THE TEXTILOPEDIA

ITT

INSTITUTE OF TECHNICAL TEXTILES

Official Newsletter of Institute of Technical Textiles

We are pleased to present the 4th Edition of our newsletter, highlighting the key insights and learnings from the four-day workshop on *High Performance Materials: Protective Textiles*. The programme was conducted under the National Technical Textiles Mission (NTTM), Ministry of Textiles, Government of India, with Textile SSC as the Implementation Agency, and supported by ITTA, and AIC. The workshop was successfully held from 18–21 December 2025.

This edition has been thoughtfully curated to provide readers with a comprehensive summary of workshop lectures, enabling a clear understanding of the key concepts, discussions, and practical insights shared during the program. This newsletter also features the abstract of a research project on the FMEA analysis of para-aramid gloves, currently being carried out by NIT Kurukshetra, highlighting systematic approaches to risk assessment and product performance improvement in protective textiles.

In previous editions of our newsletter, we have covered abrasion, cut, and tear testing methodologies. Building on this foundation, the current edition focuses on puncture resistance testing as per ISO 13996:1999. In addition, this issue provides an overview of related international standards, including ASTM F1342/F1342M-05 (2022) and ASTM F2878-19, offering readers a comparative perspective on testing methodologies and performance evaluation across different global frameworks. This series further celebrates the successful completion of a student research project on impact-protective gloves, reflecting our continued commitment to encouraging hands-on research and innovation among students.

For our readers, a dedicated health and wellness section is always included, where a yoga pose is demonstrated to promote physical well-being and balance. Through this edition, we continue our mission of connecting industry, academia, and research while fostering innovation, awareness, and holistic development in the field of technical textiles.

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SUMMARY OF NTTM-TSC Workshop

The presentations were focused on different high-performance fibres and their applications in protective, home furnishing, and other similar applications. The importance of testing and validation is highlighted for such technical textiles which is crucial for innovation, development, and market growth.

NTTM funded workshop in collaboration with TSC, ITTA, & AIC IIT Delhi

Interaction with students at ITT Sonipat

Day 1: 18th December 2025

Introduction to High-Performance Fibres & Yarns: Dr Nandan Kumar, HPT Pvt Ltd

In the first comprehensive session, Dr. Kumar detailed the strategic role of high-performance materials in the technical textile industry, focusing on providing advanced solutions for protection against thermal, mechanical, and electrostatic hazards.

High-performance fibres are distinguished from conventional fibres by possessing at least one outstanding property, such as extreme tenacity (reaching 17–35 g/denier), high modulus, or exceptional thermal and chemical stability. It was emphasized that although performance remains the highest priority, fibre blending has emerged as the new standard in high-performance textile development. A thorough understanding of the properties of each fibre within a blend is essential for achieving the desired performance levels, making precise and informed material selection critically important.

The session highlighted several specialized materials:

- **Aramids:** Para-aramid (e.g., Kevlar) offers high tenacity (17–23 g/den), while Meta-aramid (e.g., Nomex) is valued for its inherent flame retardancy;
- **Liquid Crystalline Polymers (LCPs):** Materials like aromatic polyester (thermotropic) and PBO (lyotropic) provide superior strength, abrasion resistance, and high Limiting Oxygen Index (LOI) values—PBO reaching an LOI of over 68%;
- **Inorganic Fibres: Basalt and Glass** fibers are essential for both protective textiles and high-temperature insulation in automotive environments when engineered and used correctly.

These fibers are converted into diverse end products, including firefighter suits, cut-resistant gloves, and riot-control uniforms. Emerging areas include protection against high-pressure water jets (up to 1000 bars) and vibration protection. Finally, the talk addressed the growing importance of recycling high-performance textiles, such as para-aramids and UHMWPE, to support sustainable industrial practices.

Introduction to FR treated textiles: Ms Poonam Aahaan, Archroma International Pvt. Ltd.

FR-treated textiles are fabrics engineered with chemical finishes to decrease flammability. Unlike inherently flame-resistant fibers like aramids, these are typically conventional fibers- such as cotton, polyester, viscose, or rayon that acquire resistance through post-processing. The primary technical goals are to:

- Slow down ignition and reduce the rate of flame spread;
- Prevent dangerous melting or dripping when exposed to high heat;
- Enhance fire safety to protect life and property while meeting strict government regulations.

The chemical finishes applied to these textiles interrupt the combustion cycle through four primary technical pathways:

1. **Char Formation:** Creating a protective carbonaceous layer on the fabric surface to act as a barrier;
2. **Gas Dilution:** Releasing non-flammable gases that lower the concentration of oxygen around the material;
3. **Combustion Interruption:** Chemically interfering with the radical chain reactions of the fire;
4. **Heat Reduction:** Minimizing the transfer of thermal energy to the fiber.

FR- Treatments are categorized by their durability and intended end-use:

- **Durable FR Treatments:** Chemically bonded to the fiber, these finishes withstand multiple wash cycles and are essential for industrial workwear and protective clothing (e.g., for firefighters or electricians).
- **Non-Durable FR Treatments:** Temporary finishes that lose effectiveness after washing, typically used for decorative items or short-term applications.

The sector is seeing significant expansion driven by:

- **Stricter Safety Norms:** Growing global demand for mandatory compliance in public and industrial infrastructure;
- **Sectoral Demand:** Rapid growth in oil & gas, defence, and transportation (aviation and rail) where lightweight FR textiles are replacing heavier traditional materials;
- **Innovation:** Development of halogen-free and eco-friendly chemicals, as well as smart, multifunctional textiles that balance safety with comfort.

The presentation identified critical hurdles for the industry, most notably the toxicity and non-biodegradability of some legacy FR chemicals, leading to increased pressure for sustainable alternatives. Additionally, manufacturers must manage the trade-off between safety and fabric properties like breathability, softness, and colour fastness, all while navigating complex international testing standards (NFPA, EN, ISO).

Introduction to Kevlar® and Nomex® business opportunities: Mr. Gaurav Jain, DuPont Specialty Products India

Mr. Gaurav Jain detailed the engineering prowess and diverse applications of DuPont's high-performance aramid fibers, specifically Nomex® and Kevlar®. The presentation underscored their critical role in safeguarding lives and enhancing performance in protective apparel and automotive sectors. Mr. Jain highlighted Kevlar®, a para-aramid fiber renowned for its extreme tensile strength and thermal stability.

- **Mechanical Integrity:** Engineered to provide high-tenacity reinforcement, Kevlar® is essential in applications requiring superior cut, impact, and ballistic resistance.
- **Aerospace & Automotive:** The fiber's lightweight yet durable nature makes it ideal for tyre reinforcement, brake pads, and high-performance composites that demand extreme energy absorption.

The presentation also focused on **Nomex®**, a meta-aramid fiber designed to provide inherent heat and flame resistance.

- **Inherent Properties:** Unlike treated fabrics, the flame-resistant properties of Nomex® are part of its molecular structure, meaning they cannot be washed out or worn away;
- **Multi-Hazard Protection:** Mr. Jain discussed how Nomex® systems are rigorously tested to ensure performance against several industrial threats:
    - **Thermo-Man® Testing:** A life-sized instrumented mannequin system used to predict the percentage of body burn and evaluate the effectiveness of protective garments during a flash fire;
    - **Arc Flash Protection:** Specialized Nomex® blends safeguard electrical workers from the intense heat and explosive force of an electric arc;
    - **Industrial Applications:** The fiber serves as a primary barrier in firefighter turnout gear, racing suits, and military flight suits.

Mr. Jain concluded by showcasing how these materials are "transforming industries and everyday life" through leading technologies.

- **Integration:** The focus is on creating multifunctional garments that do not compromise on comfort or mobility while maintaining the highest safety levels;
- **Technical Versatility:** From providing electrical insulation in EV motors to high- temperature filtration in industrial plants, Nomex® and Kevlar® continue to thrive through constant material innovation.

Business opportunities in UHMwPE fibres and fabrics: Mr. Olivier Boubeaud, Innovarte Europe S.R.L

The landscape of personal protective equipment (PPE) is undergoing a significant transformation, driven by advancements in high-performance polymers and the refinement of global testing standards. Mr. Olivier Boubeaud, Founder and Managing, Director of Innovarte SRL, detailed the critical role of Ultra-High Molecular Weight Polyethylene (UHMWPE) and also introduced breakthrough "Fortyra Platinum Technology" which is a reinforced UHMwPE. Modern cut protection is designed to counteract two primary mechanical forces: Downward force, which creates high tension in the fabric, and friction force, which removes material from the cutting edge. To maximize resistance, next-generation materials focus on four key mechanical properties:

- **High Tensile Strength:** Utilizing fibers that resist breaking under extreme tension;
- **Hardness:** Incorporating nano-metric particles to dull cutting blades;
- **Lubricity:** Reducing friction to allow a blade to glide across the surface rather than digging in;
- **Rolling Action:** Using multifilament yarns with low cohesion to disperse energy.

The industry has moved toward the TDM method (ISO 13997) for more accurate measurement, particularly for high-cut materials. This method measures the force in Newtons required to cut through a sample at a specific distance, providing a more reliable metric than older "coupe tests". Traditional UHMWPE, while offering high strength (30–45 g/den) and a low density (0.97 g/cm3), often requires high weight-to-performance ratios to reach top-tier safety levels. Innovarte's Fortyra Platinum technology disrupts this by incorporating nano-metric graphene directly into the polymer. This graphene integration enhances hardness and lubricity, allowing garments to reach ISO Level F protection (the highest level) at a weight of approximately 200g/sqm—nearly 5 times more efficient than standard UHMWPE. This leap in efficiency allows for the creation of lightweight, stretchable "base layers" that offer heavy-duty protection previously only possible with bulky "outer layers". The versatility of these next-gen fibers is evidenced by their adoption in extreme environments:

- **High-Profile Sports:** In alpine skiing, where ski-edge cuts pose fatal risks, the FIS-DITF standard now qualifies protective undergarments using specialised test rigs that simulate cuts to limbs;

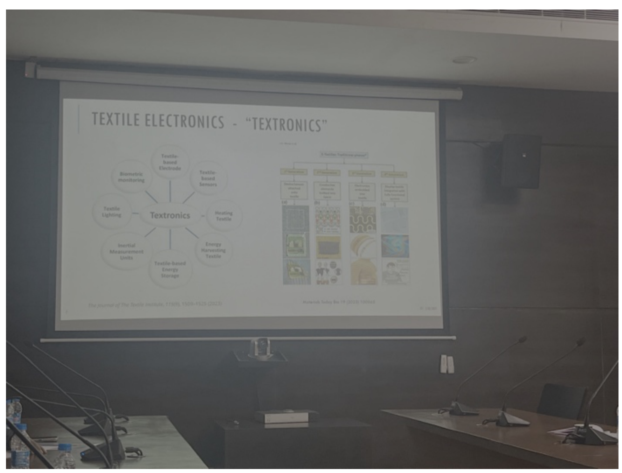
- **Military and Security:** New generations of security apparel leverage Fortyra Platinum to provide Level F protection (34 N to 54 N force) in comfortable, everyday-looking garments like sweaters and vests;
- **Industrial Workwear:** High abrasion, chemical, and UV resistance, combined with compliance for electrostatic discharge (EN1149-2), ensures durability in harsh industrial settings. On the technical front, UHMwPE is unique because it's extremely high molecular weight prevents it from being melt-spun; it is typically produced via gel spinning. This distinguishes it technically from other high-performance polyethylene.

Regarding sustainability, Mr. Boubeaud emphasised the push for eco-design and the recyclability of UHMwPE, ensuring that the lifecycle of these life- saving materials aligns with global environmental goals.

Development of Technical Sensors: Study of Polyester with Stainless Steel Fibres: Discussion on business opportunities: Dr. Suraj P Khanna, Chief Scientist, CSIR-National Physical Laboratory, New Delhi

Dr. Suraj Khanna, Chief Scientist at CSIR-National Physical Laboratory, delivered a session on the transformative potential of

"Textronics" (Textile Electronics) and its application in smart wearable materials.



Dr. Khanna traced the technological journey from "Immobile" to "Textile-based" electronics. He highlighted a chronological shift:

- Immobile: Early computing like the ENIAC (1946) and early telecommunications (1876);
- Mobile: The advent of the DynaTAC mobile phone (1973) and laptop (1983);
- Wearable/Textile: Modern integration seen in the iPhone (2007), Google Glass (2013), and the emergence of future smart textile-based technology.

To support this growth, experts advocated for structured academic courses in Textronics to prepare the next generation for this interdisciplinary field.

A core highlight of the talk was the discovery of memristor behaviour in HPT AntiStax yarns. Key technical aspects include:

- Memory Integration: These yarns function like memory devices, enabling the development of re-writable memristors based on electroconductive yarn;
- Multi-mode Control: The technology supports transitions across multiple resistive states through both contact and non-contact stimuli;
- Durability Testing: Forthcoming studies will validate real-world reliability by testing performance after 100+ wash cycles and extended sunlight exposure.

Dr. Khanna emphasized the social and practical utility of Textronics through two primary avenues:

- STEM Learning: Having developed a Memristor Educational Kit, he advocated for its inclusion in the CBSE curriculum to encourage early hands-on learning;
- Conductive Textiles in Medicine: The session detailed fabrics that transmit electrical signals while maintaining user comfort. Applications include ECG-monitoring garments, wearable biosensors, smart bandages for active healing, and real-time drug-delivery systems.

By simplifying complex concepts for both graduates and professionals, Dr. Khanna demonstrated how interdisciplinary research in materials science and electronics will revolutionize healthcare and everyday smart living

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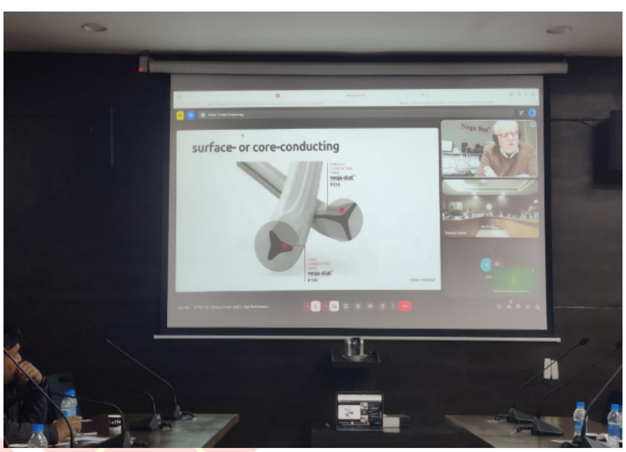
Business opportunities in Antistatic Textiles: Mr. Oliver Christof, Barnet Europe, Germany



Static electricity in textiles can lead to catastrophic failures in industrial environments or can be the basic reason for health issues. Mr. Christof presented several Nega-Stat® core conducting and surface conducting filament solutions developed to address specific processing requirements and performance demands.

The session emphasized that the effectiveness of antistatic textiles is defined by the "end-use requirement or the associated industrial risk and hazard."± Key industrial sectors include:

Battery and EV Production: Static electricity on personnel and their garments could have negative impact in critical areas such as car body shops, EV assembly lines, and battery cell and pack production. Garments incorporating Nega-Stat® core conducting and surface conducting filament solutions provides individual safety to prevent incendiary electrostatic discharges to electronic equipment which could cause mal functions, could be the reason for dust-and particle transfer and could be the initial trigger to cause explosion in inflammable atmospheres.

Industrial Workwear: In demanding industrial environments, especially where continuous and reliable grounding cannot always be guaranteed, Nega-Stat® P190 provides outstanding antistatic protection. Under fully grounded conditions, the core conductor ensures optimal charge dissipation. More importantly, in real working situations where full and permanent grounding cannot be ensured, Nega-Stat® P190 continues to deliver full and permanent antistatic protection, making it ideally suited for protective industrial workwear exposed to variable conditions.

Cleanroom Operations: Nega-Stat® solutions deliver optimum performance in cleanroom and sterile environments, complying with IEC 61340 standard. These textiles control surface voltage to below 10 volts and even lower and demonstrate high resistance to sterilization processes such as gamma radiation and steam.

Food Processing: Beyond static control, these materials help minimize risks in food-handling environments by supporting HACCP safety initiatives. They reduce the transfer of bacteria-carrying particles and fungi, contributing to cleaner and safer production conditions and a positive impact on the sale by day of specific food.

Container Bags (FIBCs): Industrial container bags (FIBCs) can generate electrostatic charge levels of up to 800,000 volts or more during the filling of fine powder materials such as paint particles, titanium dioxide (TiO_2), and polymer granulates**.** Container bags incorporating the core conductor Nega-Stat® P190 provide full antistatic protection during the filling of FIBCs under grounded conditions as well as under ungrounded conditions, as required for Type D container bags.

The presentation also addressed medical and domestic benefits of static management. Elevated electrostatic charge levels in the human body are medically associated with stress, sleep disorders, and general discomfort.

Technical Solutions introduced included:

- **Health and Relaxation:** Nega-Stat® bedding solutions designed to support asthma and allergen protection, improve sleep quality, and contribute to pain relief.

- **Automotive Comfort:** In car seats and upholstery, Nega-Stat® core conducting filament solutions reduce dust and dirt attraction and prevent low-energy discharges that could interfere with vehicle electronics or create fire risks during refuelling.

- **Medical Protective Wear:** Applications extend to nurses'uniforms, scrub wear, and reusable polyester operating gowns, ensuring electrostatic safety for both medical staff and patients.

Mr. Christof's presentation clearly demonstrated that modern technical textiles are no longer passive materials. Through the precise integration of Nega-Stat® core conducting and surface conducting filament solutions, the Barnet team enables safer industrial processes, more reliable electronics production, and enhanced human well-being through advanced and permanent static management.

Day 2: 19th December 2025

Business opportunities in FR Viscose fibres (Protective and Home Furnishing): Ms Vaishali Kamble, Aditya Birla Group

Ms Vaishali Kamble detailed the technical profile and applications of Birla SaFR, a phosphate-based, inherently flame-retardant (FR) viscose fiber designed for home textiles and protective clothing. Birla SaFR is a man-made cellulosic fiber (MMCF) derived from sustainable wood pulp. Unlike chemically treated textiles that may lose efficacy over time, SaFr features inherent flame retardancy that remains effective even after 50 wash cycles.

- **Mechanism:** It prevents the spread of fire by limiting oxygen availability at the source of ignition;
- **Environmental Impact:** The fiber is biodegradable within 8–10 weeks and offers a pathway to environmental and economic sustainability;
- **Physical Properties:** It maintains a tenacity of >2.8 gpd and elongation of >13%, available in deniers ranging from 1.42 to 2.0.

SaFR balances high-level protection with the comfort of natural fibers.

- **Thermal Protection:** It possesses a Limiting Oxygen Index (LOI) >28, providing superior protection against diverse fire hazards;
- **Comfort:** It is highly breathable, manages moisture effectively, and is skin-friendly, which reduces heat stress for the wearer compared to synthetic alternatives.
- **Flammability Testing (ISO 15025):** In surface ignition tests, SaFR fabric formed no holes & no flame propagation and afterglow.

The fiber is engineered for versatility and is often blended with high-performance fibers like meta-aramid (e.g., a 50/50 SaFr/Aramid blend) for specialized use. It is suitable for below applications;

- **Protective Clothing:** Complies with international standards including IS 16890 (firefighters), NFPA 2112 (flash fires), and EN 469;
- **Home Textiles:** Ideal for upholstery, curtains, carpets, and bed linens. It supports compliance with India's Quality Control Order (QCO), which mandates FR standards for upholstery in non-domestic furniture. SaFR is frequently used in blends such as 60/40 SaFR/Polyester for bedding and mattresses to ensure durability and wash stability.

Sustainable Development of Recycled Para-aramid Blended With Naturally Coloured Cotton Gloves with Enhanced Protective Performance: Dr. G. Krishna Prasad, ICAR- CIRCOT, Mumbai

Dr. G. Krishna Prasad, Senior Scientist at ICAR-CIRCOT, detailed the strategic development of high-performance protective gloves using recycled para-aramid blended with naturally coloured cotton. This initiative addresses the high-growth Indian aramid market, which is projected to nearly double from USD 102.1 million in 2024 to USD 187.3 million by 2030. The core technical strategy utilizes pre-consumer recycled para-aramid sourced from manufacturing scraps and defective batches. This material offers a "quality edge" over post-consumer waste due to its longer fiber length and superior mechanical properties. Economically, using recycled para-aramid significantly reduces costs, with recycled grades priced as low as $12–$23/kg compared to $35–$50/kg for virgin fiber.

ICAR-CIRCOT has engineered binary and tertiary blended yarns specifically for cut-resistant and flame-retardant (FR) gloves. Key innovations include:

- Naturally Coloured Cotton Blends: Utilizing naturally grown brown cotton removes the need for dyeing, enhancing sustainability by reducing water usage;
- High-Performance Hybridization: Tertiary blends incorporating Recycled Para-aramid, Cotton, and UHMWPE combine heat resistance, comfort, and extreme strength for heavy-duty industrial use.

Blends were spun into 20s Ne yarn in varying proportions (100% cotton up to 10/90 cotton/aramid) and evaluated for industrial standards:

- Strength: Single yarn strength increased with higher para-aramid content, ranging from 22 g/tex (100% cotton) to 27 g/tex (10/90 blend);

- Cut Resistance: Evaluated via TDM ISO 13997. The 10/90 blend achieved a 12 Newton force-to-cut value, while the 100% cotton baseline was 4.1 Newtons;
- Flammability: Both 30/70 and 10/90 cotton/para-aramid blends attained Level 4 performance under EN 407 testing;
- Contact Heat: The 10/90 blend fabric sustained contact heat resistance for 25 seconds at 100°C, reaching Level 1;
- Abrasion: Level of abrasion cycles (hole formation) improved with higher para-aramid content, moving from <100 cycles for 100% cotton to <300 cycles for 30/70 and higher blends.

In conclusion, the research conducted by G. Krishna Prasad (Senior Scientist, ICAR-CIRCOT) demonstrates a strategic pathway for the technical textile industry to achieve both environmental sustainability and economic competitiveness.

Recycling Pathways for High-Performance Textile Waste: From Defence Waste to Circular Economy Application: Prof. Bipin Kumar, IIT Delhi

The global annual production of technical fibers is substantial, led by Modacrylic (>500,000 tons) and UHMWPE (>400,000 tons). Specifically, the Aramid fiber market is projected to grow at a CAGR of 11.2%, reaching $8.79 billion by 2029. Current disposal methods (landfill and incineration) pose significant environmental costs, necessitating high-margin recycling pathways for waste products like body armour, combat uniforms, and specialized workwear.

Prof. Bipin highlighted his team's research on a Cutter–Shredder–Opener sequence designed to recover fibres from both pre-consumer sources such as yarn and selvedge waste, and post-consumer sources including used gloves and body armour.

- **Beater Optimization:** Technical analysis shows that over-processing occurs beyond beater stage 6;
- **Property Degradation:** Fiber tenacity decreases progressively through each beater stage, dropping from 20.98 g/den (Stage 1) to 10.69 g/den (Stage 8). Similarly, mean fiber length reduces from 22.2 mm to 16.5 mm by stage 8;
- **Morphological Changes:** SEM and Atomic Force Microscopy (AFM) reveal increased surface roughness in recycled p-aramid (192.8 nm) compared to virgin fiber (109.9 nm).

A key pathway for hard waste clumps (beater filter waste) is their use as reinforcement in cementitious materials.

- **Methodology:** Clumps are individualized via lab-scale grinding (25,000 rpm), bath sonication, and hand sieving to achieve water dispersion;
- **Performance:** Aramid fiber reinforced cementitious slurry (AFCS) and mortar (AFCM) composites were tested. AFCS composites showed peak compressive strength at 0.1% fiber content (63.1 MPa), while higher percentages (0.2%) led to agglomeration and reduced strength (46.3 MPa).

In a nutshell, Prof Kumar emphasizes bridging performance and sustainability through optimization and sustainable approach;

- **Optimization:** Determining the ideal blend of virgin and recycled fibers (e.g., 90/10 to 60/40 ratios) to maintain industrial standards;
- **Circular Metrics:** Focus on reducing the CO_2 carbon footprint, improving traceability, and valorising post-consumer waste in new industrial sectors.

Comfort Properties of Protective Clothing: Prof. Apurba Das, IIT Delhi

Prof. Apurba Das (IIT Delhi) discussed the technical aspects of comfort in protective textiles, focusing on the physiological, sensory, and structural factors that influence wearer performance and safety.

Comfort is defined as a state of pleasant harmony between the human body, the clothing, and the environment. In protective textiles, comfort is not a luxury but a safety requirement; uncomfortable gear leads to non-compliance, where workers wear equipment improperly or remove it, weakening the "chain of safety".

Comfort is categorized into three primary dimensions:

- **Thermo-Physiological:** The transmission of heat, air, and moisture (liquid and vapor) to maintain a core body temperature of **36.5–37.5°C**.
- **Sensorial (Tactile):** The neurophysiological processes sensing mechanical interactions (roughness, softness, friction) via mechanoreceptors in the skin.
- **Psychological/Aesthetic:** The wearer's confidence in the gear and its visual/attitudinal perception.

The body must dissipate approximately 90 watts of basal metabolic heat even when resting. Protective textiles often create a conflict by acting as a barrier against external hazards while trapping internal heat and sweat. Below are important to understand;

- **Heat Transfer Mechanisms:** Occur via conduction, convection, radiation, and evaporation;
- **Insulation:** Measured in Clo units; 1 Clo is the insulation required to keep a resting person comfortable at 21°C. Effective insulation relies on air entrapment, as still air has very low thermal conductivity (0.024 W/m K);
- **Moisture Management:** Efficient transport of perspiration away from the skin is critical to prevent "clamminess" and heat stress. This is measured by the Overall Moisture Management Capacity (OMMC), which indexes wetting time, absorption rate, and spreading speed.

In a research project Prof. Das and his team analysed technically cut-protective and heat-protective fabrics and that reveals critical trade-offs:

- **Hybrid Structures:** Adding core materials like E-glass, aramid, UHMwPE, or meta-aramid improves the thermophysiological balance by increasing air permeability;
- **Core-Sheath Dynamics:** A higher percentage of core material (stainless steel or glass) increases fabric thickness but decreases bulk density. While this improves air permeability and OMMC, it also increases bending and shear rigidity, making the fabric stiffer and less flexible;
- **Surface Characteristics:** Increased core material often results in higher surface roughness (SMD) and friction (MIU), which can negatively impact sensorial comfort.

The comfort properties are measured using specialized apparatus:

- **Kawabata Evaluation System (KES):** Measures mechanical properties like tensile energy, shear rigidity, and surface roughness to quantify "fabric hand";
- **Sweating Guarded Hot Plate:** Quantifies evaporative resistance (Ret) and thermal resistance (Rct);
- **Moisture Management Tester (MMT):** Measures liquid moisture transport properties across fabric surfaces.

In summary, engineering a comfortable protective garment requires a precise balance between barrier integrity and permeability. Thicker, denser fabrics provide better protection but accelerate fatigue and heat stress, while engineered layered structures (hydrophilic inner/hydrophobic outer) maximize moisture transport without compromising safety.

Importance of NABL Accreditation Testing Laboratory: Mr. Nitan Garg, NABL

Mr. Nitan Garg delivered a lecture on the operations of the National Accreditation Board for Testing and Calibration Laboratories (NABL) and the core requirements of the ISO/IEC 17025:2017 standard for modern laboratories.

Mr. Garg introduced NABL as an autonomous constituent board of the Quality Council of India (QCI), an apex body under the Ministry of Commerce and Industry. He detailed the organizational structure of QCI, which oversees several key boards including:

- **NABL:** Testing and Calibration Laboratories;
- **NABET:** Education and Training;
- **NABH:** Hospitals and Healthcare Providers;
- **NABCB:** Certification Bodies;
- **NBQP:** Quality Promotion.

The lecture focused on the transition to the 2017 version of ISO/IEC 17025, which specifies requirements for competence, impartiality, and consistent operation of labs. Mr. Garg categorized the standard's requirements into five critical pillars:

- **General Requirements:** Mandatory focus on Impartiality and Confidentiality to safeguard against commercial or financial pressures;
- **Structural Requirements:** Defining the legal entity of the lab and its management structure;
- **Resource Requirements:** Ensuring adequacy in Personnel (qualified staff), Facilities (environmental control), Equipment (maintenance and calibration), and Metrological Traceability;
- **Process Requirements:** A deep dive into the operational lifecycle, including:
    - Review of requests and contracts.
    - Selection, verification, and validation of methods.
    - Sampling and handling of test/calibration items.
    - Evaluation of measurement uncertainty.
    - Ensuring the validity of results through internal quality control and proficiency testing.
- **Management System Requirements:** Implementing a robust system for document control, risk management, internal audits, and management reviews.

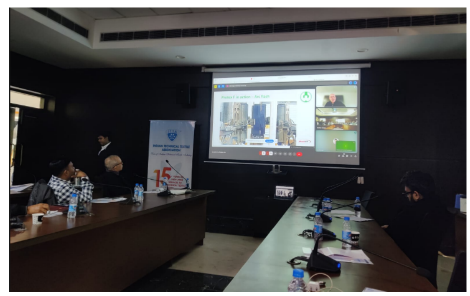
The path to NABL accreditation is a structured process involving several technical milestones:

- **Application Submission:** Laboratories must apply through the NABL web portal (e.g., Form NABL 151) with a defined Scope of Accreditation;

- **Adequacy Audit:** Scrutiny of the lab's quality manual and documentation by NABL staff;
- **Pre-Assessment:** An optional check to verify if the lab is ready for the final assessment;
- **On-Site Assessment:** A witness audit where empanelled assessors verify technical competence, equipment performance, and staff proficiency;
- **Grant of Accreditation:** After clearing all non-conformities (NCs), the accreditation committee recommends the lab for a 2-year certification cycle, subject to annual surveillance.

Mr. Garg emphasized that NABL accreditation is a formal recognition of a lab's technical proficiency, providing global acceptance of test results via the ILAC MRA.

Business Opportunities in Protex Modacrylic Fibres (Protective & Home Furnishing) : Mr Phil Briggs, Waxman Fibres Ltd



Mr. Phil Briggs, Technical Director at Waxman Fibers, detailed the evolution of high-performance fibers, with a specific focus on modacrylic solutions for protective workwear.

Modacrylics are synthetic copolymers containing between 35% and 85% acrylonitrile. Unlike conventional synthetics, modacrylics like Protex (manufactured by *Kaneka Corporation, Japan*) are inherently flame retardant (IFR); the FR properties are embedded in the polymer chain and cannot be removed by laundering. Key performance characteristics include:

- **Non-Drip Performance**: Unlike polyester, modacrylics do not melt or drip when exposed to heat, preventing secondary burn injuries;
- **Blending Versatility**: Protex is primarily used as a blending fibre, often paired with cotton or wool to combine specialized protection with natural comfort and cost-efficiency;
- **Chemical Resistance**: These fibers offer high durability against acids, alkalis, and UV light.

A critical metric for these materials is the Limiting Oxygen Index (LOI), representing the minimum oxygen concentration required to support combustion. While standard modacrylics typically feature an LOI of 28–32, the enhanced Protex F achieves a significantly higher index of 33–34 (and up to 43 in specialized configurations).

The self-extinguishing mechanism of Protex relies on halogens (chlorine) and metal compounds that off-gas under heat. This process removes oxygen from the immediate flame zone and promotes carbonization, creating a strong char barrier that prevents fabric "break-open"—a vital requirement for Arc Flash protection standards.

The industry is currently transitioning toward more sustainable practices. Recent developments include:

- **Non-Antimony Solutions**: Moving away from traditional antimony trioxide synergists toward more sustainable metal compounds;
- **Protex H**: A new non-antimony fiber specifically engineered for the home furnishings sector;
- **Recycling**: Implementing "gasification" and chemical recycling to utilize recycled acrylonitrile in production, thereby reducing the carbon footprint of high-performance textiles.

Patent, Copyright & Trademark: Mr Prateek Shrivastava, PNA Intellectual Property & Attorney

Mr. Pratik Shrivastava, an Intellectual Property attorney from PNA Intellectual Property and Attorney, delivered a session on patents, copyrights, and trademarks & provides a comprehensive technical and legal overview of Intellectual Property Rights (IPR) in India. It covers the fundamental types of protection, eligibility criteria, and the procedural stages for securing these rights.

Property is defined as any kind of movable, immovable, tangible, or intangible asset that includes a right or interest.

- **Tangible Property:** Physical assets like machinery, mobile phones, and vehicles.
- **Intangible Property:** Assets without physical existence but representing value, such as patent rights, brand names, and computer software.

A patent is a statutory right granted for a product or process invention for a limited period of 20 years.

- **Eligibility Criteria:** The invention must demonstrate Novelty (absolute newness), an Inventive Step (non-obviousness providing technical/economic advantage), and Industrial Applicability;

- **Non-Patentable Inventions:** Under Section 3, items such as frivolous inventions contrary to natural laws, discoveries of naturally occurring substances, mathematical methods, business methods, or traditional knowledge cannot be patented;
- **Process:** Includes pre-filing research, drafting (ideally by an agent), filing specific forms (Forms 1, 2, 3, 5, and 26), and a post-filing examination period.

Trademarks (Brand Names) a visual symbol used to distinguish goods or services of one undertaking from those of another.

- **Registration:** Governed by the Trademarks Act, 1999. Protection lasts 10 years and is renewable indefinitely;
- **Grounds for Refusal:** Marks that are generic (e.g., "CHAIR" for chairs), descriptive ("SWEET" for chocolates), or phonetically/visually similar to existing marks will be rejected.

Copyright, protection for creators of original works, including literary, artistic, musical, dramatic, and cinematographic works.

- **Literary Work:** Includes software, catalogues, and books;
- **Artistic Work:** Covers paintings, drawings, and photographs;
- **Limitations:** Ideas, facts, and methods of operation cannot be copyrighted, though the specific *expression* of those ideas can be.

Design, protects features of shape, configuration, pattern, or ornament applied to an article through an industrial process.

- **Criteria:** Must be novel, original, distinctive, and appeal to the eye;
- **Term:** Protection is initially for 10 years, extendable by another 5 years.

He emphasized that IP is not only about protection but also about strategic business advantage.

Day 3 & 4: 20-21st December 2025

The last two days of the workshop provided a specialized technical focus on the mechanical processing and performance validation of high-performance materials.

Advanced Spinning and Fiber Processing

Technical sessions on fiber conversion highlighted the complexities of processing high-modulus materials, specifically **para-aramid**.

- **Blow Room and Carding:** Mr. Vinay D. Joshi and the HPT team demonstrated the opening and cleaning stages, emphasizing adjustments required for para-aramid's high tenacity;
- **Card Clothing Technology:** Mr. A. Marimuthu (Lakshmi Card Clothing) detailed specialized card wire geometries engineered to handle high-strength fibers without excessive fiber breakage or nep formation;
- **Yarn Quality and Clearing:** Mr. Lalit Hooda (Loepfe India) conducted a session on the Autoconer and electronic yarn clearing, identifying critical yarn faults such as thick places, thin places, and slubs.
- **Integrated Workflow:** HPT Team concluded with a comprehensive demonstration of the spinning line, including the Draw Frame, Speed Frame, Ring Frame, and Two-for-One (TFO) twisting for para-aramid processing.

Performance Validation and Testing Standards

The program transitioned to rigorous testing methodologies for protective textiles against mechanical, electrostatic, and thermal hazards.

1. Mechanical Hazard Evaluation:

- Cut & Abrasion: Assessments included TDM Cut resistance (ISO 13997), Martindale abrasion, and specialized Darmstadt abrasion testing;
- Structural Integrity: Testing for tear, puncture, stab, and impact cut resistance was discussed to ensure compliance with industrial safety requirements.

2. Electrostatic and Antistatic Properties:

- Sessions detailed the decay of static charges to prevent incendiary discharges in hazardous environments;
- Compliance testing followed BS EN 1149-5 requirements, utilizing Surface Resistance (EN 1149-1) and Half Charge Decay Time (EN 1149-3) methodologies.

3. Thermal Transmission and Molten Metal Hazards:

- Heat Transfer: Evaluation of flammability, contact heat, convective heat, and radiant heat transmission;
- Advanced Metrics: Discussions covered thermal protective performance (TPP), electrical burners and resistance to both small and large drops of molten metal.

Certification and Academic Integration

The program concluded with a formal assessment conducted by the Textile Sector Skill Council (TSC). This accreditation process is designed to align with NTTM initiatives for Executives Training and future academic credit transfer systems, bridging the gap between industrial practice and formal education for technical textile professionals.


GPS Map Camera
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TECHN

2. Research Project: In collaboration with NIT Kurukshetra

The ongoing research project at NIT Kurukshetra utilizes Failure Mode and Effect Analysis (FMEA) to rigorously evaluate the reliability and performance of Para-aramid based protective gloves. This systematic, proactive methodology is designed to identify potential failure modes in gloves engineered for multi-hazard protection, specifically addressing the mechanical and thermal risks encountered in industrial and military environments. By pinpointing weaknesses in the Para-aramid structure—such as susceptibility to mechanical fatigue or thermal degradation after contamination—researchers can determine root causes and implement engineered solutions before hazardous failures occur in the field.

3. Student's Project

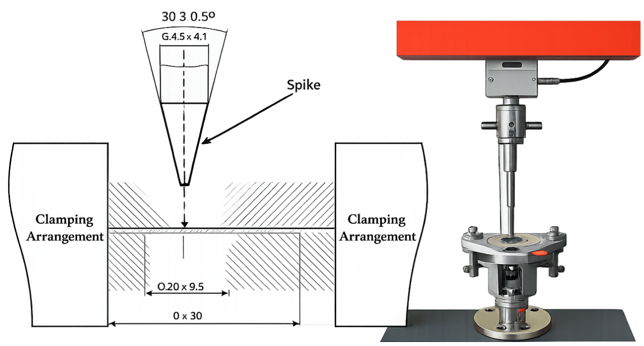
Students from PIET, Panipat, Ms. Yogita & Ms. Ekta, have conducted a technical evaluation of riot control gloves to assess their performance against impact hazards in accordance with the BS EN 13594:2015 standard. The study utilized a comparative testing matrix that examined glove samples under both dry and wet environmental conditions, as well as configurations with and without Thermoplastic Rubber (TPR) reinforcement. Technical observations indicated that the integration of TPR significantly enhances impact attenuation properties by providing a durable structural barrier that effectively redistributes mechanical energy.

4. Puncture Resistance Test as per ISO 13996: 1999

Puncture resistance is defined as the maximum force required to push a specialized steel spike through a test specimen at a specified constant speed. The result is expressed in newtons. The primary purpose is to measure the mechanical resistance of protective clothing materials to perforation by sharp objects (represented by a spike) to ensure wearer safety in hazardous environments.

- **Testing Machine: The apparatus required for this test includes:**

- **Tensile Testing Machine (Type CRE)**: Must be capable of a vertical travel of at least 100 mm and a constant compression rate of 100 ± 10 mm/min;
- **Test Spike**: A steel spike with a minimum hardness of 60 HRC and specific dimensions (4.5 mm diameter with a 30° point);
- **Clamping Rings**: Two steel plates at least 10 mm thick with a central 20 mm diameter hole to prevent specimen slippage during testing.



- **Sampling & test conditions**

Four representative test specimens must be taken from the sample material. Each specimen must have a minimum diameter of 50 mm to fit correctly between the bolt holes of the clamping rings. Tests should be conducted in a standard atmosphere, **Temperature**: 20 ± 2 °C; **Relative Humidity**: 65 ± 5%.

- **Test Procedure**
  - ◊ Secure the specimen between the clamping rings, ensuring the outer surface is exposed to the spike;
  - ◊ Place the assembly in the testing machine and advance the spike at a rate of 100 ± 10 mm/min;
  - ◊ Continue the test until the spike penetrates the specimen;

◊ If the spike travels 25 mm after contact without penetration, the test is terminated;
◊ Record the maximum force in newtons for all four specimens;
◊ Calculate the arithmetical mean of the results, rounded to the nearest integer.

- **Test Report**

The final report must include:

◊ The standard (ISO 13996:1999);
◊ Identification details of the sample tested;
◊ Individual results for each of the four specimens and the calculated mean value in newtons;
◊ Any deviations from the standard procedure.

While ISO 13996 provides a foundational methodology for puncture resistance testing, several other international standards are utilized to evaluate protective clothing and gloves based on specific hazards.

Puncture Resistance Testing Standards

- **BS EN 388:2016:** This standard is specifically used for evaluating the protective performance of gloves. It utilizes a puncture spike identical in geometry to the one defined in ISO 13996:1999;
- **ASTM F 1342 / F 1342M-05:** This standard applies to the puncture resistance of protective clothing materials. Unlike the single spike used in ISO 13996, this method utilizes three distinct test probes: Probe A, Probe B, and Probe C, to simulate different types of puncture hazards.

Specialized Medical Puncture Resistance

In medical environments, puncture-resistant textiles are critical for the safe disposal of medical waste and safeguarding personnel against hypodermic needles. Standard puncture spikes are insufficient for these scenarios because they do not mimic the fine, sharp geometry of a needle.

- **ASTM F 2878:2019:** This specialized standard is followed specifically for testing material resistance against hypodermic needles. It measures the force required for a standard medical needle to penetrate a protective barrier, which is essential for medical-grade gloves and specialized waste-handling apparel.

The selection of the appropriate standard depends on the intended end-use of the textile, whether it is for general industrial protection or high-risk medical applications.

5. Upcoming Events

The **Indian Technical Textile Association (ITTA)** Student Chapter Initiative features two upcoming technical webinars designed to connect the Industry with academic community & researchers. The first event "Learn from PhD Researchers" series is scheduled for January 24, 2026. This episode features Dr. Satyaranjan Bairagi (ETH Zurich) and Ms. Shruti Gadge (ICT Mumbai), They will present their research on triboelectric nanogenerators and Organic molecules for smart textiles respectively. Both sessions provide a technical deep dive into future product development and are free for registered participants.

The second event, which has been rescheduled for February 2, 2026, will be led by Professor Parikshit Goswami from the University of Huddersfield, UK. His lecture will focus on Medical Textiles and the "Triple Helix" model, examining the critical collaborative relationships between government bodies, industry stakeholders, and academic institutions to drive sustainable growth and research commercialization

6. HEALTH CAPSULE: *Adho & Urdhva Mukha Svanasana*

Urdhva Mukha Svanasana (Upward-Facing Dog)

Steps:

- Lie prone on the floor with your legs extended behind you and the tops of your feet on the mat.
- Place your hands on the floor next to your waist.
- Inhale and straighten your arms, simultaneously lifting your torso and legs a few inches off the floor.
- Keep your thighs firm and turned slightly inward; press your shoulder blades away from your ears.
- Look straight ahead or slightly upward without compressing the back of the neck.

This pose is a powerful backbend that opens the chest and strengthens the anterior chain.

Breathing: Inhale while straightening the arms; exhale while lying down. Maintain slow, steady breathing while holding the posture.
Duration: Hold for 15 to 30 seconds; repeat 3–5 rounds.

Adho Mukha Svanasana (Downward-Facing Dog)

Steps:

- Start on your hands and knees in a tabletop position.
- Tuck your toes under, exhale, and lift your knees away from the floor, reaching your sitting bones toward the ceiling.
- Push your thighs back and stretch your heels toward the floor (it is okay if they don't touch).
- Press firmly into your palms and knuckles, keeping your head between your upper arms.

This is a foundational inversion that builds strength while stretching the entire back body

Duration & Breathing: Hold for 30 seconds to 1 minute, breathing deeply while holding the posture.
Benefits: Improves posture, stretches the chest and abdomen, and strengthens the spine, wrists, leg and arms.

ITT is committed to building meaningful collaborations through joint projects, spreading awareness, and curbing the supply of sub-standard products to end users.
Students and researchers are especially encouraged to reach out for short-term assignments or opportunities to contribute to commercially relevant projects.

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