

Game Changing Technology for Next Generation Firefighter PPE

Manoj Jhaver
Aug 29, 2019

«DUPONT»
Kevlar | Nomex | Tyvek | Tychem



8th INTERNATIONAL EXHIBITION &
CONFERENCE ON TECHNICAL TEXTILES

TECHNOTEX-2019

Agenda topics:



- Introduction to DuPont Personal Protection
- Raising concerns and unmet needs in the fire service industry
- Impact in Fire Fighter protective equipment
- Q&A

DuPont Personal Protection: Protecting people around the globe with trusted brands



Thermal Apparel

More than 1 million workers trust and wear Nomex® annually



Mechanical Protection

1+ billion pairs of gloves and sleeves containing Kevlar® are protecting hands across the globe.



Emergency Response

From fighting fires, to hazardous material cleanup, DuPont PPE solutions are protecting ER workers.



Chemical Protection

From fighting fires, to hazardous material cleanup, DuPont PPE solutions are protecting ER workers.



Controlled Environments

Cleanroom personnel count on Tyvek® IsoClean® garments to protect sensitive processes from contamination.

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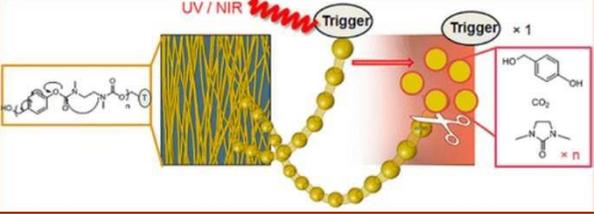
Nomex® & Kevlar® Two strong brands for the fire fighter



More than 75% of fire fighters worldwide trust Nomex® and Kevlar® in at least one of their protective equipment



Rising Concerns and Unmet Needs in Fire Service

<p>Balance Protection vs. Comfort</p>			<p>TEXILE PROTECTION AND COMFORT CENTER</p> <p>TPP/THL Control Suit Distribution</p> 
<p>Contamination / Cancer</p>	<p>EXTINGUISHING CANCER</p> <p>A FIREFIGHTER CHARITY DATE AUCTION TO BENEFIT THE AMERICAN CANCER SOCIETY</p> <p>THURSDAY, MAY 21ST</p> <p>FITZSIMONS KEYS</p> <p>7:00PM - 11:00PM EST</p> 	<p>Contamination + Surface Moisture + Heat =</p>  <p>Contamination Burn ?</p>	
<p>Durability / maintenance of the gear</p>		<p>UV / NIR Trigger</p> 	
<p>Smart fire fighter gears</p>		<p>smart@fire</p> <p>SMART PERSONAL PROTECTIVE SYSTEMS BY 2015</p> <ul style="list-style-type: none"> Intervention coordination Remote monitoring Communication & data relay Intuitive visualization Data logging Audio/visual alarms Body temperature Environmental temperature Toxic gasses Active illumination 	

Thermal Classification of Firefighting Situations

Table 1. Firefighters' Thermal Environments.

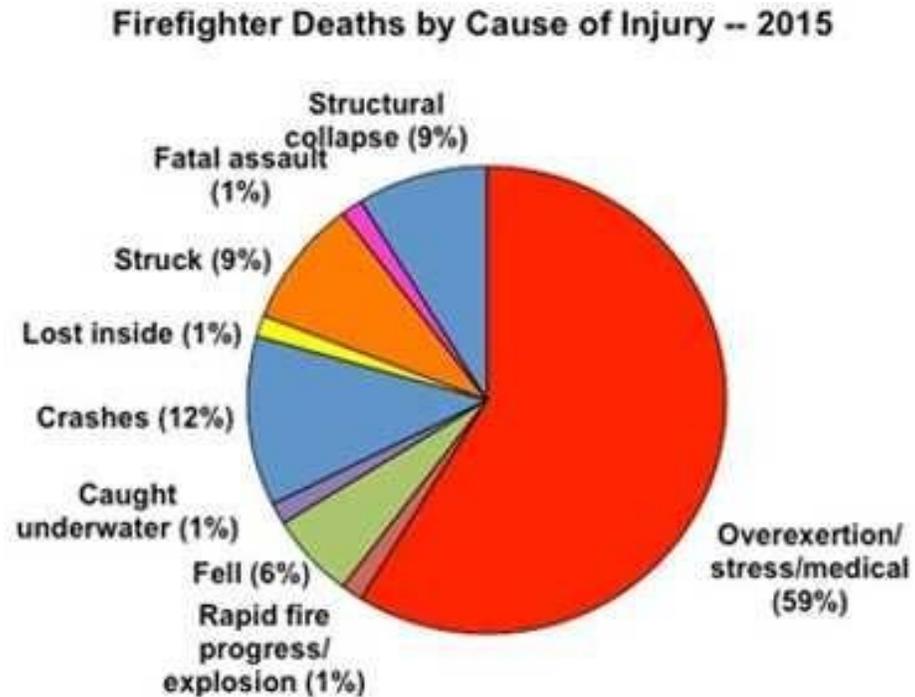
Exposure	Air Temperature (°F/ °C)	Radiant Flux (cal/cm ² ·sec)	Tolerance Time
Foster & Roberts [50]			
Routine	100°C	0.02	25 minutes
Hazardous	120°C	0.07	10 minutes
	160°C	0.10	1 minute
Emergency	160 - 235°C	0.23	< 1 minute
Abbott [2]			
Routine	20 - 70°C	< 0.04	10 - 20 minutes
Hazardous	70 - 300°C	0.04 - 0.30	1 - 5 minutes
Emergency	300 - 1200°C	0.30 - 5.0	15 - 20 seconds
Coletta [33]			
Routine	140°F (60°C)	0.03	5 - 60 minutes
Hazardous	572°F (300°C)	0.20	5 - 20 minutes
Emergency	1832°F (1000°C)	2.50	5 - 20 seconds



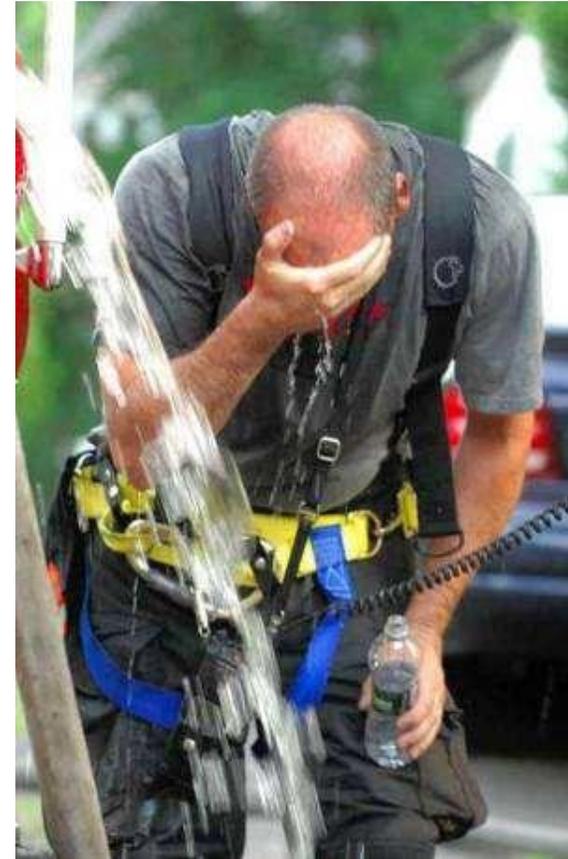
The protective gear has to work on all three situations:

- Routine, hazardous and emergency
- Consider long term wearing; >99% of situations.
- Gear should allow enough time to safely escape from an emergency situation; not to stay there or to return there!

Heat Stress: A Major Threat to Firefighters



NFPA Fire Analysis & Research, Quincy, MA



Fire fighting is a very high intensity effort
Heat stress is a major risk to fire fighters!

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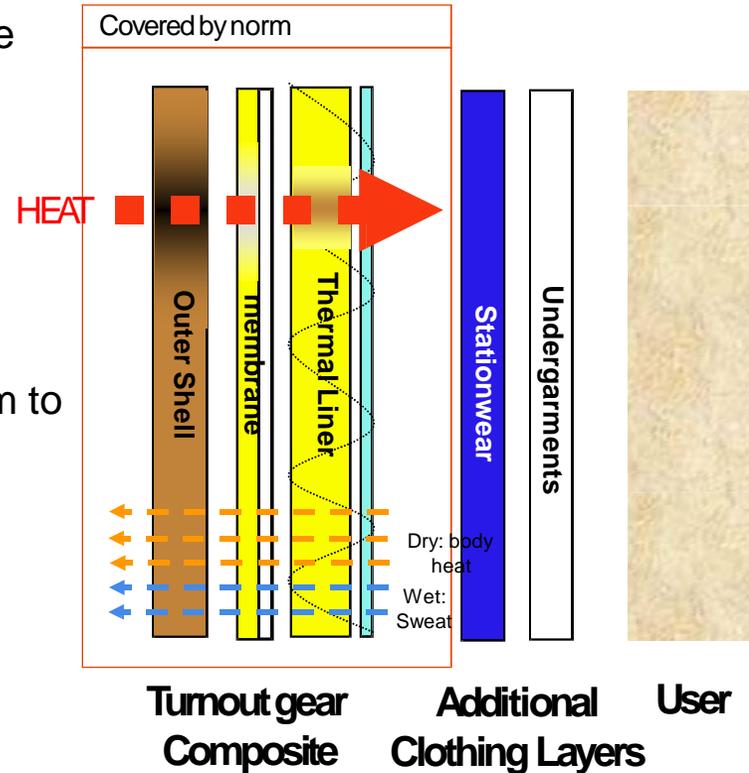
Thermal Protection vs. Heat Stress

Standard test methods measure the thermal protection of the layered turnout gear

(**TPP, HTI & RHTI**)

Likewise some standard tests aim to quantify the comfort

(**RET or THL**)



Typical materials that prevent heat penetration also prevent heat release in garments.

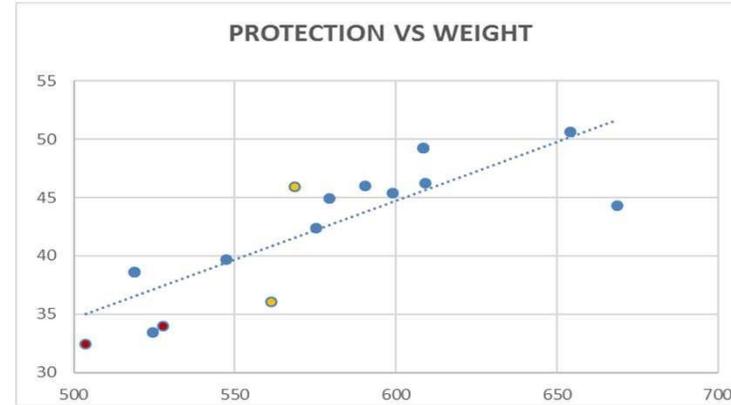
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Thermal Protection vs. Heat Stress

Modern multi-layer systems offer choices tailored to specific needs:

- Typical fire environment: Rural / Industrial
- Fire fighting tactics
- Climate
- -> **Define the level you need!**

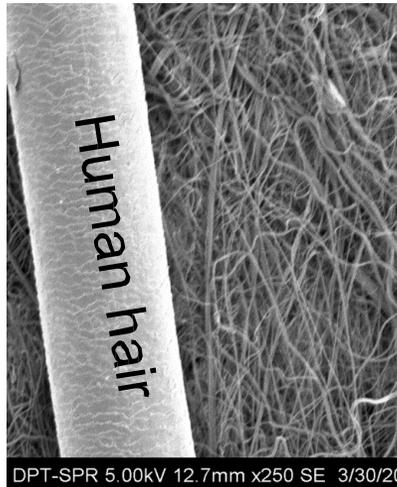


DuPont Nomex® branded outer shells examples developed together with Nomex® partners:

- **Nomex® NXT:** lightweight, robust, durable, excellent esthetics
- **Nomex® 3DP:** “airbag” - like: highest thermal protection and breathability
- **Nomex® 360:** lightest & most robust outer shell

DuPont Nomex® Nano and DuPont Nomex® NanoFlex

Nonwoven Filaments using HMT technology
Submicron Continuous filaments
Inherently Flame Resistant



- At least 1/100 smaller than human hair
- Between submicron and nano scale
- Stand-alone in sheet or in roll
- Elastic and non-elastic form
 - **Nomex® Nano – non-elastic**
 - **Nomex® Nano Flex - elastic**

Nomex® Nano and Nomex® Nano Flex
is a thin, light, breathable, highly flame resistant material

Nomex® Nano: Features and Benefits

More Comfort:

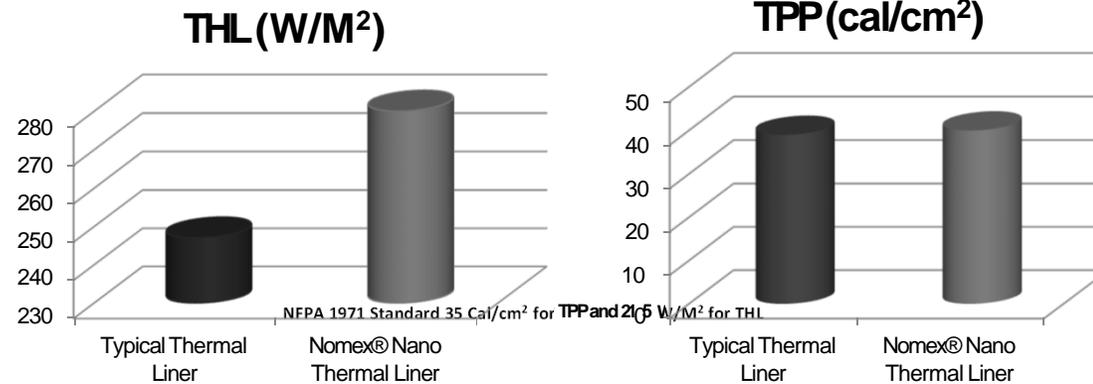
- **Lighter than other FR materials**
- **Thinner per weight = less bulky garment and better ergonomics, better breathability, quick wicking**
- **Air permeable = better comfort**
- **Small pores = faster wicking and great filtration media**

Higher Thermal Protection:

- **Higher LOI = higher fire resistance than Nomex® & Kevlar®**
- **Higher porosity = more air pockets to reduce heat flux**
- **More surface area per volume = slower convective heat flow**

Heat Stress Reduction for Turnout Gear

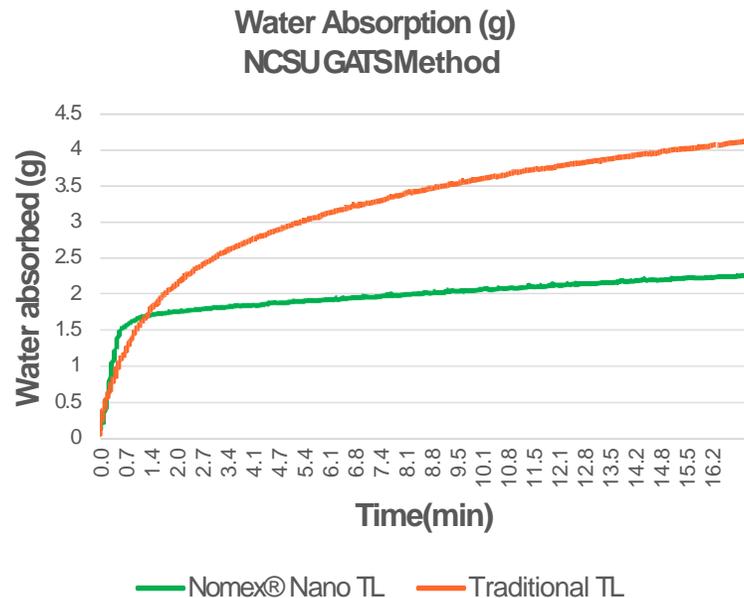
- Reduce thermal liner thickness by 40%
- Reduce TOG thickness by 20%
- Equivalent thermal protection
- Meets NFPA 1971 standard
- Durable up to 50X Laundry



Improved comfort
without compromising thermal protection

Nomex® Nano: Improved Moisture Management

	Absorption Time (min)	Water Absorbed (grams)	Absorption Rate (g/min)	%Evaporation
Traditional TL	1.4	3.2	0.72	23%
Nomex® Nano	0.5	1.3	2.14	43%



- High absorption rate to remove sweat quickly
- High evaporation rate to drive water out of thermal liner
- Low amount water absorbed to reduce steam burn and gear weight
- Validated and confirmed by numbers of wear trials in various locations

Rising Concerns and Unmet Needs in Fire Service

Contamination / Cancer

EXTINGUISHING CANCER
A FIREFIGHTER CHARITY DATE AUCTION
TO BENEFIT THE AMERICAN CANCER SOCIETY
THURSDAY, MAY 31ST
FELTZ SQUARE KEYS
7PM - 10PM EST

Contamination + Surface Moisture + Heat =

Contamination Burn?

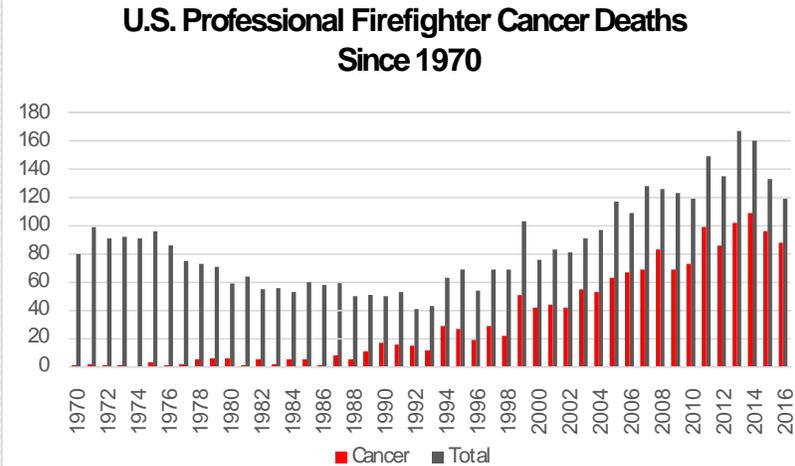
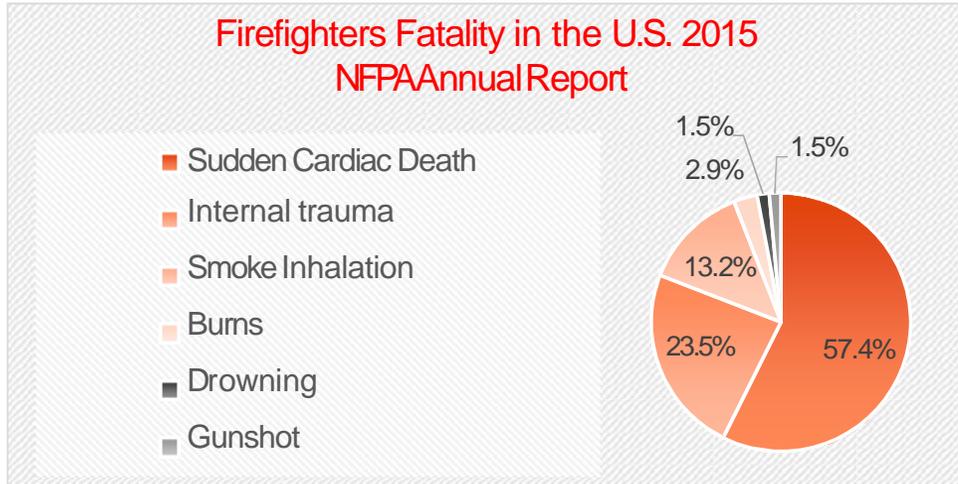
Fires in modern room have significantly changed

Fire in Modern vs Legacy Rooms



Modern Room reaches flash over in 3:40 vs 29:25 for Legacy

Statistics of Firefighter Fatalities in U.S.



- Almost 60% of U.S. firefighter on-duty deaths were due to **heat stress** in 2015, while less than 3% died due to thermal burns
- **Cancer deaths** account for over 50% of fatalities since 2000
- The rise in cancer deaths has grown at an astonishing rate compared with the general population



Several Initiatives underway :

Understanding:

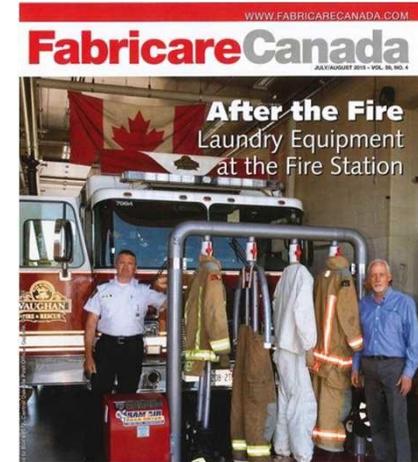
- Raise cancer awareness and prevention.
- Decontamination study on gears (EU and US)

Changes in procedures:

- Best Practices for handling contaminated gears
- NFFPA established an option for particle barrier hood
- More frequent washing and decontamination

New garment designs:

- Support washing & decontamination
- Additional barrier to prevent internal contamination



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Smoke is a Carrier for Toxic Substances



Smoke Particles

Aerosols

Gases



Carbon monoxide
Hydrogen Cyanide
Formaldehyde
Benzene
Nitrogen dioxide
Acid gases

Smoke

- Burned and unburned materials
- Small but large surface area
- Absorbs multiple chemicals
- Particle size less than 1 micron

Impacts on Health

- Lethal >100,000 in Asia
- Coronary heart disease
- Stroke
- Cancer
- Upper and lower respiratory diseases

<http://www.atl.semtechsolutions.com/category/coal-ash-analysis-gallery/coal-ash-analysis>

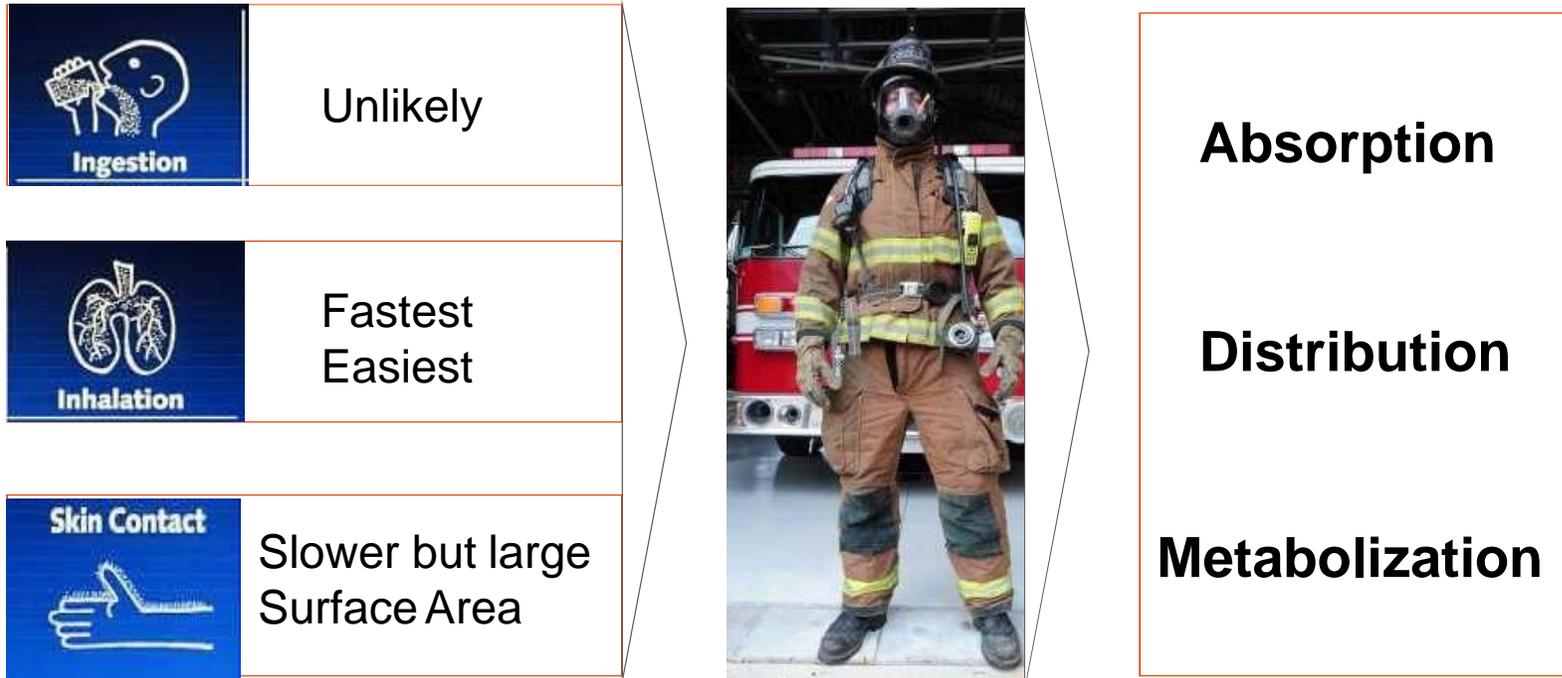
<http://www.ncbi.nlm.nih.gov/pubmed/20657302>

<https://www.seas.harvard.edu/news/2016/09/smoke-from-2015-indonesian-fires-may-have-caused-100000-premature-deaths>

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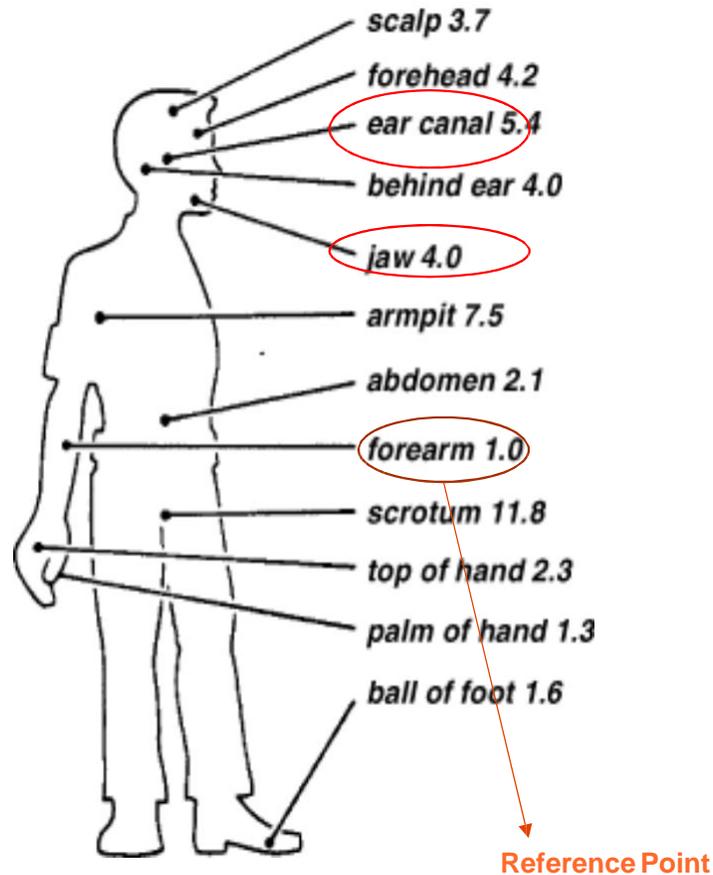
Exposure Tracks to Toxic Substances



- SCBA protects gas penetration, single most important PPE to prevent inhalation and ingestion
- Gear, glove, boot protect minimum skin particle penetration
- Is Existing Protection from PPE Enough?

Skin Absorption Rates vs Protection

Sponsored by: International Association of Fire Fighters Washington, D.C



FAST

(Fluorescent Aerosol Screen Test)

Before

After

Test Conditions

- 10 MPH
- 0.1-10 microns
- 30 minutes

- Scrotum, armpit, and head are the most absorptive areas
- Absorption rate increases as temperature increase
- High humidity of fireground and sweat dramatically increase skin absorption rate
- Absorption reaches to the highest level during structural firefighting

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<http://www2.ca.uky.edu/agcomm/pubs/pat/pat6/pat6.pdf>

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Improved Particle Blocking Efficiency

Nomex® Nano Flex Hoods

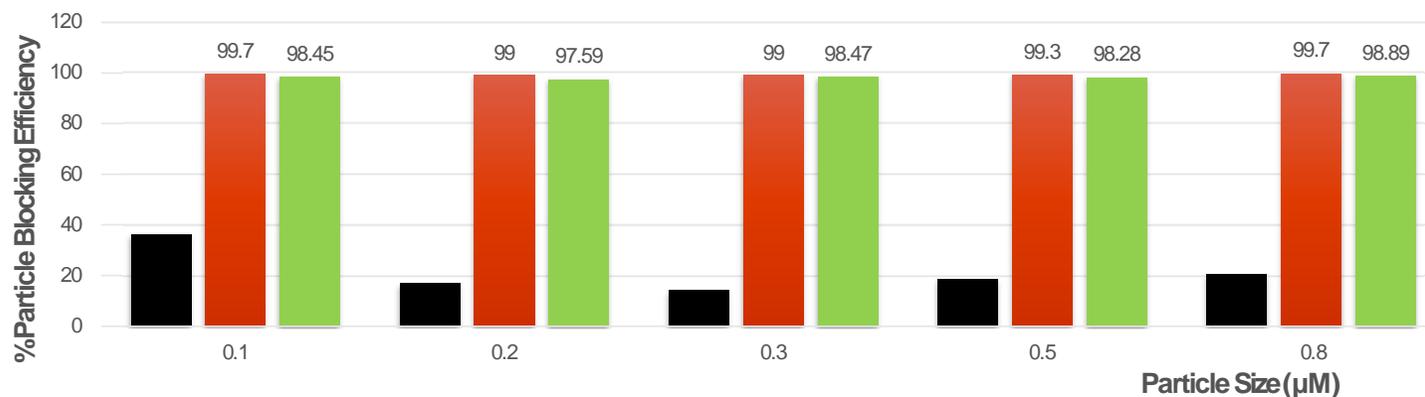
Knit 

Nomex® Nano Flex Barrier 

Knit 

- Improve TPP_{up} to 25%
- Add only 10gm or 6% weight
- Increase thickness only by 4%
- Improve blocking efficiency 4X
- > 150X Washes and Dryings

%Particle Blocking Efficiency
(NFPA 1971- 2018 Suggested Performance \geq 90% @ ASTM F2299)



■ Typical Hood w/o Nomex® Nano Flex
 ■ Nomex® Nano Flex + Knit
 ■ 150 Wash Nomex® Nano Flex + Knit

FAST Performance Visual Verification

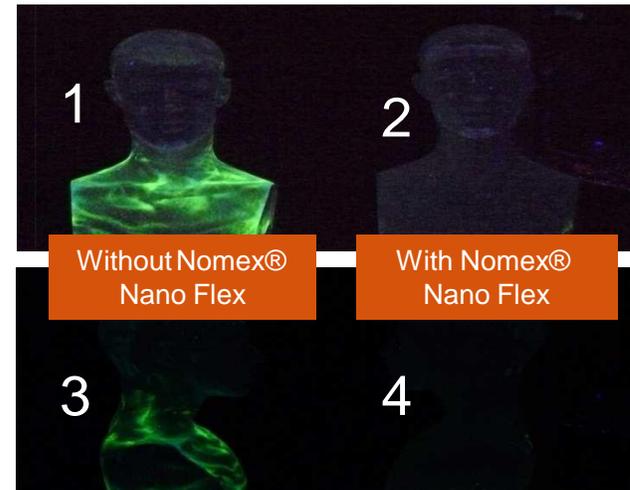
Sponsored by: International Association of Fire Fighters Washington, D.C



No Barrier With Barrier No Barrier With Barrier

Test Conditions

- 10 MPH
- 0.1 – 10 Micron
- 30 minutes



Dramatic reduction of particle penetration

Rising Concerns and Unmet Needs in Fire Service



What affects the wear and tear of garments?

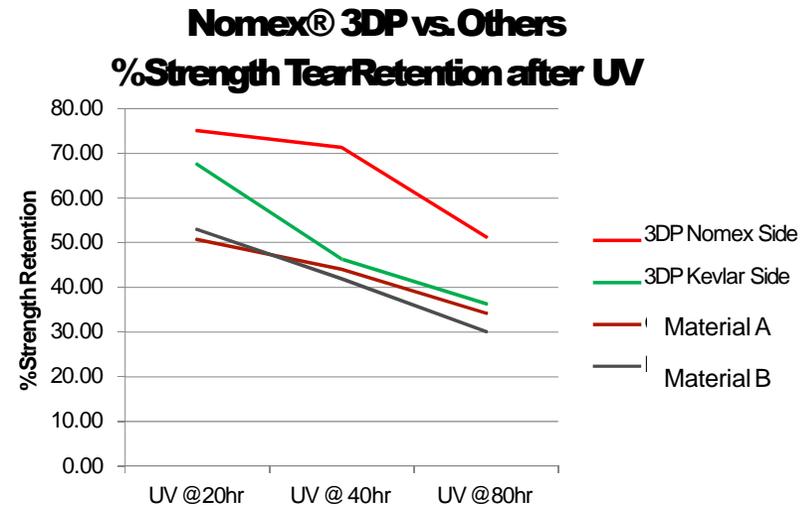
- Sharp edges (building structure, tools,...)
- Traction / Pulling (equipment, rescue,...)
- Abrasion (ramping, SCBAharness, ...)
- Washing and cleaning
- UV light (in use, when stored)



With increasing cleaning, wash durability will become more important

Smart fabric design can help to mitigate UV impact

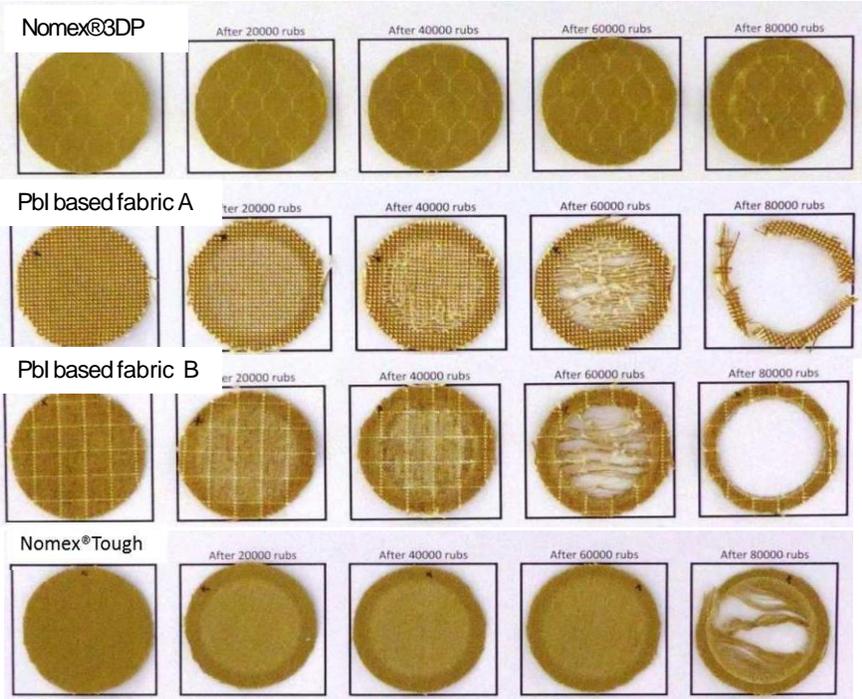
DuPont's New Development: Nomex® 3DP



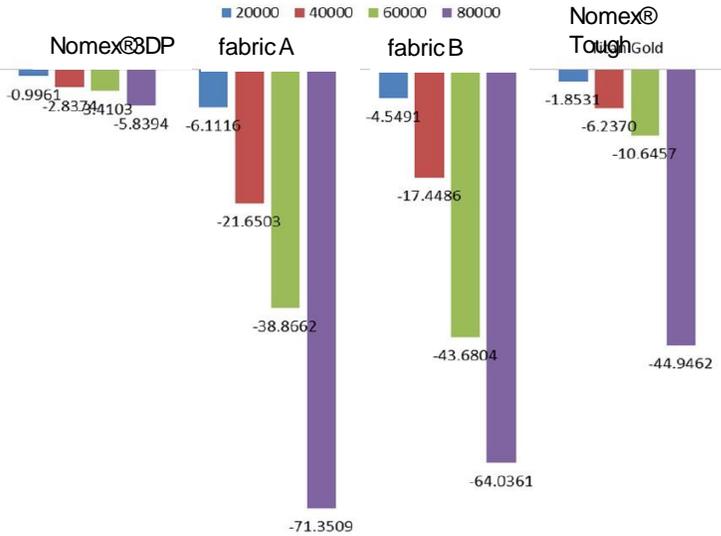
Nomex® loses much less strength vs. Kevlar®
and PBI Based fabrics
Use of smart fabric design can mitigate UV degradation

Abrasion resistance as indicator for durability

What affects the wear and tear of garments?



Weight loss after Martindale Abrasion test

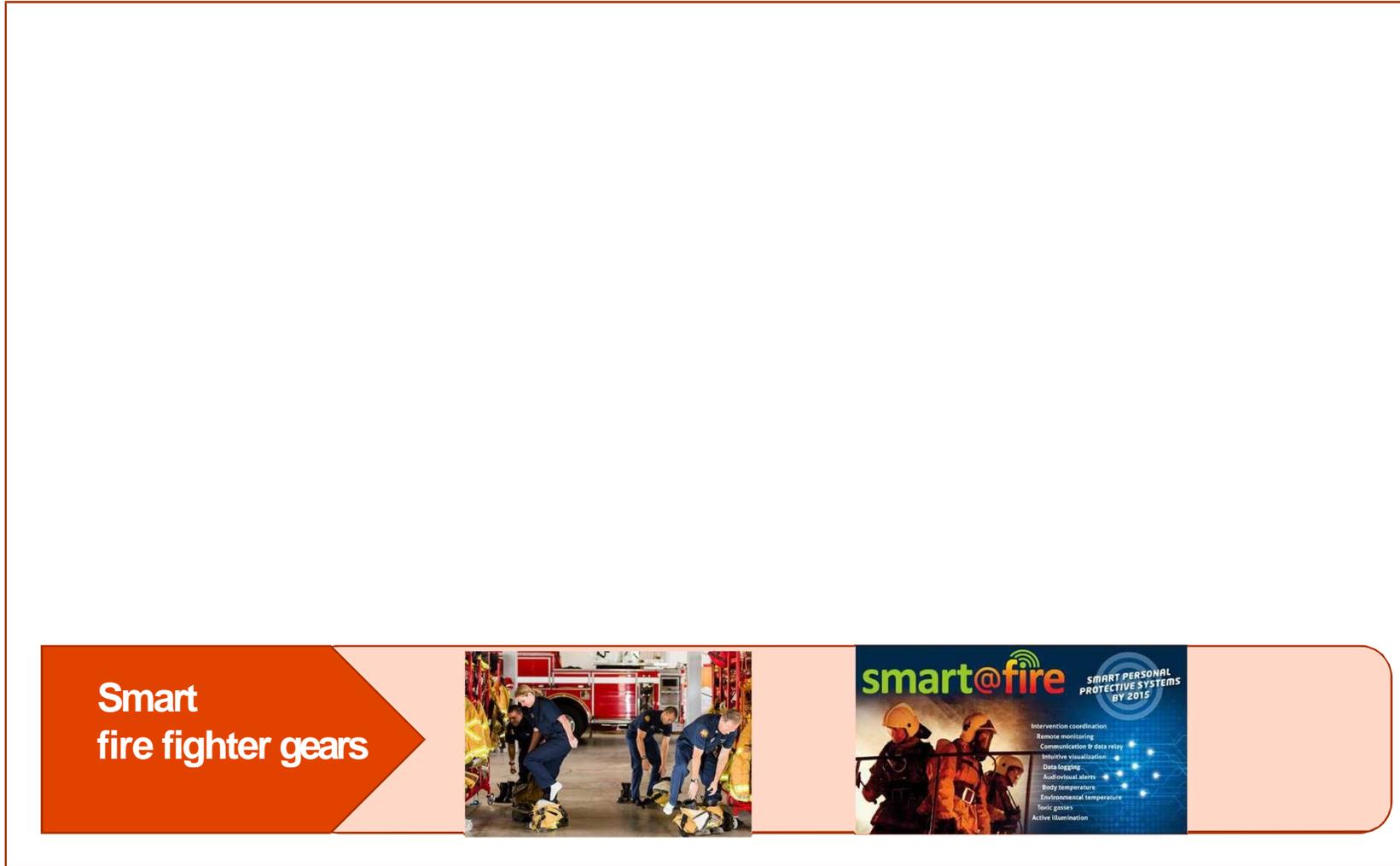


Nomex® fabrics have excellent abrasion resistance compared to other fabrics!

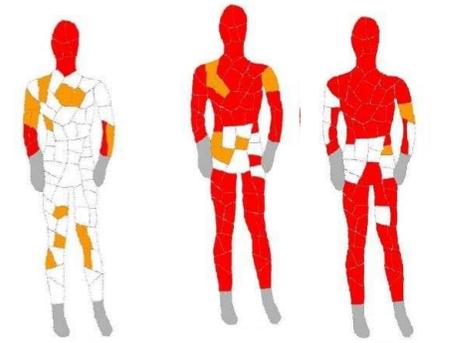
Examples of typical outer-shell in the market

Outershell category	Name	Thermal protection	Mechanical strength	Durability/ esthetics	Comfort
Premium	<ul style="list-style-type: none"> Nomex® 360 Armor AP Titan 1260 Twin PBO IB-TEX 	<p>*****</p> <p>-</p> <p>****</p>	<p>*****</p> <p>-</p> <p>****</p>	<p>*****</p> <p>-</p> <p>****</p>	<p>*****</p> <p>-</p> <p>****</p>
High performance	<ul style="list-style-type: none"> Nomex® 3DP Twin SQUARE Titan 1220 Twin ... 	<p>****</p> <p>-</p> <p>***</p>	<p>****</p> <p>-</p> <p>***</p>	<p>****</p> <p>-</p> <p>***</p>	<p>****</p> <p>-</p> <p>***</p>
Basic	<ul style="list-style-type: none"> Nomex® NXT Nomex® Tough Nomex® IIIa Nomex® Comfort Diamond 	<p>***</p> <p>-</p> <p>*</p>	<p>***</p> <p>-</p> <p>**</p>	<p>****</p> <p>-</p> <p>***</p>	<p>****</p> <p>-</p> <p>***</p>

Rising Concerns and Unmet Needs in Fire Service



Make use of all layers of Fire Fighter PPE



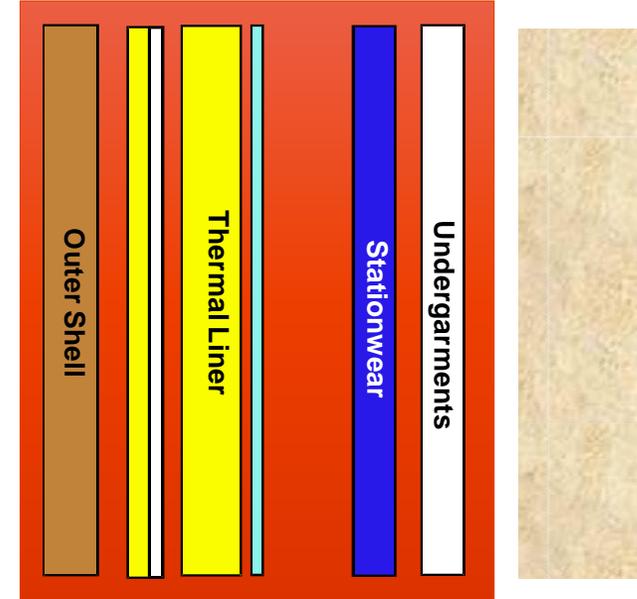
NOMEX® IIIA 40%
 Cotton 91%
 Poly/Cotton 84%*

* Sensors stopped transmitting due to fouling by molten material

Protection provided by different Station wear materials

The base layers of fire fighter clothing:

- Contribute to the protection andoverall weight
- Affect the heat transfer to and from the body
- Should be integrated in the overall PPE design whenever possible



Turnout Composite Additional Clothing Layers User



Make use of all layers of Fire Fighter PPE

Measuring Thermal Comfort of Entire Garment

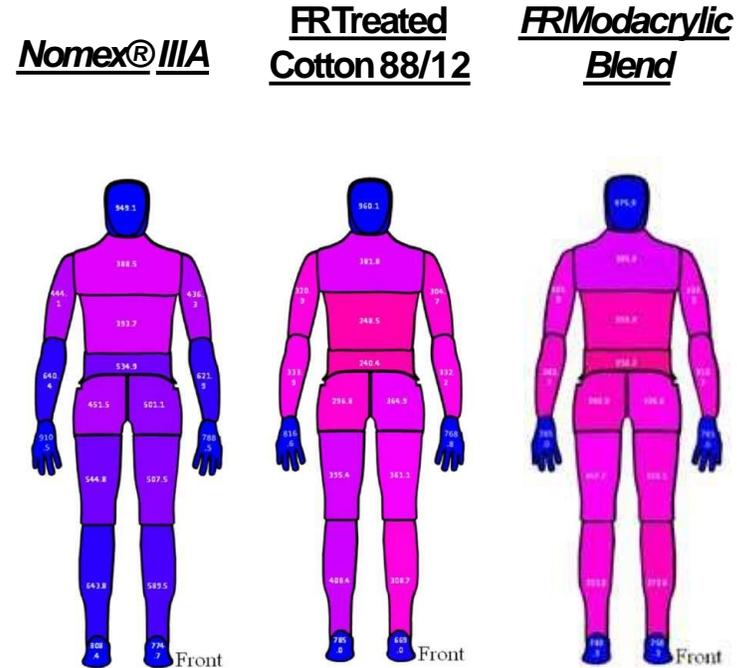
Conclusive sweating manikin testing results

Visual Indicator

- More Blue = Cooler
- Manikin has 34 temperature controlled sensors / segments

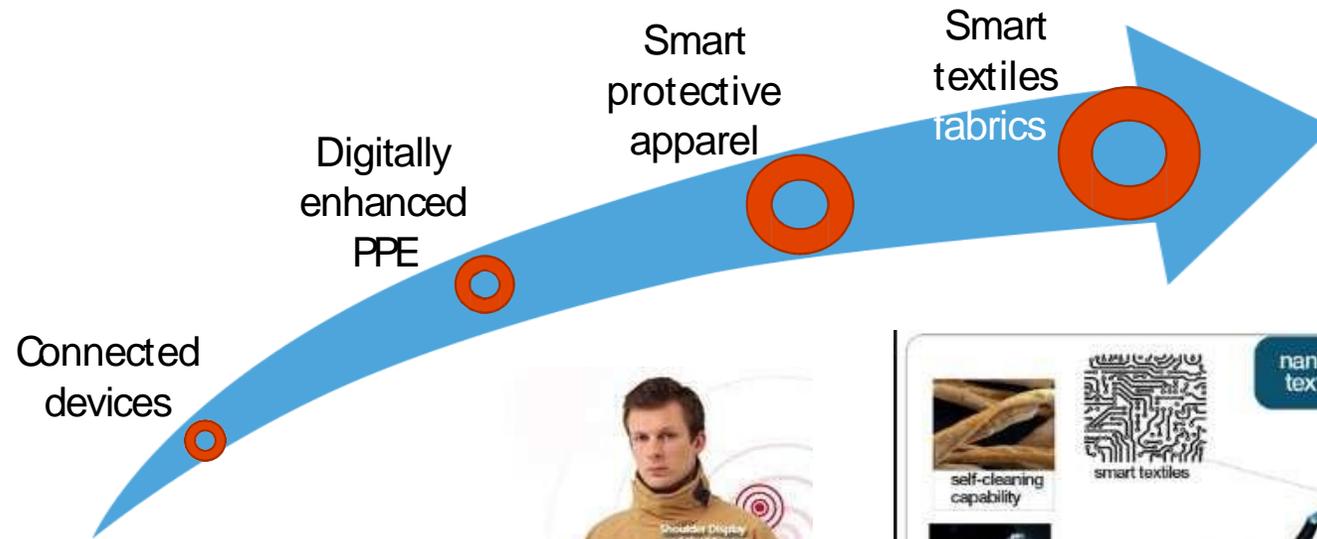
The Performance of Nomex® IIIA vs. other materials:

- 61% lower thermal resistance
- 53% lower evaporative resistance (RET)
- 24% more predicted heat loss (THL)



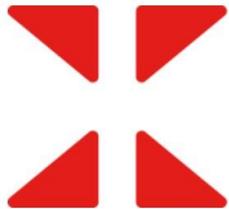
Nomex® based fabrics cool more effectively due to lower thermal and evaporative resistance

Emergence of the Smart Fire Fighter equipment

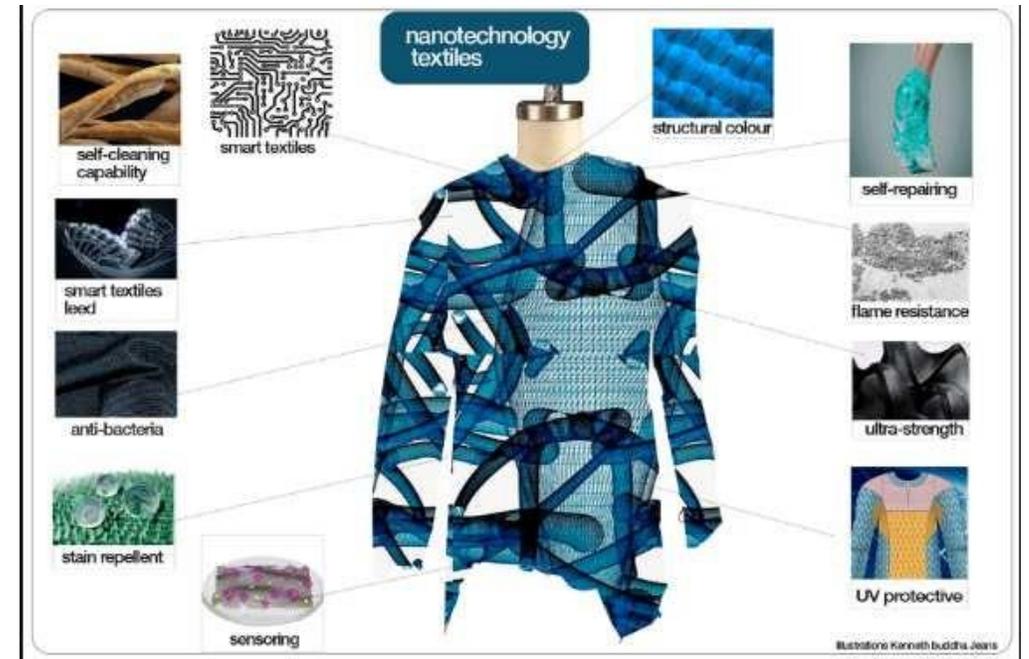


DuPont Unveils 'Smart' Athletic Clothing Technology

By Logan Bradley / August 3, 2017



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Questions





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