DEVELOPMENT OF ANTI STATIC FINISHED WORK WEAR FOR SWITCH YARD WORKERS IN NEYVELI LIGNITE CORPORATION

A PROJECT REPORT

Submitted by

D.SHRUTHIKA	**0710203038**
D.SOWMYA	**0710203040**
M.SWARNAREKHA	**0710203043**
R.LAVANYA	**0710203308**
T.PUNITHA	**0710203311**

in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

TEXTILE TECHNOLOGY (FASHION TECHNOLOGY)

DEPARTMENT OF FASHION TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY

(An autonomous institution, affiliated to Anna University of technology, Coimbatore)

APRIL 2011

KUMARAGURU COLLEGE OF TECHNOLOGY

(An Autonomous Institution affiliated to Anna University of Technology, Coimbatore)

BONAFIDE CERTIFICATE

Certified that this project report "**DEVELOPMENT OF ANTSTATIC FINISHED WORKWEAR FOR SWITCH YARD WORKERS IN NEYVELI LIGNITE CORPORATION** "is the bonafide work of

D.SHRUTHIKA	**0710203038**
D.SOWMYA	**0710203040**
M.SWARNAREKHA	**0710203043**
R.LAVANYA	**0710203308**
T.PUNITHA	**0710203311**

who carried out the project work under my supervision.

SIGNATURE

DR.J.SRINIVASAN

HEAD OF THE DEPARTMENT

Department of Fashion Technology

Kumaraguru College of Technology

Coimbatore -641049

SIGNATURE

Mr.G.RAJKUMAR

SUPERVISOR

ASSISTANT PROFESSOR

Department of Fashion Technology

Kumaraguru College of Technology

Coimbatore -641049

Certified that the candidate with the University Register No. 0710203038, 0710203040, 0710203043, 0710203308, 0710203311 was examined by us in the project viva-voce examination held on 21.04.11

21.4

(INTERNAL EXAMINER)

(EXTERNAL EXAMINER)

KUMARAGURU COLLEGE OF TECHNOLOGY

(An Autonomous Institution affiliated to Anna University of Technology, Coimbatore)

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SIGNATURE	**SIGNATURE**
DR.J.SRINIVASAN	**Mr.G.RAJKUMAR**
HEAD OF THE DEPARTMENT	**SUPERVISOR**
	ASSISTANT PROFESSOR
FASHION TECHNOLOGY	**FASHION TECHNOLOGY**
KUMARAGURU COLLEGE OF TECHNOLOGY	KUMARAGURU COLLEGE OF TECHNOLOGY
(An Autonomous Institution Affiliated to Anna University of Technology)	(An Autonomous Institution Affiliated to Anna University of Technology)
Saravanampatty, Coimbatore.	Saravanampatty, Coimbatore.

Internal Examiner **External Examiner**

ACKNOWLEDGEMENT

First and foremost we thank the "God Almighty" for endowing us with his immense blessing which helped to overcome the hurdles, paving way for successful completion of the study.

We take this opportunity to thank our Co-Chairman, **Dr. B.K. Krishnaraj Vanavarayar**, Director, **Dr. J. Shanmugam,** Kumaraguru College of Technology and Principal, **Dr. S. Ramachandran,** Kumaraguru College of Technology for their support and permitting us to use the facilities of the institution.

We express our sincere gratitude to **Dr.J. Srinivasan**, Professor & Head, Department of Fashion Technology, Kumaraguru College of Technology for having been a source of encouragement and for instilling the vigor to do the project.

It gives us great pleasure to express our deep sense of gratitude for our guide **Mr.G.Rajkumar,** Assistant Professor, Department of Fashion Technology, Kumaraguru College of Technology for his innovative guidance, expert suggestions and constant encouragement at every step for the study.

We wish to thank our project coordinator **Dr.R.Shanthi,** Assistant Professor, Department of Fashion Technology, Kumaraguru College of Technology for being a constant source of inspiration.

Our heartfelt gratitude to **Mrs. Krishnavani,** lab technician, Department of Textile Technology, **Mr.Surendar,** lab technician, Department of Fashion Technology and **Mr.Varadarajan,** lab technician, TIFAC core for their immense support throughout our study.

Last but not the least we express our deepest sense of gratitude to **Mr. Dhamodaran,** Neyveli Lignite Corporation for extending his support in completion of the study.

ABSTRACT

The accumulation of static charge on textile material and its subsequent discharge presents major problems in the thermal power plant. It also becomes a labor problem because workers have to endure the unpleasant effects of static discharge like mild shocks, as well as the clinging and unwanted crumpling of fabrics. To combat the problem of static accumulation, antistatic finishes are added to the substrate. These finishes generally act by adding polar groups to the substrate increasing the hydrophilicity and making it more amenable to dissipating away the excess charge.

The requirement of the workers working in switch yard in the Neyveli Lignite Cooperation who have been facing issues with electrostatic build-up in their garments are studied. 100% cotton, 100% polyester, cotton/polyester (60:40) blend and 100% micro polyester fabrics are selected based on the requirements of switchyard workers in Neyveli Lignite Corporation. These four fabrics are finished with ultrafab upe and innocelle uniq for anti static finish using pad-dry-cure method.

The fabrics are tested for abrasion resistance, drape, stiffness, crease recovery angle, air permeability, water vapor permeability and anti static property. Cotton/polyester blended fabric has shown very good anti static property than other samples. The air permeability, water vapor permeability, drape and stiffness of cotton/polyester blended fabric has shown very good results.

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INTRODUCTION

1. INTRODUCTION

A thermal power station is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different fuel sources. Some prefer to use the term *energy center* because such facilities convert forms of heat energy into electricity. Some thermal power plants also deliver heat energy for industrial purposes, for district heating, or for desalination of water as well as delivering electrical power

Neyveli Lignite Corporation Limited (NLC) is a government-owned lignite mining company in India. NLC operates the largest open-pit lignite mines in India and mines some 24 million tonnes of lignite per year for fuel, with an installed capacity of 2490 MW of electricity per year which is supplied to Tamil Nadu, Kerala, Karnataka, and Andra Pradesh. The company operates thermal power plants, three large mines. The company also supplies a large quantity of sweet water to Chennai, thanks to the artesian aquifers in the lignite mines.

It is a known fact that the build up of electrostatic discharge is hazardous in an area which contains not only flammable material but also an extensive electronic equipments. Apart from fire hazards and malfunction of the equipment, the workers have faced countless discomforts due to electrostatic discharge during their long hours of work.

The accumulation of static charge on textile material, and its subsequent discharge, presents major problems in the power plants. It also becomes a labour problem because workers have to endure the unpleasant effects of static discharge like mild shocks, as well as the clinging and unwanted crumpling of fabrics. To combat the problem of static accumulation, antistatic finishes are added to the substrate during dying. These finishes generally act by adding polar groups to the substrate, increasing the hydrophilicity and making it more amenable to dissipating away the excess charge. It has been common practice for personnel handling these devices in electronics manufacturing industry to wear a special protective clothing, called ESD garments, over their normal cloths to avoid, or at least minimise, the risks of ESD failures to ESDS due to charged clothing.

LITERATURE REVIEW

2. LITERATURE REVIEW

Electrostatic discharge (ESD) is the sudden and momentary electric current that flows between two objects at different electrical potentials. ESD is a serious issue in solid state electronics, such as integrated circuits that are made from semiconductor materials such as silicon and insulating materials such as silicon dioxide. Either of these materials can suffer permanent damage when subjected to high voltages; as a result, there are now a number of antistatic devices that help prevent static build up. ESD also poses as a threat where there are highly flammable material present in the vicinity which can lead to explosions and related fire hazards.

2.1 SWITCH YARD

A switchyard is essentially a hub for electrical power sources. For instance, a switchyard will exist at a generating station to coordinate the exchange of power between the generators and the transmission lines in the area. A switchyard will also exist when high voltage lines need to be converted to lower voltage for distribution to consumers. Therefore a switchyard will contain; current carrying conductors, grounding wires and switches, transformers, disconnects, remotely controlled arc snuffing breakers, metering devices, etc.

2.1.1 PROBLEMS FACED IN SWITCH YARD

Inductions occur in situation with high electric field levels. That is, close to High-and Extra-High Voltage Sources. Induction shocks typically involve sparking between a hand and earthed metal in a switchyard environment. Typical situations are substation and switchyards in the vicinity of High- and EHV lines; particularly under separated phase overhead lines.

2.2 CAUSES OF ESD

One of the causes of ESD events is static electricity. Static electricity is often generated through tribocharging, the separation of electric charges that occurs when two materials are brought into contact and then separated. Examples of tribocharging include walking on a rug, rubbing plastic comb against dry hair, rubbing a balloon against a sweater, ascending from a fabric car seat, or removing some types of plastic packaging. In all these cases, the friction between two materials results in tribocharging, thus creating a difference of electrical potential that can lead to an ESD event.

Another cause of ESD damage is through electrostatic induction. This occurs when an electrically charged object is placed near a conductive object isolated from ground. The presence of the charged object creates an electrostatic field that causes electrical charges on the surface of the other object to redistribute. Even though the net electrostatic charge of the object has not changed, it now has regions of excess positive and negative charges. An ESD event may occur when the object comes into contact with a conductive path. For example, charged regions on the surfaces of styrofoam cups or plastic bags can induce potential on nearby ESD sensitive components via electrostatic induction and an ESD event may occur if the component is touched with a metallic tool.

2.3 TYPES OF ESD

The most spectacular form of ESD is the spark, which occurs when a strong electric field creates an ionized conductive channel in air. This can cause minor discomfort to people, severe damage to electronic equipment, and fires and explosions if the air contains combustible gases or particles.

However, many ESD events occur without a visible or audible spark. A person carrying a relatively small electric charge may not feel a discharge that is sufficient to damage sensitive electronic components. Some devices may be damaged by discharges as small as 10 V. These invisible forms of ESD can cause device outright failures, or less obvious forms of degradation that may affect the long term reliability and performance of electronic devices. The degradation in some devices may not become evident until well into their service life.

2.3.1 SPARKS

A spark is triggered when the electric field strength exceeds approximately 4–30 kV/cm — the dielectric field strength of air. This may cause a very rapid increase in the number of free electrons and ions in the air, temporarily causing the air to abruptly become an electrical conductor in a process called dielectric breakdown. Perhaps the best known example of a natural spark is a lightning strike. Sparks can cause serious explosions because of the high temperatures reached in a spark. Methane and coal dust explosions have been caused by electrostatic discharges.

2.3.2 CORONA DISCHARGE

A corona discharge occurs between a highly curved electrode, for example the tip of a needle or a small diameter wire, and an electrode of low curvature such as a flat plate. The high curvature produces a high potential gradient around one electrode.

2.3.3 BRUSH DISCHARGE

A brush discharge occurs between an electrode with a curvature between 5 mm and 50 mm and a voltage of about 500 kV/m. The resulting discharge paths have the shape of a brush.

2.4 GENERATION OF STATIC

The triboelectric series is an empirically compiled series where materials are arranged from top to bottom depending on their relative ability to lose or gain electrons, beginning with the most positively charged substance and ending with the substance carrying the most negative charge. A simple triboelectric series for fibers can be illustrated in table given below:

Glass
Wool
Nylon 6
Nylon 6,6
Rayon
Cotton
Acetate
Hemp
Silk
Polyester
Acrylic, Modacrylic
Polyethylene, polypropylene
Polytetrafluoroethylene

For example if fibers of glass and polyester are rubbed together, glass acquires positive charges and polyester, a negative charge because polyester has better ability to gain electrons than glass. On the contrary, the same polyester fibers will acquire positive charges when rubbed with polypropylene fibers because it has a greater tendency to lose electrons as compared to polypropylene.

2.5 STATIC IN TEXTILE PROCESSING

The processing of polymer fibers and fabrics may present problems in processing because of the accumulation of static charge on these fibers due to friction with machine surfaces. Charging may also occur due to exposure to ionized gases or plasma or due to repeated deformation. When two dielectric polymer fibers or fabrics are rubbed against each other, one of them loses electrons and is positively charged while the other one accepts electrons and gets negatively charged. The propensity of a dielectric polymer to lose or gain electrons with respect to each other, makes them either positive or negatively charged, and this is listed in triboelectric series. The electrostatic charges generated cause inconveniences like ballooning due to the repelling of fibers containing like charges. Charged fiber and fabrics attract dust and may need cleaning before further processing. The rate of charge dissipation from the charged fibers and fabrics depends on several factors such as the molecular structure of the polymer and environmental conditions such as humidity and impurities.

Static also causes handling problems for fibers and fabrics. Static generated in fabrics interferes with the operation of computers and other sensitive electronic devices in or around which such textiles are used. Discharges of sufficient magnitude can cause fires as the spark caused can ignite flammable vapors and dust causing dust explosions.

It is essential to incorporate certain chemical additives into textile substrates in order to overcome static charges for both processing and consumer use. There are different methods that are used to control static in textile processing. Most textile mills include conditions of high humidity in them in order to help dissipate any charge built up on the fibers. During processing, synthetic fibers are coated with spin finishes that are essentially lubricants and have antistatic agents added. Spin finishes enable the fibers to be processed at higher speeds, with no static related problems. Antistatic agents can be either added to the bulk or to the surface of fibers.

2.6 MECHANISM OF CHARGE DISSIPATION

The three mechanisms of charge dissipation are:

2.6.1 CONDUCTION

If the fabric is grounded, the charge on or near the conducting element of the conducting thread will be conducted to earth. The conduction mechanism depends on:

- Resistivity of the threads
- Resistivity of base material
- Resistance over garment seams, in such cases when the charge cannot be effectively

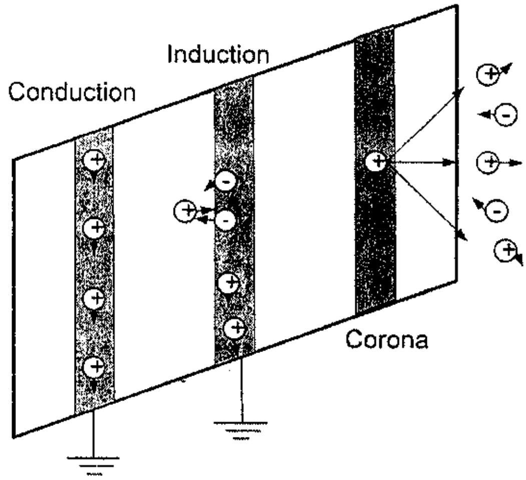
[illegible]

due to field coupling to grounded fibres, but above we defined the voltage suppression as the coupling to operator's body. Secondly, the mechanism appears like charge decay when the conductive elements have a finite resistivity. The induction mechanism depends on:

- Conductive grid design and materials used in particular fabrics
- Capacitance of the charged garment system

[illegible]

Fig 2.1 mechanism of chorona



It has been found that for grounded ESD fabrics charged by controlled triboelectrification there are three clearly distinguishable regions and processes in the charge decay curve at dry humidity (12 % RH). There is a fast initial charge decay response with a time constant (charge decay to e^{-1} of the peak value) of only 10-30 ms, mirroring the initial response of conductive threads. The second region has a time constant typically of about a few seconds at 12 % RH. The third distinguishable region has a time constant typically of tens of seconds or even minutes, mirroring the slow charge migration on the base fabric. In ungrounded fabrics the corona discharge is the principal charge dissipation mechanism. We made experiments with different kinds of charged core conductive fabrics and found that the corona mechanism effectively limits the fabric charging of core conductive fabrics typically to 2-5 kV by self-decay.

2.7 ANTISTATIC TEXTILES

Antistatic finishes are generally applied when the antistatic nature of the substrate is to be maintained for a longer time. Depending on how they are applied, antistatics include internal and external finishes. Internal antistatic agents are the ones which are added to the bulk of the polymer, forming a pathway for the charges to flow from the polymer surface to ground.

External antistatic agents are applied externally from solutions to the textile surface through a variety of methods including padding baths, spraying, plasma grafting, vapour deposition etc.

External antistatic agents have hydrophobic and hydrophilic functionalities in their molecular structure. The hydrophilic part orients itself towards the air and promotes the absorption of moisture, resulting in better ion mobility and dissipation. Conventional antistatic finishes include durable or non durable finishes depending on their ease of removal. The following sections discuss non durable finishes and durable finishes respectively.

2.7.1 NON-DURABLE FINISHES

Non-durable antistatic agents are used to treat substrates that will not undergo repeated or any laundering in their lifetime. These include products like conveyor belts and driving cords.

Many common non-durable antistatic finishes are considered anionic and include compounds like esters of phosphoric acid. Here the phosphoric acid group (-PO3-2) containing finish is deposited onto the substrate and allows for charge dissipation. The durability of these phosphoric acid esters increases with the size of the molecule. Some other examples would include alkyl phosphates, ethoxylated secondary alcohols, glycerol mono- and distearate, sodium alkyl sulfonates, neutralized alcohol phosphate, sorbitan monolaurate and sorbitan monooleate. The chemical groups of these compounds include –OH, -ONa, -COOR, -PO4 and –SO4 functionalities. Esters migrate quickly onto textile surfaces, are relatively thermally stable and perform well even under low humidity conditions.

Another class of non-durable finishes contains quaternary ammonium compounds. The most common compounds used are ditallowdimethylammonium chloride and dehydrogenated tallowdimethylammonium chloride. These fall under the category of cationic antistatic finishes, due to the presence of a cationic group (N+) that is quaternarily bonded. These compounds are applied by exhaustion processes as they have natural affinity for textile fibers, because of the presence of positive charges on their structure.

These compounds improve pigment dispersibility .and have fast and efficient migration properties. They generally exhibit good thermal stability due to the presence of saturated structures. Amines generally form aqueous solutions and have excellent dispersibility even in cold water. Quaternary amines, also impart softness to the fabric, which makes them extremely capable of value addition in the consumer sector, as antistatic finishes. The important industrial processing methods of applying amine antistats include extrusion, calendaring, immersion, dipping, compounding, blow molding, sheet extrusion, spraying, surface printing etc. The important textile polymers which amines are applied on are PET, PP, PA and acrylic.

The third group of non-durable antistatic finishes includes non-ionic compounds. These are mostly ethoxylated fatty esters, alcohols and alkylamines. The ethoxy groups provide good hydrogen bonding, and as a consequence, become moisture friendly or hygroscopic. The moisture in turn provides the required antistatic properties.

Mixtures of ionic and non-ionic antistatic finishes are also used to provide better antistatic properties. The ions provided by the ionic surfactant are mobilized by the moisture absorbed on account of the non ionic surfactant, providing better antistatic.

2.7.2 DURABLE FINISHES

Conventional durable antistatic finishes are obtained by forming a functional polymer network on the surface of the substrate. The polymer network has hydrophilic groups that assist in the dissipation of any charge. The polymers can be formed prior to application on fabrics or they can be formed on the surface of the substrate itself.

Durable finishes are traditionally polyamines that are reacted with polyepoxide. With these compounds, the level of hydrophilicity is inversely related to the fastness and durability of the finish. This happens because the hydrophilic polymer absorbs water, resulting in swelling and softening. In this state, the polymer becomes susceptible to removal by laundering and abrasion, thus reducing the effectiveness of its antistatic function. Due to the difficulty in finding the balance between hydrophilicity and durability, conventional durable antistatic finishes are still not widely used.

2.8 ANTISTATIC GARMENTS

Anti-static garments or anti-static clothing is required to prevent damage to electrical components or to prevent fires and explosions when working with flammable liquids and gases.

One of the ways to bond or electrically connect personnel to ground is the use of an ESD (Electrostatic Sensitive Device) garment. ESD garments have conductive threads in them, creating a wearable version of a faraday cage. ESD garments attempt to shield ESD sensitive devices from harmful static charges from clothing such as wool, silk, and synthetic fabrics on people working with them. For these garments to work properly, they must also be connected to ground with a strap. Most ESD garments are not conductive enough to provide personal grounding so antistatic foot straps and antistatic wrist straps are also worn. ESD garments are considered an optional method to control ESD.

An ESD protected area is a defined location with the necessary materials, tools, and equipment capable of controlling static electricity to a level that minimizes damage to ESD susceptible items. In the ESD protected area, all conductors in the environment, including personnel, shall be bonded or electrically connected and attached to a known ground or contrived ground. This attachment creates an equipotential balance between all items and personnel. Electrostatic protection can be maintained at a potential above a "zero" voltage ground potential as long as all items in the system are at the same potential.

2.8.1 REQUIREMENTS OF ANTISTATIC GARMENTS

An ESD protective garment should ideally have the following functions:

- The protective garment should effectively shield the electric field originating from the insulating parts of the operators normal clothing.
- The protective garment should prevent direct discharges from the operators normal clothing.
- The protective garment should not itself cause similar problems. That is, it should not generate electrostatic field external to the garment and it should not be a potential source of direct electrostatic discharges.

In practice the targets may not always be met.

Requirements for the ESD protective clothing in electronics industry are very diverse. Some manufacturers, handling very ESD sensitive devices, require high ESD protective performance for the upper garments of their production personnel, while another manufacturer would be satisfied with much lower ESD protective performance. In some cases the ESD garments also play other important roles such as protection of electronics from dust particles originating at the operator (cleanroom clothing). Then the major electrostatic function of the garment could be to reduce electrostatic attraction (ESA) instead of minimising ESD failures.

All these have lead to situation where ESD-garments are typically made of composite fabrics where a grid or stripes of conductive threads are present inside a matrix of cotton, polyester or mixtures of these materials. Furthermore, the conductive threads are more and more frequently made by composites, that is by a mixture of conductive and insulating fibres (surface conductive fibres, core conductive fibres, sandwich type fibres etc. All the latter elements lead to very heterogeneous fabrics for garments.

The diverse requirements for the ESD garments as well as the diverse structure of the garments give a great challenge for the test methods characterising the protective performance of the clothing and for the recommendations for the performance and use of these garments. In practice, there is a need for different level of garment tests:

- Approval tests for new products to enter the market, which should be done in laboratories under controlled conditions, and
- Periodic field/audit tests done for garments already in use, which tests would be done in production sites or in laundries after washing.

Ideally the test methods should be the same for both of the levels, but that is not a necessity. Furthermore, while the end-users of garments are interested in garment tests, manufacturers of protective garments as well as garment fabrics do need also fabric level tests in order to be able to produce garments fulfilling the end-user needs.

2.8.2 RISK OF INDUCED EMI CURRENTS

Risks of ESD failures by radiation are related to EMI currents induced by nearby ESD, such as a discharge from operator's ordinary clothing to his grounded ESD-garment. In our tests we measured EMI currents induced on test circuits with maximum peak values of about 20 mA. With reference to garments, the risk is relevant only when handling MR heads or other components with ESD withstand less than a few volts. The risks can be minimised, when necessary, by paying attention on the clothing used under the ESD garment. Furthermore, the electromagnetic shielding performance of ESD fabrics is negligible in the frequency range of interest. Therefore, the risk mechanism is not of concern when evaluating the protective performance of ESD garments, i.e. the electromagnetic shielding performance of a garment or garment fabric is not of relevance.

2.8.3 IMPORTANCE OF GARMENT GROUNDING

Most of the ESD risks associated with charged clothing are minimised by using ESD protective garments where all garment panels are grounded satisfactory well. It would require that the conductive fibres shall be grounded and all parts of the garment shall be connected to each other or to ground, i.e. the conductive parts of the garment should be continuous. Depending on which ESD safety level is required, exceptions could be allowed, particularly if the system is used in higher humidity (>40 %RH) where a charge on a garment surface can drain slowly to ground through the normal clothing of the operator.

A part of a garment fabric panel, which is insulated from the rest of the garment, acts in principal as a non-grounded garment and constitutes an ESD-risk. Like all non-grounded conducing objects inside an EPA. The level of the risk depends on the resistivity of the conductive elements of the panel risk of direct discharges and the strength of the electrostatic field outside to the garment panel risk of induced voltages.

A core conductive garment cannot be adequately grounded due to the buried conductive elements and can never be considered as continuous at dry conditions. We cannot, however, conclude anything from this in itself about their potential value in ESD protective garments. Measurement of peak current and charge transferred in ESD sourced from a fabric can be used in the evaluation of risk of damage from direct ESD, whether the material is groundable or not. Similarly, measurement of external electrostatic fields gives a general good method of evaluating risks from induced potentials on devices.

2.8.4 KEY PARAMETERS TO CONTROL

The following parameters have been identified as the key parameters to control in order to minimise ESD failures with reference to garments:

- Peak ESD current

- Charge transfer in a direct discharge to a victim device
- Induced device charging due to electric field external to the garment.
- Device charging due to accidental rubbing by garment

Risks of direct discharges from garment into devices are minimised when all the garment panels are grounded satisfactory well. Also charge decay through conduction and induction mechanisms as well as electrostatic shielding depend on the grounding of the garment.

Therefore the evaluation of the ESD protective performance of a garment should include the measurement of

- Resistance to ground or to a groundable point of the garment
- The integrity of the electrical resistance of the seams.

We cannot conclude anything from the measurement of resistance-to-ground of a garment panel in itself about the potential value of the garment as an ESD protective garment. Measurements of the factors of the key parameters to control would always give the principal information on the ESD protective performance of a garment.

Accordingly, it will be important to distinguish two types of ESD garments and fabrics

- Garments and fabrics that require grounding for ESD safe operation
- Garments and fabrics that do not require grounding.

Most of the factors above are directly related to the structure and electrostatic properties of the garment material and, thus, can be studied by fabric tests. Only few factors require potentially full garment or system tests related to earthed or non-earthed environment especially the operator.

2.9 MECHANISM OF THE ANTISTATIC FINISH

2.9.1 EFFECT OF THE ANTISTATIC FINISH ON CELLULOSE

Cellulose is used extensively in the form of wood, paper and fiber products for numerous end uses. The structure of cellulose comprises a basic repeating unit called cellobiose, consisting of two ringed glucose structures. The rings in the cellobiose unit are mutually inverted with respect to each other. Each ring is called an anhydroglucose unit. Each cellobiose unit contains six alcohol hydroxyl (-OH) groups which are capable of forming hydrogen bonds, both at intramolecular and intermolecular levels. The resulting structure of pure cellulose is therefore, highly crystalline and polar. Each cellulose chain typically has between 300 and 1700 repeating units for wood, and between 800 and 10000 for plant fibers like cotton.

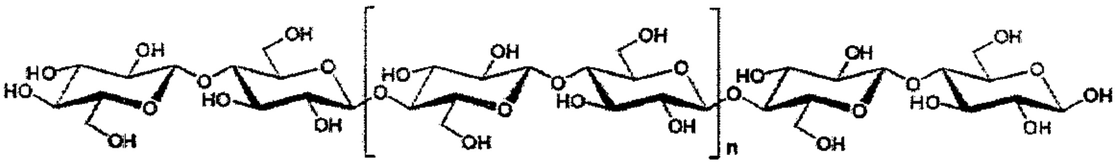


Fig 2.2 The structure of cellulose

In most cellulosic fibers however, there are both amorphous and crystalline regions. The crystalline regions are characterized by ordered, tightly packed chains with a high degree of hydrogen bonding. The amorphous regions are characterized by a general disorder in the packing of the chains. The effect of the antistatic finish on cellulosic substrates has generally been observed to alter wettability characteristics and increase surface energy of cellulosic fibers. The antistatic finish treatment has also been proven to improve the surface resistivity properties of cotton.

The antistatic finish treatment improves the dyeability of the cotton substrate after grafting with the right monomers, where cotton substrates were dyed with acid dyes after the antistatic finish treatment. The antistatic finish treatment of cellulose creates free radicals on the surface of the substrate. It has been observed that the intensity of the free radicals created depends on factors such as the nature of the gas used, the type of plant fibers, the length of the cellulosic chains and the antistatic finish treatment time. Free radicals can be created at different sites on the anhydroglucose unit. It has been observed that most stable radicals are created at sites C1, C2 and C5.

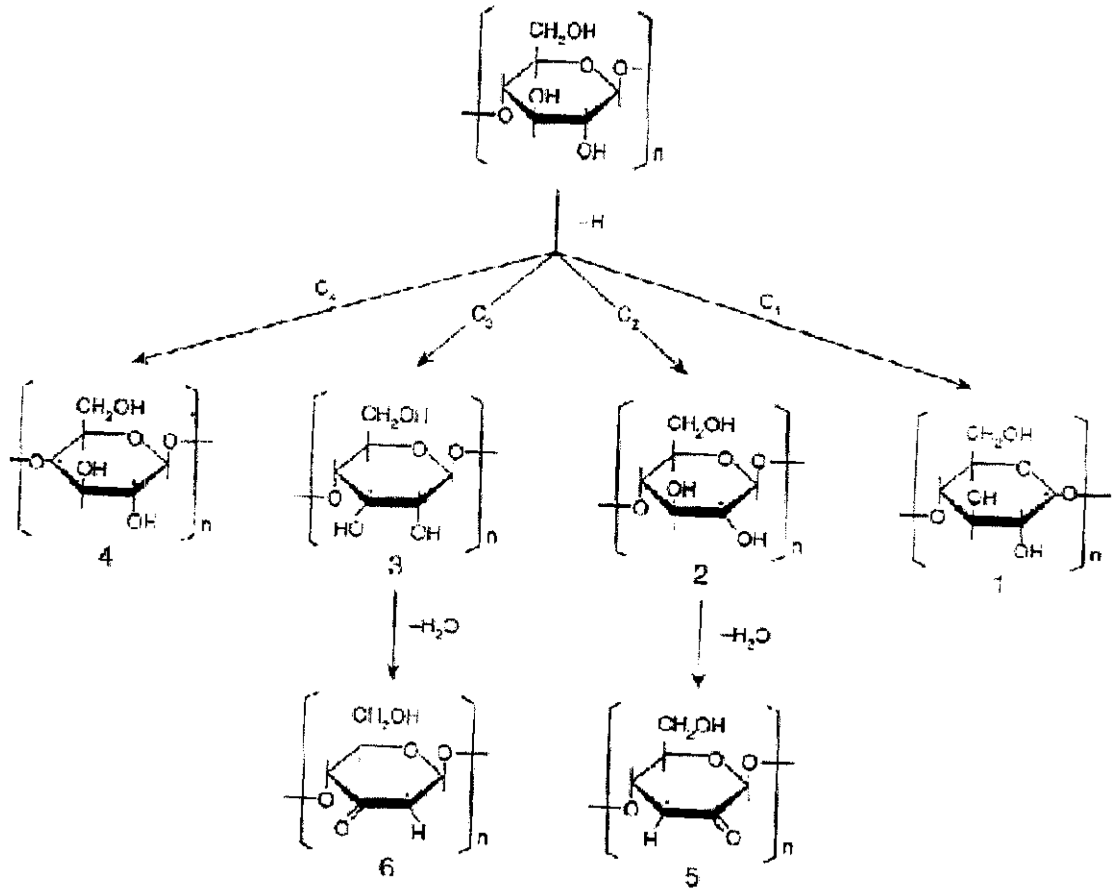


Fig 2.3Free radicals on cellulose induced by the antistatic finish

2.9.2 EFFECT OF THE ANTISTATIC FINISH ON POLYMERS

The antistatic finish treatment has a pronounced effect on synthetic polymers as regards hydrophilicity. Numerous research results have led to the establishment of a relation between the antistatic finish treatment and the resulting hydrophilicity of the synthetic polymer. The antistatic finish works to create different types of free radicals and polar groups on the surface of the substrate and therefore increase the hydrophilic properties, as well as adhesive properties. Treatment of polyester, for example, with oxygen the antistatic finish leads to an increase in the number of oxygen containing polar groups such as –OH, -OOH and –COOH on the fiber surface which attract water molecules, and also help dissipate excess static charge.

An increase in hydrophilicity also decreases the charge buildup and would thus improve the ntistatic properties of the polymers. The antistatic finish treatment has been shown to reduce he surface resistivity of polyester, with increasing the antistatic finish treatment time having a direct relation to decreasing resistivity and better antistatic properties. This can also be, in part, attributed to the increase in wettability of polyester surfaces after treatment.

The antistatic finish treatment increases the surface roughness of the textile material due to the etching effect, thus increasing the available surface area. Thus the antistatic finish treatment has a significant effect on the behaviour of textile substrates.

2.9.3 THE ANTISTATIC FINISH-INDUCED POLYMERIZATION

The antistatic finish-induced polymerization can lead to the attachment of solid polymeric materials with desired properties on textile substrates. The antistatic finish is an extremely functional tool in order to develop highly specific surface finishes. This is because different monomers can be used to carry out polymerization with the antistatic finish. The antistatic finishing ensures that the polymer film formed is thin (in the order of a few nanometers), and thus provides great functionality while maintaining the bulk properties of the substrate intact. Also, crosslinking of polymers can be introduced during the antistatic finish treatment, with the advantage of being able to control the degree of crosslinking with the antistatic finish treatment to provide superior mechanical properties.

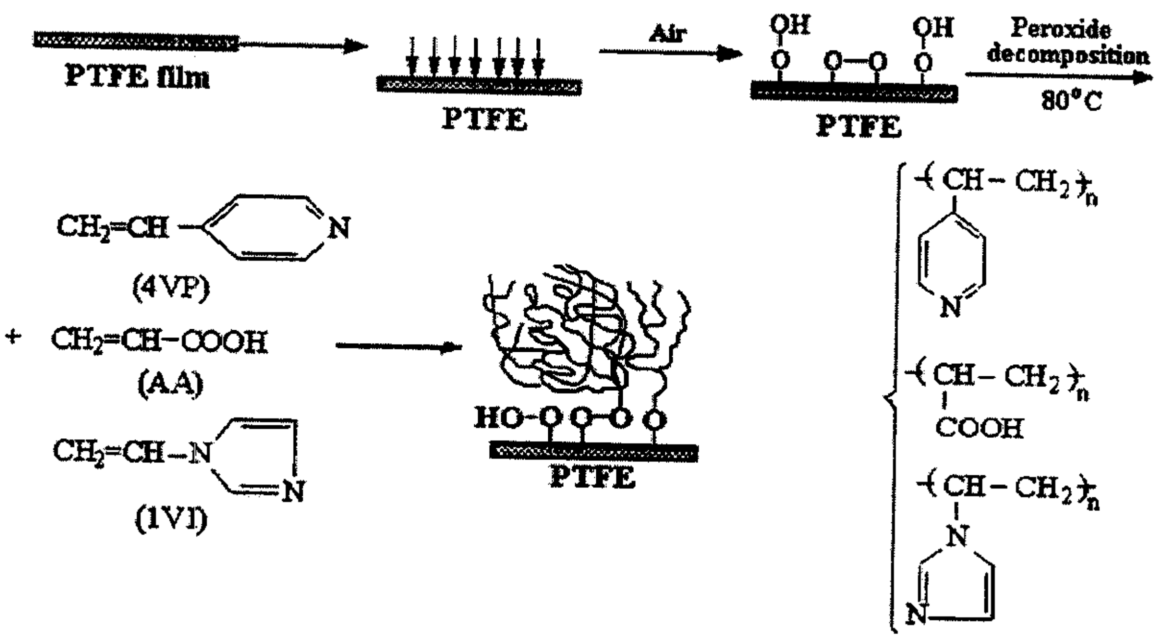


Fig 2.4 Mechanism of the reaction of the antistatic finish on PTFE surface

The mechanism here involves the formation of stable free radicals on the surface of PTFE that serve to initiate the polymerization reaction for sodium vinylsulfonate using the mechanism of double the antistatic finish treatment, wherein, the antistatic finish treatment was imparted to the raw fabric, followed by treatment with the monomer. This treatment was then followed up with another round of the antistatic finish treatment. This method would initially seek to form free radicals on the fabric surface by the antistatic finish treatment. The air drying method, after the initial the antistatic finish treatment would help in the formation of stable peroxides on the fabric surface. The antistatic finish is frequently employed to impart a varied set of functionalities to the polymer substrate in question. In case of a ubiquitous resource like cotton, which is hydrophilic, research has been carried out to make cotton hydrophobic. Cotton was rendered water repellent and flame retardant by low-pressure the antistatic finish induced polymerization of 1,1,2,2, tetrahydroperfluorodecylacrylate (a flame retardant monomer), with CF4 the antistatic finish. Therefore, the antistatic finish induced graft polymerization is a clean and efficient way to achieve the desired functionalities on the substrate surface.

2.9.4 USE OF SILICONES IN ANTISTATIC FINISH

Adding silicones is an inexpensive way of modifying the surface properties of a textile material. The most common supplication found for silicones is the creation of water repellency. Silicones can themselves form transparent layers that adhere well to the textile surface, with the common diameters of the particles being in the range of 10-50 nm. The application of silicones is typically achieved by the sol-gel process, wherein the particles are firstly formed from a chemical solution that reacted to form particles in colloidal form (sol). The advantages of silicones is that they are thermally stable to temperatures of up to 500°C, which implies that a wider range of application procedures and temperatures can be suited to them. This substance undergoes decomposition and forms silica and hydrogen chloride. This process has been applied extensively by the Evonik Degussa Corporation and is popularly called the "Aerosil" process.

The formation of silica particles consists of several intermediate stages, initially forming protoparticles, and progressively coalescing while cooling, to form branched, chain like aggregates. The physical aggregates have a size of about 100nm, and they cannot be broken down again by dispersion. The fused silicones can be characterized as having a low bulk density (0.02 to 0.05 g cm-3), but high surface area values (100 to 400 m2g-1); the density of the aggregates are approximately 0.7 gcm-3. By varying different parameters such as temperature of the flame, reactant concentrations and dwell time of the silica in the reaction chamber, it is possible to change the size of the particles, the size distribution and most importantly, the surface properties of the particles. It is also possible to use another chemical process to after-treat the silicones, in order to achieve special properties like hydrophilicity or hydrophobicity. This treatment can be done with halogen silanes, alkoxysilanes, silazanes or siloxanes.

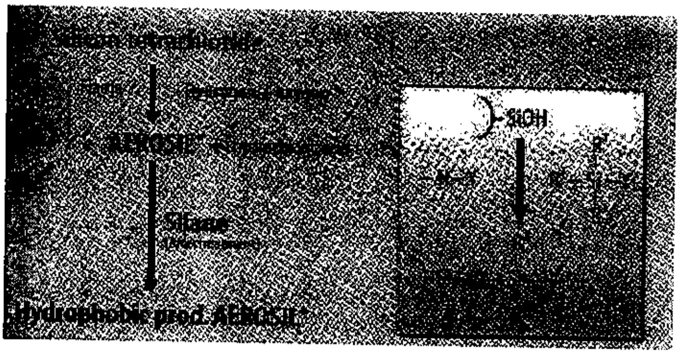


Fig 2.5 Chemical after-treatment of Si nanoparticles; a schematic diagram

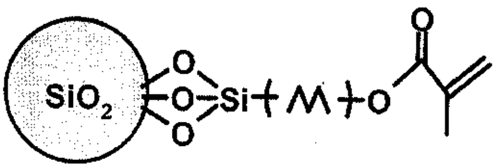


Fig 2.6 R711 particle structure

2.9.5 METHODS FOR TESTING FABRIC ANTISTATIC BEHAVIOR

Many tests have been devised in order to test the electrostatic properties of textiles and consequently establish a pattern for their antistatic behavior. Four major organizations that publish electrostatic standards are the American Society of Testing and Materials (ASTM), Electrostatic Discharge (ESD) Association, American Association of Textile Chemists and Colorists (AATCC), and International Standard Organization (ISO). These organizations have developed test methods to assess resistivity, static charge generation and accumulation. There are three accepted categories of test methods which measure the electrostatic propensity of textile materials. They are :

- direct measurement
- indirect measurement
- use of simulation

The direct measurement category typically consists of measuring electrical properties such as electrical field (E), potential (V), charge amount (Q), or the rate of electrostatic discharge, after developing charges on the material by standard treatments. Instruments like the electrostatic field meter and electrostatic voltmeter can be used for the measurement of electric field and potential on the surface of textile material, respectively. The obtained values can then be converted to charge density and charge per unit area, which represent the probability of an electrical discharge.

The indirect method of treatment generally involves the use of other indicators like electrical resistance (R) or conductance of the textile materials. Resistance is the property of a substance indicating how it opposes the flow of an electric current through it. Conductance is the reciprocal of resistance, and it refers to the property of the material that allows current to flow through it when a potential difference is applied. They are still generally believed to represent electrostatic properties

The third category, simulation, consists of methods which study the behavior of textile materials in a situation simulating the end-use for which they are intended, instead of actual electrostatic properties. Common tests in this category are the cling and walking tests. The cling tests observe and study the clinging behavior of textiles when charged with static electricity, as an indicator of their static property. Walking tests simulate the action of walking on carpets, and observe static charges generated by walking, mainly on carpet materials.

The antistatic finish treatment modifies fabric surfaces both physically and chemically. The antistatic finish technology would help create active sites on the surface of the substrate. These active sites or free radicals initiate the grafting polymerization reaction of the ionic monomers on the fabric surface. The antistatic finish treatment is a totally dry-processing technology, unlike conventional wet-processing.

Functionally modified silicones are used in this research as they have very small particle diameter (approximately 12 nm) and a large number of surface methacrylate groups (~565 methacrylate groups/particle). The silica particles are themselves covalently bonded to the surface of the fabric. These help to improve the roughness of the fabric surface and thus better the durability of the finish on the fabric surface. The increased surface roughness leads to increased surface area due to the undulations, and provides more sites for the monomers to attach and begin polymerization. Ionic monomers that were used in this research were 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS) and sodium vinylsulfonate (NaVS) provide free ions which increase the surface conductivity of the fabric, thus imparting the desired antistatic properties.

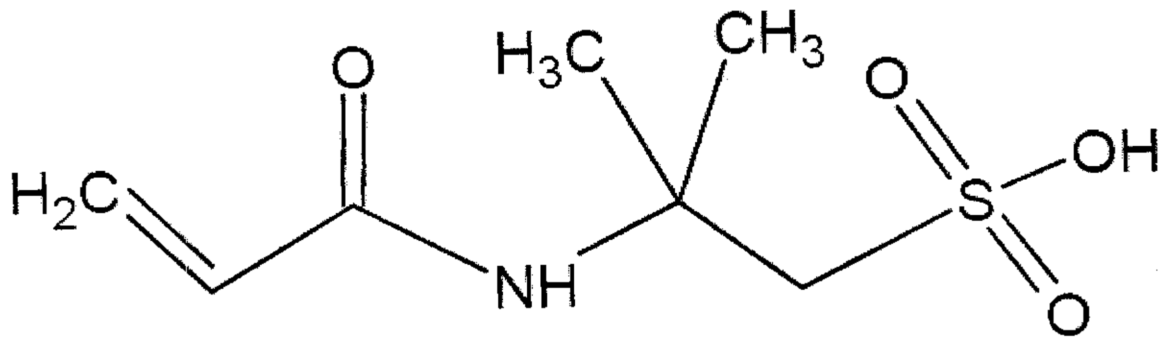


Fig 2.72-acrylamido-2-methyl-1-propanesulfonic acid (AMPS)structure

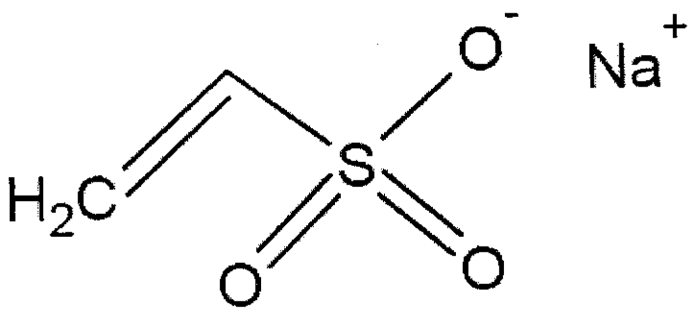
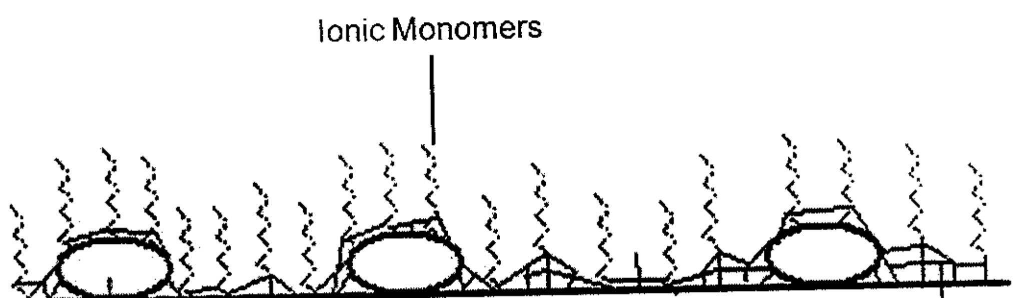


FIG 2.8 Sodium vinylsulfonate (NaVS)structure

The crosslinkers work to form a three-dimensional network between the silica particle clusters and the ionic monomers. The attachment of the ionic monomers to the fabric surface through direct bonding and through the crosslinkers and on top of the silicones help to give an uneven and rough surface which can help impart better antistatic properties.



2.10 CHARGE DECAY TEST METHODS

Electrostatic charge build-up depends on the balance between charge generation and charge dissipation. If the charge is dissipated more quickly than it is generated, no static electricity builds up. Therefore, the measurement of charge decay of material has traditionally belonged to basic electrostatic tests, in addition to the resistance measurements.. The term 'charge decay' covers the potential created by rubbing a material or surface, initially at earthed potential, and the time after rubbing and taken for this voltage to fall away as the charge migrates away. The measurement of the charge decay of a material, however, is not as straightforward as the measurement of surface resistance. The reason for this is that the charge decay of electrostatic dissipative or insulating materials, at given environmental conditions, depends on:

- the intrinsic material properties
- how the charge is generated on the tested material (initial charge distribution)
- the initial density of the charge generated on or in the tested material
- how the material is grounded
- the geometrical and dimensional arrangement of the system.

As a result the measured charge decay curve may depart considerably from the ideal exponential form and the measured time constant can vary with measurement conditions even for homogeneous materials. With heterogeneous materials the situation is even more complex. There can be significant differences in the results between different charge decay test methods and even between results from different test set-ups of the same method.

The complexity of the charge decay measurement has lead to variety of different test methods. The methods can be fundamentally discriminated by the way how the charge is generated on or in the test sample:

- triboelectric charging
- induction charging
- contact charging
- corona charging.

Because of the five factors influencing the charge decay listed above, there is no single universal, ideal charge decay test method for all materials. There are, however, suitable methods for limited use. When evaluating charge decay test methods for a specific use (such as for the characterisation of ESD garment fabrics), the following criteria should be kept in mind:

- the method should have demonstrated relevance to end-user applications,
- a non-tribocharging method should have demonstrated comparability to tribocharging.

In this report we consider in more detail one fabric level method from each charge generation category:

- IEC 61340-2: representing corona charging method
- prEN 1149-3: representing tribocharging method
- prEN 1149: representing induction charging methods
- Charge plate monitor method (VTT-method): representing contact charging methods.

2.10.1 CORONA CHARGING METHOD

The method seems to be very suitable for electrostatic homogenous materials with sufficiently high surface resistance of about $\geq 10^9$ Ω. For more conductive materials the charge decay time would be too fast to be measured using this technique because of the 20 ms initial delay between the sample charging by corona and the start of the sample potential measurement.

The method is suitable also for heterogeneous Type A materials where the electrostatic dissipative layer is on the surface. The charge is deposited on the sample surface, like in tribocharging. With Type B heterogenous materials (surface and core conductive materials), however, there are severe problems in the use of the method as it is described in the standards. In the present form the method cannot correctly characterise the ESD protective performance of surface and core conductive ESD materials. The problem is pronounced at low humidity but is present also at normal conditions.

The principle of the method itself is fine and universally suitable to all kinds of materials. The problem is how the results are interpreted in the current standards (IEC 61340-2-1 and

EC 61340-5-1). The use of the 10% criterion leads too often a rejection of good ESD material for improper reasons (measured decay time $t_{10} > 2$ s). In reality the 10% decay time could be << 2 s, but the measurement gives a very different result. The problem arises from the 20 ms initial delay of the measurement. In a heterogeneous material consisting of highly conductive elements in an insulating matrix (such as ESD fabrics with surface or core conductive fibres) the majority of the charge decay happens during the first 20 ms, which are missed in the measurement. After that the charge decay behaviour emphasises the slow charge decay processes on the insulating base fabric between the conductive fibres. For example, the initial surface potential of an ESD garment fabric, with surface conductive fibres (5 mm x 5 mm grid) on a PES base fabric, at t=20 ms after the corona charging was about 300 V. The use of the 10 % criterion leads to unpractically low final potential values, in this case 30 V. Below 100 V the influence of insulating base fabric on the behaviour of the material is pronounced, easily leading to decay times of several seconds or even tens of seconds. Measured charge decay times do not characterise the material behaviour in a proper way: Good ESD protective materials can be rejected for improper reasons. One can also argue that, is there any meaning to measure the surface potential below 100 V where the ESD risks are negligible for V_{HBM}=100 V devices.

2.10.2 TRIBOELECTRIC CHARGING METHOD

In the method test materials are charged by rubbing against cylindrical rods mounted on a vertically running slider. The electrical field strength from the charge generated on the test material is observed and recorded using an electrostatic fieldmeter connected to a graphical recording device. The standard draft specifies two materials for the charging rods: aluminium and dissipative HDPE (high density polyethylene). The test sample is grounded at one end of the sample. The test is done for samples made in the warp (or machine) direction and for samples made in the weft (or width) direction. Charge decay is defined as the time taken for the indicated field strength to decay to $E_{max}/2$, i.e. t_{50}. Also the maximum electric field strength after triboelectric charging, E_0, and the electric field strength 30 s after E_0, E_{30}, are reported.

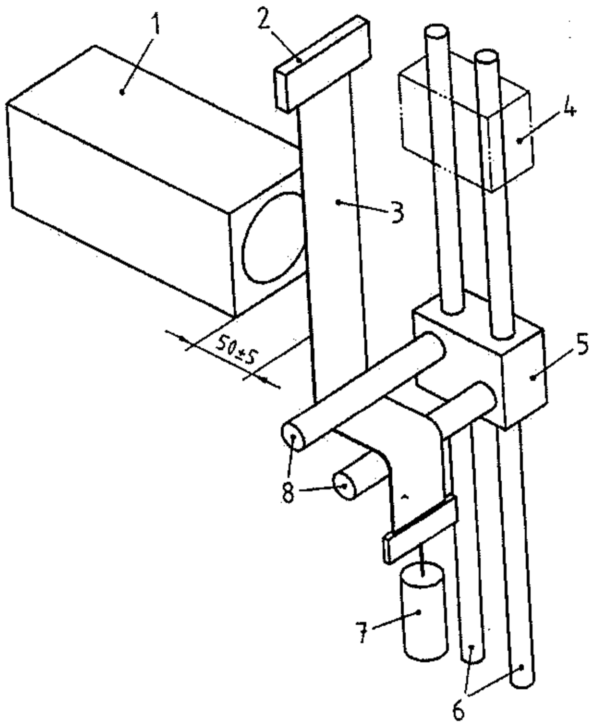


FIG 2.10 Example of an equipment for triboelectric charging test method according to prEN 1149-3:

(1) fieldmeter, (2) fixed clamp, (3) test specimen, (4) start position of slider, (5) slider in end position, (6) guide rail, (7) tensioning device (weighted clamp), (8) cylindrical rods.

A major disadvantage of the method is related to the approximately 0.1 s delay between the charging of a sample location and the moment when the measuring field instruments can measure the charged location. The fast processes in heterogeneous Type B fabrics have already decayed during that time. For homogeneous materials and Type A heterogeneous materials this is not a serious drawback, but for those materials there are simpler ways to evaluate the charge dissipation capability of the material. Therefore, we are not recommending the method as a general charge decay test method for ESD fabrics.

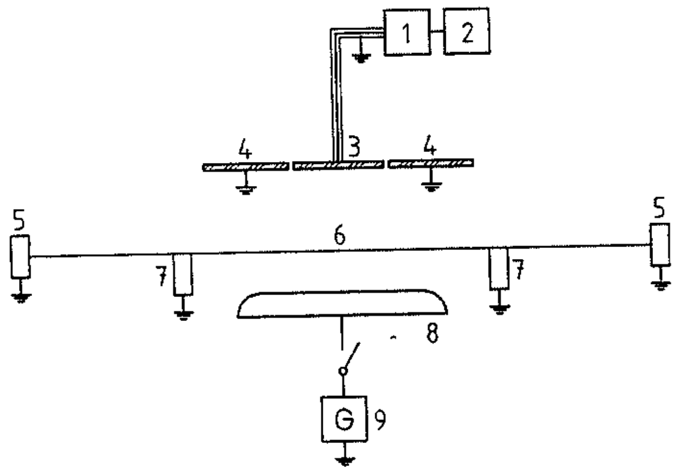
2.10.3 INDUCTION CHARGING METHOD

In the method charging of the test specimen is carried out by an induction effect. Immediately under the test specimen, which is horizontally arranged, a field-electrode is positioned, without contacting the specimen. A high voltage is rapidly applied to the field-electrode. If the specimen is conductive, or contains conducting elements, charge of opposite polarity to the field-electrode is induced on the specimen. Field from the field-electrode which impinges on the conducting elements does not pass through the test specimen and the net field is reduced in a way that is characteristic of the material under test.

This effect is measured and registered behind the specimen with a suitable field-measuring probe. As the amount of induced charge on the test specimen increases, the net field registered by the measuring probe decreases. It is this decrease in the field that is used to determine the half decay time t_{50} (specified in the same way as in the prEN 1149-3 tribo charging method as the time taken for the field strength to decay to $E_{max}/2$) used for the characterisation of charge decay of the material.

Thus the method is potentially suitable for the correct characterisation of all types of ESD garment fabrics. This is a major benefit of the method. It is also possible to reduce information on the resistance of the conductive path (i.e. conductive fibres) from the charge decay curves. The measurement gives at the same time information to evaluate the electrostatic shielding performance of the fabric.

A major hole of the method is that comparability of the results to those done by tribocharged samples is not yet shown. In heterogeneous samples the charge is generated differently on or in the material by induction and triboelectric charging. In the induction charging, the charge movement can happen anywhere in the conductive elements of the fabric. It cannot distinguish between what happens in the volume of a material and at its surface. It is not clear how this will influence on the results. It may appear that the relevancy of the method as a charge decay test is not high for end-users, if the correspondence of the charge decay behaviour results to those of surface charge generated by rubbing is poor.



Arrangement of equipment for induction charging test method according to prEN 1149-3: (1) charge amplifier, (2) recording device, (3) field-measuring probe, (4) guard ring, (5) specimen clamping ring, (6) test specimen, (7) support ring, (8) field-electrode, (9) voltage generator.

2.10.4 VTT METHOD

The method is based on the application of charge plate monitor (CPM). A sample of fixed dimensions (width and length) is placed on the metal plate of the CPM. One end of the sample is charged, at first, to a predetermined voltage using the CPM (or alternatively metallic plate + insulator + high-voltage (HV) power supply). Then the charging plate is disconnected from the power supply and the other end of the sample is grounded using an electronic HV switch and the voltage of the charged region is monitored as a function of time by the field meter of the CPM or by an external field meter or by a non-contact electrostatic voltmeter above the sample. In order to guarantee good electrical contact between the charging electrode and the sample, non-conducting and low-charging plate should be used above the sample as a weight.

A PC can be connected to the field meter for the recording of charge decay curves, or alternatively one could rely just to the time counter of the CPM.

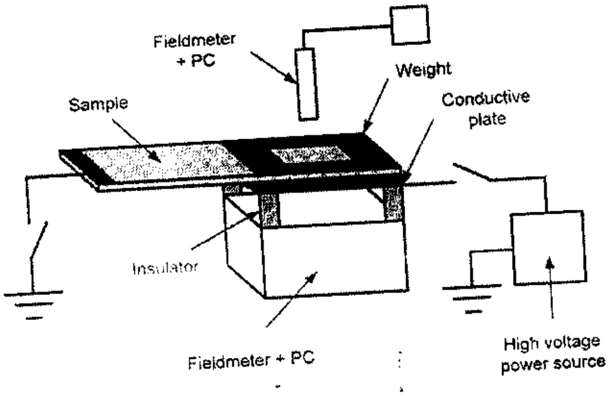


FIG 2.11 Sketch of the VTT contact charging method set-up

According to the results the method is suitable for homogeneous and Type A heterogeneous fabric samples. However, for these materials the method does not give much additional information with respect to the standard point-to-point resistance measurements. For heterogeneous Type B fabrics the method characterises, in principle, only the conductive path of the material.

There is no correlation to tribocharging methods, where the behaviour of the whole sample surface is taken into account. The contact charging method, however, characterises correctly the practical situation where the garment is really charged by an accidental contact to a charged electrode. In those heterogeneous fabrics where the conductive elements are buried (such as core conductive fibres) the method actually charges the test samples by induction – not by contact. For those samples the method is similar to the prEN 1149-3 but is less precise.

2.11 COTTON FABRIC

Cotton is the world's most important apparel fiber, making up over 50% of the fabric sold throughout the world, including cotton suits, cotton shirts, and cotton underwear. This isn't by accident. With a long history, it has endured because of its unique properties that make it ideal for much of the clothing we wear. Cotton is attractive, durable, comfortable, and has proven itself countless times to be a superior fiber for clothing manufacturing.

2.11.1 PHYSICAL CHARACTERISTICS OF COTTON

Cotton is divided into various groups depending on its physical characteristics; we will focus on two of the most important characteristics, the length of the cotton fiber and its fineness. ... in length considerably, from half an inch to 2 inches. Higher quality is often associated with longer length, and achieving this desired state is more expensive due the risk of a longer growth cycle and an increased demand on resources. Long fibers make up only 3% of the worldwide output, and their use is typically reserved for high end shirt fabrics and other luxury. A few varieties of this long fiber cotton used in shirt fabrics are American Pima, Egyptian, and Sea Island Cottons. For a complete article on men's shirt fabrics, click here.

Cotton fineness (the fiber's diameter) is another quality characteristic; immature fibers tend to be 20% thinner than mature fibers, and therefore are less strong. Very high end fabric producers seek to separate the mature from the immature fibers, ensuring high durability.

2.11.2 PROPERTIES OF COTTON

- **Absorbency:** This is what makes cotton so comfortable in hot weather. It absorbs the moisture from your skin allowing it to evaporate by passing through the fabric, thus allowing your body to regulate your temperature. This combined with the spun yarns ability to hold the fabric slightly off the skin allows greater comfort than other fabrics in hot conditions.
- **Heat Conduction:** Heat passes freely through cotton; combining this property along with the absorbency characteristic above, you have an unbeatable fiber for making hot weather wearing fabric. However, in cold weather, this strength is a weakness; typically cotton jackets are not good at retaining the body's heat.
- **Durability:** Cotton is tough (at least when compared with other common clothing fibers!). In fact, when wet it increases in strength by 30%; thus throwing 100% cotton shirts in the washing machine may mean a lot of ironing, but you can be sure the fabric will remain intact. It can be washed with strong detergents, and the only thing you may want to watch out for is it losing some of its color (thus the case for hand washing). Cotton's molecular structure resists heat damage, so ironing is a great way to get the fabric looking crisp; a quick tip - shirts respond best to ironing when they come immediately out of the dryer still a bit damp and warm.

2.11.3 ENVIRONMENTAL IMPACT OF COTTON

Mainstream farms use chemical pesticides and bioengineering to get the highest quality and highest yield per acre. The unintended consequences of chemical runoff and more resistant pest insects are well documented. Cotton is water intensive, and the tilling necessary can lead to soil erosion.

Cotton is a renewable resource that has successfully clothed man for centuries. In part to the Green movement, Organic Cotton has risen in importance and economic viability. Organic cotton uses no synthetic fertilizers or pesticides, and therefore leaves a smaller footprint on the environment. However, because of lower yield per acre and a lack of economies of scale in the industry, the cost to get this to the consumer often doubles the price. Another niche being filled is the re-emergence of naturally colored cottons. Cultivated for thousands of years, naturally colored cotton can be grown in red, brown, beige, and green with other colors in development.

2.11.4 ADVANTAGES OF COTTON CLOTHING

The world uses cotton more than any other natural fiber and it is primarily grown and used to make cloth. Other parts of the cotton plant are put to good use and are used in the production of foods, plastics and in paper products, according to the National Cotton Council of America. Because cotton is a natural product and because of the way it is designed and manufactured into clothing, it has many advantages, such as its ability to control moisture, insulate, provide comfort and it is also hypoallergenic, weatherproof and is a durable fabric.

- **Moisture Control:** Cotton fabric is breathable and transmits moisture away from the body and is absorbent and removes liquid from the skin, like a towel, according to Cotton Incorporated. Cotton allows you to remain comfortable as you exercise, keeping moisture from building up between your skin and clothing. The International Forum for Cotton Promotion states that cotton can take up to one-fifth of its weight in water before feeling damp.
- **Insulation:** Cotton clothing protects against from heat in the summer and cold in the winter by providing thermal insulation as the cotton fabric traps air between the fabric fibers. The cotton fibers in clothing hold the fabric away from the skin, further allowing for more air to be trapped between the skin and fabric which helps with insulation and comfort.
- **Hypoallergenic:** Cotton fabric rarely causes allergic reactions and wearing cotton is often recommended for those with skin allergies, notes Cotton Incorporated. Because

cotton is hypoallergenic and does not irritate skin, it is used in medical products like bandages and gauze, and is the fabric of choice when it comes to baby clothing.

- **Weatherproof**: Cotton fabrics can easily be manufactured into weather-resistant garments through construction and finishing of the fabric. For example, cotton can be made into a tight, dense fabric with a weather-repellent finish to make weather resistant clothing, yet the cotton fabric retains its comfort and breathability.
- **Comfort:**Cotton clothing is soft and easily stretches, making it a comfortable fabric to wear. Due to its softness and comfort, it is often used in underwear and undershirts, according to the International Forum for Cotton Promotion.
- **Durability:** The International Forum for Cotton Promotion states that cotton has a high tensile strength, making it strong, durable and less likely to rip or tear. It is 30 percent stronger when wet, withstanding many washings in hot water.

2.12 POLYESTER FABRIC

Polyester fabric is a versatile and important man-made fabric. It has an outstanding characteristic of resisting wrinkle and springing back into its crisp smooth shape. It is strong, and soft hand. The fabric is resistant to stretching and shrinkage. These are quick to dry and are resilient. It has an excellent pleat retention property. It requires minimum care and is easily washable.

Polyester is a polymer, which is produced from the coal, air, water, and petroleum products. It was first commercially produced in 1953 by E. I. Du Pont de Nemours & Company, Inc. in the United States. It is next to cotton in worldwide use.

Polyester fabric blends well with fabrics. It blends with wool, acetate, or rayon to improve the durability of the fabric and even to make it easy washable, if the percentage of polyester is high. It adds the quality of wrinkle resistance to the fabric and eliminates crushing of napped fabrics, and reduces fading. The fabric aggravates pilling problems after being blended with wool.

2.12.1 PROPERTIES OF POLYESTER

- It is strong, stretchable, and durable.
- It does not wrinkle.

- ➢ It does not shrink.
- ➢ It is resistant to crease.
- ➢ It is resistant to mildew.
- ➢ It is abrasion resistant.
- ➢ It is resistant to most chemicals.
- ➢ It is not damaged by sunlight or weather.
- ➢ It dries quickly. It is crisp and resilient when wet or dry.
- ➢ It is easily washed.
- ➢ It does not absorb moisture making it hot and clammy when worn in hot temperatures.

2.12.2 USES OF POLYESTER FABRIC

Polyester clothing has a good stability and strength and is resistant to stretching and hrinkage. It is not damaged by sunlight or weather. It is widely used as dresses, blouses, ackets, separates, sportswear, suits, shirts, pants, rainwear, lingerie, children-wear.

Polyester fabric is manufactured in many weights and it is used as fiberfill in pillows and pholstery. In upholstery, polyester is generally blended with wool to eliminate crushing and educe fading.

olyester is also used in casement curtains, draperies, floor coverings, throw rugs, bedding, nd as a cushioning or insulating material.

abrics made of a polyester cotton blend are exactly what they sound like, made from fibers f both the natural cotton and the synthetic polyester. While both fibers have pros and cons, a end is often used in garments to give the consumer the benefits of both.

.13 COTTON POLYESTER BLEND FABRIC

polyester cotton blend can be versatile, as it most likely retains the coolness and lightness the cotton fiber, but also adds the strength, durability and wrinkle-resistance of polyester. polyester cotton blend should only shrink slightly in comparison to a garment or fabric that 100 percent cotton. This blend is often preferred by at-home sewers and quilters as it is tremely easy to sew.

3.1 CHARACTERISTICS

- ➢ **Stretch:** Polyester can add a "revolutionary" amount of stretch to fabric. This makes cotton-polyester blends more functional than pure cotton fabrics.

- **Durability**: The polyester fibers add resilience to the cotton ones. Therefore, cotton-poly fabric blends tend to "spring back" into shape much better than pure cotton. Cotton-polyester fabric is also resistant to shrinkage as well as moth and sun damage.
- **Care:** Polyester-cotton blends require less care, but they do require more care than most pure cotton or polyester fabrics. Cotton-polyester blends resist fading and can be washed at higher temperatures.
- **Cost:** The growing demand for cotton-polyester fabrics has been attributed to it being roughly 10 percent less expensive than pure cotton.
- **Comfort:** The cotton content of a blend can make cotton-poly fabrics more comfortable than their pure polyester counterparts. Of course, the degree of comfort will be dictated by the ratio of the cotton used in the cotton-poly blend.
- **Inflammability:** A polyester-cotton blend is more flammable than pure polyester, but it's not as flammable as pure cotton. On a scale of inflammability, this blend is dangerously at the top.

2.13.2 ADVANTAGES OF COTTON POLYESTER FABRIC

- This is as light as cotton and as strong as polyester.
- It will undergo less shrinkage as compare to cotton.
- Cotton polyester is easy to sew so used to make most of the home furnishing and garment products.
- It does not need much ironing.
- It will retain its shape for a longer period of time.
- Less expensive than 100% pure cotton fabric.
- Cotton polyester fabric is tear resistant and is an abrasion-resistant fabric.

2.14 MICROPOLYESTER FABRIC

Performance with beauty describes the potential of microfibers. They are very fine fibers compared to more conventional forms which gives them unique and desirable properties. To provide a measure for comparison, microfibers are half the diameter of a fine silk fiber, one-third the diameter of cotton, one-quarter the diameter of fine wool, and one hundred times finer than human hair.

"Denier" is the term used to define the diameter or fineness of a continuous or filament fiber such as silk or man-made fibers. Denier is the weight in grams of a 9000-meter length of fiber or yarn. The higher the number, the thicker the fiber.

In order to be called a "microfiber," the fiber must be less than one denier. Fine silk, for example, is approximately 1.25 denier. A microfiber would need to be 0.9 denier or finer. Many microfibers are 0.5 to 0.6 denier. For another comparison, very fine nylon stockings are knit from 10 to 15 denier yarns consisting of 3 to 4 filaments. A 15 denier yarn made of microfiber would have as many as 30 filaments.

So what is so special about very fine or microfibers? The many fine fibers packed together create a depth and a body to fabrics from which they are made. Fabrics have luxurious drape. Although fine and lightweight, they don't exhibit a flimsy quality. The many tiny filaments or fibers can slide back and forth and maneuver around within the yarns in a fabric allowing the fabric to flow and drape freely, yet still possess body.

Consider a very thick rope. If you bend it, it will be stiff and form a rounded arc. If you take many finer threads or yarns together until they form the same diameter as the thick rope and bend them, they will form a sharper bend or curve. Each of the individual strands can move independently to create more flexibility or pliability. This effect occurs with microfibers. Each of the many very fine fibers moves independently to create lovely drape, yet the fine fibers can be packed together tightly for body in a fabric.

Microfibers are not necessarily new, but they are being used in different ways today. The first fabric made from microfiber was UltrasuedeT in which short polyester microfibers were embedded into a urethane base. Today, microfibers are being used in both long continuous lengths as well as short or staple lengths.

4.1 PROPERTIES OF MICROPOLYESTER FABRICS

Microfiber fabrics are generally lightweight, resilient or resist wrinkling, have a luxurious drape and body, retain shape, and resist pilling. Also, they are relatively strong and durable in relation to other fabrics of similar weight.

Because microfibers are so fine, many fibers can be packed together very tightly. The denseness results in other desirable properties. With many more fine fibers required to form a yarn, greater fiber surface area results making deeper, richer and brighter colors possible.

Also, since fine yarns can be packed tightly together, microfibers work well in garments requiring wind resistance and water repellency. Yet, the spaces between the yarns are porous enough to breathe and wick body moisture away from the body. When comparing two similar fabrics, one made from a conventional fiber and one from a microfiber, generally the microfiber fabric will be more breathable and more comfortable to wear. Microfibers seem to be less "clammy" in warm weather than conventional synthetics.One caution related to synthetic microfibers is heat sensitivity. Because the fiber strands are so fine, heat penetrates more quickly than with thicker conventional fibers. As a result, microfibers are more heat sensitive and will scorch or glaze if too much heat is applied or if it is applied for too long a period. Generally, microfibers are wrinkle resistant, but if pressing is needed at home or by drycleaners, care should be taken to use lower temperatures.

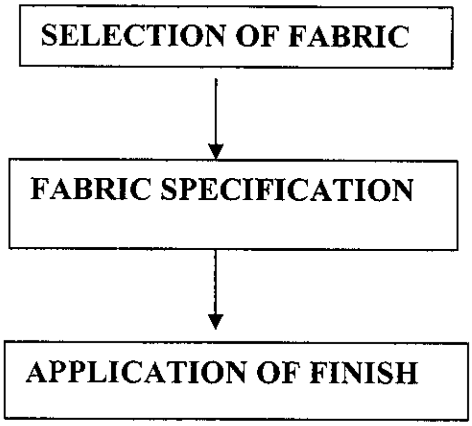
2.14.2 FIBER AVAILABILITY

Man-made fibers are formed by forcing a liquid through tiny holes in a device called a spinneret. With microfibers, the holes are finer than with conventional fibers. Potentially, any man-made fiber could be made into a microfiber. Microfibers are most commonly found in polyester and nylon. Some rayon and acrylic micros are in production and available to consumers. Micros can be used alone or blended with conventional denier man-made fibers as well as with natural fibers such as cotton, wool, and silk.

METHODOLOGY

3.METHODOLOGY

Process flow chart



3.1 SELECTION OF FABRIC:

On our initial visit to Neyveli Lignite Corporation we found that the uniform used by switch yard workers is made of 100 percent polyester.

The following four samples are selected namely

- Cotton
- Polyester
- Cotton polyester blend (60:40)
- Micropolyester

Based on their properties and physical characteristics we decided to go ahead with our objective to create a suitable work wear for the switch yard workers.

3.2 FABRIC SPECIFICATIONS:

Cotton, Polyester, cotton/polyester and micro polyester fabrics with same GSM are selected to avoid more deviation in further process. And the fabric's properties ie, EPI. PPI, warp count, weft count are calculated.

TABLE 3.1 Specification of cotton fabric

PROPERTIES	VALUES
EPI	122
PPI	99
WARP COUNT	70
WEFT COUNT	50

TABLE 3.2 Specification of polyester fabric

PROPERTIES	VALUES
EPI	128
PPI	96
WARP COUNT	110
WEFT COUNT	95

TABLE 3.3 Specification of cotton polyester fabric

PROPERTIES	VALUES
EPI	114
PPI	99
WARP COUNT	55
WEFT COUNT	45

TABLE 3.4 Specification of micropolyester fabric

PROPERTIES	VALUES
EPI	132
PPI	82
WARP COUNT	110
WEFT COUNT	120

3.3 APPLICATION OF FINISH:

3.3.1 CHEMICALS USED:

- ULTRAFAB UPE ---This type of chemicals is used for polyster. It has to be done by using padding method
- INNOCELLE UNIQ --- This type of chemicals is used for cotton fabrics. It has to be done by using padding method.
- Both type of chemicals has to been apply for cotton polyster blend with equal ratio.

.3.2 RECEIPE:

LTRAFAB UPE :

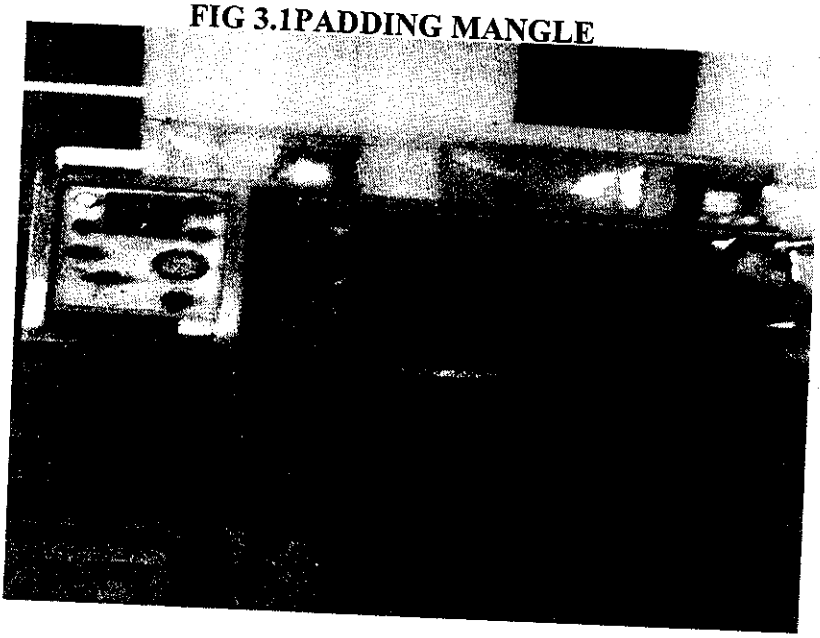
- ULTRAFAB UPE -5 to 20 gpl
- pH- 5.0-6.0
- Followed by drying.

OCELUE UNIQ:

- INNOCELUE UNIQ-30-50 gpl
- pH-5.5-6
- Dry-120-140

3.4 APPLICATION OF ANTISTATIC FINISH:

FIG 3.1PADDING MANGLE

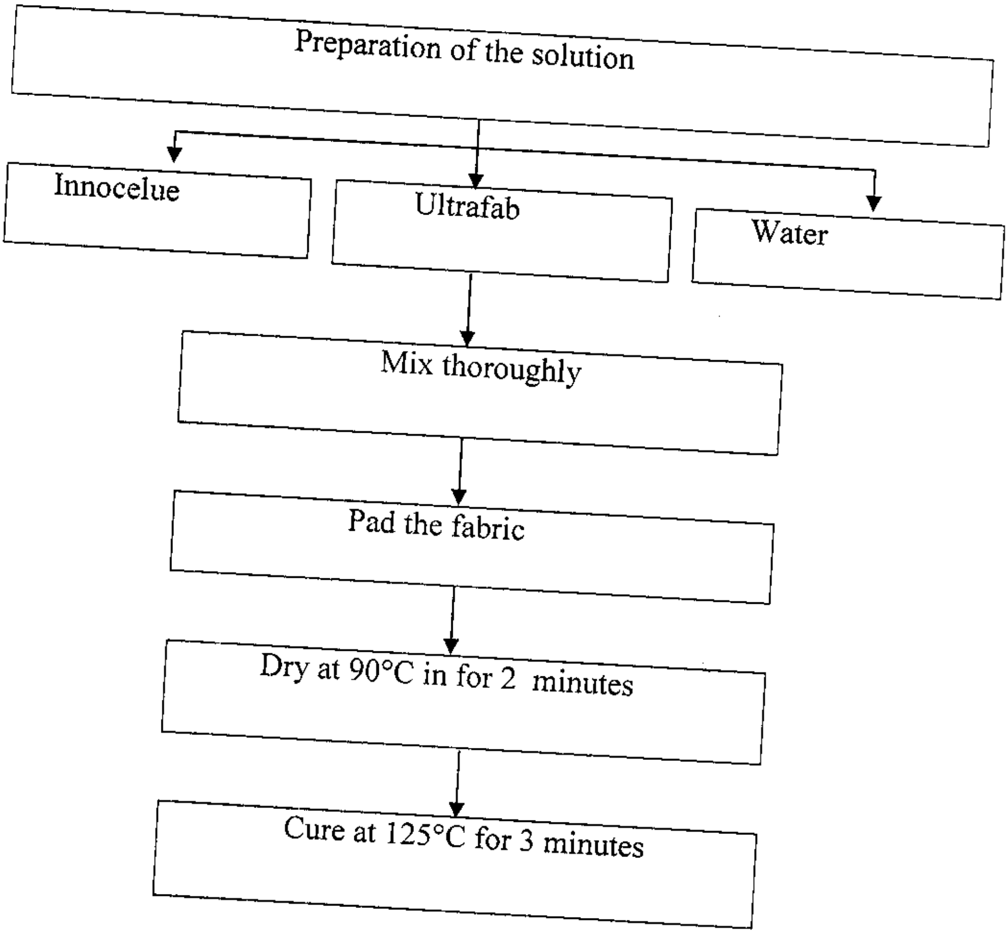


3.4.2PaddingMangles

The pad dyeing machines overcome the deficiency of winch and jigger dyeing machines of smaller batch size and discontinuity in finishing. Padding mangle offer continuous process of the fabric in concerned liquor, such as pre-treatment, dyeing or finishing.

Application of chemicals is conducted in the pad dyeing machines with single or multiple dipping in solution .During padding, the fabric passes into a solution of chemicals, under a submerged roller and out of the bath. It is then squeezed to remove excess solution .The objective of this process is to mechanically impregnate the fabric with the solution or dispersion of chemicals Pad impregnation is common for the dyeing of fabric and for the of application finishing chemicals.

3.4.3 PROCESS AND SEQUENCE :



Before the finishing process starts, the appropriate solutions are prepared. For cotton fabric the chemical ultarfab is used for achieving antistatic inish, for polyester fabric innocelle is the suitable chemical and the mixture of ne both chemicals are used for the cotton polyester blend. After the solution is repared impregnate the fabric into the solution and pad it. After padding the abric has to be dried at 90°C for 2 minutes. The dried fabric is then cured at 25° for 3 minutes. Thus the finishing is achieved using pad-dry-cure method.

3.5 TEST AND ANALYSIS

Tests and analysis are the process, which is done to check the efficiency of the process that has been carried out. It helps in evaluating the success rate of any innovation.

The testing process should be carried out accurately according to prescribed standards to enable accurate evaluation of the study. The following tests were carried out to analyze the effectiveness of the flame retardant finish applied on the fabric and to check if this finish affects the physical properties of the fabrics.

- Antistatic test
- Tensile strength
- Abrasion resistance
- Fabric drape
- Stiffness test
- Crease recovery
- Air permeability
- Water permeability

3.5.1 ANTISTATIC TEST

Non-durable antistatic agents are usually hygroscopic surface-active materials, closely allied in composition to softeners and wetting agents. A permanent antistatic finish can be given by using a combination of a cationic and an anionic compound

- Ultrafab UPE ---This type of chemicals is used for polyster.It has to be done by using padding method.
- Innocelue UNIQ --- This type of chemicals is used for cotton fabrics.It has to be done by using padding method.
- Both type of chemicals has to been apply for cotton polyster blend with equal ratio.

EST METHOD IN BTRA

STM D4238-90 Standard Test Method for Electrostatic Propensity of Textiles

his test method covers the determination of the relative electrostatic propensity of fibers, rns, and fabrics by a corona discharge. This includes the measurement of the maximum arge voltage and the decay half-life.

3.5.2 TENSILE STRENGTH TEST

FIG 3.3 Tensile strength tester

Cut samples of length 10 cms and width 2.5 cms.Take three samples along warp wand weft each, such that no two warp samples have the same threads No two weft samples have the same threads.

Note the gsm, thickness of the fabric from which samples are taken.

3.5.2.1PROCEDURE

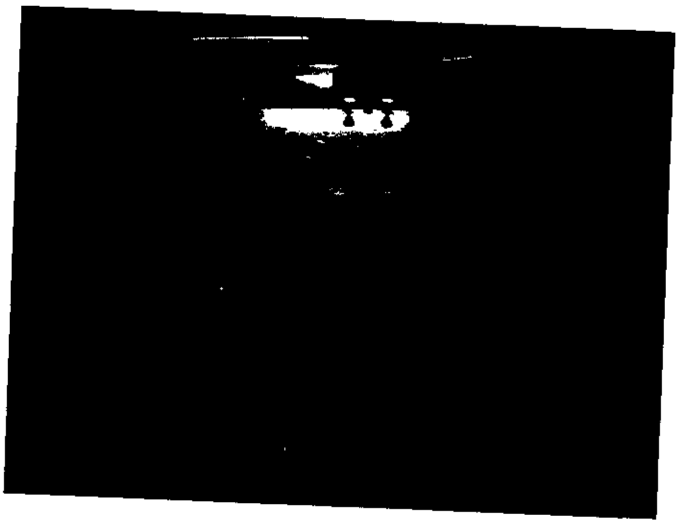
The details of the fabric namely the gsm, thickness are fed as inputs to the system. The type of test, namely tensile strength is selected. The load to be applied is elected to be 50N which is fixed according to the type and thickness of the fabric. Now the neatly cut fabric samples are fixed between the upper and lower clamps and tightened with the help of screws. Now the machine is switched ON, the load is applied and the machine automatically stops once the fabric breaks under the weight of the load. The same procedure is repeated for all the samples.

3.5.3 ABRASION RESISTANCE

Abrasion is one aspect of wear and is the rubbing away of the component fibres and yarns of the fabric. Type of abration done here is

- Flex abrasion (the flat area of the fabric is abraded)

FIG 3.4 Abrasion resistance tester



3.5.3.1 PROCEDURE

Prepare sample of 38mm dia. The initial weight of the sample is found using electronic balance. Fix the sample in the mushroom shaped sample holder. Fix the mushroom shaped sample holder in the machine in such a way that the samples are exposed to abradent material (emery paper). Select suitable weight and place it on the sample holder.

Start and run the machine for 50 cycles. Remove the sample holder from the machine and remove the sample from sample holder.

Calculate the weight loss and abrasion resistance from the given formulae.

3.5.4 FABRIC DRAPE

Drape is the ability of a fabric to a assume a graceful appearance in use. Drape ability of a fabric can be determined using the instrument drape meter and is expressed in terms of drape co-efficient

FIG 3.5 Drape meter

3.5.4.1 PROCEDURE

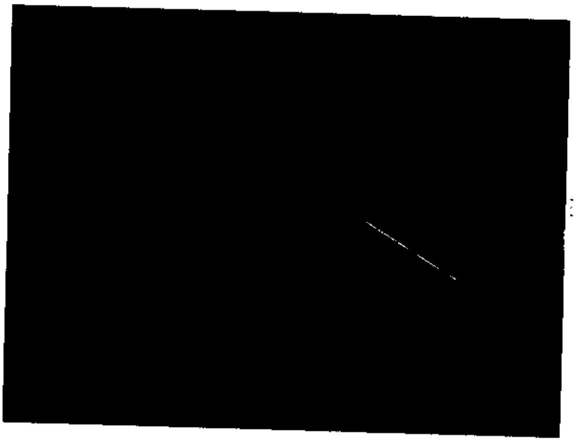
Prepare a sample of the required size. Open the transparent lid of drape meter, Fix the sample over the bottom supporting disc. (Platform should be at lowest position).Place the top supporting disc and secure it by tightening the screw. Release the supporting disc unit and allow to rise by means of a compressed spring. This allows the edge of the fabric to drape freely under its own weight. Close the lid and place a white paper over the lid. Switch on the light. Draw the outline of the projected and area of the specimen.

Calculate the drape co-efficient from the formulae.

3.5.5 FABRIC STIFFNESS

Fabric stiffness indicates the resistance of the fabric to bending and it is a key factor in the study of handle and drape. Cantilever principle of working is used to determine the stiffness of fabrics stiffness is related with handle and drape of the fabric.

FIG 3.6 Fabric stiffness tester



3.5.5.1 PROCEDURE

Prepare sample from the given fabric in warp and weft direction. Place the specimen on the platform in the stiffness tester and place the template over the fabric sample in such a way that the zero mark in the template should coincide with the datum line in the instrument.
Push both the template and fabric in forward direction.

The fabric will tend to drop are the edge on its own weight.

- Stop moving the fabric if the tip of the fabric cuts the index lines engraved in the side wall of the instrument when viewed in mirror Record the reading from the template.

3.5.6CREASE RECOVERY

The creasing of textile material is a complex effect involving tensile, flexing, compressive and tortional stresses. Creasing of a fabric results in the bending of the constituent fibres. During bending, the molecules near the inner surface are compressed. These deformations are tensile in nature and hence any chemical treatment which enhances the tensile recovery of fibres would result in a fabric of improved crease recovery. The resistance offered by a textile material against creasing during use is called crease recovery. The resistance to creasing should be distinguished from the ability to recover from the creases already formed in the fabric.

FIG 3.7 Crease recovery tester

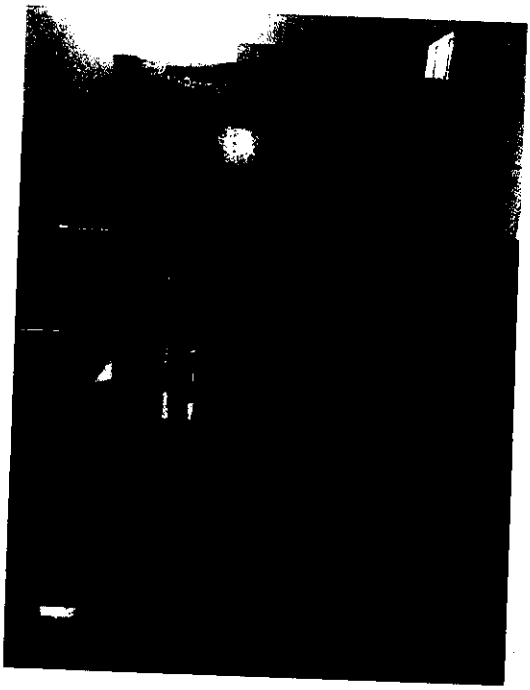
3.5.6.1 Procedure

Prepare sample of required size and fold the sample exactly half.Place the sample in the loading machine for 2 minutes. Remove the sample from the loading machine and mount one limb of the sample in the crease recovery tester. Allow 2 minutes time for recovery from crease. Rotate the dial in the instrument in order to coincide the specimen with the knife edge. Record the crease recovery angle

3.5.7 AIR PERMEABILITY

Air permeability is the degree to which the material is penetrable by air. It is also the rate of air flow through a fabric when there is a different air pressure on either surface of the fabric

FIG 3.8 Air permeability tester



3.5.7.1 PROCEDURE:

Choose the set of rings of given area (4.10cm) for which the test is conducted. Take the ring from one set, which have groove at one face and rubber lining at other face and then place this ring on the groove in sample holder the grooves in the ring must be download .The other mount to the other part of the sample holder by using the knurling bolts. Place the sample on the bottom sample holder.

Place two parts of the sample holder in such a way the two rings have same axis .Move this screw so that two rings are tightened. Close all the rotometers by the knob, which are attached to the rotometers. Put the water in the upper cup which is provided at left side of the machine (in manometer type model),set the zero in digital manometer. Then Switch on the vacuum pump. Slightly open the knobs of the rotometer and set the given suction pressure in the manometer (10mm of water column) Take the rotometer readings.

RESULTS AND DISCUSSION

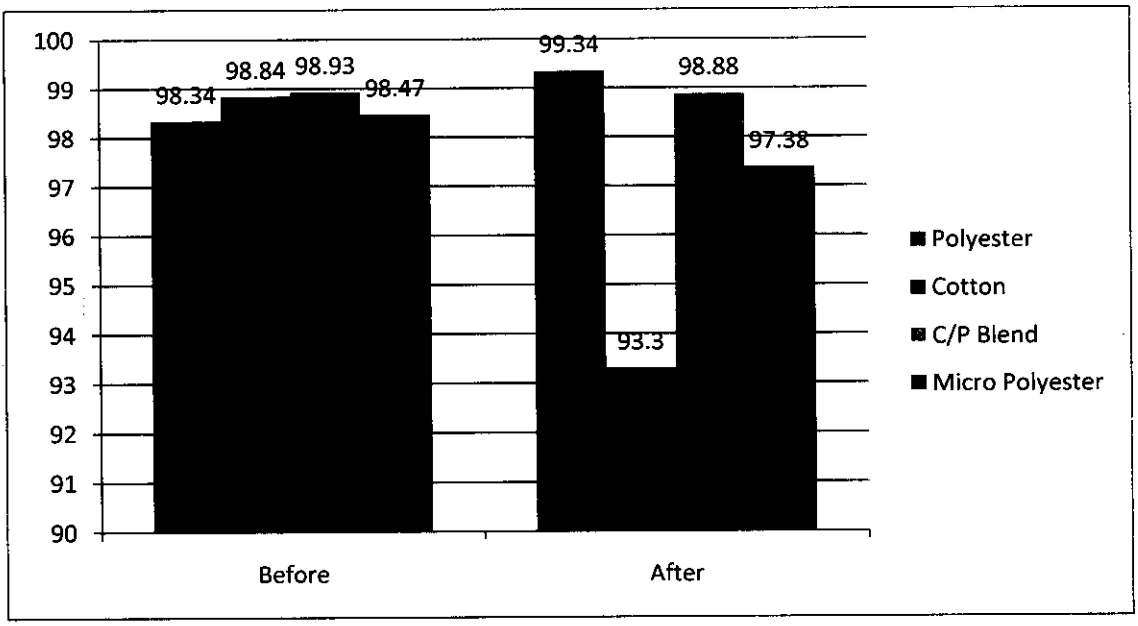
4. RESULT AND DISCUSSION

4.1 ABRASION

TABLE 4.1 Abrasion test values

Abrasion %	Polyester		Cotton		C/P Blend		Micro Polyester	
	Before	After	Before	After	Before	After	Before	After
	98.34	99.34	98.84	93.30	98.93	98.88	98.47	97.38

FIG 4.1 Abrasion test graph



INFERENCE

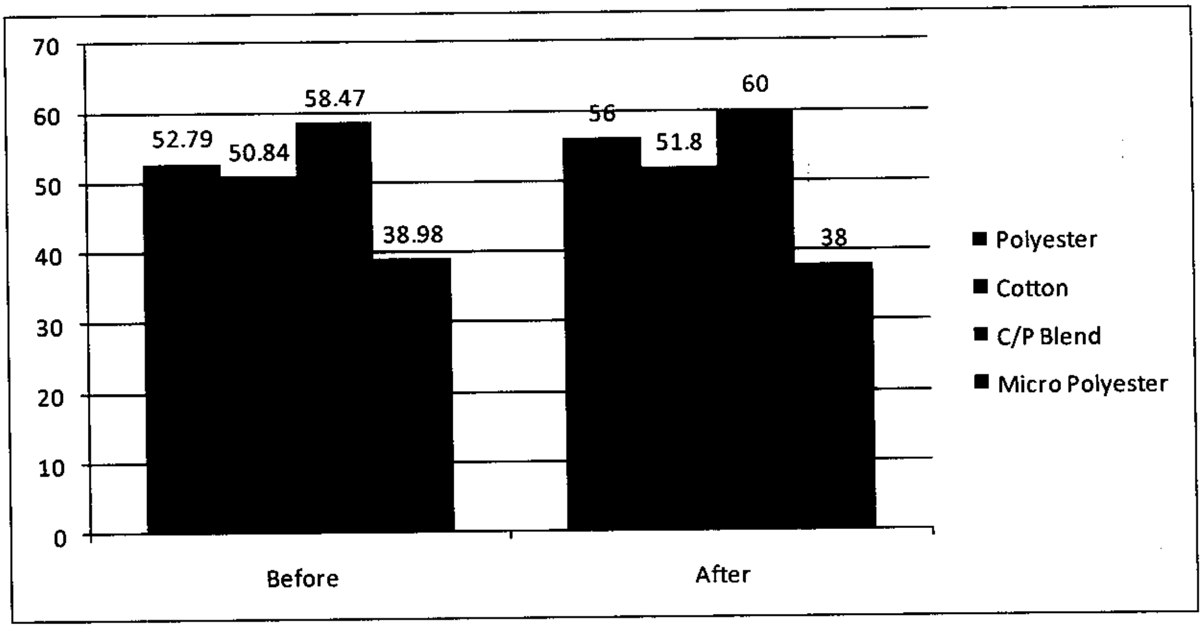
- The Cotton Polyester Blend does not show a significant change in abrasion after the finish was applied.
- The Cotton fabric shows the greatest decrease in abrasion after the fabric has been treated.

4.2 FABRIC DRAPE

TABLE 4.2 Fabric drape values

Fabric Drape %	Polyester		Cotton		C/P Blend		Micro Polyester	
	Before	After	Before	After	Before	After	Before	After
	52.79	56	50.84	51.8	58.47	60	38.98	38

FIG 4.2 Fabric drape graph



INFERENCE

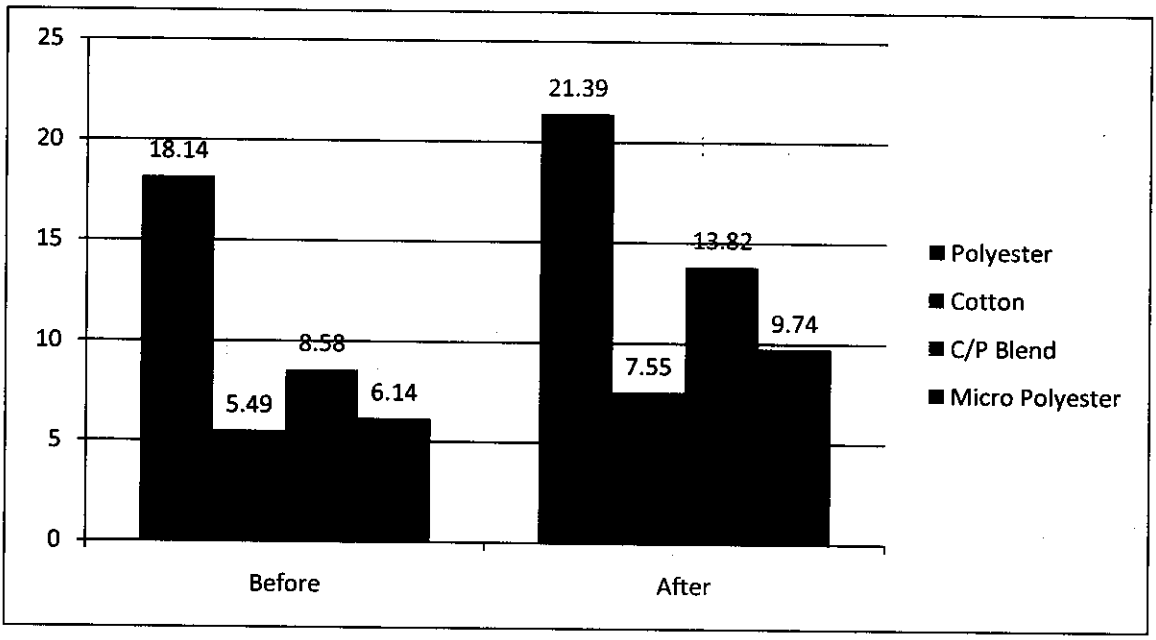
- The C/P blend has the highest percentage of drape after the antistatic treatment
- The polyester shows the highest increase in the drape percentage after the finish has been applied.

4.3 STIFFNESS

TABLE 4.3 Fabric stiffness values

Stiffness kg/cm^3	Polyester		Cotton		C/P Blend		Micro Polyester	
	Before	After	Before	After	Before	After	Before	After
	18.14	21.39	5.49	7.55	8.58	13.82	6.14	9.74

FIG 4.3 Fabric stifness graph



INFERENCE

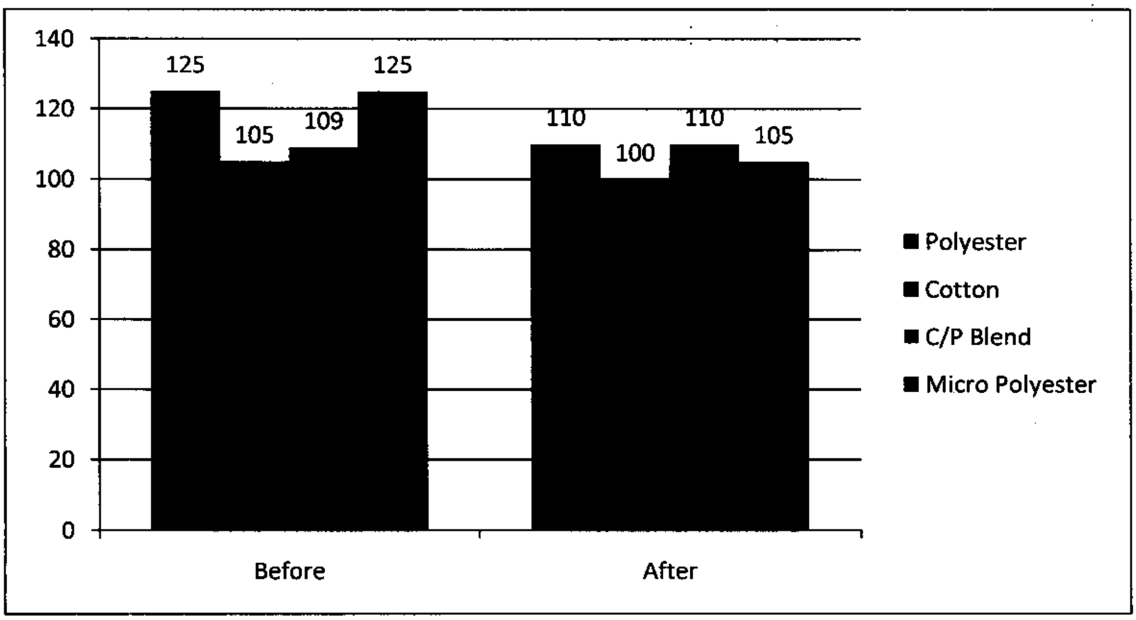
- All fabrics show a significant increase in stiffness after the finish has been applied, with cotton polyester blend showing the highest increase in stiffness.
- Cotton fabric shows the least increase in stiffness after the fabric is treated with the finish.

4.4 CREASE RECOVERY

TABLE 4.4 Crease recovery values

Crease Recovery (°)	Polyester		Cotton		C/P Blend		Micro Polyester	
	Before	After	Before	After	Before	After	Before	After
	125	110	105	100	109	110	125	105

FIG 4.4 Crease recovery graph



INFERENCE

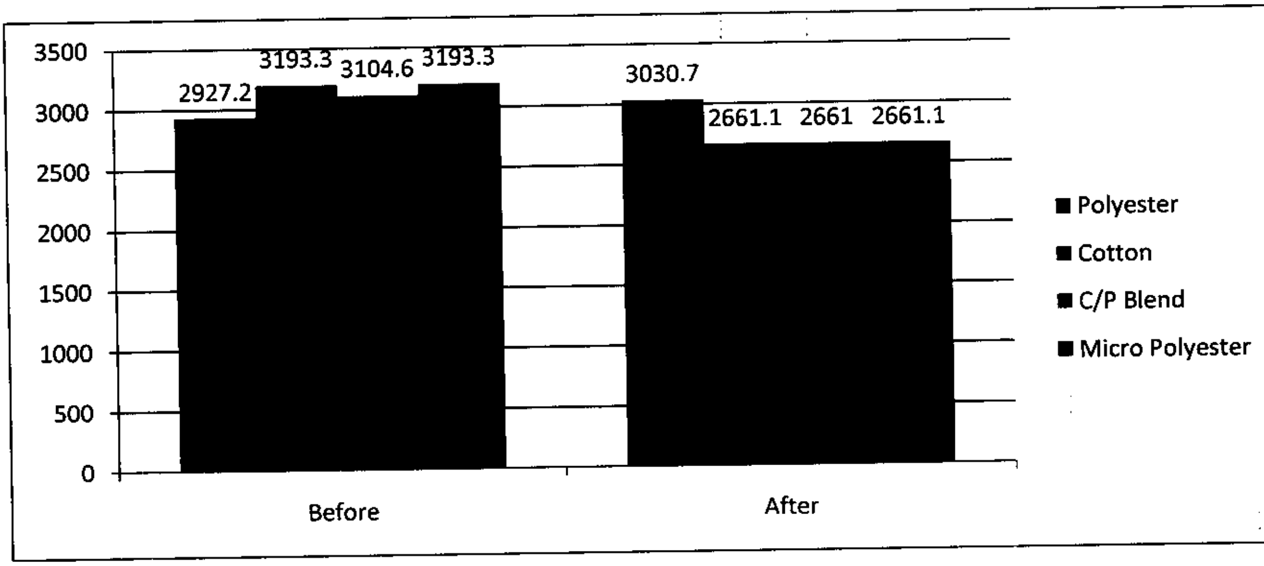
- Cotton Polyester blend does not show a significant change in crease recovery after the finish has been applied.
- Cotton shows the highest increase in this parameter after the finish has been applied.

4.5 WATER VAPOR PERMEABILITY

TABLE 4.5 Water vapour permeability test values

Water Vapor Permeability ($g/m^2/day$)	Polyester		Cotton		C/P Blend		Micro Polyester	
	Before	After	Before	After	Before	After	Before	After
	2927.2	3030.7	3193.3	2661.1	3104.6	2661	3193.3	2661.1

FIG 4.5 Water vapour permeability test graph



INFERENCES

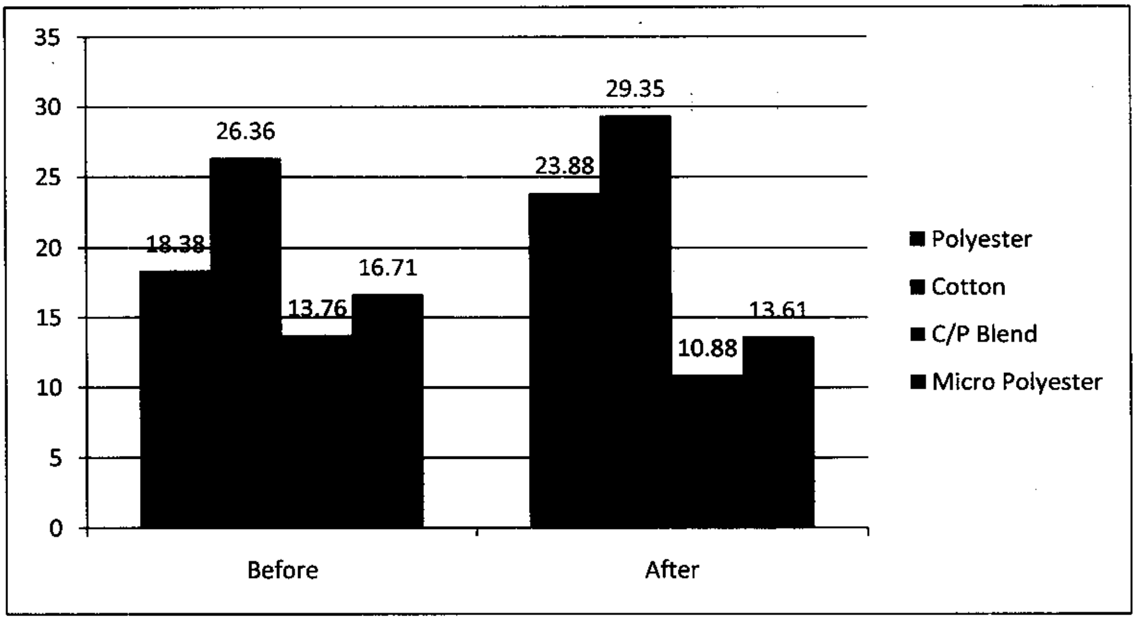
- Cotton is the only fabric which shows increase in water permeability after the finish has been applied.
- Cotton Polyester blend and other fabrics show a significant decrease in this property.

4.6 AIR PERMEABILITY

TABLE 4.6 Air permeability values

Air Permeability (cc/sec/cm)	Polyester		Cotton		C/P Blend		Micro Polyester	
	Before	After	Before	After	Before	After	Before	After
	18.38	23.88	26.36	29.35	13.76	10.88	16.71	13.61

FIG 4.6 Air permeability test graph



INFERENCES

- Cotton Polyester blend has the least air permeability after the finish has been applied.
- Cotton and polyester shows vast improvement in this property.

4.7 FIELD TEST

The garment was treated with the antistatic finish and was tested with 5 workers in the switch yard in the thermal power plant of Neyveli Lignite Corporation. We made a comparative study of our garment with the garment used by the workers and measured the following parameters:

- Static Electricity Discharge
- Soil Release Property
- Breathability
- Sweat Absorption
- Softness

It has been found that the garment treated by our antistatic finish is far superior in all our test parameters and was received positively by the workers and management in NLC.

PROPERTIES/WORKERS	A	B	C	D
STATIC ELLECTRICITY DISCHARGE	1	1	1	1
SOIL RELEASE PROPERTY	2	1	1	1
BREATHABILITY	1	1	1	2
SWEAT ABSORPTION	2	1	2	1
SOFTNESS	1	1	1	1

1-VERY GOOD, 2-GOOD , 3-SATISFACTORY,4-NOT GOOD

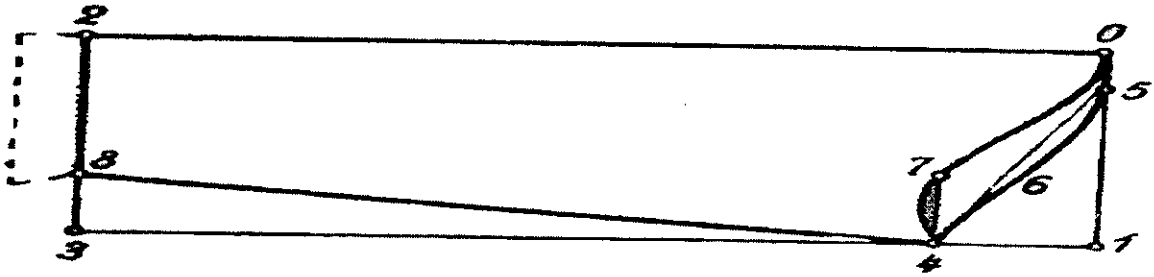
PRODUCT DEVELOPMENT

5. PRODUCT DEVELOPMENT

FIG 5.1 Finished garment

5.1 SLEEVE

FIG 5.2 Sleeve pattern



5.2 FRONT AND BACK

FIG 5.3 Front and back bodice pattern

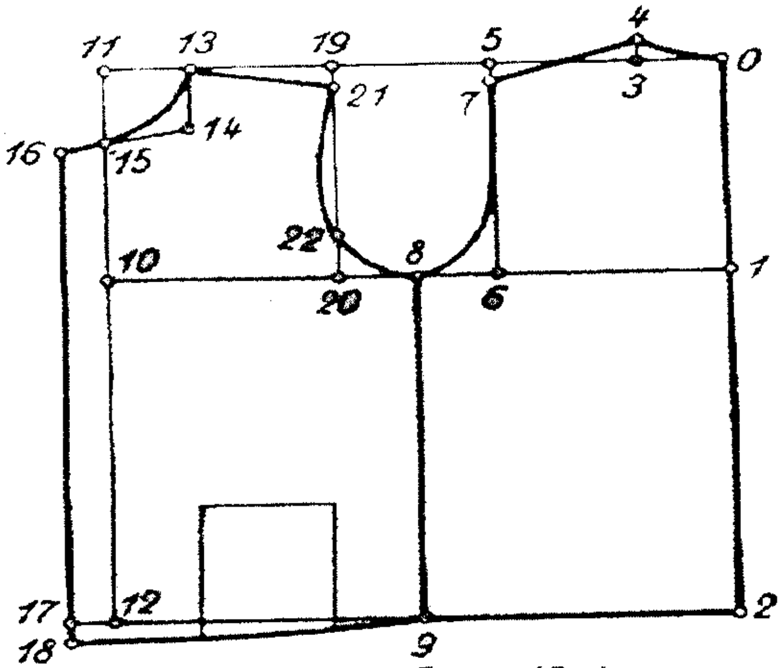


Diagram - Front and Back

5.3 BACK

- Square lines from 0
- fold at 0-1-2
- 1-0 one fourth chest
- 2-0 full length
- 3-0 one twelfth chest
- 4-3 1.5cm(1/2")
- shape neck 0-4
- shoulder plus 1cm
- square down from 5 to 6
- 7-5 1.5 cm, join shoulder 4-7
- 8-1 one-fourth chest plus 2.5cm.shape scye 7-8
- square down from 8 to 9

5.4 FRONT

- 10-8 one-fourth chest plus 2.5 cm
- 11-12 is square from 10
- 13-11 one-twelfth chest
- 14-13 4cm
- 15-11 one-twelfth chest
- Join 14-15 and produce2.5 cm to 16.Shape neck 13-16.
- 17-12 2.5 cm
- Join 16-17 and produce 1.5cm to 18.
- Shape bottom 9-18.
- 19-11 shoulder plus 1cm
- Square down from 19-20
- 21-19 1.5cm

- Join shoulder 21-13
- 22-20 about 2.5 cm
- Shape scye 21-22-8

5 SLEEVE

- Square lines from 0,fold at 0-2
- 1-0one-fourth chest less 1.5cm
- 2-0 sleeve length from shoulder plus 2cm
- 3-2 same as 1 to 0
- Join 3-1.
- 4-1 one-eight chest less 1.25cm
- 4cm
- Join 4-5.
- Shape back side 4-6-5-0
- Square up from 4 to 7.
- 7-4 one twelfth chest.
- Taking 1cm above point 4,shape front side 4-7-0.
- 8-2 one –eight chest plus6.5cm.
- Join 4-8 by straight line
- Keep 1 to 4cm out side 2-8 for hem or inturns.

.6 COSTING

ABLE 5.1 Costing table

NO	MATERIAL	RATE/UNIT(Rs)	QUANTITY	COST(Rs)
	Cotton poly blend	40	4 mt	160
	Finishing	85	4mt	340
	Thread	2	2	4
	Velcro	12	¼	3
	Button	6	5	2.75
	Stitching charge	175	1	175

	684.75
Profit	10%
Total Cost	755

ic charge estimation testing in THE BOMBAY TEXTILE RESEARCH
SOCIATION,Mumbai=Rs.1544

l Costing=material cost+testing cost

5+1544
2300

CONCLUSION

6. CONCLUSION

The experimental methodology and the results highlight the objective i.e. to levelop an antistatic protective garment for switch yard workers by reducing the risk due to electrostatic discharge in work environment. The main objective of the project has been to frame a new experiment methodology that will render a cost efficient antistatic finish which will not cause any health hazards and at the same time can be affordable by a common man.

- Various tests are conducted for all four fabrics before and after finish application.
- In abrasion test the cotton/polyester fabric shown very little difference before and after application of finish and also it has got more abrasion resistance than other fabrics.
- Cotton/polyester blend has got good crease recovery property after finishing when compared to other fabric samples.
- As well as other properties like drape, air permeability and water permeability also got improved in cotton/polyester blend after application of finish than other samples.
- The static resistance also found better in the cotton polyester blend and thus the cotton/polyester fabric is used for the product development.
- Finally the field survey is conducted and the result shows that the fabric got good static resistance and can be used in the switch yard to resist electric charge accumulation.

REFFERENCE

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APPENDIX

NEYVELI LIGNITE CORPORATION LIMITED
(A Govt. of India Enterprise)
Neyveli, Cuddalore District, Tamil Nadu, India

OFFICE OF THE GENERAL MANAGER,
(7X210MW) Thermal Power Station – II,
NEYVELI – 607 807

Telex: 0461-215 to NLC-IN
Fax: 91-4142-252688
Phone: 04142-252611
Extension : 807
E. mail: dgm.em1,ts2@nlcindia.com

09/10/2010

TO WHOMSOEVER IT MAY CONCERN

The Final year B.Tech (Fashion Technology) students comprising of Ms. D. Shruthika, Ms. D. Sowmya, Ms. M. Swarnarekha, Ms. T. Punitha and Ms. R. Lavanya of KUMARAGURU COLLEGE OF TECHNOLOGY has visitied Neyveli Lignite Corperation, Thermal Station-II on 09/10/2010 for doing their project study.

Office of the Dy. General Manager/MR-I
NLC Ltd., Neyveli.
TPS-II

S. Rama

DEPUTY GENERAL MANAGER.
ELECTRICAL /EM-1/ TS-II.

Dy. General Manager
Electrical Maintenance
Thermal Station - II

THE BOMBAY TEXTILE RESEARCH ASSOCIATION
LAL BAHADUR SHASTRI MARG,
GHATKOPAR (WEST),
MUMBAI - 400 086.
es : 022 - 2500 1811
022 - 25003651 / 2652
2117 / 1119 / 1135
: 91-22-2500 0459
l : btra@vsnl.com
btralabs@yahoo.co.in
site: www.btraindia.com

BTRA TEST LABORATORIES

BL / 03A
Analysis & Testing of All Textile Materials Including Eco Testing, Trouble Shooting for Providing Complete Solutions

TEST REPORT

ort Details : BTL/TR/ 1054 /2011 DT.: 29.03.2011

Sample : FABRIC

omer : Ms. PUNITHA T
4/M-16, Madwa Nagar, P. G. Pudur, K. Vadamadurai, Thudiyalur, Coimbatore-641017.

Code: BL/FA/987 & 988

erence : LETTER DTD. : 18.03.2011.

No. of Samples : TWO

eived on : DTD. : 18.03.2011

Total Pages: 1 OF 1

of performance of Test : 19.03.2011 to 26.03.2011.

Despatched on :

TEST RESULTS

SAMPLE NO.	:	BL/FA/987	BL/FA/988
SAMPLE MARK	:	Sample A Unfinished	Sample B Finished

STATIC CHARGE ESTIMATION

TEST METHOD No. : **ASTM D : 4238 : 95**

Charging Voltage : **10 KV** **Relative Humidity** : **45 ± 5%**

Sample Distance : **15 mm** **Temperature** : **25 ± 2°C**

Sample Conditioning : **At 45% RH for one week**

Sr. No.	Sample No.	Total Charge Developed (Volts)	Half Decay Time (Secs.)
1	BL/FA/987	150	1.9
2	BL/FA/988	350	2.0

29/03/2011

(M. K. K. Kaimal)
Laboratory Manager
BTRA Test Laboratories

(2/TR/ 1054 – 29.03.2011)

Samples are not drawn by the Laboratory.

NEYVELI LIGNITE CORPORATION LIMITED
(A Govt. of India Enterprise)
Neyveli, Cuddalore District, Tamil Nadu, India

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02/04/2011

TO WHOMSOEVER IT MAY CONCERN

The Final year B.Tech (Fashion Technology) students comprising of Ms. D. Shruthika, Ms. D. Sowmya, Ms. M. Swarnarekha, Ms. T. Punitha and Ms. R. Lavanya of KUMARAGURU COLLEGE OF TECHNOLOGY has visitied Neyveli Lignite Corperation, Thermal Station-II on 02/04/2011 for doing their project study.

They developed an antistatic protective jacket for the workers in the thermal power plant. The jacket is found to be effective in the work environment for reducing the static build-up and also comfortable for the workers.

Office of the Dy. General Manager/MR I TPS-II NLC Ltd., Neyveli.

S. Raman

DEPUTY GENERAL MANAGER.
ELECTRICAL /EM-1/ TS-II.
Dy. General Manager
Electrical Maintenance
Thermal Station - II