.1.1)

**Table 1 Fabric samples with code number**

| Sample | Code | Sample | Code |
|---|---|---|---|
| Grey | G1 | Jinguard Eco PCD (25g/l) | T5 |
| Singed | S1 | Jinguard Eco PCD (45g/l) | T6 |
| Desized | D1 | DPT (20 g/l) | T7 |
| Scoured | SC1 | DPT (60 g/l) | T8 |
| Bleaching | B1 | DPT (100 g/l) | T9 |
| Mercerized | M1 | ULTRA (30g/l) | T10 |
| Product 6000 (40g/l) | T1 | ULTRA (50g/l) | T11 |
| Product 6000 (50g/l) | T2 | ULTRA (70g/l) | T12 |
| Product 6000 (60g/l) | T3 | Jinsof Eco MAS Conc (40g/l) | T13 |
| Jinguard Eco PCD (5g/l) | T4 | Jinsof Eco MAS Conc (60g/l) | T14 |

**Table 2 Fabric samples properties**

| Sample code | Mass, g/m$^2$ | End /inch | Picks /inch | Tensile strength, N | | Tear strength, g | | Crease Recovery angle (warp + weft), Degree | | Bending length, cm |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Warp | Weft | Warp | Weft | Warp | Weft | |
| G1 | 128 | 120 | 72 | 576 | 259 | 1138 | 569 | 106 | 2.45 | 1.75 |
| S1 | 124 | 122 | 72 | 560 | 270 | 1112 | 536 | 110 | 2.40 | 2.80 |
| D1 | 118 | 126 | 78 | 520 | 230 | 1150 | 720 | 140 | 1.58 | 1.46 |
| SC1 | 124 | 128 | 80 | 580 | 240 | 1064 | 676 | 144 | 1.55 | 1.42 |
| B1 | 126 | 134 | 82 | 600 | 248 | 897 | 640 | 146 | 1.56 | 1.40 |
| M1 | 127 | 136 | 80 | 681 | 258 | 977 | 670 | 156 | 1.40 | 1.38 |
| T1 | 122 | 135 | 70 | 396 | 111 | 1342 | 823 | 173 | 1.26 | 1.16 |
| T2 | 124 | 136 | 72 | 363 | 148 | 1380 | 790 | 178 | 1.22 | 1.12 |
| T3 | 123 | 135 | 72 | 371 | 133 | 1340 | 773 | 180 | 1.18 | 1.10 |
| T4 | 129 | 136 | 71 | 457 | 216 | 918 | 615 | 160 | 1.48 | 1.36 |
| T5 | 121 | 136 | 72 | 452 | 185 | 919 | 652 | 162 | 1.44 | 1.30 |
| T6 | 122 | 135 | 72 | 482 | 195 | 1001 | 685 | 164 | 1.40 | 1.28 |
| T7 | 123 | 132 | 70 | 431 | 197 | 1380 | 892 | 180 | 1.30 | 1.24 |
| T8 | 123 | 132 | 72 | 449 | 164 | 1496 | 940 | 182 | 1.22 | 1.20 |
| T9 | 125 | 132 | 72 | 456 | 156 | 1516 | 947 | 186 | 1.18 | 1.16 |
| T10 | 123 | 136 | 71 | 412 | 176 | 1338 | 913 | 188 | 1.18 | 1.14 |
| T11 | 125 | 135 | 72 | 384 | 160 | 1340 | 849 | 182 | 1.16 | 1.12 |
| T12 | 126 | 136 | 72 | 428 | 167 | 1404 | 821 | 184 | 1.12 | 1.10 |
| T13 | 126 | 136 | 72 | 433 | 176 | 1428 | 959 | 186 | 1.20 | 1.16 |
| T14 | 127 | 135 | 72 | 425 | 186 | 1426 | 949 | 190 | 1.14 | 1.12 |

**Table 4A.** Testing smoothness behaviour of cotton fabric at various stages of wet processing

| S. No. | Time required to stop pendulum, millisecond | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G1 | | S1 | | D1 | | SC1 | | B1 | | M1 | |
| | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt |
| 1. | 470 | 420 | 419 | 411 | 519 | 449 | 448 | 439 | 432 | 439 | 599 | 559 |
| 2. | 486 | 434 | 429 | 419 | 519 | 419 | 439 | 440 | 418 | 438 | 539 | 569 |
| 3. | 488 | 428 | 439 | 418 | 518 | 459 | 439 | 438 | 428 | 420 | 599 | 559 |
| 4. | 447 | 430 | 418 | 429 | 528 | 479 | 440 | 448 | 438 | 428 | 589 | 569 |
| 5. | 445 | 440 | 399 | 420 | 529 | 418 | 438 | 439 | 418 | 438 | 560 | 611 |
| 6. | 466 | 430 | 399 | 419 | 519 | 478 | 436 | 449 | 448 | 439 | 539 | 559 |
| 7. | 454 | 434 | 418 | 419 | 519 | 479 | 432 | 448 | 438 | 429 | 500 | 558 |
| 8. | 442 | 442 | 419 | 429 | 522 | 479 | 441 | 438 | 438 | 428 | 579 | 559 |
| 9. | 439 | 438 | 420 | 428 | 519 | 479 | 439 | 449 | 429 | 439 | 500 | 499 |
| 10. | 447 | 444 | 429 | 418 | 528 | 468 | 438 | 448 | 419 | 439 | 499 | 499 |
| **Average** | **458** | **434** | **419** | **421** | **522** | **460** | **439** | **444** | **430** | **434** | **550** | **554** |
| **Grade** | **2** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |
| **COF*** | **1.50** | **1.52** | **1.51** | **1.50** | **1.37** | **1.48** | **1.53** | **1.57** | **1.53** | **1.52** | **1.29** | **1.26** |

COF* Coefficient of friction by Kawabata analysis

**Table 4B.** Testing smoothness behaviour of cotton fabric at various stages of wet processing

| S. No | Time required to stop pendulum, millisecond | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | T1 | | T2 | | T3 | | T4 | | T5 | |
| | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt |
| 1 | 520 | 516 | 610 | 590 | 625 | 610 | 520 | 540 | 570 | 590 |
| 2 | 518 | 510 | 600 | 565 | 610 | 600 | 510 | 530 | 568 | 580 |
| 3 | 522 | 508 | 612 | 578 | 620 | 605 | 500 | 524 | 570 | 592 |
| 4 | 518 | 512 | 600 | 580 | 604 | 604 | 512 | 530 | 560 | 588 |
| 5 | 514 | 510 | 598 | 588 | 610 | 610 | 514 | 520 | 570 | 578 |
| 6 | 516 | 508 | 604 | 568 | 630 | 612 | 522 | 528 | 580 | 580 |
| 7 | 510 | 512 | 605 | 572 | 628 | 598 | 512 | 530 | 583 | 590 |
| 8 | 512 | 514 | 598 | 570 | 600 | 596 | 514 | 532 | 582 | 579 |
| 9 | 514 | 514 | 594 | 568 | 620 | 600 | 510 | 534 | 560 | 590 |
| 10 | 510 | 516 | 600 | 566 | 628 | 604 | 520 | 540 | 563 | 580 |
| **Avg.** | **515** | **512** | **602** | **574** | **618** | **604** | **513** | **530** | **570** | **584** |
| **Grade** | **3** | **3** | **4** | **3** | **4** | **4** | **3** | **3** | **3** | **3** |
| **COF*** | **1.32** | **1.34** | **1.17** | **1.20** | **1.12** | **1.14** | **1.34** | **1.28** | **1.20** | **1.18** |

COF* Coefficient of friction by Kawabata analysis

**Table 4C.** Testing smoothness behaviour of cotton fabric at various stages of wet processing

| S.No | Time required to stop pendulum, millisecond | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | T6 | | T7 | | T8 | | T9 | | T10 | |
| | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt |
| 1 | 590 | 536 | 510 | 500 | 528 | 490 | 566 | 556 | 604 | 610 |
| 2 | 595 | 528 | 515 | 505 | 526 | 494 | 589 | 594 | 601 | 698 |
| 3 | 578 | 532 | 500 | 498 | 520 | 498 | 590 | 590 | 690 | 690 |
| 4 | 580 | 528 | 598 | 490 | 528 | 510 | 580 | 588 | 610 | 692 |
| 5 | 594 | 526 | 596 | 499 | 520 | 502 | 588 | 558 | 607 | 694 |
| 6 | 586 | 530 | 508 | 506 | 518 | 504 | 502 | 560 | 612 | 689 |
| 7 | 588 | 532 | 506 | 510 | 524 | 506 | 510 | 550 | 580 | 688 |
| 8 | 578 | 540 | 502 | 502 | 522 | 508 | 590 | 548 | 678 | 684 |
| 9 | 580 | 525 | 498 | 596 | 518 | 498 | 592 | 560 | 690 | 601 |
| 10 | 584 | 528 | 512 | 590 | 520 | 502 | 580 | 564 | 678 | 690 |
| **Avg.** | **585** | **530** | **505** | **502** | **522** | **501** | **589** | **567** | **695** | **693** |
| **Grade** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **4** | **4** |
| **COF*** | **1.24** | **1.26** | **1.35** | **1.35** | **1.34** | **1.38** | **1.16** | **1.22** | **1.04** | **1.04** |

COF* Coefficient of friction by Kawabata analysis

**Table 4D.** Testing smoothness behaviour of cotton fabric at various stages of wet processing

| S.No | Time required to stop pendulum, millisecond | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | T11 | | T12 | | T13 | | T14 | |
| | Wp | Wt | Wp | Wt | Wp | Wt | Wp | Wt |
| 1 | 610 | 602 | 650 | 646 | 710 | 701 | 740 | 680 |
| 2 | 620 | 621 | 652 | 642 | 1720 | 706 | 734 | 688 |
| 3 | 622 | 608 | 640 | 638 | 1725 | 690 | 729 | 690 |
| 4 | 625 | 610 | 642 | 635 | 702 | 698 | 720 | 680 |
| 5 | 605 | 615 | 647 | 632 | 704 | 692 | 724 | 682 |
| 6 | 610 | 616 | 646 | 630 | 710 | 696 | 725 | 698 |
| 7 | 609 | 618 | 647 | 640 | 722 | 697 | 722 | 690 |
| 8 | 606 | 610 | 652 | 645 | 710 | 694 | 718 | 675 |
| 9 | 620 | 611 | 654 | 633 | 715 | 699 | 732 | 680 |
| 10 | 623 | 612 | 640 | 638 | 716 | 695 | 730 | 682 |
| **Avg.** | **615** | **612** | **647** | **638** | **713** | **697** | **727** | **685** |
| **Grade** | **4** | **4** | **4** | **4** | **5** | **4** | **5** | **4** |
| **COF*** | **1.12** | **1.14** | **1.08** | **1.10** | **1.02** | **1.04** | **1.01** | **1.06** |

COF* Coefficient of friction by Kawabata analysis

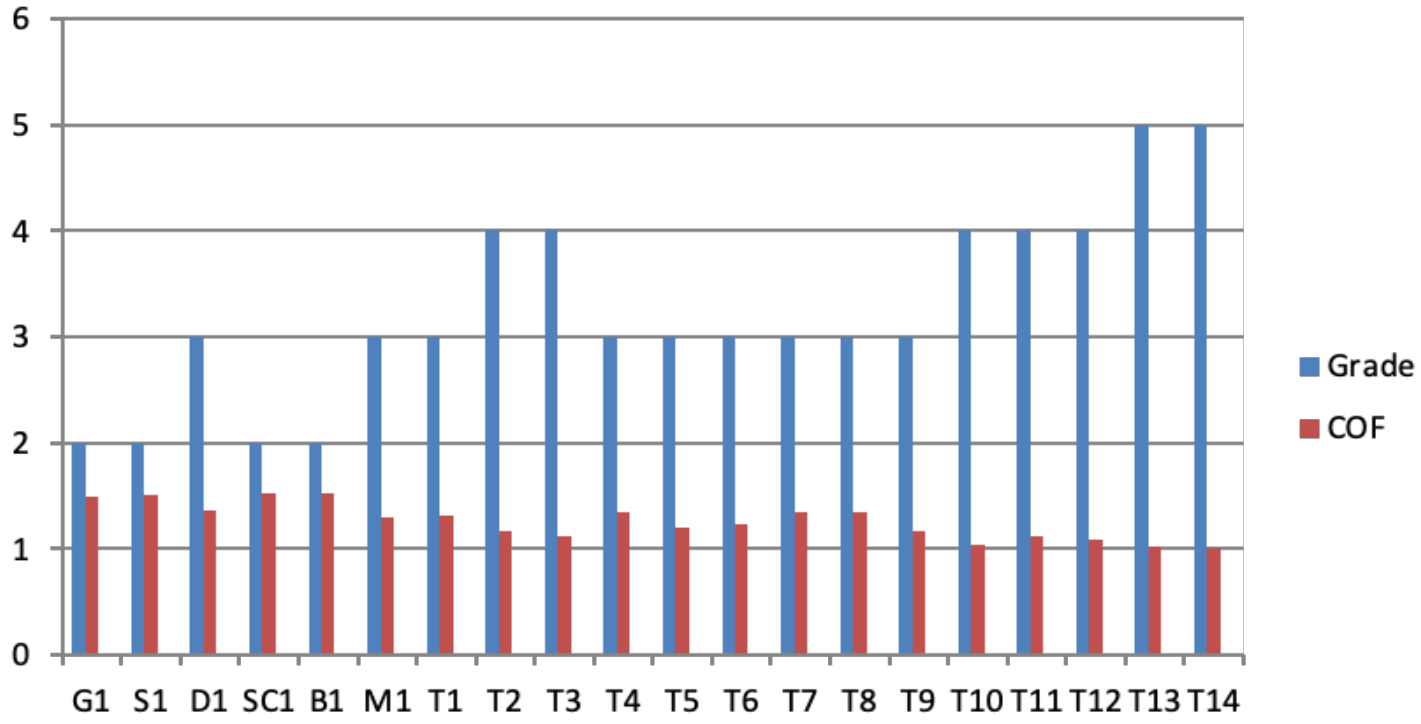



**Figure 3: Smoothnes Grade Vs COF of warpwise fabric samples**

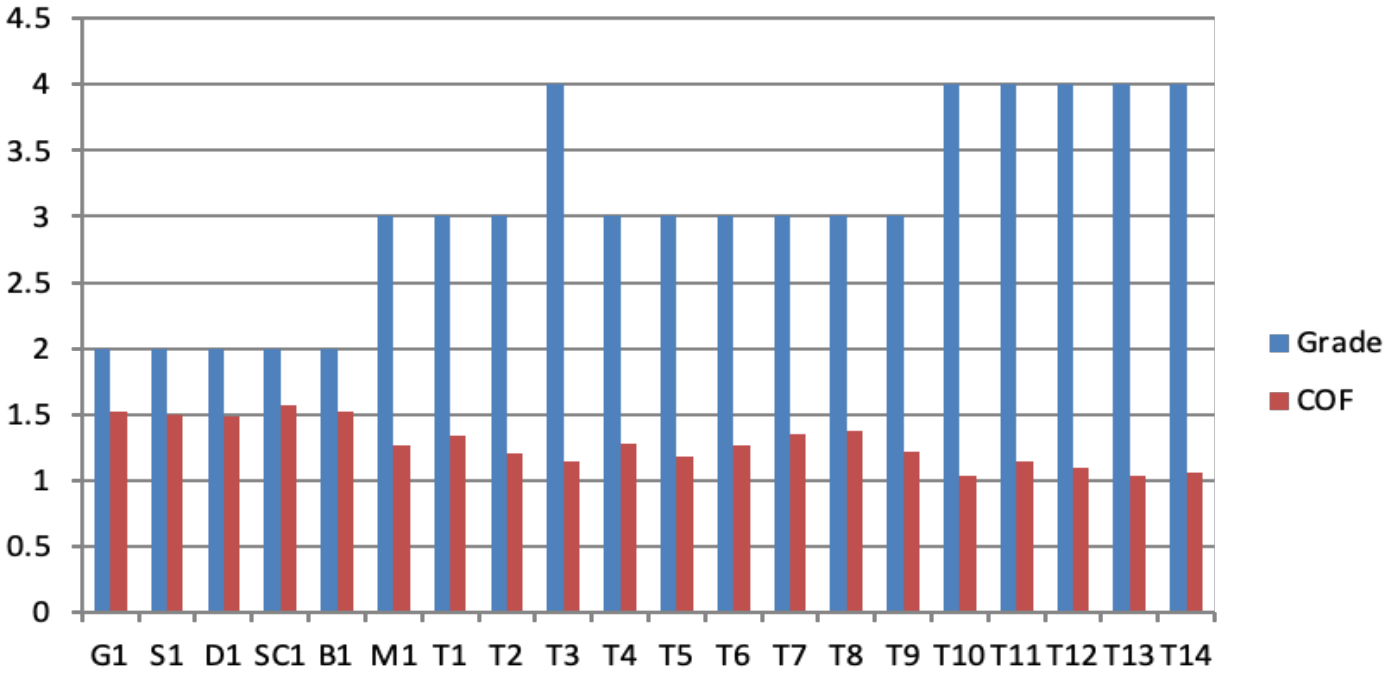



**Figure 4: Smoothness Grade Vs COF of weftwise fabric samples**

## Annex 4

(*Item* 2.1.1)

Sample Code :- Description as per client : **Fabric: Dyed wool.**

| Sl.No. | Test Parameter | Test Method | Unit | Test Results | |
|---|---|---|---|---|---|
| 1 | Smoothness Test | In house method | | **Length Wise** | **Width Wise** |
| | -Specimen 1 | | mili second | **951** | **832** |
| | -Specimen 2 | | mili second | **831** | **892** |
| | -Specimen 3 | | mili second | **833** | **895** |
| | -Specimen 4 | | mili second | **894** | **890** |
| | -Specimen 5 | | mili second | **833** | **900** |
| | -Specimen 6 | | mili second | **832** | **898** |
| | -Specimen 7 | | mili second | **832** | **896** |
| | -Specimen 8 | | mili second | **870** | **880** |
| | -Specimen 9 | | mili second | **894** | **900** |
| | -Specimen 10 | | mili second | **850** | **860** |
| | -Avg. | | mili second | **862** | **884** |
| | -CV | | % | **4.68** | **2.49** |
| | -Max. | | mili second | **951** | **900** |
| | -Min. | | mili second | **831** | **832** |
| | -Grade | | - | **5** | **5** |

Any Observation / Comments : Test condition: Load Applied-400g, Test Room Condition: Temp-27±2°C & Relative humidity= 65±2%

As per a research paper published in the Indian Journal of Fibre & Textile Research (M S Parmar, Nidhi Sisodia & Maheshwar Singh, Development of fabric smoothness tester, Indian Journal of Fibre & Textile Research Vol 45, June 2020, pp. 190-196), the grading system of the fabric samples is given as per the following table:

Time (ms) to stop pendulum ----- Smoothness grade
Up to 400----- Grade 1 (very poor)
401-500 ----- Grade 2 (poor)
501-600 ---- Grade 3 (good)
601-700 ----- Grade 4 (very good)
>700----- Grade 5 (excellent)

**Authorised Signator** **Authorised Signatory**

Sample Code : Description as per client : **Fabric: Silk.**

| Sl.No. | Test Parameter | Test Method | Unit | Test Results | |
|---|---|---|---|---|---|
| 2 | Smoothness Test | In house method | | **Length Wise** | **Width Wise** |
| | -Specimen 1 | | mili second | **1311** | **1431** |
| | -Specimen 2 | | mili second | **1492** | **1493** |
| | -Specimen 3 | | mili second | **1510** | **1500** |
| | -Specimen 4 | | mili second | **1431** | **1435** |
| | -Specimen 5 | | mili second | **1380** | **1491** |
| | -Specimen 6 | | mili second | **1410** | **1510** |
| | -Specimen 7 | | mili second | **1500** | **1490** |
| | -Specimen 8 | | mili second | **1430** | **1460** |
| | -Specimen 9 | | mili second | **1462** | **1495** |
| | -Specimen 10 | | mili second | **1480** | **1510** |
| | -Avg. | | mili second | **1441** | **1482** |
| | -CV | | % | **4.30** | **1.96** |
| | -Max. | | mili second | **1510** | **1510** |
| | -Min. | | mili second | **1311** | **1431** |
| | -Grade | | - | **5** | **5** |

Any Observation / Comments : Test condition: Load Applied-400g, Test Room Condition: Temp-27±2°C & Relative humidity= 65±2%
As per a research paper published in the Indian Journal of Fibre & Textile Research (M S Parmar, Nidhi Sisodia & Maheshwar Singh, Development of fabric smoothness tester, Indian Journal of Fibre & Textile Research Vol 45, June 2020, pp. 190-196), the grading system of the fabric samples is given as per the following table:
Time (ms) to stop pendulum ---------- Smoothness grade
Up to 400------- Grade 1 (very poor)
401-500--------Grade 2 (poor)
501-600-------Grade 3 (good)
601-700--------Grade 4 (very good)
>700-------Grade 5 (excellent)

**Authorised Signator** **Authorised Signatory**

-- End of the Report --