



Superior Protection against Thermal Hazards

DuPont™ Nomex® Applications for Industrial Workers



Nomex®

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Nomex® Branded Solutions Overview

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DuPont™ Nomex® Applications

Nomex® fibres are used across a broad range of applications.

It is a critical component in protective apparel and accessories as used by fire fighters all over the world.

Nomex® protects the wearer from the flames and the intense heat a **fire-fighter** may encounter. It offers superior thermal insulation, durability and freedom of movement.

Nomex® is also used in apparel worn by **military pilots** and **combat vehicle crews**. In the **motor racing industry**, Nomex® brand fibres are the most commonly used materials in racing apparel protecting a large number of drivers, pit crew members and track officials against the danger of flash fires at the race track.

Nomex® used in **personal protective clothing** responds to a wide variety of **industrial end uses**. From offshore drilling platforms, petrochemical, chemical, and pharmaceutical industries to electrical utilities, electricians and foundries, wearers have found reliable and trusted solutions in the Nomex® garments, whether their hazards are flash fire, fire, explosion, electric arc, molten metal splashes, static discharge, chemical splashes or low visibility.



DuPont - Official Supplier of the BMW Sauber F1 Team

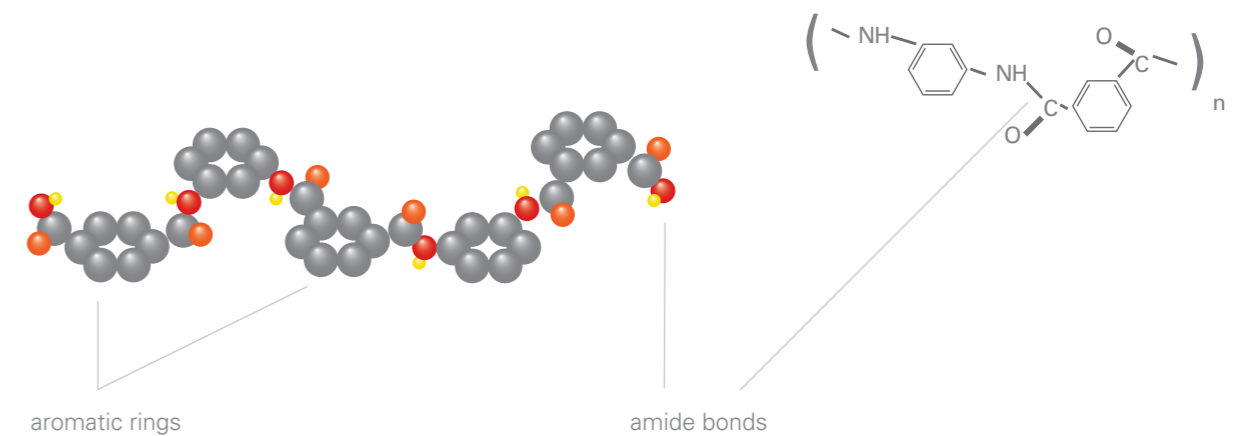




Why Nomex®?

Nomex® is an **inherently flame-resistant**, high-temperature resistant meta-aramid fibre **that doesn't melt and drip or support combustion in the air**. A key factor in the protection provided by Nomex® is its ability to carbonize and thicken when exposed to intense heat.

This typical reaction increases the protective barrier between the heat source and the wearer's skin and minimizes burn injury, almost comparable to the way a modern car protects its occupants with air-bags.



Schematic representations of a Nomex® molecule.

Nomex® derives its flame resistant properties from its **unique structure** of aromatic rings and conjugated amide bonds. As this thermal behaviour is obtained by its molecular structure and not by applying a flame retardant chemical substance to the fabric, yarn, fibre or polymer, Nomex® offers permanent protection, which cannot be washed out or worn away.

The history of Nomex®

Nomex® was invented by DuPont in 1967.

During the past 40 years, DuPont has continuously **enhanced** the Nomex® fibres.

- All Nomex® PPE solutions have been blended with the para-aramid fibre **DuPont™ Kevlar®**, also developed by DuPont, resulting in a fibre which provides **additional strength** and **structural integrity** when exposed to heat and flame. Pure meta-aramid solutions are not recommended for use in PPE applications.
- DuPont added electrostatic charge dissipative **P-140** fibres to most Nomex® PPE offerings for assured protection against electrostatic discharge hazards.

Fabrics made from Nomex® fibres offer inherent and durable heat resistance.

Terminology in PPE

Common terms in Thermal Personal Protective Equipment

The DuPont Personal Protection division together with its Nomex® Quality Partners develops and produces fibres and fabric systems that are used in apparel worn by people who work in challenging environments and require protection from heat and flame or dangerous substances.



Flame resistant fabric is a term used to describe a material that is **self extinguishing** after removal of an external ignition source. Material can be flame resistant because of the inherent properties of the fibre, or the presence of flame retardants. Also different yarn properties and fabric construction may contribute to increase flame resistance.

Inherently flame resistant fabrics are fabrics manufactured with fibres such as Nomex® whose innate properties make them **naturally flame resistant** without a chemical treatment.

Flame retardant treated fabrics are produced by applying a finish to a fibre or the fabric to reduce its flammability, or by incorporating a flame retardant chemical into the fibre prior to spinning. The flame retardant treatment chemicals are “activated” by intense heat, producing char and gases that inhibit combustion for a certain time.

Conventional fabrics that were not treated with flame retardant chemicals do not provide adequate protection against thermal hazards. They can ignite, melt or continue to burn on the body, increasing the extent of a worker's burn injury.

It is very important that workers wear **adequate thermal protective flame resistant clothing** because it provides escape time, it reduces burn injury and it increases the wearer's chances of survival.

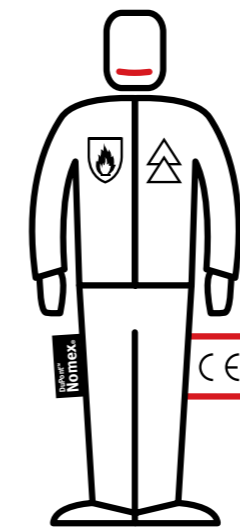


Nomex.

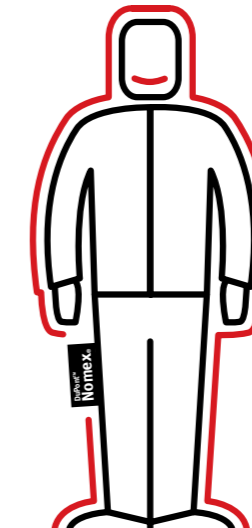
Choosing the Right Thermal PPE

Six Selection Criteria

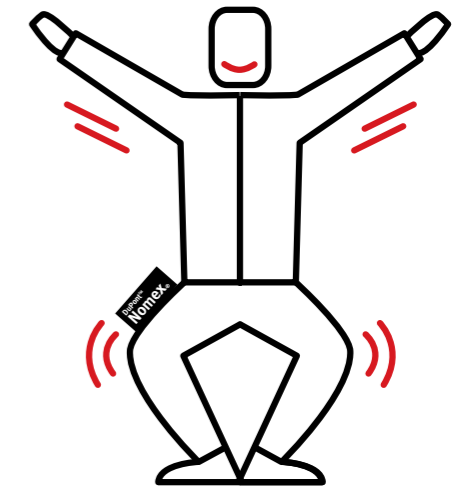
DuPont recommends to use the following six selection criteria when choosing the most appropriate material for Personal Protective Equipment:



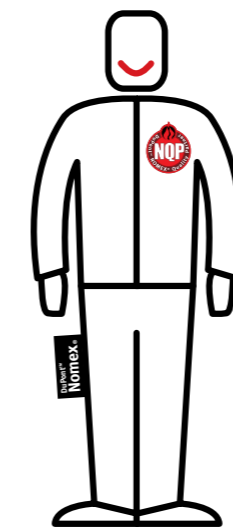
**CE Marks,
Norms and
Regulations**



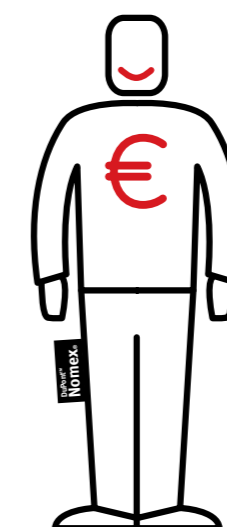
**More
Protection**



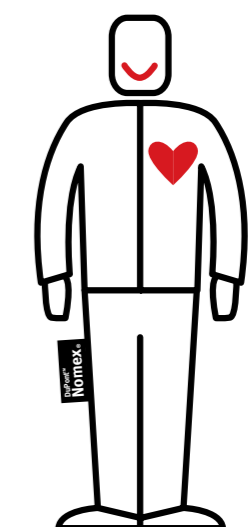
Wearer's Comfort



Quality Assurance

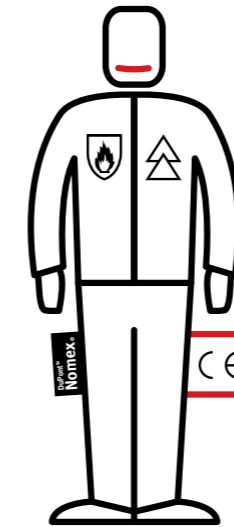


Cost Effectiveness



Peace of Mind

1. CE Marks, Norms and Regulations



1.1 European Directives

Two EC mandatory directives regulate PPE which must be transposed into national law by all European Union member countries.

European directive on PPE - 89/686 EEC

is the mandatory directive (colloquially called the "Product Directive") that applies to **manufacturing of protective clothing** defines the "essential" requirements that a PPE product shall meet before it can be put onto the market, i.e. distributed or used. More than 150 harmonised EN standards have been developed by CEN/CENELEC as basis for checking whether a specific item of PPE complies with these essential requirements.

Requirements above the minimum performance for CE certification may be specified by users with respect to specific particular hazards or other considerations.

Achieved CE certification, as indication by the CE mark on the product, tells the end user that the PPE fulfils the essential requirements that have been defined for protection against certain hazards in certain uses as well as appropriate ergonomics, innocuousness and sizing.

European directive on the use of PPE - 89/656 EEC

is the mandatory European directive (colloquially called the "User Directive") that applies **for End Users of protective clothing**.












It sets the obligations and regulates the measures that need to be taken by employers and employees to **maintain and improve the safety and health of workers** in every aspect related to their work.

The directive regulates about risk assessment, the need for preventive measures, training and information, and stipulates that Personal Protective Equipment has to be provided free of charge by the employer.

It considers 'the improvement of workers' safety, hygiene and health at work to be an objective which shall not be subordinated to purely economic considerations.



1.2 Main European Standards for Body Thermal Protective Clothing

	Thermal Hazards				Electrostatic Discharge Hazards	Chemical Hazards	Electrical Current Hazards	Environmental Hazards	Low Visibility Hazards
	Heat & Flame	Electric Arc	Large Molten Metal Splashes	Small Molten Metal Splashes	Antistatic properties	Low volume Splash & Mist	Low voltages	Rain	High Visibility
	EN 531* prEN ISO 11612*	IEC 61482-1** IEC 61482-1-1/CDV** IEC 61482-1-2** IEC 61482-2/CDV*	EN 531* prEN ISO 11612*	EN 470-1*  EN ISO 11611*	EN 1149-1** EN 1149-3** EN 1149-5*	EN 13034*	EN 50286*	EN 343* EN 14360** 	EN 471*
								Cold & Cool Environment EN 342* EN 14058** 	
Nomex® Comfort				3		1	2	2	
Nomex® IIIA				3		1	2	2	
Nomex® III				3	if combined with additional antistatic fibre	1	2	2	only for specific high-vis colours
Nomex® MetalPro									
Nomex® MetalPro Plus									
Nomex® Tough						1			

All PPE are subject to the European Norm EN 340 specifying general requirements for protective clothing. It is the user responsibility to carry out risk analysis and select the appropriate personal protective equipment.

1. With fluorocarbon finish

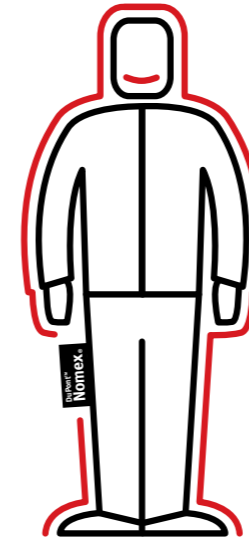
2. Properties can be achieved by combining fabrics made from Nomex® fibres with other materials to provide protection against environmental hazards of rain (EN 343 and EN 14360) cold & cool environment (EN 342 and EN 14058) and against low voltage electrical current hazards (EN 50286).

3. Heavy weight Nomex® fabrics (eventually finished with fluorocarbon) fulfill the requirements of the standards for protective clothing for use in welding and allied processes.

DuPont does not recommend to use such solutions for heavy welding applications due to reduced wearlife of the garment.

*Standards: performance requirements **Standards: test methods

2. More Protection



In industrial applications, the main thermal hazards against which workers need to be protected are heat and flame, heat of an electric arc and molten metal splashes.

The condition and quantity of heat, flame or fire that a worker can be exposed to is expressed - amongst others - in terms of

- estimated incident energy, measured in cal/cm² or kW.s/m²
- heat flux, or the rate of heat flow across a unit area measured in cal/cm²/sec or kW/m²

Hazards characterization

Thermal Hazard	Typical Exposure Time	Temperatures	Heat Transfer
Heat and Flame	up to 15s	up to 1.000°C	50% convective heat 50% radiant heat
Heat of an electric arc	up to 1s	up to 10.000°C	10% convective heat 90% radiant heat
Molten metal splashes	long	< 2000°C	100% contact heat

DuPont European Technical Centre

Near Geneva, in Switzerland, DuPont has set up its **European Technical Centre (ETC)**. This is an innovating testing facility for application development, where a number of standardized tests are performed. DuPont also developed specific tests which are performed at the ETC and which measure the protective performance against specific simulated thermal hazards (e.g. DuPont™ Thermo-Man®, DuPont™ Arc-Man®, DuPont™ Molten Metal Man, steam heat transfer of protective fabrics and garments).



2.1 Nomex® Protects against Heat and Flame

Thermal protective clothing is subject to norms EN 531 and the drafted harmonized standard prEN ISO 11612. DuPont developed two relevant **additional test methods** which measure the thermal protection level of a fabric or garment.

2.1.1. DuPont Thermal Protection Performance test (known as “TPP”)

The first test is a fabric test, in which a fabric sample is subjected to circumstances typical for fires: a constant combination of 50% radiant heat and 50% convective heat, at a constant heat flux of 84 kW/cm².

The test then measures the time that elapses and the amount of heat energy (**TPP value**) needed before the temperature at the back of the fabric reaches a level which would cause a 2nd degree burn to the wearer of the PPE.

By dividing the TPP value (cal/cm²) by the fabric basis weight (in g/m²), the **Fabric Failure Factor** or **FFF** value is obtained, indicating the thermal insulation performance of the fabric.

A high FFF factor stands for a better thermal protection performance per kilo fabric. It thus allows for an **objective comparison of materials** on an equal basis, taking into account the protection/weight ratio. This test cannot predict the thermal performance of a garment, as other factors such as design of the garment and accessories are important.





2.1.2 DuPont™ Thermo-Man®

The second test developed by DuPont is a garment test. Thermo-Man® is a **life-size mannequin** equipped with 122 heat sensors, which is dressed in test garments and is then totally engulfed into flames generated by propane gas burners.

This test exposes the garment surface to a flash fire with temperatures rising up to 1.000°C, thus simulating a typical industrial heat and flame incident. This excess fuel fire simulator validates the garment's protective performance and integrity against heat and flame.



The thermo-sensors record the temperature rise on the surface of the mannequin while a computer simulation programme calculates:

- the predicted percentage of 2nd and 3rd degree burns a person might suffer on their body under similar conditions
- the position of the burns, and the percentage of burns compared to the total body
- the burn evolution over the measuring time, resulting in the person's chance to survive the incident (in %) in conjunction with the victim's age.

2.1.3 Test results, Thermal Protection Performance Test

In this test, Nomex® fabrics were compared with cotton and several cotton blend fabrics which were treated with flame retardant chemicals.

- Nomex® fabrics better shield the wearer from the onset of body burns
- Nomex® fabrics provide up to a 35% higher TPP factor or 35% additional time before the wearer would suffer 2nd degree burns
- Nomex® fabrics retain their protective performance even after 200 washes
- on a kilo by kilo basis, Nomex® fabrics provide up to twice the thermal efficiency or FFF factor value compared to chemically treated cotton and cotton blended fabrics
- Personal Protective Equipment made of Nomex® fabrics allows for comfortable lower weight solutions while maintaining excellent protection against heat and flame

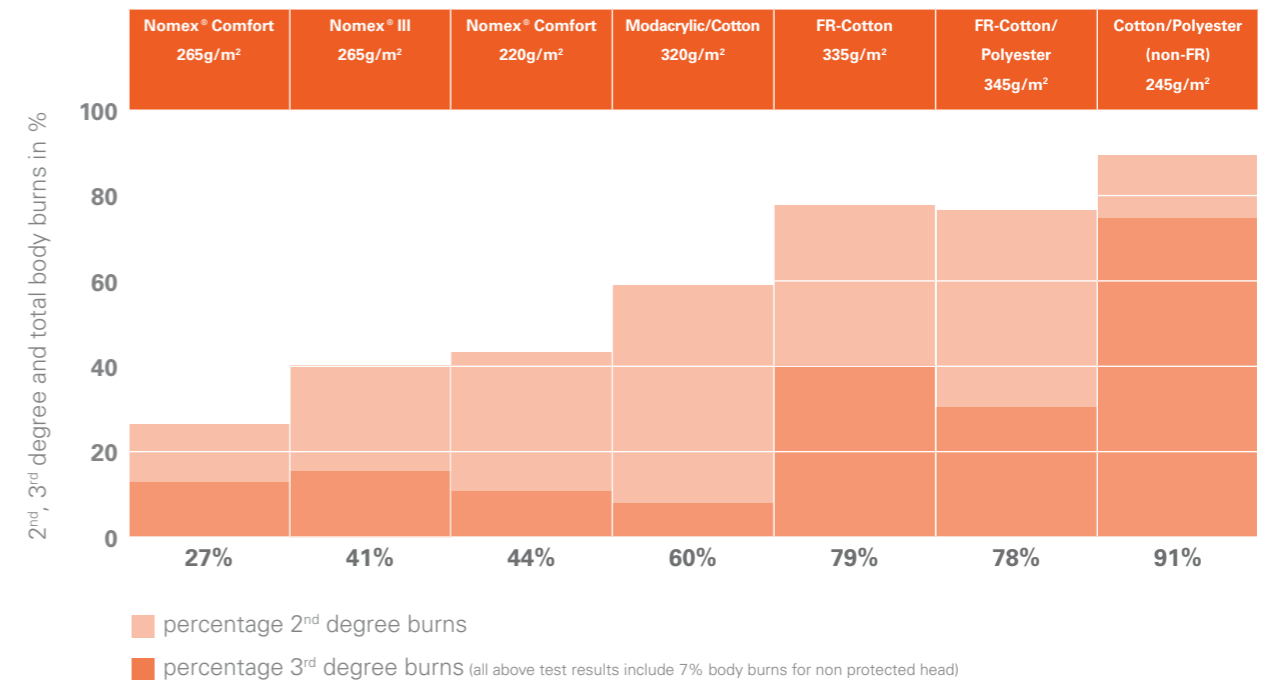
2.1.4 Test results, Thermo-Man® Test (relates to ISO 13506)

Standard coveralls (same style and size) of several fabric types and fabric weights (worn together with standard short sleeve cotton underwear), are exposed to heat energy levels of 2 cal/cm²/sec (a reasonable "mean value" in petrochemical fire incidents), for a duration of 4 seconds.

Nomex® garments were compared to cotton and cotton blended garments which had been treated with flame retardant chemicals.

- Wearing protective clothing made of Nomex® fabrics results in the lowest percentage of total body burns, increasing the survival chances of a heat and flame victim considerably

Comparison of Thermo-Man® Body Burns for workwear made from commonly used fibres



MORE PROTECTION



2.2 Nomex® Protects against Heat of an Electric Arc

Heat from an electric arc is an important hazard that workers need to be protected from. Personal Protective Equipment is subject to norm IEC 61482-2/CDV.

2.2.1 What is an electric arc?

An electric arc is a **continuous electric discharge of high current** between conductors, generating very bright light and intensive heat.

The arc blast presents a **very serious hazard** (potentially fatal) because of the risk of severe burn injuries caused by intensive heat and by molten metal splashes. The electric arc also generates hazardous noise and pressure and it can cause inhalation injury.

The **incident heat energy** that an electric arc can produce is determined by the amount of the arc current, the duration of the arc, the distance between the worker and the arc and the configuration of the conductors and the surrounding environment.

In order to choose adequate protective clothing, the potential incident heat energy (in units of energy per square surface) caused by an electric arc and to which a worker may be exposed, needs to be calculated in a thorough risk assessment. For example, the US NFPA 70E guidelines categorize electric arc hazards and set up guidelines for protective clothing performance requirements.





2.2.2 Quantifying the arc rating of a protective garment

1. The arc rating is most commonly quantified by the **Arc Thermal Performance Value (ATPV)** determined by the **open arc test** method IEC 61482-1. This test method is currently being revised to IEC 61482-1-1/CDV. The ATPV represents the **maximum incident thermal energy** in units of energy per surface area (e.g. kJ/m² or cal/cm²) that a fabric can support before the wearer will suffer 2nd degree burns.

The break-open threshold energy (or E_{BT}) is another fabric characteristic. It represents the highest incident energy exposure value on a fabric where the garments do not exhibit break-open.

The formation of holes in the fabric caused by break-open would allow heat or flames to pass through.

Workers are assumed safe if the arc rating of their clothing (or ATPV value) **exceeds** the electric arc incident energy as calculated in the worst case scenario of a risk assessment.

2. **The box test** is another way to measure the protective performance of clothing against the thermal effects of an electric arc, and is defined in the IEC 61482-1-2 test method. In this test, the fabric is exposed to an electric arc confined in a specific box with a specific electrode arrangement.

Box Test	Arc Duration	Arc Current
Class 1	0.5 s	4kA
Class 2	0.5 s	7kA

A fabric passes the test:

- if the heat transferred behind the fabric does not cause second degree burn (i.e. is below the Stoll curve)
- if the after flame time is below 5 seconds
- if there is no melting to the inner side of the fabric
- if a hole caused by the arc is not larger than 5 mm in every direction (in the inner most layer)

Test conditions for Class 1 try to simulate typical exposure conditions for a short circuit current of 4 kA protected by devices limiting the duration of the arc to 0.5 seconds in confined space, and of 7 kA respectively for Class 2.



2.2.3 DuPont™ Arc-Man®

This equipment developed by DuPont measures the ATPV value of protective fabrics and garments in simulated open electric arc incidents. It exposes the materials to energy levels of up to 70 cal/cm² (for information, continuous exposure to 1.2 cal/cm² may be enough to cause a 2nd degree burn on human skin generated by an open arc).

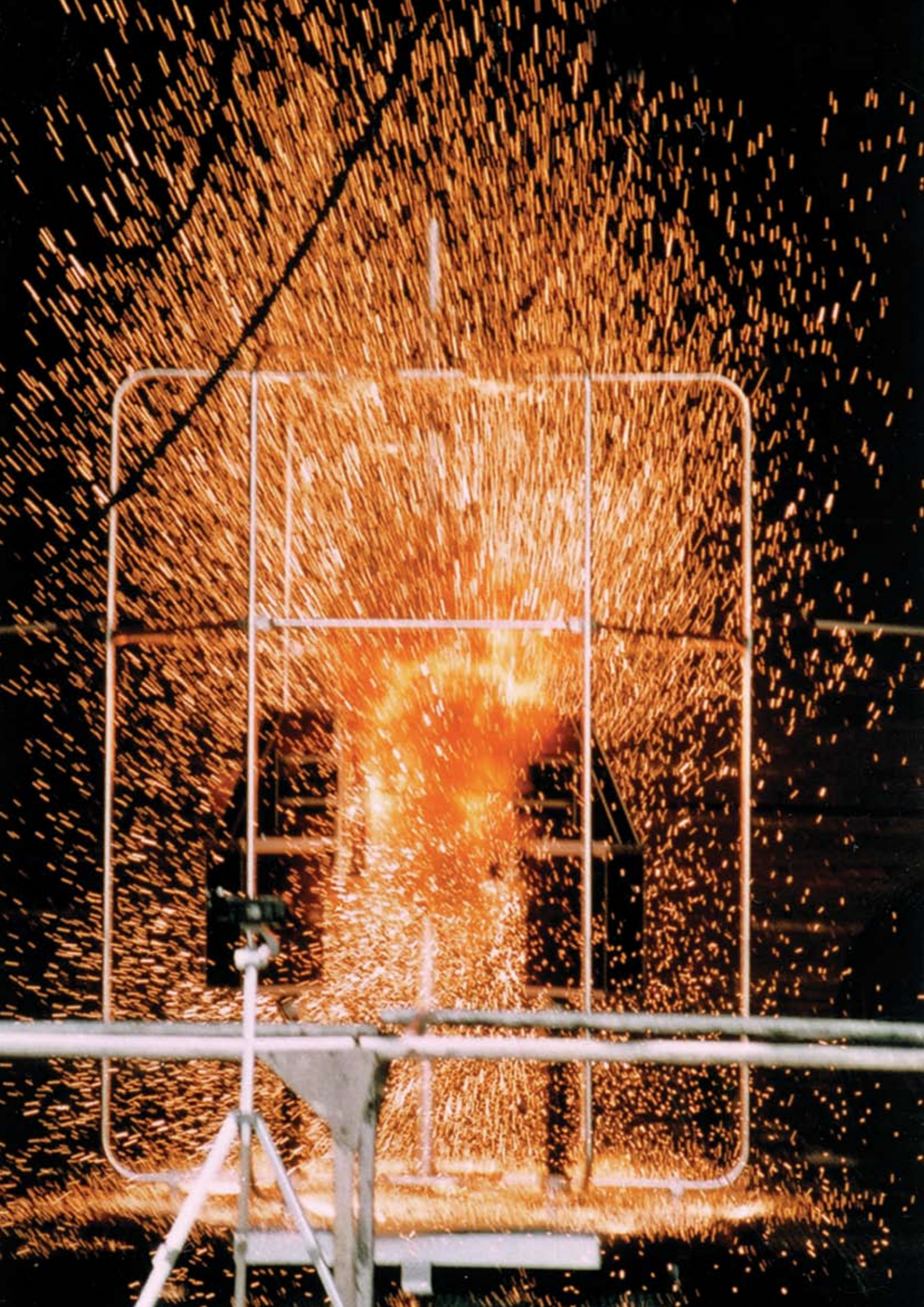
Incident energy is calculated based on several parameters influencing an electric arc, such as current, duration of the arc, electrode material, the gap between the electrodes and the distance of the tested fabrics or garments to the arc.

Arc-Man® performs the tests according to the current valid standard parameters in IEC 61482-1. A revised version, IEC 61482-1-1/CDV, is currently being prepared.

Arc-Man® can test **fabrics** on panels, measuring the ATPV value of the fabric system (in cal/cm²) so that it can be compared with the incident energy calculated in the end user's risk assessment. Arc-Man® can also perform complementary **garment tests** on a torso to show the effect of a garment's design and integrity of manufacture, allowing an assessment of the garment's behaviour (e.g. of the closure system, the pockets, etc.).

The box test according to IEC 61482-1-2 (equivalent to EN 61482-1-2) can also be performed on the DuPont™ Arc-Man® testing facility.





2.2.4 Electric arc test results and recommendations

- DuPont recommends that all layers are made of inherently flame resistant materials
- inappropriate underwear could ignite or melt, thus having an adverse effect on protection and aggravating the outcome of an electric arc incident
- Nomex® offers single layer and multi-layer protective clothing solutions against electric arc hazards, conforming to IEC 61482-2 when tested according to IEC 61482-1 (Open arc incidents), and IEC 61482-1-2 (Arc in a Box or confined arc incidents)

Electric arc protective clothing can receive IEC 61482-2/CDV certification if one of the following requirements are met:

- the ATPV value of the clothing must be at least 4 cal/cm²
- the clothing has to pass at least the electric arc box test Class 1.

Number of layers	Fabric or fabric systems (from the outside to the inside of the garment)	Total system weight (g/m ²)	Arc Rating of the final PPE	
			Open Arc ATPV* (cal/cm ²)	Arc in box Class 1 and 2**
1	Nomex® Comfort 150 g/m ² , weave	150	5.6	not tested
1	Nomex® SL 170 g/m ² , weave	170	not tested	1
1	Nomex® Comfort 205 g/m ² , knit	205	7.8	not tested
1	Nomex® Comfort 220 g/m ² , weave	220	7.3	not tested
1	Nomex® Comfort 265 g/m ² , weave	265	9.6	1
1	Nomex® Comfort 300 g/m ² , weave	300	12.2	1
1	Nomex® Comfort 400 g/m ² , weave	400	not tested	2
2	Nomex® Comfort 220 g/m ² weave + Nomex® Comfort 180 g/m ² weave	400	21.6	1
2	2 layers Nomex® Comfort 220 g/m ² , weave	440	22.2	1
2	2 layers Nomex® Comfort 220 g/m ² , weave	440	not tested	2
2	Nomex® Comfort 265 g/m ² weave + Nomex® Comfort 220 g/m ² weave	485	31	1
2	2 layers Nomex® Comfort 265 g/m ² , weave	530	34.4	2
3	Nomex® SL 170 g/m ² weave + Nomex® N 401 50 g/m ² + Nomex® Comfort 220 g/m ²	440	not tested	2
3	Nomex® Comfort 225 g/m ² weave + Felt 150 g/m ² + Nomex® Comfort 110 g/m ² weave	485	40.7	2
3	Nomex® Comfort woven with membrane 250 g/m ² + Nomex® Comfort lining 110 g/m ² + Nomex® Comfort Polar 370 g/m ²	730	82.3	2

All fabrics or fabric systems have been laundered 5 times prior to testing according to the pre-treatment requirements of IEC 61482-2/CDV.

* The ATPV values indicated in the table have been tested according to IEC 61482-1:2002

** The Arc in box test class 1 & 2 have been measured according to the IEC 61482-1-2:2007

The table lists a few examples of fabrics and fabric systems and their arc rating. The two examples of the fabric systems with 485 g/m² have been chosen to indicate that the arc rating of a fabric is not only depending on weight, but to a large extent also on other characteristics of the used Nomex® fibres, yarns and fabric constructions and combinations.

DuPont recommends to the user to ask weavers and garment manufacturers for an offering of fabrics, fabric systems and garments, which meet his or her specific arc rating needs and also his needs of other important properties in the best combination.



2.3 Nomex® Protects against Metal Splashes

Our NQP weavers, knitters and garment manufacturers can provide you with tested and certified solutions. The risk of injury by molten metal splashes is a third group of thermal hazards which is addressed by Nomex®.

To qualify against this particular hazard, a PPE is subject to the following norms:

- EN ISO 11611 (replacing EN 470-1) for **small molten metal splashes** or droplets of metal in welding and allied processes.
- prEN ISO 11612 and still valid EN 531 for **large molten metal splashes**, i.e. projection of metal of a minimum of 100 g for aluminium, or 60 g for iron

The hazard of molten metal splashes is present in **foundries** and can also occur during **welding**. Although the temperature of metal splashes is normally lower than those reached in fuel fires, the sparks and splashes may be in contact with the protective garment for several minutes. Molten metal splashes can stick to the surface of a protective garment and conduct heat through the fabric. This can lead to ignition of the garment and/or the splashes burning through it, causing burn injuries.

The severity of the molten metal splash hazard depends on the **temperature of the metal splashes**, and on their **shedding behaviour**. A worker's protective clothing should ideally evacuate, or "shed" this heat source immediately and totally, not allowing molten metal splashes to stick to the surface of the garments.



2.3.1 DuPont™ Molten Metal Man

This is a new test equipment developed by DuPont to assess the impact of molten metal splashes on protective clothing.

DuPont™ Molten Metal Man allows the evaluation of whether a fabric passes the test EN ISO 9185 (previously EN 373 or ISO 9185), which is a molten metal splash run off test with visual PVC skin evaluation. DuPont™ Molten Metal Man is a testing device for scientific, repeatable & reproducible results in a safe environment and allows the evaluation of different metal types with melting temperatures up to 1,700 °C.

DuPont's standard assessment uses iron, aluminium, copper and zinc.



Nomex.



2.3.2 DuPont™ Nomex® MetalPro and Nomex® MetalPro Plus

For this particular hazard, DuPont developed Nomex® MetalPro and Nomex® MetalPro Plus.

Nomex® MetalPro is a **special fibre and fabric blend** intended for protective clothing in less hazardous situations in the hot iron and steel manufacturing process, in foundries, forging (coils) and during occasional welding in industries.

Nomex® MetalPro is typically worn during an entire work shift, and provides protection against iron splashes. It is not intended to replace protective clothing in highly hazardous situations (such as aluminized or leather garments worn very close to the furnace and heat source).

Nomex® MetalPro Plus is a new product that has been developed to offer an **even higher protection** to the parts of the garment that are most exposed to frequent contact with molten metal splashes.

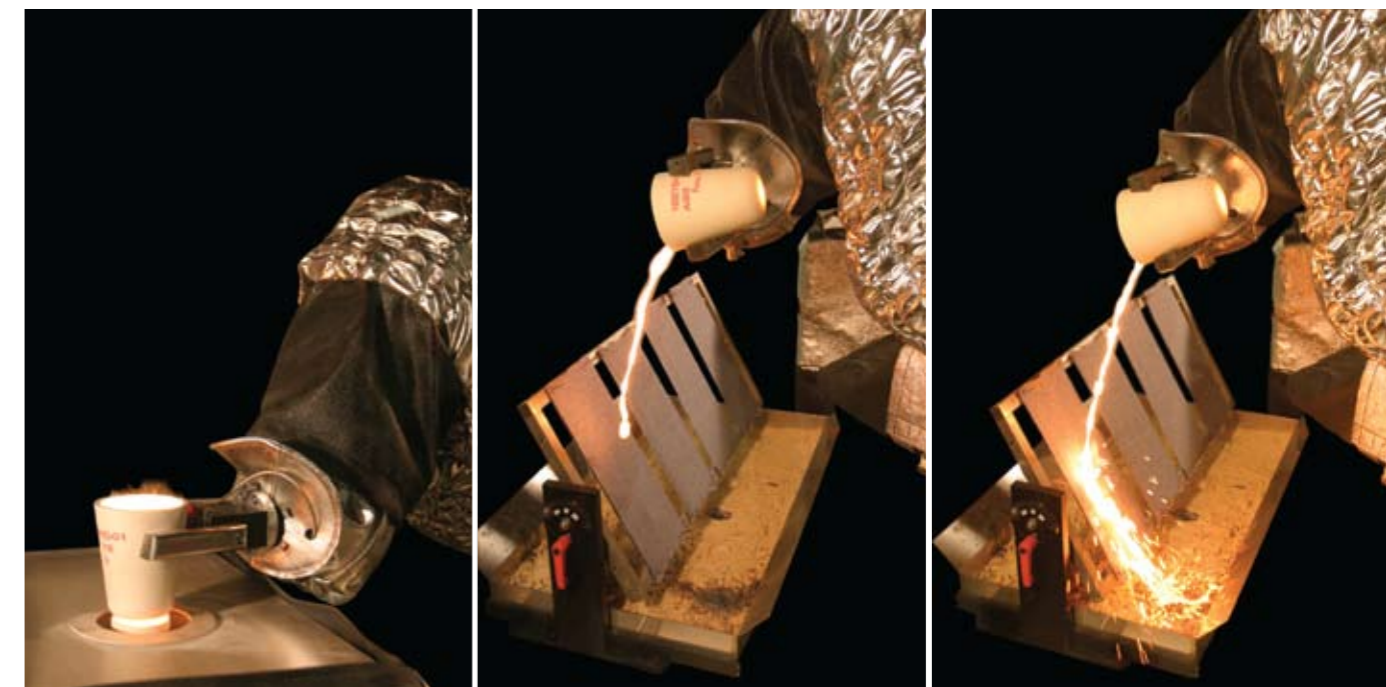
Test results

Nomex® MetalPro successfully meets the performance requirements of EN 531 and prEN ISO 11612 when tested for exposure to molten iron (letter E) on the DuPont™ Molten Metal Man test equipment.

Fabrics achieve ratings of E1, E2. Nomex® MetalPro does not protect against large aluminium splashes (letter D).

The recently developed Nomex® MetalPro Plus fabrics successfully meet the performance requirements of EN 531 and prEN ISO 11612 when tested for exposure to molten iron (E3) and aluminium splashes (D2) on the DuPont™ Molten Metal Man.

Nomex® MetalPro and Nomex® MetalPro Plus also offer extremely good results when exposed to flash fire on the Thermo-Man® as well as to arc on the Arc-Man®.



MORE PROTECTION



2.4 Nomex® Protects against Additional Hazards

2.4.1 Nomex® protects against chemical splash hazard

For this hazard, a PPE is typically subject to norm EN 13034.

Chemical hazards can occur in conjunction with thermal hazards, such as accidental splashes of chemical products on to protective clothing, or through leakages of chemical products.

Nomex® fabrics successfully pass “**Elbow lean tests**,” in which the fabric is exposed to a concentrated acid during 15 minutes, whereas cotton or cotton blends which received flame retardant chemical treatment came out destroyed. The test also showed that Nomex® fibres are **inherently resistant to many chemicals**, on top of their flame resistant properties.

Nomex® fabrics can offer additional protection against chemical hazards (fulfilling EN 13034, type 6 accidental splashes) if the fabric is treated with an appropriate **fluorocarbon finish**. However, this fluorocarbon finish may need to be regularly reapplied to maintain performance, and can reduce the breathability or the comfort of a fabric or garment.

2.4.2 Nomex® protects against static electric discharge hazards

A PPE protecting against this hazard is subject to norm EN 1149-5.

Electrostatic discharge (ESD) can lead to generation of sparks with energy levels sufficient to ignite possible surrounding vapours, aerosols of flammable liquids or dust particles, and **cause ignition** and explosion.

DuPont developed a Nomex® fibre blend using an antistatic fibre **P-140**. This is a permanent antistatic carbon core polyamide fibre which helps fabrics made with Nomex® to quickly dissipate static electricity that could have built up on the fabric through rubbing on another non-conductive surface.

P-140 is included in the Nomex® solutions:

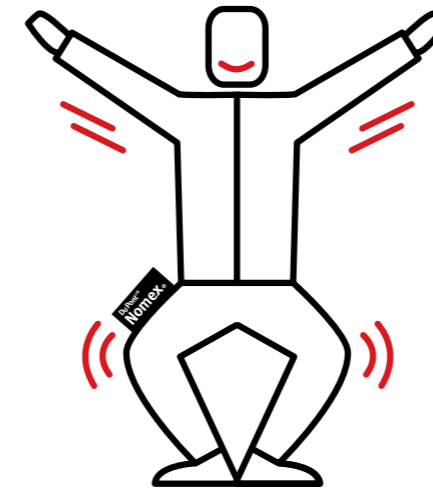
Nomex® Comfort and Nomex® IIIA

Nomex® MetalPro, Nomex® MetalPro Plus

Nomex® Tough

Garments made of these materials are tested in accordance to EN 1149-3 and fulfill the electrostatic protection requirements of EN 1149-5 for protective clothing.

3. Wearer's Comfort



3.1 Selecting protective clothing based on garment weight, antistatic properties and moisture management.

There are factors other than safety that determine the effectiveness and wearability of protective apparel, namely comfort and appearance.

DuPont offers design assistance aimed at **translating ergonomic needs into wearer benefits**, so that protective work wear can be as **attractive** and **comfortable** as street wear whilst still meeting stringent protection standards.

Comfort is not a luxury, but allows for **more efficient working** and safer decision making.

There are **three basic characteristics** which have an impact on a wearer's comfort, and which can be measured objectively:

Garment weight

Typical protective fabrics made of Nomex® fibres are between 150-265 g/m² or up to 40% lighter than cotton and cotton blended fabrics which were treated with flame retardant chemicals. Nomex® solutions provide better protection against heat and flame at a lower basis weight.

Antistatic properties

The antistatic properties of a garment or fabric help protect the wearer from the electrostatic discharge hazard but as an additional effect, they also help preventing nuisance static which makes the worker feel more comfortable.

Moisture management

A criterion of moisture management is the evaporation of moisture or perspiration from the skin through the fabric structure. The Sweating Guarded Hotplate test method (ISO 11092) measures the resistance of a material to let water vapour through which is expressed as Ret (water vapour resistance in m².Pa/W).

A fabric's moisture management performance is also influenced by its air permeability, the capacity to let air pass through (tested according to ISO 9237). Air permeability (expressed in litre/m²/sec) is an important measure of comfort, because it is a measurement of the air moving through a fabric and around the skin, leaving a dry feeling on the wearer skin.



Test results

Typical Nomex® single layer fabrics can have **better moisture management properties** than cotton or cotton blended fabrics which were treated with flame retardant chemicals. The unique dog-bone fibre shape allows for good moisture transport along the fibre by capillarity.

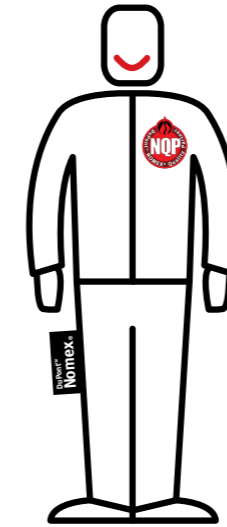
Typical Nomex® single layer fabrics **maintain their high air permeability**, even after 200 washes. Cotton based fabrics loose up to 35% of their air permeability after 50 washes, most likely due to fabric shrinkage, as fabrics get denser through washing.

Fabric construction, weave types or finishing treatments can positively or negatively impact the air permeability and the moisture management capacity of a fabric. This is why DuPont works with a network of Nomex® Quality Partners for the proven quality they can offer.



WEARER'S COMFORT

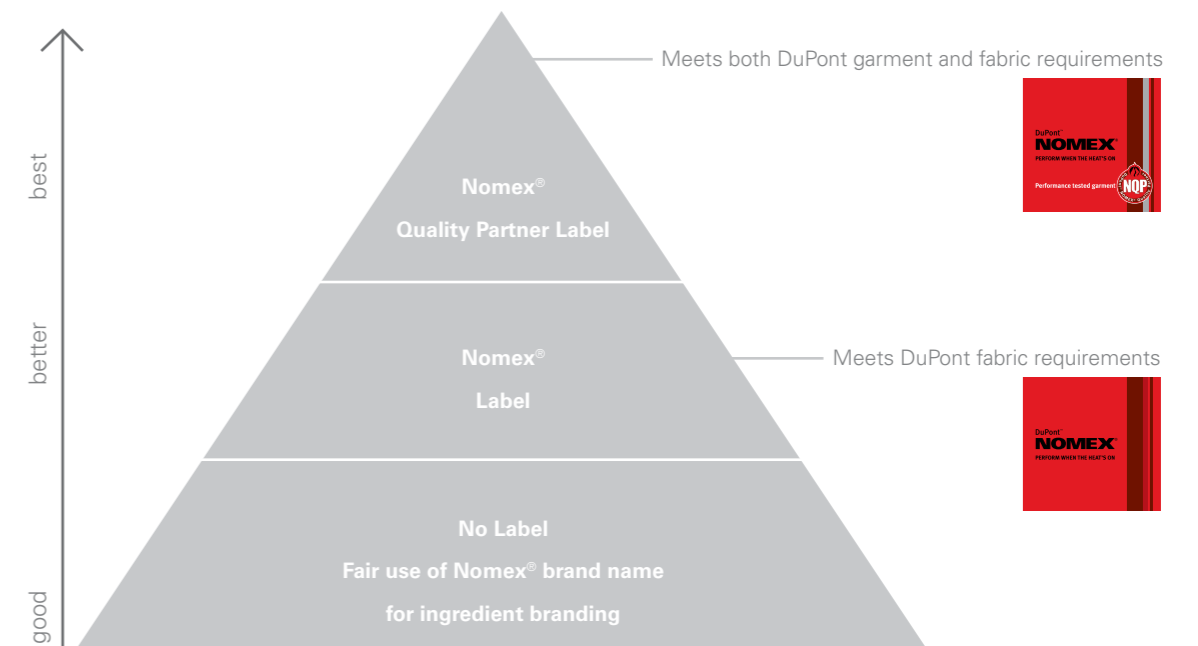
4. Quality Assurance



DuPont Personal Protection has carefully selected **value chain partners** who are committed to delivering **controlled quality products** to the wearers of PPE.

Such partners belong to the **Nomex® Quality Partners** network (known as NQP). The NQP value chain covers all levels from the fibre production at the DuPont manufacturing plant to the garment manufacturing, in order to deliver the most qualitative personal protective clothing that guarantee superior thermal protection. Our NQP partners, **identified with the NQP seal**, have long-standing relationships with key end users across Europe and have detailed knowledge of their needs. DuPont brings a global overview of technology and product development. Working together, we'll be able to anticipate and respond to market developments with greater speed and insight. In the end, the winners will be the men and women our products protect.

Nomex® NQP members will have privileged access to DuPont fibre and fabric innovation, technical expertise and **state-of-the art product testing facilities**, including unique Thermo-Man®, Arc-Man® and DuPont™ Molten Metal Man equipments that enable the quality and performance of finished garments to be precisely monitored. Garments that meet DuPont's NQP highest performance standards will be identified by an NQP seal on new Nomex® labels.



The Nomex® labelling programme distinguishes between two levels of labels



The quality promise of products made with Nomex® fibres and fabrics is visible to the end-user through the Nomex® labelling programme.

Garments belonging to the DuPont™ Nomex® Quality Programme can be recognized by the quality label inside the garment as well as the sew-in label and swing-tags outside the garment.

Requirements developed in the DuPont™ Nomex® labelling programme **go beyond the requirements of European thermal standards** and ensure that the Nomex® personal protective clothing you selected will retain its quality over the lifetime of the product.

4.1 Nomex® Quality Partner (NQP) Label



This label ensures that the manufacturer complies with DuPont's **most stringent requirements for both fabric and garment**, and assures the best possible safety performance of personal protective clothing.

The NQP label can only be used by NQP Partner Garment Manufacturers and incorporates DuPont's performance criteria specific to industry and end-user needs.

These criteria include mandatory testing on Thermo-Man® for all garments, a comfort test for multi-layer garments and testing on Arc-Man® for electric arc evaluation for selected end uses.

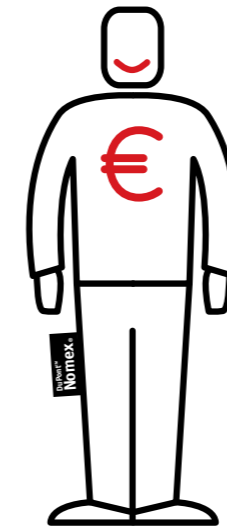
DuPont also requires that the garment is made with 100% Nomex® solution (including sewing thread).

4.2 Nomex® label



This label certifies that the fabric used in the protective garment has met DuPont's quality standards.

5. Cost Effectiveness



5.1 What influences the cost effectiveness of protective clothing?

Durability

A wash study (in accordance to the ISO 15797 test for industrial washing, drying and finishing of work wear) was conducted at an external laboratory, commissioned by DuPont.

The study assessed the durability of 3 Nomex® fabrics and 4 cotton and cotton blended fabrics which were treated with flame retardant chemicals.

The Nomex® fabrics **were washed 200 times**, the cotton and cotton blended fabrics 50 times which is the manufacturer's suggested lifecycle of some of those fabrics.

Throughout the wash study, all fabrics were subjected to **mechanical resistance and dimensional stability tests**, looking at the effects of intense washing on:

- **tear strength** (according to ISO 13937-2), which measures the resistance to the propagation of an existing tear (i.e. the possible widening of holes in a fabric)
- **tensile breaking strength** (according to EN ISO 13934-1), which tests the resistance of a fabric to ripping
- **abrasion resistance** (Martindale abrasion resistance test EN ISO 12947-2), measuring the resistance of a fabric to rubbing on its surface
- **dimensional stability test**, to assess the shrinkage of a fabric (ISO 3750)
- **aesthetics** over time

Test results

- Nomex® fabrics maintain their **exceptional strength** during entire wear life, even after 200 washes, whereas cotton and cotton blended fabrics significantly lose mechanical strength, after only 50 washes
- Nomex® fabrics also maintain their **dimensional stability**, even after 200 washes, yet FRT (flame retardant treated) cotton and cotton blended fabrics showed significant shrinkage, after only 50 washes
- Nomex® fabrics maintain their **excellent appearance**, the original colours are stable



Ease of care

Garments made of Nomex® fibres are suitable for home or industrial laundering and dry-cleaning, have a wrinkle free appearance and do not require ironing after washing. Garments made of Nomex® fibres allow for easy removal of soil and stains (stain release finishes can be applied to the fabric to help enhance this). Full washing and drying recommendations are printed on every Nomex® garment swing-tag.

Note: Nomex® MetalPro and Nomex® MetalPro Plus products are subject to special washing instructions also available on the Nomex® MetalPro and Nomex® MetalPro Plus swing-tags.

Lifecycle cost: purchase price and cost per wear

The purchase price of a garment made of Nomex® fibres is higher than that of a typical garment made of cotton or cotton blend, which was treated with flame retardant chemicals.

This purchase cost can be offset against the higher average number of washings that the garment will undergo during its lifetime, so that the cost per wear of a typical Nomex® garment is 45% cheaper than its cotton counterpart.

Garments made of Nomex® fibres maintain their aesthetics over time, even after 200 washes.

NOMEX® PROVIDES EXCELLENT BUILT-IN HEAT AND FLAME PROTECTION

Congratulations! You have selected a garment made of NOMEX®!

NOMEX® garments offer the following benefits:

- Permanent heat and flame protection.
- Durability and long wear life.
- Ease of wash and care.
- Resistance to most chemicals.

Wash & care recommendations:
NOMEX® garments can be cleaned by home or industrial laundry or dry cleaning. The following suggestions will help keep your garments looking their best and optimise their wear life.

- Read and carefully follow manufacturer's laundering instructions.
- Close/cover all Velcro™ and zippers.
- Empty all pockets.
- Launder NOMEX® garments separately from other garments.
- Do not overload laundry equipment.
- Use detergents for coloured textiles, preferably liquid without bleaching agents.
- Tumble dry garments at low temperature settings or hang dry away from any lightsource.
- Store NOMEX® garments away from any lightsource.

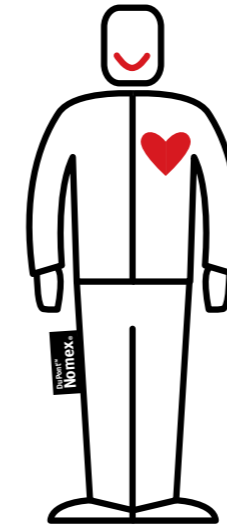
DuPont™
NOMEX®
PERFORM WHEN THE HEAT'S ON

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DuPont™
NOMEX®

COST EFFECTIVENESS

6. Peace of Mind



6.1 Nomex® is developed and produced by DuPont, a recognized leader in safety.

DuPont has a corporate commitment to safety with a proven track record of almost 100 years of industrial safety management, and holds a safety record better than the industrial average.

DuPont has worldwide safety expertise, and holds over 40 years of experience in the protective apparel market. It has excellent contacts and collaboration with industry experts and norm committees (ISO, CEN, ASTM, IEC), and harbours an extensive technical database.

Nomex® fibres are engineered to protect:

Nomex® solutions combine the excellent thermal and textile properties of the Nomex® meta-aramid fibre. They also have the high tenacity of the Kevlar® para-aramid, and P 140, the permanent antistatic carbon core polyamide fibre.

Inherent and durable heat resistance

Fabrics made from Nomex® fibres

- do not continue to burn when the flame is removed and do not melt
- do not break open when exposed to heat
- carbonize only at temperatures above approx. 427 °C
- do not generate toxic or irritating fumes when exposed to heat & flame
- are resistant to a wide range of chemicals
- are abrasion, tear and wear resistant for long wear-life
- are comfortable, thanks to their better moisture management along the fibre by capillarity

Nomex® personal protective clothing is used by key players in

- oil & gas, petrochemical, pharmaceutical and chemical industries
- utility companies
- foundries
- formula 1 racing
- emergency response, the police and military services

6.2 Other DuPont Safety Offerings

Kevlar® for cut and abrasion protection

Extraordinarily strong, light and cut-resistant, DuPont™ Kevlar® brand fibre is highly resistant to cuts, abrasion, and high temperatures. Protective gloves made of Kevlar® brand fibre help prevent injuries and lost-time hours. The light weight, flexibility and comfort of Kevlar® enable workers to maintain a high level of dexterity and effectiveness.

DuPont™ Kevlar® is a man-made fibre of the aromatic polyamide (aramid) family. The chemical structure of para-aramids distinguishes them from other commercial man-made and natural fibres and gives Kevlar® its unique properties. It has high strength, high modulus (stiffness), toughness and thermal stability. In addition, it is resistant to many of the chemicals and solvents encountered in today's industrial environment. This combination of properties makes it an exceptional fibre for use in tyre reinforcement, ballistics applications, ropes and cables, and in protective apparel where high strength, and thermal, puncture (if coated), and cut resistance are required.

Its value for use in gloves and sleeves has been demonstrated repeatedly in many industrial applications, including the automotive, steel, glass and metal, aerospace and electronics industries.

The offering include:

Kevlar® Armor Technology, Kevlar® Comfort Technology, Kevlar® Clean Technology

Kevlar® innovative solutions

www.dpp-europe.com

email: info.kevlar@che.dupont.com

Tel: +41 22 717 5111 or fax: +41 22 717 6131

Tyvek® for inherent chemical barrier protection

Tyvek® is a unique and versatile nonwoven material that is tough, yet extremely light and soft. Tyvek® was invented and is manufactured exclusively by DuPont. Tyvek® is permeable to air and water vapour, yet repels water-based liquids and aerosols. It acts as an excellent barrier against particles and fibres. It is low-linting and also antistatically treated.

Garments made of Tyvek® offer protection against a variety of liquid or solid chemicals, as well as dust and fibres and prevents human contamination of products and processes in clean-room environments, in pharmaceutical or food industries.

Garments made of Tyvek® are compatible for use in many cleanroom classes. By using Tyvek® garments, you can ensure the garment performance is consistently high.

Garments made of Tyvek® offer protection, durability and comfort, the ideal combination.

- Protection: Good particle resistance due to its structure of extremely fine, continuous fibres. It is resistant to low-level liquid aerosol and to low concentrations of water-based chemicals.
- Durability: Tyvek® is extremely tough, tear and abrasion resistant. Coveralls remain intact under controlled movement conditions as described in chemical protective clothing norms and therefore maintain protection levels throughout application.
- Comfort: Tyvek® is permeable to both air and water vapour. It is very soft, light and flexible and feels pleasant against the skin.

Tyvek® chemical protection solutions

www.dpp-europe.com

email: personal.protection@lux.dupont.com

Tel: +800 3666 6666 or fax: +352 3666 5071

Tychem® chemical protection solutions

The Tychem® product range delivers lightweight comprehensive protection starting at low toxic chemicals up to toxic gases and biological hazards.

Benefits for the wearer's safety and comfort of the Tychem® garment offering:

- Combination of chemical and biological protection
- Innovative design features for increased protection and enhanced comfort
- Lightweight garments helping workers to perform at their best
- For applications where decontamination is needed, the fabric is resistant to commonly used decontamination substances
- Contains no halogen compounds, so can be disposed of via standard means

Tychem® chemical protection solutions

www.dpp-europe.com

email: personal.protection@lux.dupont.com

Tel: +800 3666 6666 or fax: +352 3666 5071

Sontara® MicroPure for contamination cleanroom protection

Increasing productivity in cleanroom manufacturing is a challenge. Therefore, choosing an appropriate wipe is critical to product quality and not putting your image at risk. Sontara® MicroPure is a woodpulp/polyester nonwoven fabric. Made by DuPont hydroentangling technology, using jets of filtered, high-pressure water, Sontara® fabric is continually "washed" during manufacture. Ideally for cleanroom use since it doesn't contain binders or require chemical treatment. The high cleanliness and purity are ensured by low extractable level and ion content as well as extremely low particle generation by the material itself.

Sontara® MicroPure for contamination cleanroom protection

www.dpp-europe.com

email: personal.protection@lux.dupont.com

Tel: +800 3666 6666 or fax: +352 3666 5071

Contact Information

For more information on the DuPont™ Nomex® products, visit our website:

www.dpp-europe.com

The website features:

1. An overview of our European Nomex® Quality Partners

- spinner
- weavers
- knitters
- garment manufacturers

2. A list of events and demonstrations you can attend

- calendar of seminars organised by DuPont
- calendar of industry fairs and events with DuPont™ Nomex® presence

3. Opportunity to register online for regular DuPont Personal Protection e-Newsletters

DuPont™ Nomex®

www.dpp-europe.com

email: info.nomex@che.dupont.com

Tel: +41 22 717 5111 or fax: +41 22 717 6131

DuPont is a science-based products and services company. Founded in 1802, DuPont puts science to work by creating sustainable solutions essential to a better, safer, healthier life for people everywhere. Operating in more than 70 countries, DuPont offers a wide range of innovative products and services for markets including agriculture and food; building and construction; communications; and transportation. DuPont is the inventor and the world's largest producer of high-performance protective materials and solutions with leading world brands such as Nomex®, Kevlar®, Teflon®, Tychem® and Tyvek®, providing personal protection, be it thermal, mechanical or chemical. DuPont developed leading edge flash-fire and high-temperature testing technologies, including Thermo-Man®, Molten Metal Man and Arc-Man®, contributing to the development of industry norms and standards.

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DuPont Personal Protection

DuPont International Operations Sàrl

Chemin du Pavillon 2, PO Box 50

1218 Le Grand-Saconnex

Switzerland

Tel: +41.22.717.5111

Fax: +41.22.717.6131

e-mail: info.nomex@che.dupont.com

www.dpp-europe.com

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Please turn the page for the full DuPont™ Nomex® Branded Solutions Overview

For more information on the DuPont™ Nomex® products, visit our website:

www.dpp-europe.com

For further information please contact:

DuPont Personal Protection

DuPont International Operations Sàrl

Chemin du Pavillon 2, PO Box 50

1218 Le Grand-Saconnex

Switzerland

Tel: +41 22 717 5111

Fax: +41 22 717 6131

e-mail: info.nomex@che.dupont.com



The miracles of science™