



Faculty of Engineering
Department of Textile Engineering

**Project report on
Comparison among various methods of pilling tests.**

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A thesis submitted in fulfillment of the requirements for the
degree of **M.sc in Textile Engineering**

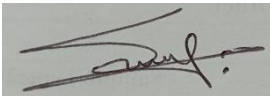
Master of Science in Textile Engineering

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Declaration

I, hereby declare that this thesis (project) has been done by myself under the supervision of my honorable teacher **Mr. Mahbubul Haque**, Department of Textile Engineering, Faculty of Engineering, Daffodil International University. I, also declare that, any part this project has not been submitted elsewhere for any degree. But few parts of others attached here for more clarification with proper reference.

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Letter Of Approval

This thesis (project) report prepared by Nurul Hasanat, Id: 183-32-380 and is approved to fulfillment of the requirement for the degree of Master of Science in Textile Engineering.

The said student has completed his project work under my supervision. During the research period I found him sincere, industrious and passionate.

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A handwritten signature in brown ink, appearing to read 'Mr. Mahbubul Haque', enclosed in a circular stamp.

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Acknowledgement

Firstly, I want to convey my gratefulness to almighty Allah for his amazing blessing to complete this thesis (project) successfully.

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ABSTRACT

The pilling resistance of fabric is an important factor that affects the wear ability of clothing. It is an important criterion to reach the acceptance of buyer. Thus, a variety of methods have been developed to appraise and determinate this property.

Though my work area is related with both knit and woven, here my study is fully based on only knit fabric. Mainly three fabrication is used in my study: Interlock, Fleece & Single jersey. These three types of fabrication tested on four mostly used pilling Machine.

- ICI pilling Machine
- Martindale Pilling Machine
- Random pilling drum Machine
- Random Tumble Pilling Machine

All methods are related with different conditions like testing time, equipment's, and cycle time.

This analytical report will be a guideline for both buyer and different testing institution.

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Chapter-1:

Introduction:

The fuzzing and pilling resistance of fabric is an important factor that affects the wearability of clothing. It will seriously affect the appearance performance of textile fabric. Thus, a variety of methods have been developed to appraise and determinate this property. [1]

Pilling is a phenomenon that ensues during use and washing. Pills are tangled fibres/fibre ends that are stuck to the fabric surface. As we use and move in our clothes, abrasion/rubbing occurs on different surfaces, which leads to that fibres/fibre ends are pulled up from the surface and fuzzing and pills can appear. Textile materials have different ability to form pills and fuzzing, depending on the nature of the fibre/yarn, the fabric's construction and if finished.[2]

When a fabric surface's fibres "tease out" and tangle together while being worn, pills are created. The level of consumer acceptance of a particular level of pilling will vary depending on the type of garment and the intended use of the fabric, but such surface degradation is typically undesirable.

The amount of pilling that forms is influenced by how quickly these parallel processes occur:

- Fibre entanglement leading to pill formation;
- Development of more surface fibre;
- Fibre and pill wear-off.

The characteristics of the fiber, yarn, and fabric determine the rates of these processes. Extreme situations can be found in fabrics with strong fibers versus weak fibers, for example. A result of the strong fiber is a higher rate of pill formation than wear-off. As a result, there is an increase in pilling as wear increases. The rate of pill formation and the rate of wear-off are in competition when the fiber is weak. This would cause the amount of pilling to fluctuate as wear increased. In some other constructions, pill formation happens before surface fibre wear-off. These examples all highlight how difficult it is to assess how the surface changes on various types of fabric.

Here haven't yet created a perfect laboratory test that can accelerate wear processes uniformly for all types of fibers, yarns, and fabrics. However, it has developed a test method that can rank fabrics based on their likelihood of pilling, fuzzing, and matting in a similar way to what happens during real-life use.

There are different types of pilling machines; here are some examples below,

1. Martindale pilling Machine
2. ICI pilling Machine
3. Random drum pilling Machine
4. Random tumble pilling Machine

Chapter-2

Literature Review:

The pilling of textile fabrics is a very complex property because it is affected by many factors which may include type of fiber or blends, fiber dimensions, yarn and fabric construction etc. [3] The level of pilling which develops is determined by the rates of different parallel processes like fibre entanglement, surface fibre, fibre and pill wear-off.

Scientists and researchers have come up with different ways to test and predict how fabrics will perform in terms of pilling. They have developed standard methods that involve using devices to either brush the fabric surface or tumble the fabric randomly. These methods help generate pills and assess the fabric's tendency to pill.

The aim of this work was to compare different testing Machine, to indicate the most suitable Machine for knit fabrics. The considered test machines were:

- Martindale pilling Machine:

The Martindale Rub Test simulates natural wear of fabric when attached to a seat cover (which when testing is placed in the Martindale Machine). The cover is then put through its paces and rubbed with varying levels of force against an abrasive surface. [4]

- Random pilling drum Machine

Marks & Spencer approved drum for pilling. Drum can attach to the M227A/B ICI Pilling Tester. It requires a unique set of sample tubes (106841), Liner and Step for the drum (106885). [5]

- ICI pilling Machine

ICI Pilling Tester is used to assess fabric surface pilling and fuzzing by tumbling randomly. The sample tube with the test sample is placed in the pilling test chamber, the instrument is started, and the sample is flipped and rubbed in the box body. After the number of rollovers is agreed, the sample is taken out for rating. [6]

- Random tumble pilling Machine

The random tumble pilling tester would tumble specimens randomly inside of the lined cylindrical test chamber by with the help of impeller and compressed air. After a certain period, check the textile fabric samples pilling, fuzzing and matting visually. [7]

Factors that influenced to produce pilling:

1. Yarn type and structure

Yarn type can affect pilling insofar as it influences the yarn structure, particularly in terms of the arrangement (orientation) of fibres within the yarn cross-section, the ease with which fibres can migrate to the yarn surface (fibre binding), and yarn hairiness.

2. Yarn linear density (count)

Finer yarns are generally spun to higher twist factors and are converted into fabrics, both knitted and woven, with more yarn cross-over points and shorter float lengths, all factors which contribute towards a lower incidence of pilling.

3. Yarn twist factor

If there exist greater inter fibre friction and cohesion that reduced tendency for fibres to move to the yarn surface and reduced yarn hairiness.

4. Yarn hairiness

An increase in yarn hairiness is generally linked with an increase in pilling.

5. Yarn irregularity

More irregular yarns tend to be linked with increased pilling.

Features of Experiment

The knitted fabric samples: [8]

This research is an associate work of my M.Sc. course. Samples fabrics were collected from EPYLLION FABRIC LTD., which is composite knit dyeing unit of Epyllion Group, Jangalia para, Bangla Bazar, Joydebpur. The reason of behind the sample collection from Epyllion that they are produce the different type of knit products for renowned buyer. The experiment done on below fabrics:

- 63% polyester 33% viscose 4% Elastane Interlock
- 75% cotton 25% polyester, Inside Brush Peach Finish
- 47% cotton 47% modal 6% Elastane, Single Jersey
- 85% cotton 15% polyester, Fleece
- 84% polyester 14% linen 2% lurex

Testing of fabric samples:

The knitted fabric samples were tested at EPYLLION TESTING LAB LTD, which is an In-house laboratory of Epyllion Group and 3rd party laboratory certified and accredited textile testing laboratory in Bangladesh.

Chapter 3: Methodology

3.1 Modified Martindale Method (ISO 12945-2)

This method is developed by Mr. J.G. Martindale. It is the most popular method in the world. First it is used for abrasion resistance, after then some modified versions were used for fabric pilling resistance.

The modified Martindale method is a widely used method to evaluate the pilling resistance of fabrics. In this method, a circular specimen of the fabric is placed on a disc and subjected to a specified number of cycles of mechanical abrasion using abrasive pads. The Martindale Pilling Tester is an instrument used to determine the pilling and abrasion resistance of fabrics according to ISO 12945-2. It consists of a base on which a circular test specimen is mounted using a clamping ring. The specimen is then rubbed against a standard abrasive surface, either a piece of cotton duck fabric or abrasive paper, under a specified pressure and for a specified number of cycles. The pilling and abrasion resistance of the fabric is then evaluated based on the amount of pilling and/or the extent of abrasion observed.



Image of Martindale pilling Machine

3.1.2. Apparatus and Equipment:

1. Martindale abrasion testing Machine it's following the requirements : -
 - i. The two outer synchronized drive units and the central drive unit move the specimen holder guide plate, with a distance of 12.025 mm between the axes of the drive units and their central axes.
 - ii. The specimen holder guide plate's maximum stroke is 24.05mm in both the traverse and length directions.
2. Pilling specimen holders with a mass of $155 \pm 1g$.

3. Auxiliary weights with a mass of $260 \pm 1\text{g}$ (stainless steel discs applied to the specimen holders to give a combined mass of $415 \pm 2\text{g}$).

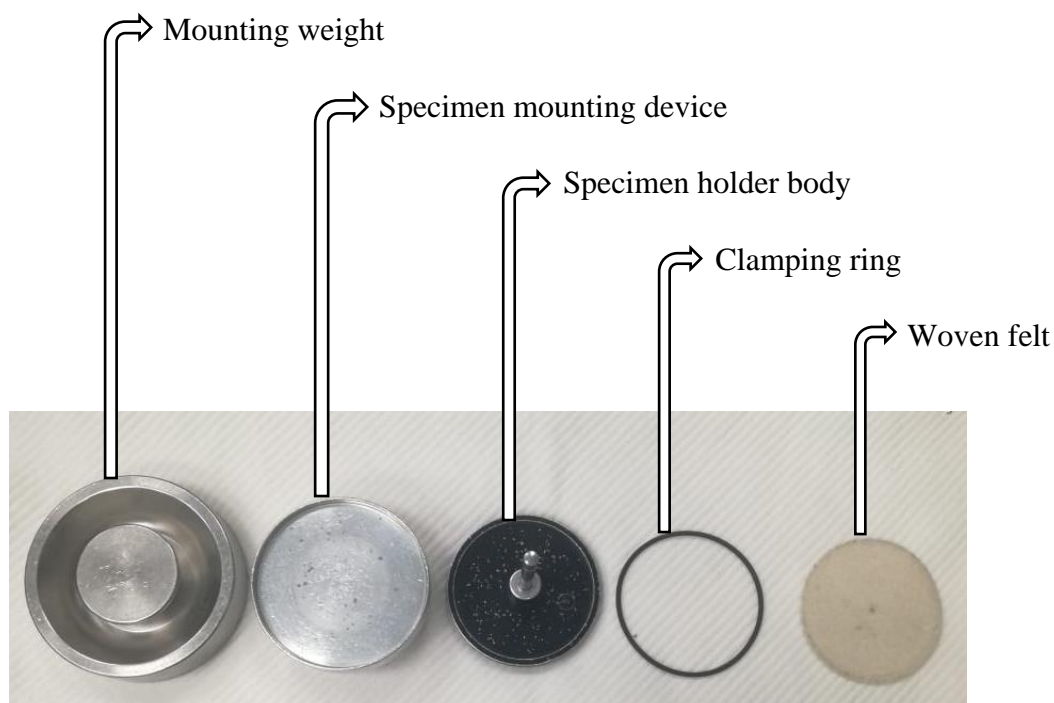


Fig-Some Machine tools

4. Mounting device.
5. Woven Wool Felt as specification, cut into pieces 104.0 -104.5 mm in diameter, or length and width, for the bottom (pilling table) and pieces $90 \pm 1\text{mm}$ in diameter for the specimen holders.
6. Wool abradant fabric if required (commonly known as repp) as specification cut into pieces at least 140mm in diameter, or length and width (used for upholstery fabrics and when specified by retailers).
7. Specimen holder rings.
8. Pilling assessment viewer (see Fig 3) situated in a darkened room.
9. Card for mounting tested samples.
10. Conditioned room controlled to $20 \pm 2^\circ\text{C}$ and $65 \pm 2\% \text{RH}$

3.1.3 Quality Control:

- i. Ensure equipment is in calibration.
- ii. Ensure that specimens are flat, not stretched or distorted and without creases.

- iii. Felt should be replaced when it becomes heavily stained, soiled, worn or otherwise damaged.
- iv. New supplies of the wool abrasant fabric (if used) should be checked using a standard fabric before use.
- v. Ensure that new abrasant is used for every test (when used).
- vi. Ensure that specimen holder rings have not perished (i.e., are flexible enough to hold specimen securely).
- vii. All areas should be clean and tidy to prevent contamination.

3.1.4 Sample preparation:

- i. If required, launder or dry-clean the sample before preparing the specimens.
- ii. Ideally the sample should be conditioned for at least 16 hours before or after specimen preparation.
- iii. Cut 3 specimens 140.0-140.5mm in diameter for the specimen holders. Cut one additional specimen and retain this for assessment purposes.
- iv. If the test is to be carried out against self-fabric cut a further 3 specimens at least 140.0mm in diameter, or 150 ± 2 mm in length and width for the abrading tables. Note For some end uses (or if specified) abrasant is used on the bottom abrading tables in place of the specimen fabric (see Table 1).
- v. Mark the direction of the fabric on the back of each specimen but DO NOT mark the test area of the specimen. These marks will ensure that the test specimens are aligned in the same orientation for assessment. Note: No specimen shall be cut from within 100mm of a selvedge.



Sample preparation Figure

I. Machine set up (see Fig 1 & 2)

- i. Ensure that the Martindale testing Machine is set to the pilling mode.
- ii. Lift the top plate away from the abrading tables.
- iii. Remove the abrasant clamping rings.
- iv. Place a piece of felt 140.0-140.5mm in diameter on each abrading table.
- v. If the test is to be carried out against self-fabric, place a fabric specimen face side uppermost over the felt, face side uppermost.
- vi. If the test is to be carried out against wool abrasant fabric, place a piece of abrasant over the felt.
- vii. Place the press weight on top, and fit the clamping ring to secure the felt and specimen/abrasant firmly.
- viii. Remove the press weight and replace the top plate.

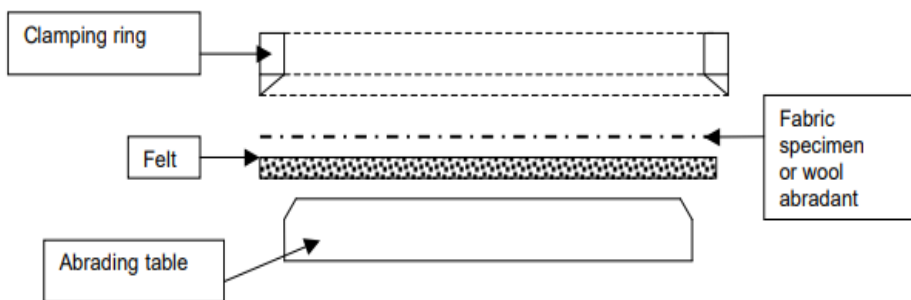


Figure-1

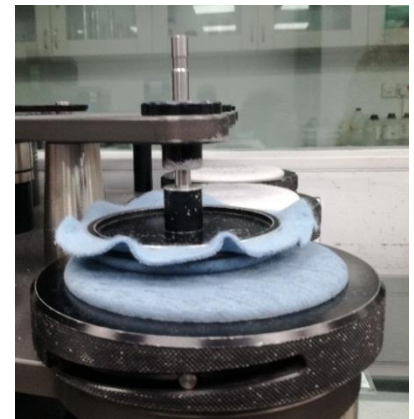


Figure-2

II. Mounting of specimens (see fig 3)

- i. Place the rubber securing ring at the bottom of the mounting device.
- ii. Place a fabric specimen face side down centrally on top of the mounting device, and then place a piece of felt 90 ± 1 mm in diameter on top of the fabric.
- iii. Place the specimen holder on top of the felt/fabric and roll the rubber securing ring upwards to the finishing position to secure the specimen in place. The ring fits into a groove around the specimen holder. Repeat with the other the other 2 specimens.
- iv. For Knitted fabrics are tested without the additional weights

- v. Position the prepared specimens/holders and their spindles in the top plate of the Martindale tester.

Note. No weights are placed onto the spindles for this test method.

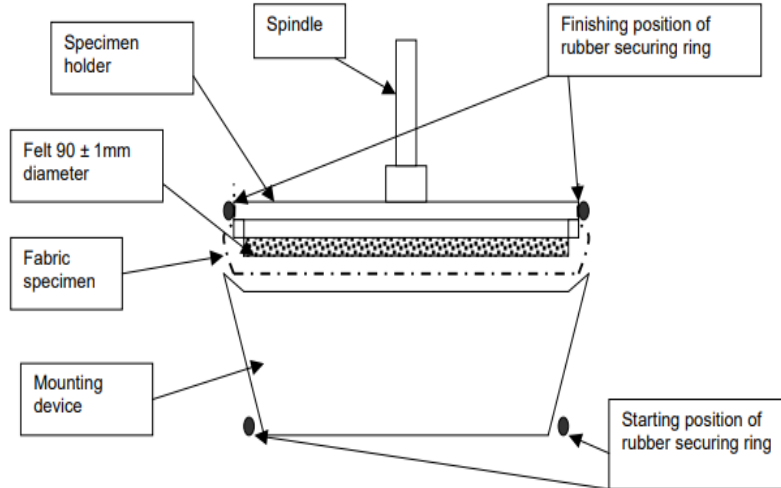


Figure-3

III. Test Procedure

- i. Set the Machine counter to the number of rubs specified for assessment stage 1 as given in Table (Unless otherwise specified).

Textile type	Fabric on abrading table	Loading weight	Assessment stage	Number of rubs
Knitted Apparel fabric	Knitted fabric under test (face/face)	No auxiliary weight added (155+/-1g)	1	125
			2	500
			3	1000
			4	2000

Table-1

- ii. Start the Machine.
- iii. When the present number of rubs is reached, remove each specimen holder in turn and, without removing the specimen, place the holder in the viewing area of the pilling assessment viewer.
- iv. Examine and grade each specimen as detailed in section 5.

- v. Replace the specimen holders in the Martindale tester and continue the test, assessing the specimens at each assessment stage until the final numbers of rubs are completed.
- vi. Note: Some retailers ask for grading at different assessment stages.

IV. Grading (see fig 4 & 5)

- i. Place the specimen holder into the hole on the left-hand side of the pilling assessment viewer.
- ii. Place a piece of the original fabric on the right-hand side.
- iii. Grading should be carried out by at least two independent graders.

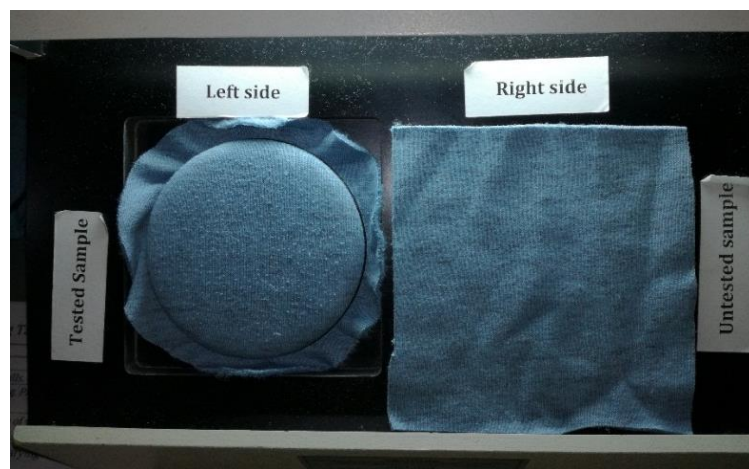


Figure- 4

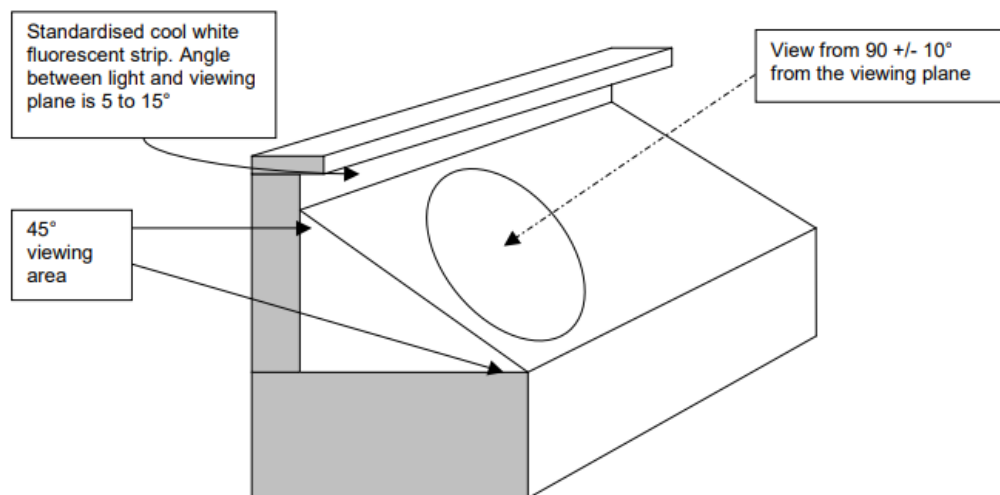


Figure-5

- iv. Grade the specimens using the descriptions given in table 2.
Note Photographic assessments may be used in addition.
- v. Calculate the mean score after recording the numerical ratings for each specimen and each grader. If the average result is not a whole number, round it to the nearest 12th grade.
- vi. Include a written description using the words in Table 2, stating whether the grade was due to fuzzing or pilling or both.

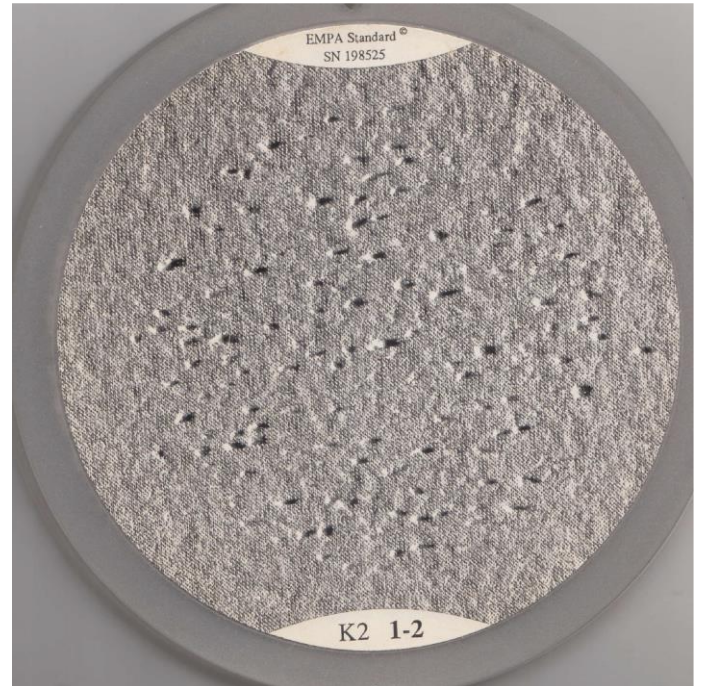
Grade 5	No change
Grade 4	Slight surface fuzzing and / or partially formed pills
Grade 3	Moderate surface fuzzing and / or moderate pilling. Pills of varying size and density covering the specimen surface.
Grade 2	Distinct surface fuzzing and / or distinct pilling. Pills of varying size and density covering a large proportion of the specimen surface
Grade 1	Dense surface fuzzing and / or severe pilling. Pills of varying size and density covering the whole of the specimen surface
Half grades e.g. 4-5, 2-3 may be given	

Table-2

- vii. If there is a variation of more than ½ grade between the specimens report the grade for each specimen.
- viii. If the fabric was ‘pre-treated’, then a piece of the pre-treated fabric shall also be graded against the original fabric.

3.1.5 Pilling/fuzzing grade of washed face side (by use of EMPA photo standards) :

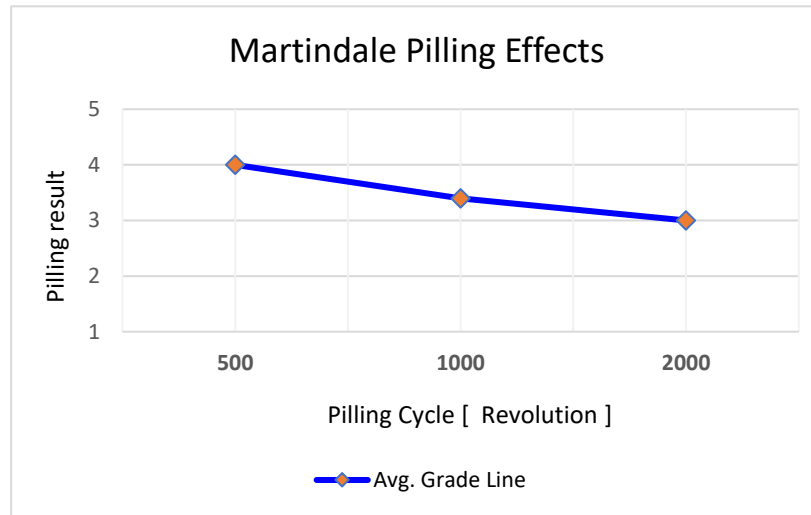




3.1.6 Pilling assessment results of knit fabric by using Martindale pilling Machine.

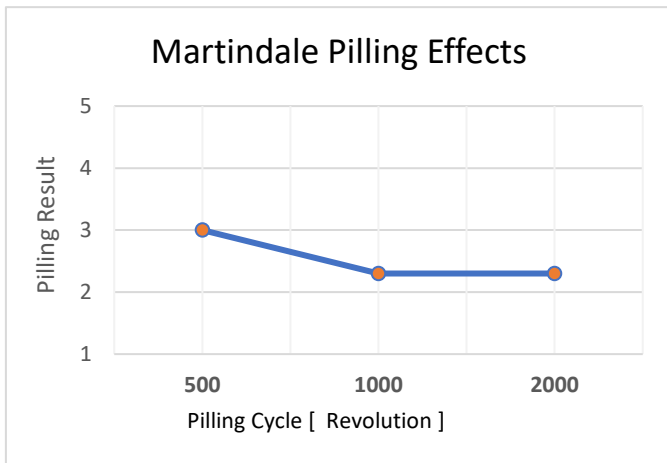
SL No	Fabric composition	GSM	Revolution	Grade
1	63% polyester 33% viscose 4% Elastane, interlock	Interlock, 310 gsm	500 rev	4
			1000 rev	3-4
			2000 rev	3
2	75% cotton 25% Polyester, inside brush peach	Fleece ,270 gsm	500 rev	3
			1000 rev	2-3
			2000 rev	2-3
3	47% cotton 47%modal 6% Elastane, Single jersey	Single jersey,180 gsm	500 rev	3-4
			1000 rev	3
			2000 rev	2-3
4	85% cotton 15% polyester, Fleece	Fleece ,280 gsm	500 rev	3
			1000 rev	2-3
			2000 rev	2-3
5	84% polyester 14% linen 2% lurex	Single jersey ,150 gsm	500 rev	3-4
			1000 rev	3
			2000 rev	3

Pilling assessment result presenting on graph:



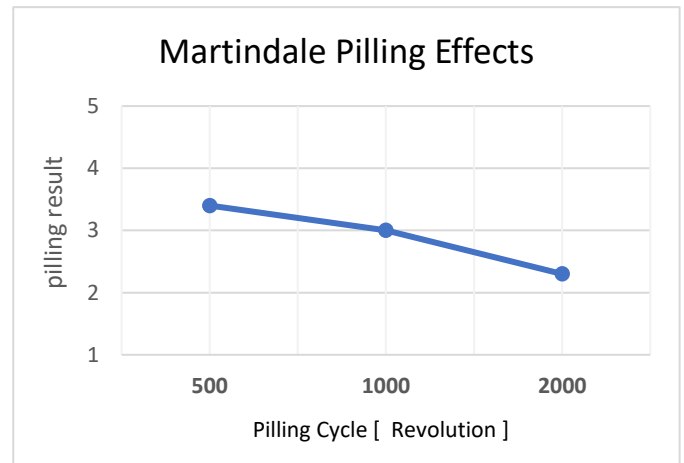
Pilling Effects of Martindale Pilling m/c

(65% polyester 33% viscose 4% elastane, interlock knit fabric)



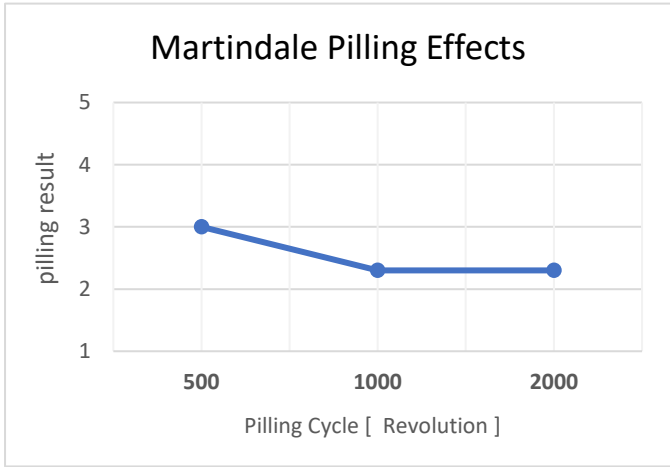
Pilling effects of Martindale pilling Machine

95% Cotton 5% Elastane, [Brush Fleece]

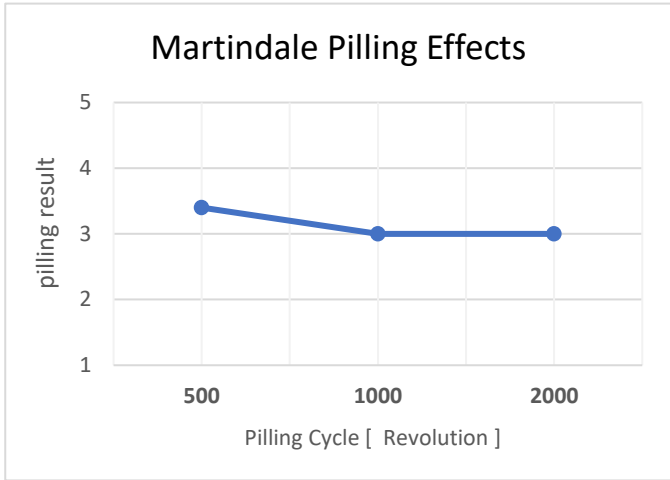


Pilling effects of Martindale Pilling Machine

45% Cotton 45% Modal 6% Elastane, [Single Jersey]



Pilling effects of Martindale pilling Machine
 85% Cotton 15% Polyester, [Brush Fleece]



Pilling effects of Martindale pilling Machine
 84% polyester 14% linen 2% lurex, [single jersey]

3.2 Pilling Box Method (12945-1)

The ICI Pilling Tester, also known as the ICI Pilling Box, is a Machine designed to test the pilling resistance of fabrics according to the ISO-12945-1 standard. It is widely used in the textile industry to assess the quality and durability of fabrics. The ICI Pilling Tester consists of a wooden box with a hinged lid, which has four compartments that rotate in a circular motion. The compartments contain abrasive material (usually cork or emery paper) and are used to abrade the surface of the fabric samples. The Machine also has a motor that rotates the compartments at a fixed speed. To perform a test, fabric samples are placed inside the compartments along with the abrasive material. The compartments are then rotated for a specified period of time (usually 4 hours) at a fixed speed. After the test, the fabric samples are evaluated for pilling using a standard rating scale. The ICI Pilling Tester is a reliable and accurate method for testing the pilling resistance of fabrics. It is widely used in the textile industry and is recognized by international standards organizations. Once the machine completes a specific number of rotations, the fabric is taken out, and someone visually inspects it for pilling. Pilling refers to the formation of small balls or pills of fiber on the fabric's surface. The degree of pilling is rated on a scale from 1 to 5, with 1 being the most severe pilling. The ICI pilling test is commonly used in the textile industry to assess the quality and durability of fabrics. It is particularly useful for evaluating knitwear and other fabrics that are prone to pilling. By conducting this test, manufacturers can determine how well a fabric will hold up over time and make adjustments to improve its performance



Image of ICI pilling Machine

3.2.1. Principle

In a cork-lined box, we place the fabric samples on polyurethane tubes and rotate them at a steady speed. After a specific amount of tumbling, we visually examine the fabric for fuzzing and pilling. If we need to handle the samples differently, like washing or cleaning them, we need permission and must document it in the test report.

3.2.2 Apparatus:

- i. A cubic pill testing box with 235 mm of internal space before lining. Cork jointing material with a 3,2 mm thickness must be used to line the interior surfaces of the box. The box must rotate at a rate of (60 ± 2) revolutions per minute around a horizontal axis that runs through the centre's of two opposing faces. The box's one side must be detachable for access.
- ii. Four polyurethane specimen tubes, each measuring (140 ± 1) mm in length, (31,5 ± 1) mm in outside diameter, and (3,2 ± 0,5) mm in wall thickness, and weighing (52,25 ± 1) g are needed.
- iii. Specimen mounting jig for mounting specimens on tubes.
- iv. Polyvinyl chloride (PVC) tape that is self-adhesive and 19 mm wide
- v. Sewing Machine.
- vi. A viewing cabinet with a white fluorescent tube or bulb (the light source's color temperature is not important) shining evenly over the width of the specimen(s) and a mask that prevents the observer from staring directly into the light. Place the illuminate between 5 and 15 degrees away from the specimen's plane (see Figure 1). For normal corrected vision, the distance between the eye and the specimen should be between 30 cm and 50 cm.

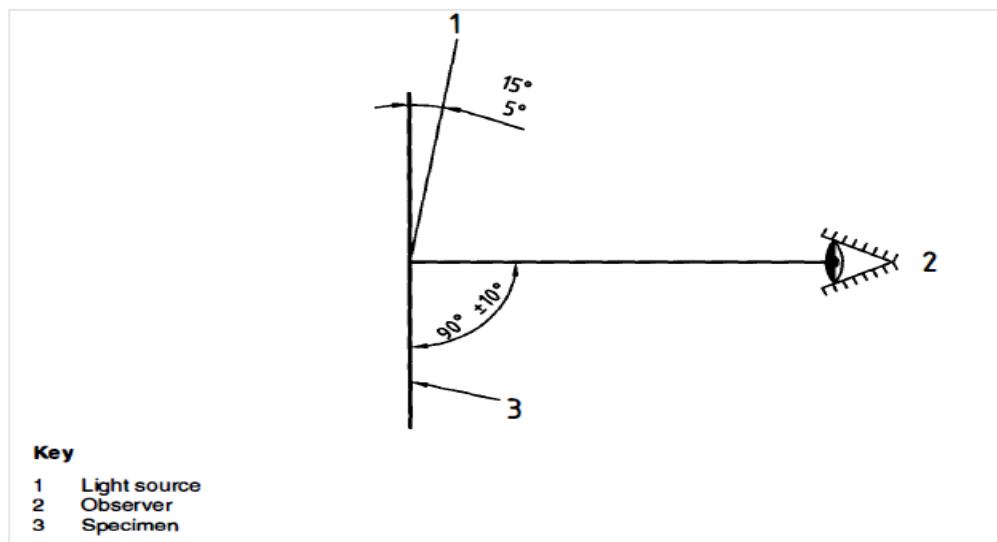


Figure 1: Illumination

3.2.3 Conditioning and testing atmosphere

The standard temperate environment specified in ISO 139 for conditioning and testing textiles must be used, which calls for a temperature of 20 ± 2 °C and a relative humidity of 65 ± 2 %.

3.2.4 Preparation of test specimens

i. Pre-treatment

Unless otherwise specified, dry clean or wash the sample in accordance with a procedure decided upon by the parties involved.

Note 1: The procedures described in ISO 6330 or ISO 3175-1 and ISO 3175-2 may be suitable.

Note 2: To ensure consistent results, it is advised to wash or dry clean the fabric samples before testing. This helps protect the friction surfaces of the pilling box and specimen tubes from any lubricants or finishes that could affect the results. If you do wash or dry clean the samples, make sure to evaluate them using the grading scheme described in clause 9 both before and after the pre-treatment. [9]

ii. Cutting out

Cut four 125 mm x 125 mm test specimens from the sample. Mark the length direction and the fabric's back on each test specimen. Test both sides of a fabric if there is no visible face to it. For assessment, a second 125 mm x 125 mm cut specimen is needed.

Note: Test specimens should be randomly placed with none of the test specimens having common warp or weft threads.

iii. Number of test specimens

Take two samples, fold each one with the face, if visible, facing inward, and run the Machine in the fold's direction. Form a tube by sewing 12 mm from the cut edges with a stitch density that results in a balanced seam. Prepare the other two specimens in a similar manner, with the cross direction following the fold's direction.

iv. Mounting of test specimens

To remove any sewing irregularities, cut 6 mm from both ends of the fabric tube. Then, turn each specimen inside out so that the fabric's front side faces outward and forms the tube's exterior. Using the mounting jig, attach one prepared specimen to each polyurethane specimen tube, ensuring that the specimen ends are evenly spaced from the tube's ends (refer to Figure 2). Flatten the section with the seam as much as possible. Use self-adhesive PVC tape to secure the cut ends of each specimen to the tube, leaving 6 mm of the polyurethane specimen tube exposed. Remember that the tape on each end of the specimen should not exceed a specific length.

v. Conditioning

Condition the samples for at least 16 hours in the environment described in clause 6. Conduct the test in the same environment.

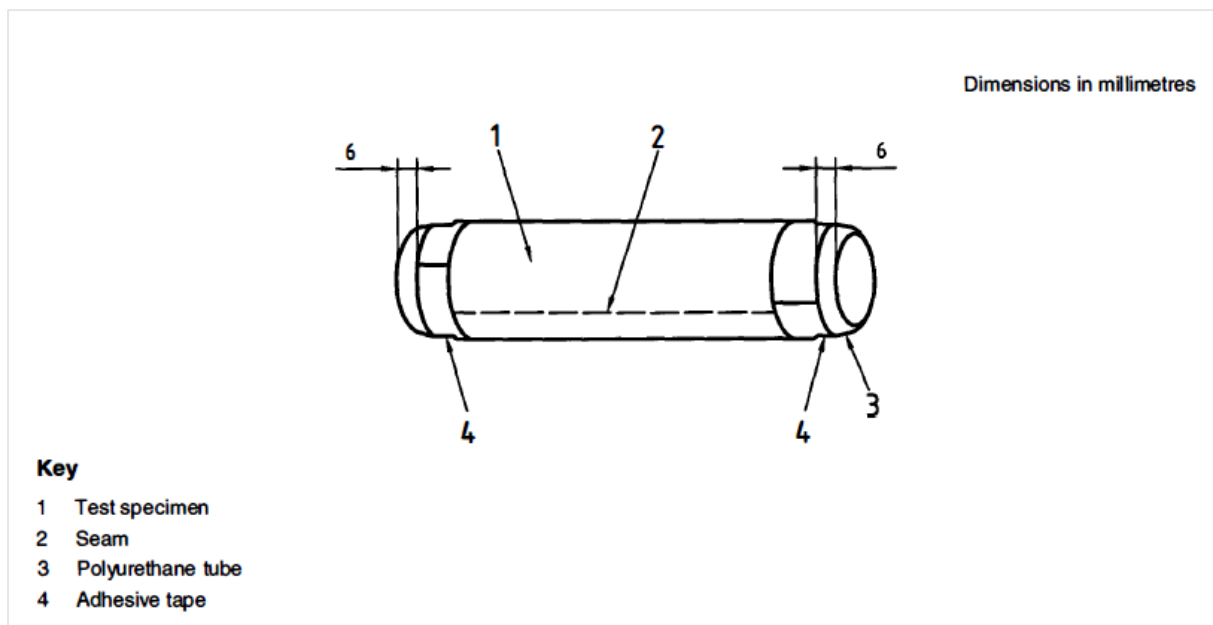


Figure 2: Mounting of specimen on to polyurethane tube

3.2.5 Procedure

Make sure the pill testing box's interior is spotless and lint-free. Put the sample's four mounted specimens in the same pill testing box. The lid should be tightly closed. Turn the tubes in the box around for the predetermined number of times.



Figure 3: Sample preparation

Here don't have predictions for how different textile fabrics will perform in tests or wear. That's why it's crucial for everyone involved to decide on the number of rotations needed for the specific fabric being tested. Once that's agreed upon, remove the samples from the box and carefully undo the stitching of the seam.

3.2.6 Assessment of fuzzing and/or pilling

The viewing cabinet must be put in a room that is completely dark. Place the tested specimen and a portion of the original sample vertically on the lectern in the viewing cabinet (see Figure 1), with or without pre-treatment (see i). To ensure proper positioning, if necessary, use a piece of self-adhesive PVC tape (iv). Mount the original sample on the right and the tested specimen on the left. View each specimen from just outside the viewing cabinet to avoid glare from the light source (vi). as shown in (Figure1), directly in front of the specimen. It is advised that the specimens be evaluated by multiple observers due to the subjective nature of the assessment. Each specimen should be graded using the



Figure: Pilling Assessment view

As agreed upon by interested parties, photographic assessment may be used to support the primary descriptive method of assessment. Rotating the specimen to a location where there is more obvious pilling allows for a second assessment. This evaluation may be used to provide information for an "extreme" situation, such as when a surface is being viewed along its plane. Any other feature that exhibits a decline in outward appearance should be reported.

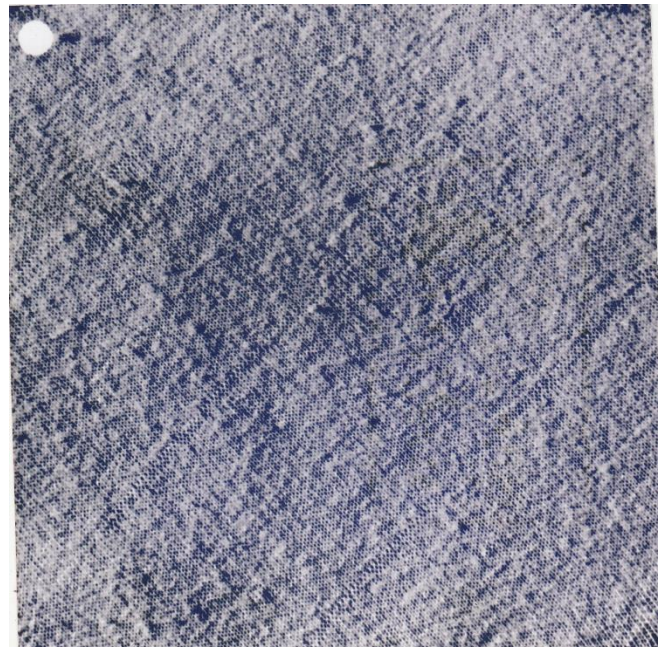
Table 1 - Visual assessment Pilling grading scheme

Grade	Description
5	No change.
4	Pills with a partial form.
3	Moderate pilling. The specimen surface is partially covered by pills of varying size and density.
2	Distinct pilling. Pills of varying size and density covering a large proportion of the specimen surface.
1	Severe pilling. Pills of varying size and density covering the whole of the specimen surface.

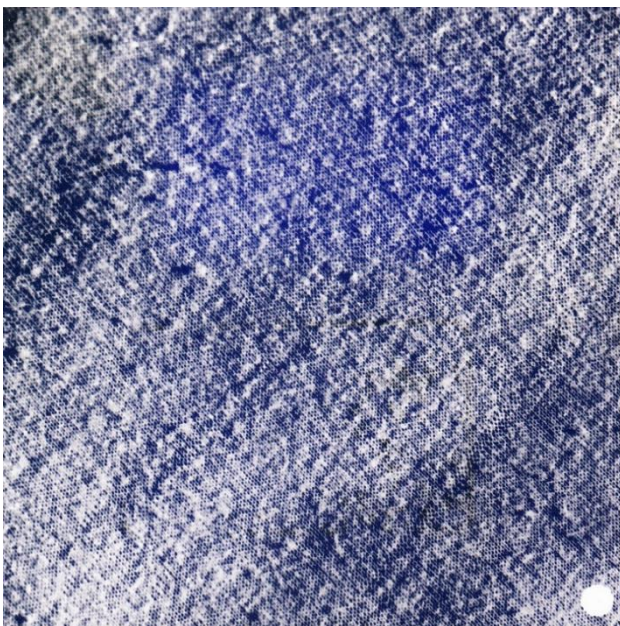
3.2.7 Pilling photograph scheme:



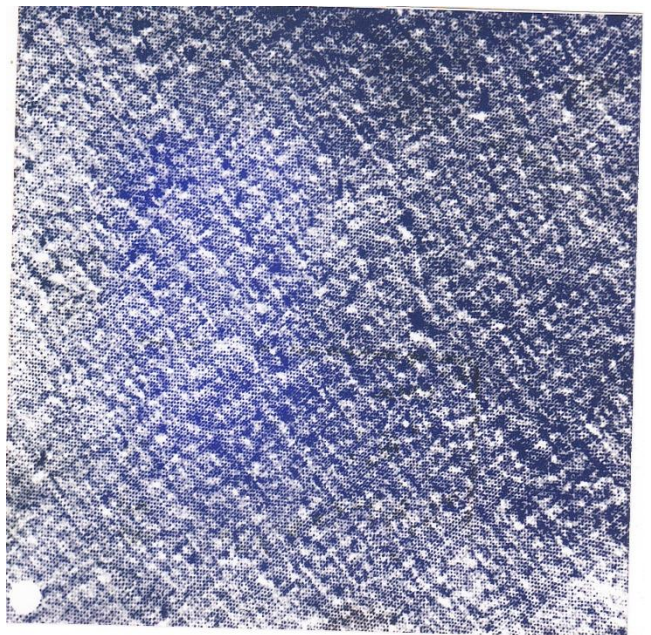
Grade-5



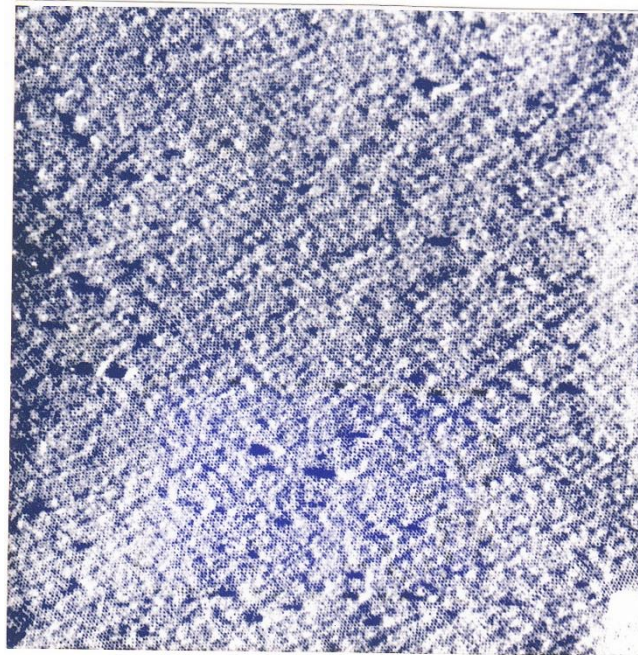
Grade-4



Grade-3



Grade-2



Grade-1

3.2.8 Results:

Record the grades for each specimen and determine the average of all evaluations made in accordance with clause 9. Round the mean result to the nearest half grade if it is not a whole number. There shouldn't be more than a half-grade difference in the outcome based on the mean of the four test specimens. The grading of each specimen must be reported if this variation exceeds half a grade.

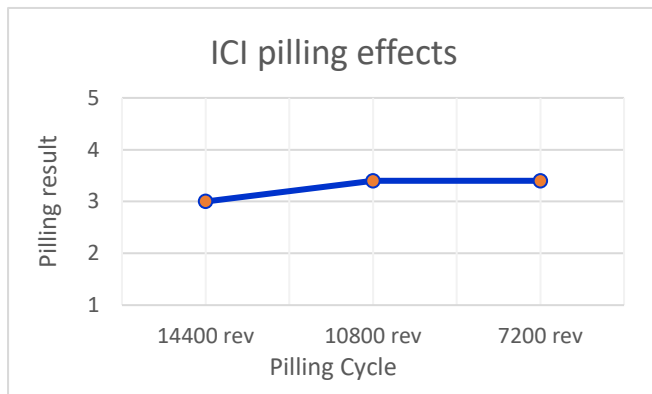
3.2.9 Pilling assessment results of knit fabric by using ICI pilling Machine. Non-wash fabric:

SL No	Fabrication	GSM	Revolution	Grade
1	63% polyester 33% viscose 4% Elastane	Interlock ,310 gsm	7200 rev	3
			10800 rev	3
			14400 rev	2-3
2	75% cotton 25% polyester, inside brush peach	Fleece ,270 gsm	7200 rev	4
			10800 rev	3-4
			14400 rev	3
3	47% cotton 47%modal 6% Elastane ,Single jersey	Single jersey,180 gsm	7200 rev	4
			10800 rev	4
			14400 rev	3-4
4	85% cotton 15% polyester, Fleece	Fleece ,280 gsm	7200 rev	4
			10800 rev	4
			14400 rev	3-4
5	84% polyester 14% linen 2% lurex	Single jersey ,150 gsm	7200 rev	3-4
			10800 rev	3-4
			14400 rev	3

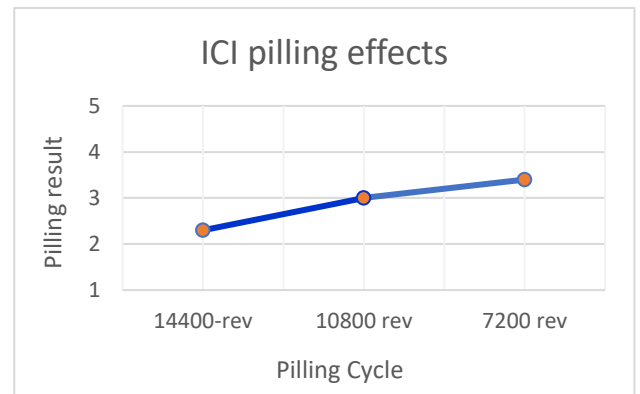
After wash fabric:

SL No	Fabrication	GSM	Revolution	Grade
1	63% polyester 33% viscose 4% Elastane	Interlock ,310 gsm	7200 rev	3-4
			10800 rev	3-4
			14400 rev	3
2	75% cotton 25% polyester, inside brush peach	Fleece ,270 gsm	7200 rev	3-4
			10800 rev	3
			14400 rev	2-3
3	47% cotton 47%modal 6% Elastane ,Single jersey	Single jersey,180 gsm	7200 rev	4
			10800 rev	4
			14400 rev	3-4
4	85% cotton 15% polyester, Fleece	Fleece ,280 gsm	7200 rev	4
			10800 rev	3-4
			14400 rev	3
5	84% polyester 14% linen 2% lurex	Single jersey ,150 gsm	7200 rev	3
			10800 rev	2-3
			14400 rev	2-3

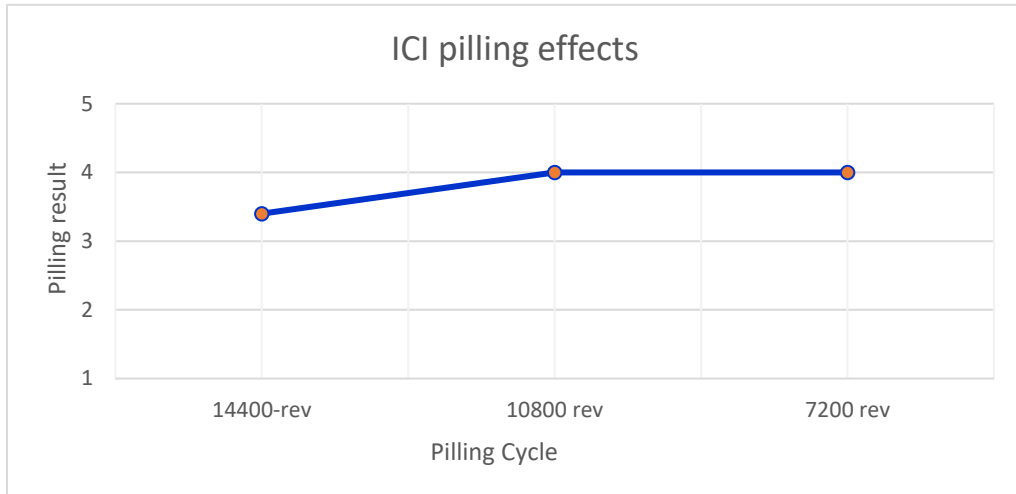
Pilling assessment result presenting on graph:



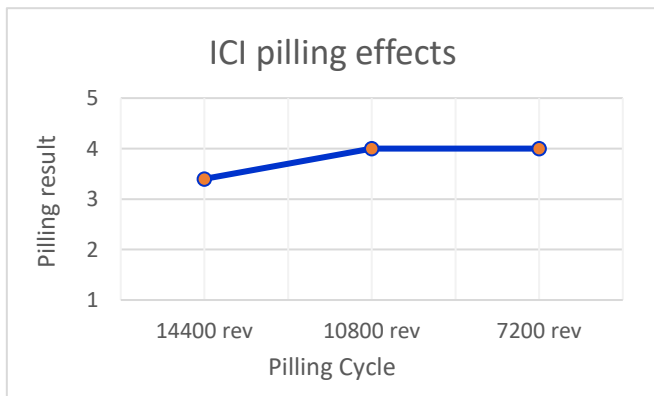
Pilling effects of ICI pilling m/c
(63%polyester 33% viscose 4% Elastane, interlock knit fabric)



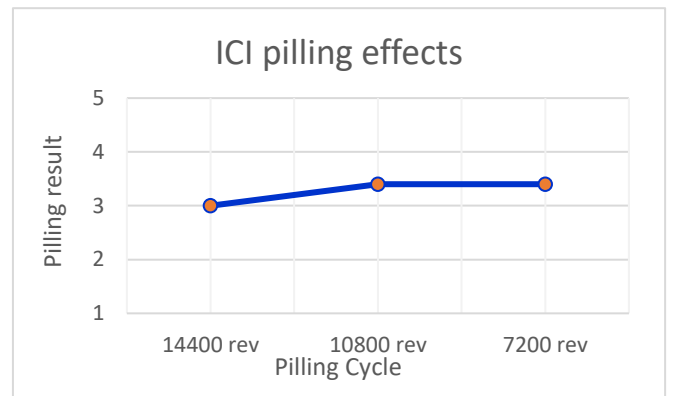
Pilling effects of ICI pilling m/c
(95% cotton 5% elastane, brush fleece knit fabric)



Pilling effects of ICI pilling m/c
(47% cotton 47% modal 6% elastane, Single jersey knit fabric)



85% Cotton 15% polyester, Brush fleece fabric



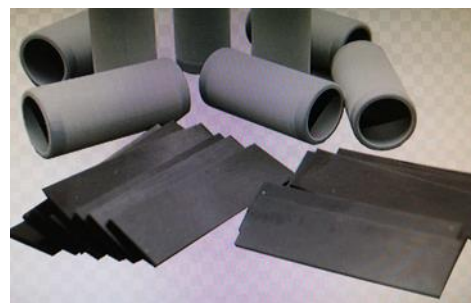
84% Polyester 14% linen 2% Lurex, single jersey fabric

3.3 Method of test marks and Spencer random pilling drum (P18A)

The method of test marks and Spencer random pilling drum is a widely used method to evaluate the pilling resistance of fabrics. Marks & Spencer has approved a drum specifically designed for pilling and snagging tests. This drum can be connected to the M227A/B ICI Pilling Tester. To use the drum, you will need a specific set of accessories, including sample tubes (106841), a liner and step for the drum (106885), snagging bars (M227FMS), and bean bags (M227F1MS). To evaluate the potential of a woven or knitted fabric to pill. [10]

3.3.1 Apparatus:

- i. Marks and spencer random pilling and snagging drum with a speed of rotation of 30 ± 1.0 r.p.m
- ii. Polyurethane pilling tubes and locking rings.
- iii. Liner support
- iv. Specimen mounting jig.
- v. Double –sided adhesive tape approx. 25mm wide.
- vi. Lockstitch or chain stitch sewing Machine.
- vii. Marks and spencer template for specimen preparation
- viii. Hoscope with woven or knitted holograms
- ix. Bull nosed tweezers
- x. metal ruler graduated in mm.



Picture: polyurethane tubes& locking ring

3.3.2 Test Specimen:

Dry clean only fabric to be tested in original sate, fabrics that are washed to be prepared for test in the following way.

For washable fabrics. Avoid fabric within 50mm of the selvage cut a piece of fabric of sufficient size to enable the test specimen to be prepared, over lock the edges to prevent fraying. The sample should be washed as per care label instruction. Always wash with the face side outside. Record if any change occurs in surface appearance after washing e.g fuzzing, matting, surface disturbance.

Cut a second piece 200mm X 250mm for grading purpose. From the washed or original specimen cut a 970mm x 165mm rectangle for lining the drum. Overclock the edges. Cute four specimens each 125mm X 125mm. square of the length direction of the specimens, and prepare as follow:

1. Fold two of the squares in the length direction with the face of the fabric inside out & two along the width direction.
2. Sew a seem 12mm from the cut edge and parallel to the fold to form a tube with an open flat seam.

3. Turn the four specimens face outwards and trim thread ends

4. The specimens should be mounted on the polyurethane tubes. To always avoid needless handling of the specimens: -

- i. Place the tube's collapsed end on the two-pronged jig
- ii. Push the metal sleeve over the tube.
- iii. Place a specimen on the sleeve with the seam flattened out.
- iv. with approximately 25 mm of the specimen protruding beyond the collapsed tube gently hold specimen and remove the sleeve leaving the specimen firmly mounted (not loose or tight) on the tube with an equal amount of fabric protruding over the ends.
- v. Remove the tube from the jig. Tuck the excess fabric into the tube ends and secure by inserting the rolled-up locking rings, such that they are not protruding.

3.3.3 Conditioning:

Condition the ready test specimens in the standard atmosphere for testing at a temperature of $20^{\circ} \pm 2^{\circ}\text{C}$ and a relative humidity of $65\% \pm 2\%$ for a minimum of four hours.

3.3.4 Machine Specification:

The location of the equipment must be in this environment. Conduct the tests in this environment. Clean the drum and door by wiping with a dry paper towel. Apply a strip of double-sided adhesive tape in the positions indicated on the ramp and the liner support. Apply at least a further three pieces of double-sided adhesive tape to the liner support. These should run lengthwise between the two pieces already applied across the width. One is applied to each of the two sides and the third is positioned centrally. Starting at the line marked 25mm from the end of the support, attach the fabric liner to the adhesive tape, ensuring both are wrinkle free. The tape must be fully covered. The final 95mm of fabric liner remains loose. It is preferable for the fabric liner to be in one continuous piece of fabric. Only when this is not possible should the liner consist of not more than 3 separate pieces, these must be joined together with a 12mm lockstitch or chain stitch seam which is opened flat when attached to the liner. Place the liner support into the drum by bending into a circle. The uncovered 25mm end fits under the vertical face of the ramp and the other end under the tapered section of the ramp. Take care not to trap the fabric liner. Smooth the remaining fabric over the ramp and attach to the adhesive tape. Place the four composite specimens in one pilling drum. In the same drum place four uncovered polyurethane tubes without locking rings. Run the drum for the number of revolutions indicated in the performance standards. Remove the samples after testing. Look inside the drum for any loose pills or other debris and make a note of it. To remove the specimen from the tubes, use tweezers to remove the locking rings and then cut along the seams. Trim extra fabric to the seam line. Keep the ends that were tucked inside the tubes. Do not cut them off.



Untested sample



Tested sample

3.3.5 Important:

Do not leave the double-sided tape attached to the liner any longer than necessary so as to avoid problems with its removal

3.3.6. Assessment:

1. All specimens should be graded on the holoscope which should be sited in a dark room or curtained off area. Place the viewing mask squarely over each specimen to cover the localized pills, fuzzing or abrasion so that they are covered etc. by the left and right sides of the viewing mask. Grade change in appearance.
2. Compare the individual tested specimens against the holograms and retained specimen of original fabric. If necessary use the following descriptions to help grade the overall change in appearance. Half grades may be quoted using e.g. A – B on individual specimens.

Grade description points to be taken into consideration during assessment:

A	5	No change	No visual change
B	4	Slight change	Slight surface fuzzing
C	3	Moderate change	The test specimen may exhibit either or both of the following: (a). moderate fuzzing (b). isolated fully formed pills
D	2	Significant change	Distinct fuzzing and/or pilling
E	1	Severe change	Dense fuzzing and/or pilling which covers the specimen

Numerical grades given for calculation purposes only.

Fuzzing is the roughing up of the surface fibres and/or teasing out of the fibres from the fabric which produces a change in the appearance. This change can occur during washing/dry cleaning or testing.

Pills are formed by the same mechanism as fuzzing but are of such density that light will not penetrate and will cast a shadow.

3. Grade the degree of localized pilling/fuzzing or abrasion where the fabric has covered the tube ends.

Quantify this as:



- i. Staple the four tested specimens onto an A4 sized card with the length direction of each specimen running downwards.
- ii. Mount the original comparison fabric on the reverse of the specimen card with the length direction running downwards.

Results Report the following:

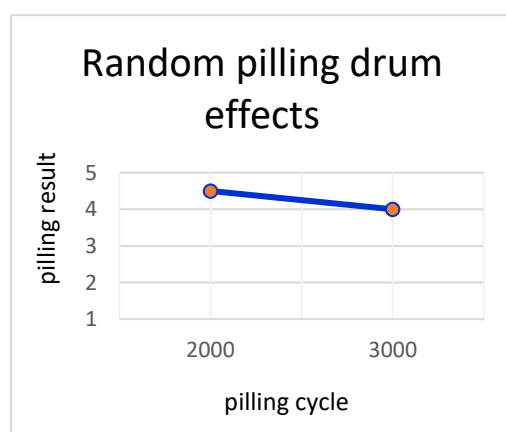
1. Any change due to washing and the washing procedure carried out.
2. The number of revolutions used.
3. The overall grade. Take the average of the four specimens. Report to the nearest half grade E.g., B-C.
4. The assessment of localized pilling, fuzzing or abrasion.
5. The presence of loose pills or debris in the pilling drum at the end of the test.

Note: New polyurethane tubes must be placed uncovered in the pilling drum and run for 36,000 revs. Using any available fabric as the liner. This is to remove any molded edges which may be present. After this the tubes and locking rings should be cleaned in- a solution of approximately 20ml Teepol to 5 liters water. Rinse and allow to dry at room temperature before re-use. Because with use the tubes become contaminated with oils, lubricants etc. which will affect their frictional properties, the cleaning procedure should be repeated monthly on all tubes.

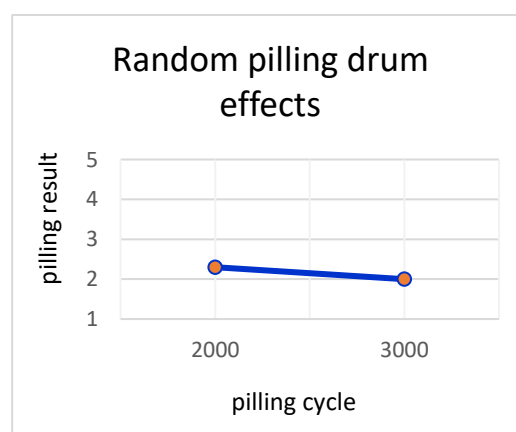
3.3.7 Pilling assessment results of knit fabric by using Random pilling drum.

SL No	Fabrication	GSM	Revolution	Grade
1	63% polyester 33% viscose 4% Elastane	Interlock ,310 gsm	2000 revolution /1.48 hours	A-B/4-5
			3000 revolution /1.48 hours	B/4
2	75% cotton 25% polyester , inside brush peach	Fleece ,270 gsm	2000 revolution /1.48 hours	C-D/2-3
			3000 revolution /1.48 hours	D/2
3	47% cotton 47%modal 6% Elastane ,Single jersey	Single jersey 180 gsm	2000 revolution /1.48 hours	B-C/3-4
			3000 revolution /1.48 hours	B-C/3-4
4	85% cotton 15% polyester, Fleece	Fleece ,280 gsm	2000 revolution /1.48 hours	B-C/3-4
			3000 revolution /1.48 hours	B-C/3-4
5	84% polyester 14% linen 2% lurex	Single jersey ,150 gsm	2000 revolution /1.48 hours	D-E/1-2
			3000 revolution /1.48 hours	E/1

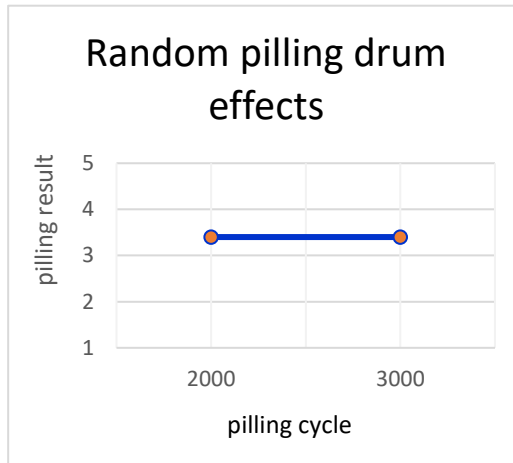
Pilling assessment result presenting on graph:



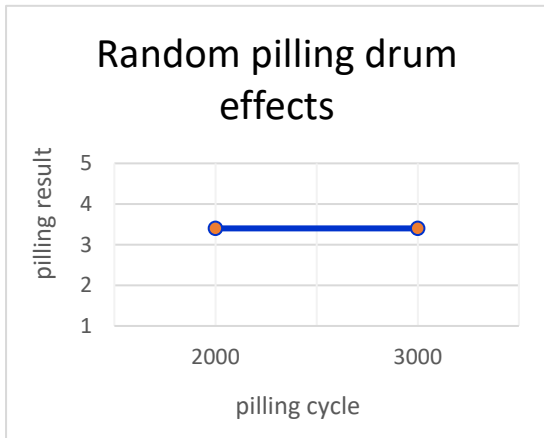
Pilling effects of random pilling drum m/c (63% polyester 33% Viscose 4% elastane, interlock knit fabric)



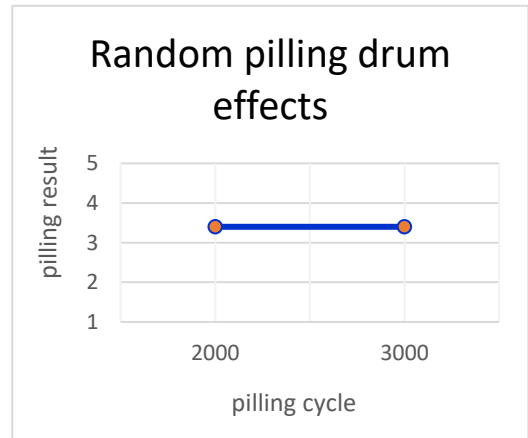
Pilling effects of random pilling drum m/c (95% Cotton 5% elastane, Fleece knit fabric)



Pilling effects of random pilling drum m/c
(47% Cotton 47% modal 6% elastane, S/j knit fabric)



Pilling effects of random pilling drum m/c
(84% Cotton 15% Polyester fleece, knit fabric)



Pilling effects of random pilling drum m/c
(84% polyester 14% Linen 2% Lurex, S/j knit fabric)

3.4 Random tumble pilling tester method (ASTM D3512)

The Random Tumble Pilling Test is a common method used to assess how well a textile material resists pilling. This test is described in ASTM D3512-19, which is the standard method for evaluating pilling resistance and surface changes in textiles using a Random Tumble Pilling Tester. The test involves using a machine with a hexagonal steel box covered in abrasive material. Inside the box, there are fixed baffles and a rotating drum lined with the same abrasive material, measuring 146 mm in diameter. During the test, a fabric sample and a standard abrasive reference material are placed inside the drum. The drum is then rotated at a specific speed for a set duration. Afterward, the samples are assessed for the amount of pilling using a standard rating scale. This test helps determine how well a fabric can resist the formation of small, fuzzy balls of fibers on its surface. It is useful for evaluating fabric durability under normal wear conditions and aids in selecting the most suitable fabric for a specific use.



Random tumble pilling Machine

3.4.1. Accessibility:

- i. Using a random tumble pilling tester, this test method examines a fabric's resistance to the development of pills and other related surface changes. All woven and knitted apparel fabric types can be used with the procedure.
- ii. This method may not test some fabrics that have been treated with silicone resin satisfactorily because the silicone resin may transfer onto the cork liners in the test chamber and lead to inaccurate results.
- iii. Internal replicas of "SATISFACTORY" and "UNSATISFACTORY" are used instead of ASTM photographic pilling standards for evaluation as default procedure, unless the client specified, when performing the appearance after wash procedure for polar fleece.

3.4.2 Apparatus and Equipment:

1. Random Tumble Pilling Tester.
 2. Injection of Air Device that either comes standard with new testers or is added to older testers to provide 14–21 kPa (2–3 psi) air pressure in each test chamber.
 3. Cork Cylinder Liners
 4. White all-purpose adhesive for sealing specimen edges.
 5. A plastic bottle with a cap and a spout for dispensing diluted adhesive
 6. A canister-style home vacuum cleaner for cleaning specimens after testing
7. Fabric Evaluation Apparatus – Facilities for illumination (cool white fluorescent tube) and simultaneous viewing of test specimen and fabric or photograph rating standards.

3.4.3. Reagents and Consumables:

- i. Cork cylinder liners, about 146 mm (5.75 in) wide by 452 mm (17.81 in) long from 1.5 mm (0.63 in) thick flat sheets of type P2117A material.
- ii. White all-purpose adhesive (Val-A Tear Mender), either full strength or dilution to 1 part of adhesive with 10% or less part of water may be used.
- iii. Cotton silver 4301 tex.

3.4.4 Sample preparation:

1) Sampling:

- i. Three are cut spaced overly across the width of the laboratory sample specimens cannot be taken near the selvedge than 1/10 the width of the fabric.

2) Cutting:

- A. Samples may be cleaned using methods suitable for the fabric's intended use or methods that have been agreed upon by all parties involved before the test specimens are cut.
- B. Cut the samples into squares that are 105 mm (4.13 in) on the bias and at a 45° angle to the warp (wale) and filling (course) directions, or roughly 0.78 rad.

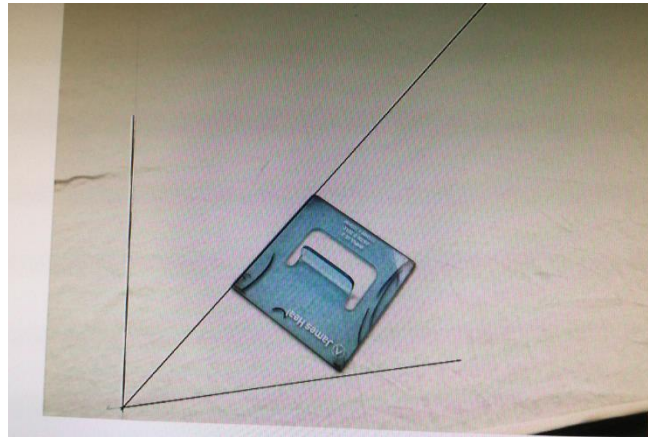


Fig: Sample preparation

C. Collect three samples from each laboratory section. Take the samples from three different panels in a garment, or evenly space them across the width of the laboratory sample. The spacing between specimens should be chosen so that no two specimens contain the same yarns. Avoid wrinkly and other distorted areas. Cut samples no closer to the selvage than one tenth the fabric's width, unless otherwise instructed.

D. Mark replica specimens with the corresponding number 1, 2, or 3 in a corner of the fabric's face.

E. When applying identification markings, loosely woven specimens may fray. To prevent this, cut the specimens with sides parallel to the warp and filling, ravel the sides no more than 5 mm (0.2 in) on each side, and then leave the fringe.

F. All specimen edges should be adhered to the fabric's face at a maximum width of 3 mm (.13 in). The specimens should be left to dry on racks for at least two hours.

3) Conditioning:

The sample are conditioned at standard atmosphere of $21\pm 1^{\circ}\text{C}$ ($70\pm 2^{\circ}\text{F}$), $65\pm 2\%$ RH for 4 hours prior to testing.

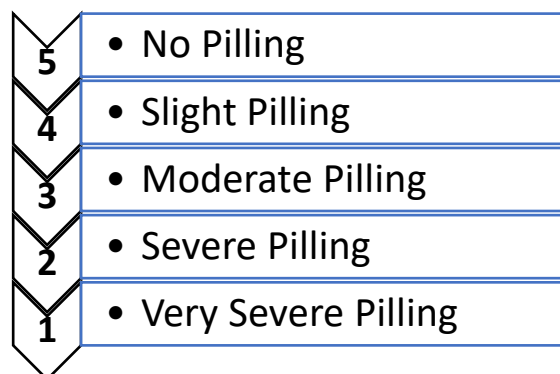
4) Testing Procedure:

- i. All tests are conducted in the standard atmosphere for testing textiles.
- ii. Perform individual tests on replicate specimens only in a particular chamber.
- iii. The inner surface of a cleared chamber had a cork liner fitted that had never been used before on the side facing the rotor blades.
Note: the cork liner can use on 1 hour on each side.
- iv. Insert the test chamber with three specimens from the same sample and about 25 mg of cotton fiber that is 6-mm (0.2-in) in diameter and gray-dyed.
- v. Cover the chamber with the cover, and program the timer for 30 minutes.
- vi. Start the airflow by turning the motor switch to "ON" and pressing the "START" button.

- vii. Remarks if the specimen is wedged around the impeller on against the wall of the chamber, stop the Machine & remove the specimen for testing again.
- viii. Each specimen is removed and cleaned of excess cotton that is not actually entangled in pills using a home canister type vacuum cleaner after each time test (the default cycle for a test cycle is 30 minutes).As the specimen is firmly gathered by a corner, let the vacuum draw the specimen in.
- ix. Test chamber is also cleaned by vacuum cleaner.

5) Evaluation:

- a. Three trained observers should rate each test stated report the average rating to the nearest half grade toward the higher rating, if there is my discrepancy with more than half grade deviated between rating result more experienced rater should be involved in the pilling assessment on the tested specimen.
- b. Using the ASTM photographic pilling standards and the apparatus for fabric evaluation, the face (as indicated by using marking, for each specimen is rated after respective tumbling times using the following scale.



- c. Inspect the pilled samples for irregular pilling. Report this condition if the pills are concentrated in any one strip in either fabric direction or in any one area of a specimen. Stripes suggest that various yarns might have been used to create the fabric under test.
- d. Examine the pilled samples for signs of erroneous tumbling. Consider a specimen to have been wedged around the impeller for one or more periods of the test if any of the specimens exhibit a high concentration of pills in a general direction that is not parallel to either fabric direction. Throw these away and conduct the test again using fresh samples.
- e. Check the fabric for additional surface flaws like fuzzing. Each surface effect should be rated using a different set of internal fabric rating standards.

6) Datasheet Criteria:

Remove the face plate, stop the Machine, turn off the air, and free the specimen if it becomes wedged around the impeller without tossing or if it is stationary on the bottom or side of the chamber. Any hang-ups or other unusual behaviour of the samples should be noted on the data sheet.

3.4.5. Reporting Criteria:

- I. Verify that the samples were tested in accordance with Test Method D 3512's instructions. Describe the sampled material or product and the sampling technique that was employed.
- II. Provide the following details in accordance with a material specification or contract order for the lot and for the laboratory sampling unit.
- III. Ratings for each specimen individually, the average rating for the lot, and the ratings for the three specimens from each laboratory sampling unit

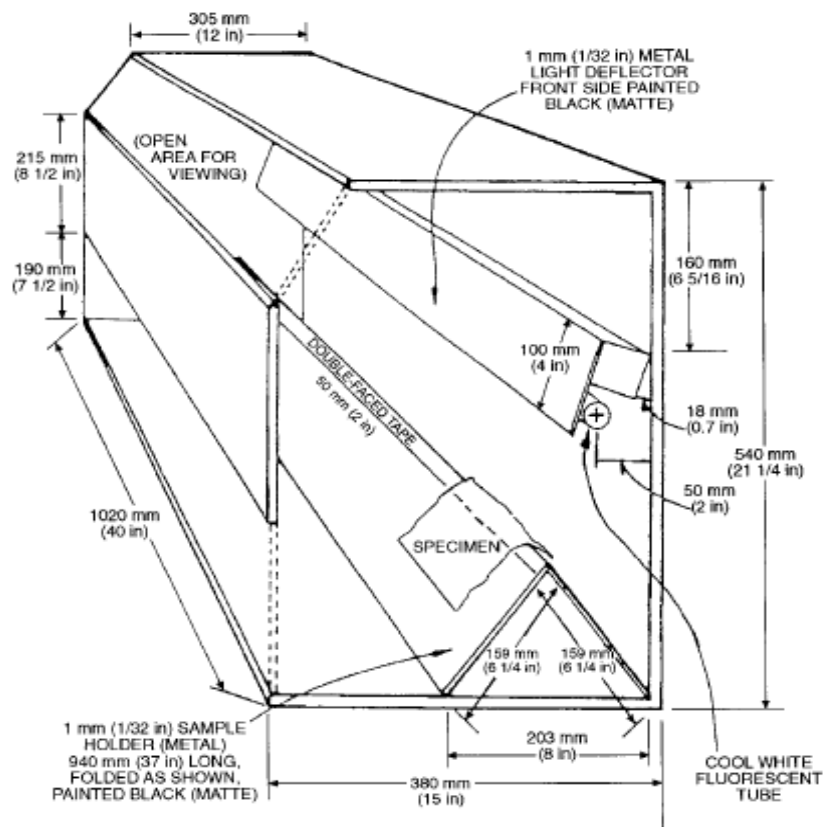


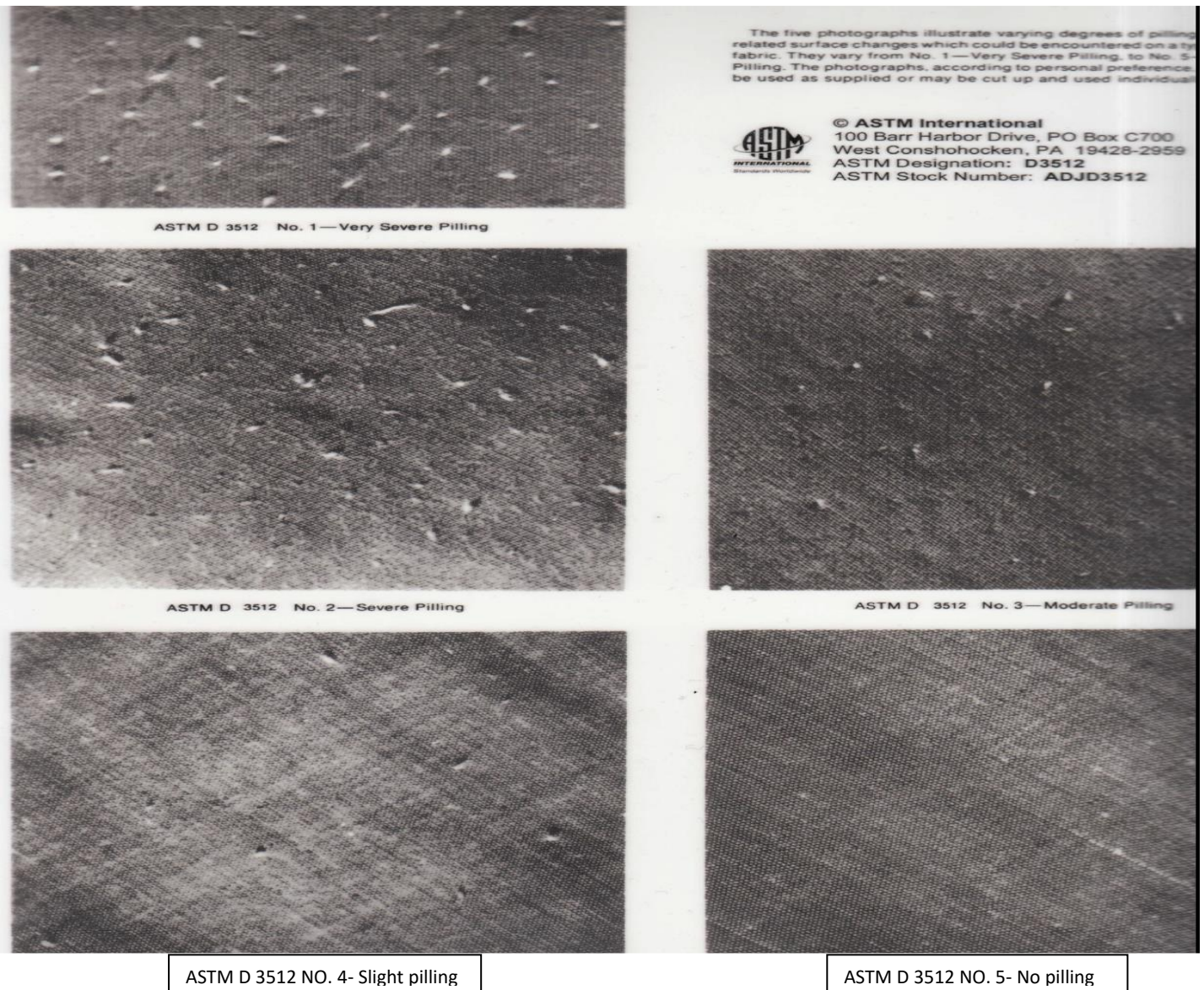
FIG. 2 Apparatus for Fabric Evaluation

- IV. Whether or not the specimens' edges were glued with adhesive
- V. If the fabric was washed prior to testing, what were the laundering conditions.
- VI. If the fabric was dry-cleaned before testing, conditions used,
- VII. Running times, viewing options, and the rating scale that was applied.

3.4.6. Modifications from Standard:

- VIII. Internal Guidelines of “SATISFACTORY” & “UNSATISFACTORY” are used instead of ASTM photographic pilling standards for evaluation as default procedure, unless the client specified.
- IX. The water used for dilution of adhesive is based on supplier information.

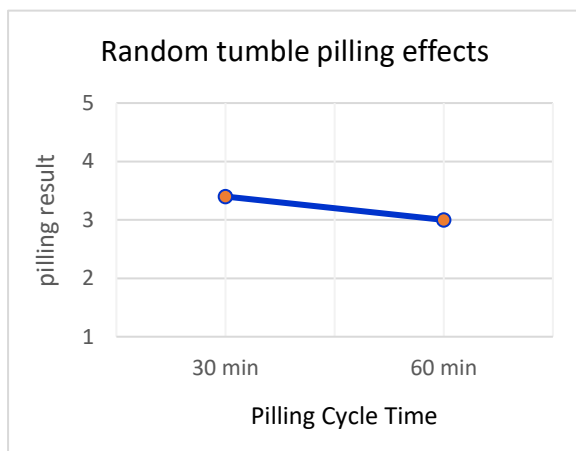
Pilling Grading Scheme:



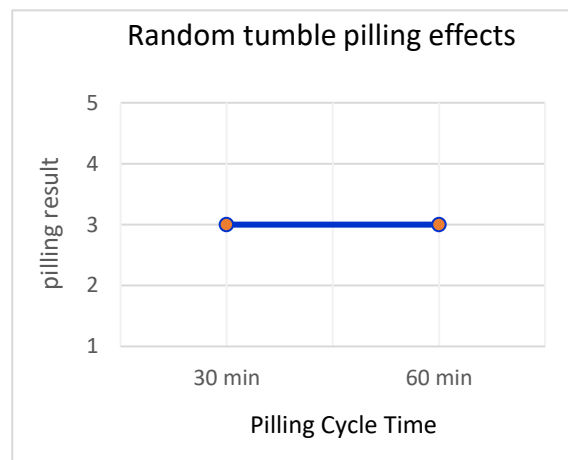
3.4.7 Pilling assessment results of knit fabric by using Random Tumble pilling Machine.

SL No	Fabrication	GSM	Revolution	Grade
1	63% polyester 33% viscose 4% Elastane	Interlock ,310 gsm	30 minutes	3-4
			60 minutes	3
2	75% cotton 25% polyester, inside brush peach	Fleece ,270 gsm	30 minutes	3
			60 minutes	3
3	47% cotton 47%modal 6% Elastane, Single jersey	Single jersey 180 gsm	30 minutes	4
			60 minutes	3-4
4	85% cotton 15% polyester, Fleece	Fleece ,280 gsm	30 minutes	4
			60 minutes	3-4
5	84% polyester 14% linen 2% lurex	Single jersey ,150 gsm	30 minutes	3-4
			60 minutes	3

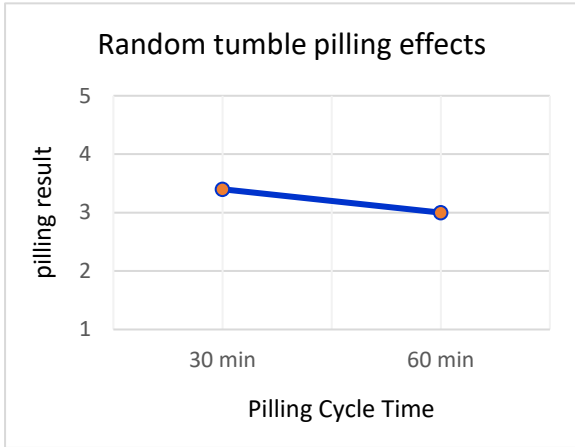
Pilling assessment result presenting on graph:



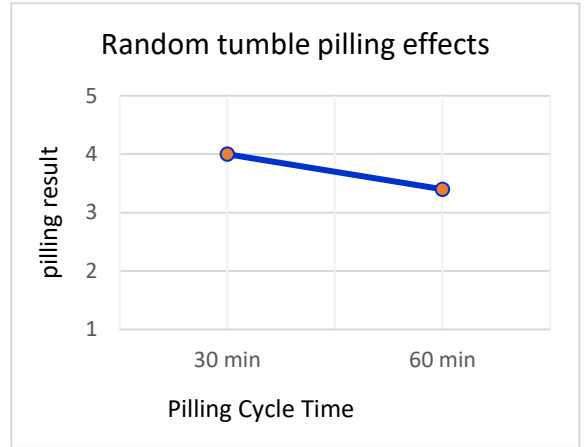
Pilling effects of random tumble pilling m/c
(63% polyester 33% viscose 4% elastane, Interlock
knit fabric)



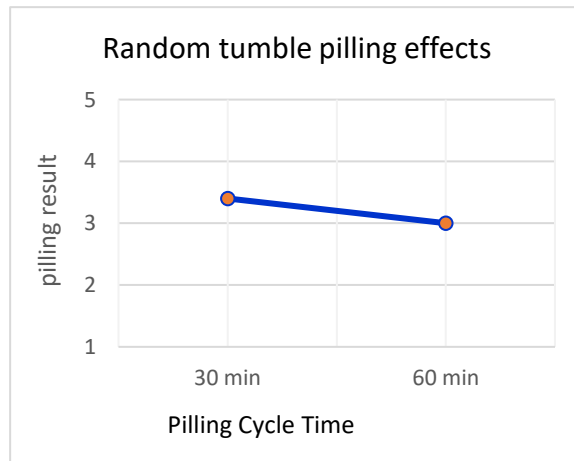
Pilling effects of random tumble pilling m/c
(95% polyester 5% elastane, fleece knit fabric)



Pilling effects of random tumble pilling m/c
(47% cotton 47% modal % 6% elastane, S/j knit fabric)



Pilling effects of random tumble pilling m/c
(84% cotton 15% Polyester , Fleece knit fabric)

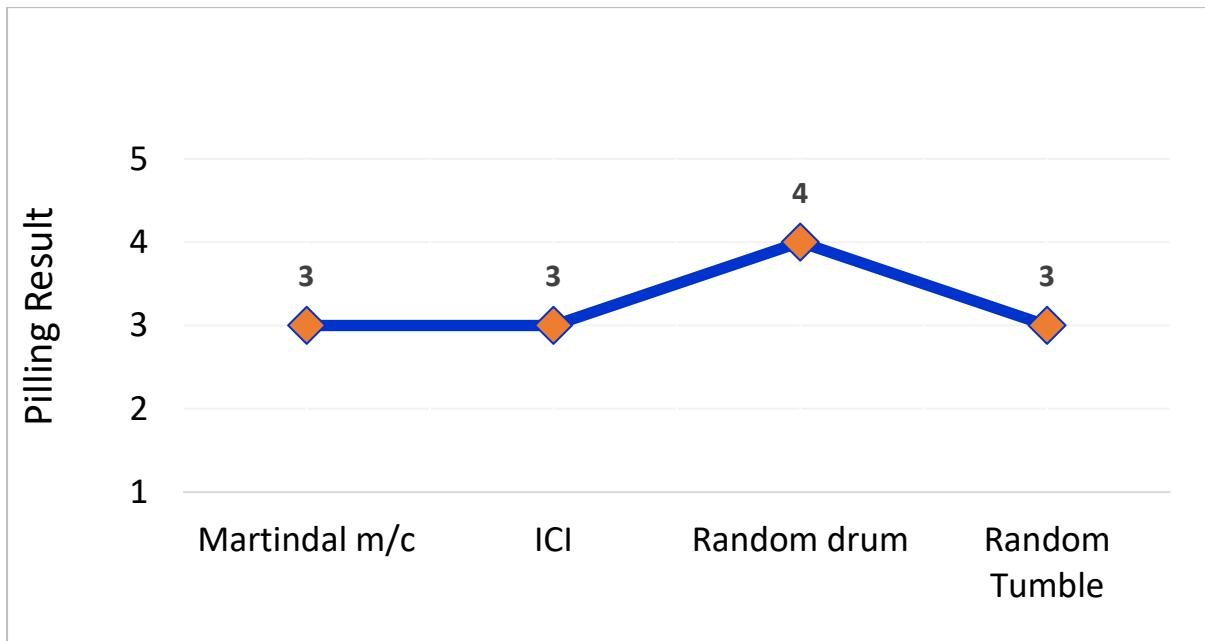


Pilling effects of random tumble pilling m/c
(84% Polyester 14% Linen 2% lurex, Fleece knit fabric)

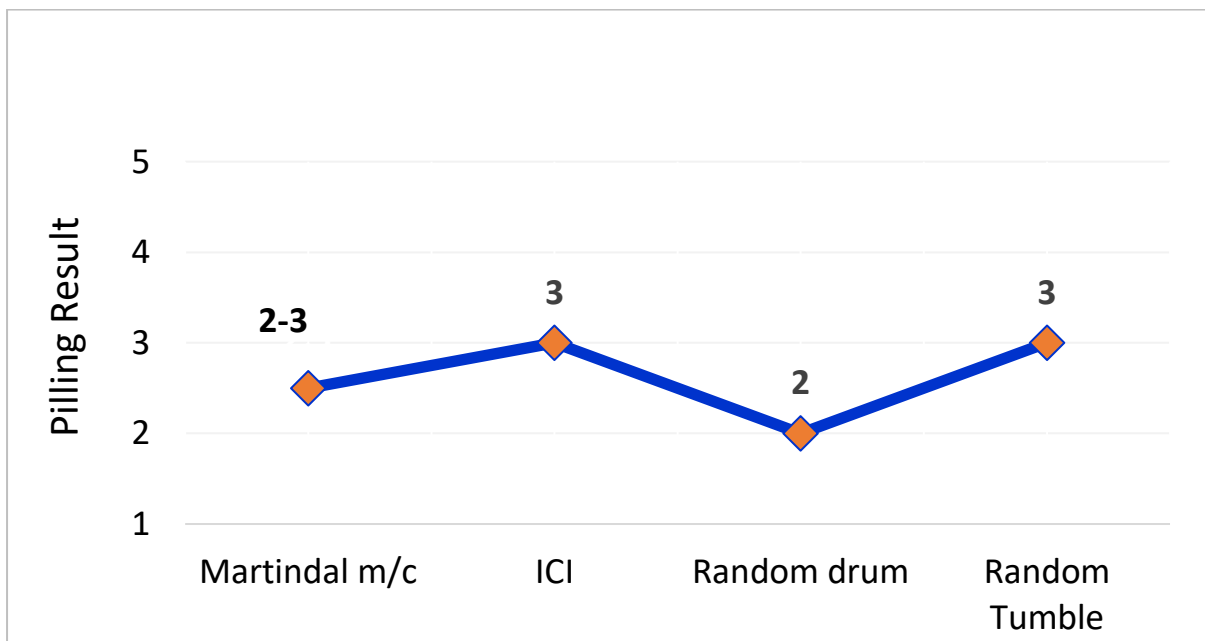
3.5 Comparison among various methods of pilling tests results:

Fabric Name	Criteria	Martindale pilling Machine	Random pilling drum Machine	ICI pilling Machine	Random Tumble pilling Machine
63% Polyester 33% Viscose 4% Elastane, Interlock Fabric	Pilling grade	3	Grade B = 4	2-3	3
	Fabric Condition Time	4 hr	4 hr	16 hr	4 hr
	Sample Preparation time	15 Min	20 Min	15 Min	2 Hr & 30 Min
	Machine Run time	45 Min	1 Hr & 45 Min	4 Hr	1 Hr
75% Cotton 25% polyester, Inside Brush Peach Finish Fabric	Pilling grade	2-3	Grade D = 2	3	3
	Fabric Condition Time	4 hr	4 hr	16 hr	4 hr
	Sample Preparation time	15 Min	20 Min	15 Min	2 Hr & 30 Min
	Machine Run time	45 Min	1 Hr & 45 Min	4 Hr	1 Hr
47% Cotton 47% Modal 6% Elastane Single Jersey	Pilling grade	2-3	Grade B -C= 3-4	3-4	3-4
	Fabric Condition Time	4 hr	4 hr	16 hr	4 hr
	Sample Preparation time	15 Min	20 Min	15 Min	2 Hr & 30 Min
	Machine Run time	45 Min	1 Hr & 45 Min	4 Hr	1 Hr
85% cotton 15% polyester, Fleece Fabric	Pilling grade	2-3	Grade B -C= 3-4	3-4	3-4
	Fabric Condition Time	4 hr	4 hr	16 hr	4 hr
	Sample Preparation time	15 Min	20 Min	15 Min	2 Hr & 30 Min
	Machine Run time	45 Min	1 Hr & 45 Min	4 Hr	1 Hr
84% polyester 14% linen 2% lurex Single Jersey Fabric	Pilling grade	2-3	Grade E = 1	3	3
	Fabric Condition Time	4 hr	4 hr	16 hr	4 hr
	Sample Preparation time	15 Min	20 Min	15 Min	2 Hr & 30 Min
	Machine Run time	45 Min	1 Hr & 45 Min	4 Hr	1 Hr

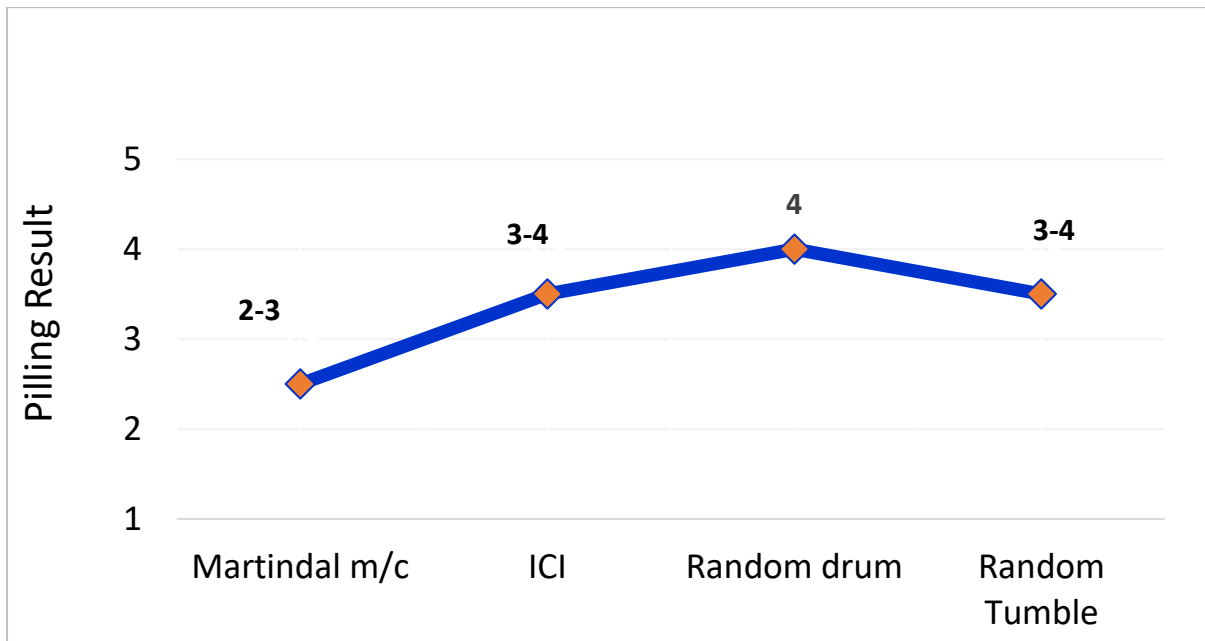
3.5.1. 63% Polyester 33% Viscose 4% Elastane, Interlock Fabric:



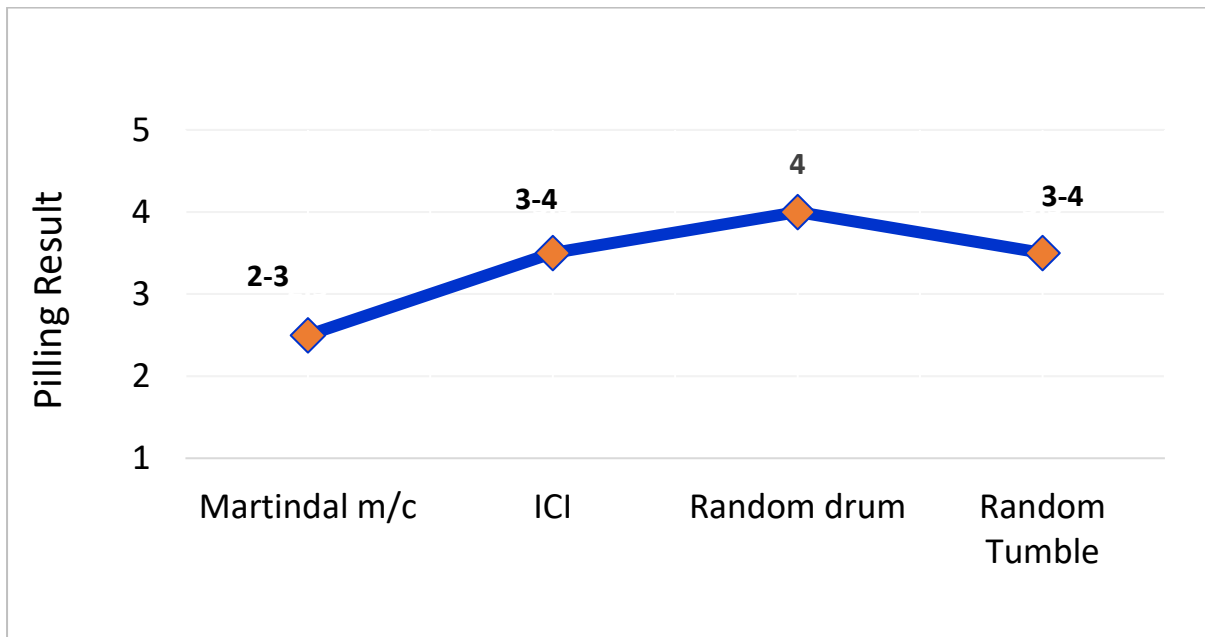
3.5.2. 63% Polyester 33% Viscose 4% Elastane, Interlock Fabric:



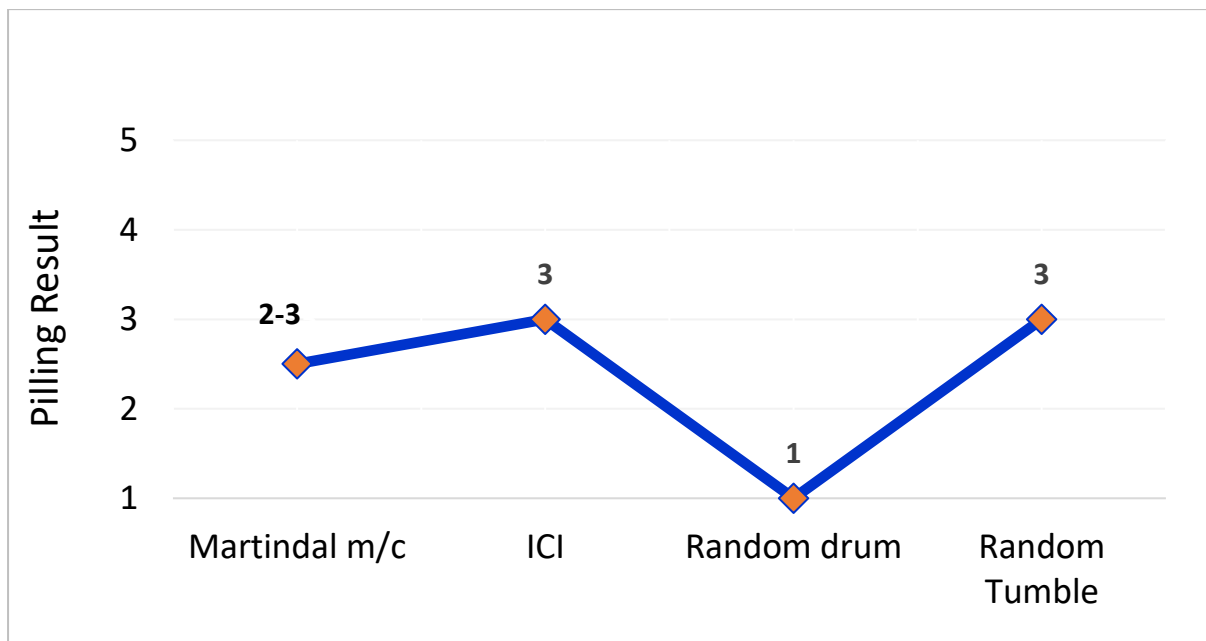
3.5.3. 47% Cotton 47% Modal 6% elastane Single Jersey:



3.5.4. 85% cotton 15% polyester, Fleece Fabric:



3.5.5. 84% polyester 14% linen 2% Lurex Single Jersey Fabric:



Chapter-4:

Discussion of Results:

4.1 For 63% Polyester 33% Viscose 4% Elastane, Interlock Fabric:

It can see the lower grade result in ICI Machine than Martindale Machine. But difference is not significant.

Similar grade shows as Martindale Machine in random tumble pilling Machine but procedure and time is comparatively long.

Rest Random pilling drum Machine shows the better pilling grade than all. So it can't consider this Machine for testing purpose.

Here the Machine can select considering the buyers lead time.

For less lead time order, Martindale Machine can use and long lead time order ICI Machine will be preferable.

4.2 For 75% Cotton 25% polyester, Inside Brush Peach Finish Fabric:

It can see the lower grade result in random pilling drum Machine than all. Here required both testing equipment and time is more.

In comparison with random pilling drum Machine & Martindale Machine, result grade is half upper in Martindale. But here testing time requirement is too less than random pilling Machine.

In ICI Machine, result grade is good and required testing time is high. So it can't consider this Machine for testing purpose.

In ICI & random tumble pilling Machine result grade is similar but testing time requirement is less in random tumble Machine.

From above all Machine Martindale is much preferable than others in respect of testing purpose.

4.3 47% Cotton 47% Modal 6% Elastane Single Jersey:

It can see the lower grade result found in Martindale Machine. For Martindale Machine, testing process time is also comparatively less.

In ICI Machine, result grade is good and required testing time is high. So it can't consider this Machine for testing purpose.

For rest two Machine Random pilling drum & random tumble pilling Machine both result grade and testing time required is similar.

From above all Machine Martindale is much preferable than others in respect of testing purpose.

4.5 85% cotton 15% polyester, Fleece:

In Martindale Machine, lower pilling grade showing within minimum time and less revaluation. Process is completed on non-wash specimen. Here process complexity is less.

In rest of Machine's, pilling grade is higher and process preparation & run time also high comparatively Martindale Machine. For these Machine's, process complexity is more.

4.6 84% polyester 14% linen 2% lurex:

In Martindale Machine, pilling grade showing as moderate. Considering the process preparation and process run time, this Machine is perfect for short lead time order. Except this, specimen no need to wash.

In Random pilling drum Machine, pilling grade is very poor. If here more focused on the product quality, then it have to choose this Machine for this fabric. But one fact is also important and that is the time. Here process preparation time and process run time is more. So, it can select this Machine, if here have sufficient time to execute the order.

Rest two Machine's shows similar pilling grade (moderate) with non-wash specimen. Both process preparation time is more comparatively previous two Machine's.

Here is the details comparison among all machines considering my tested four sample fabrics:

Chapter-5:

Conclusions:

Comparing four pilling testing methods with Five different fabrics; shows the variance of pilling effect. Method to method maximum variance found one and half grades. Variety of method are related with different testing time and equipment's.

Our study indicates the better method as Martindale considering testing time and tested fabric appearance. Here shows the result as lower grade in maximum case. So, that specimen can be easily accepted by buyer even it may have tested with others method.

It is noticing in recent days, buyer Puma preferred Martindale method rather ASTM method to ensure the better quality within available parameter. It can confidence on my analysis and observation that it will be applied by all other buyers in near future.

Chapter-6

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