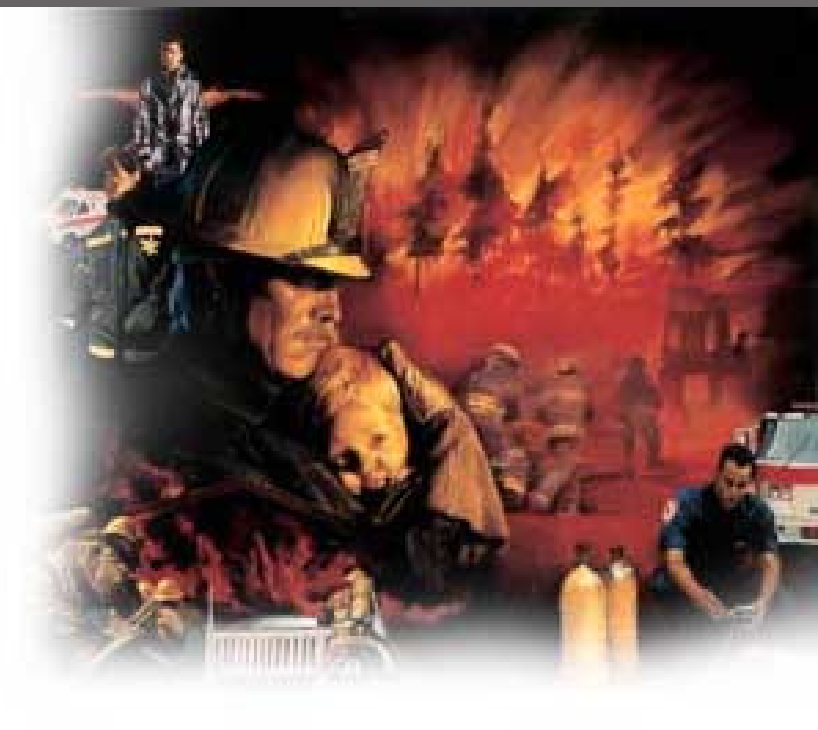
Protection for Fire Service

Flame Resistant Protective Apparel



Special Thanks to:

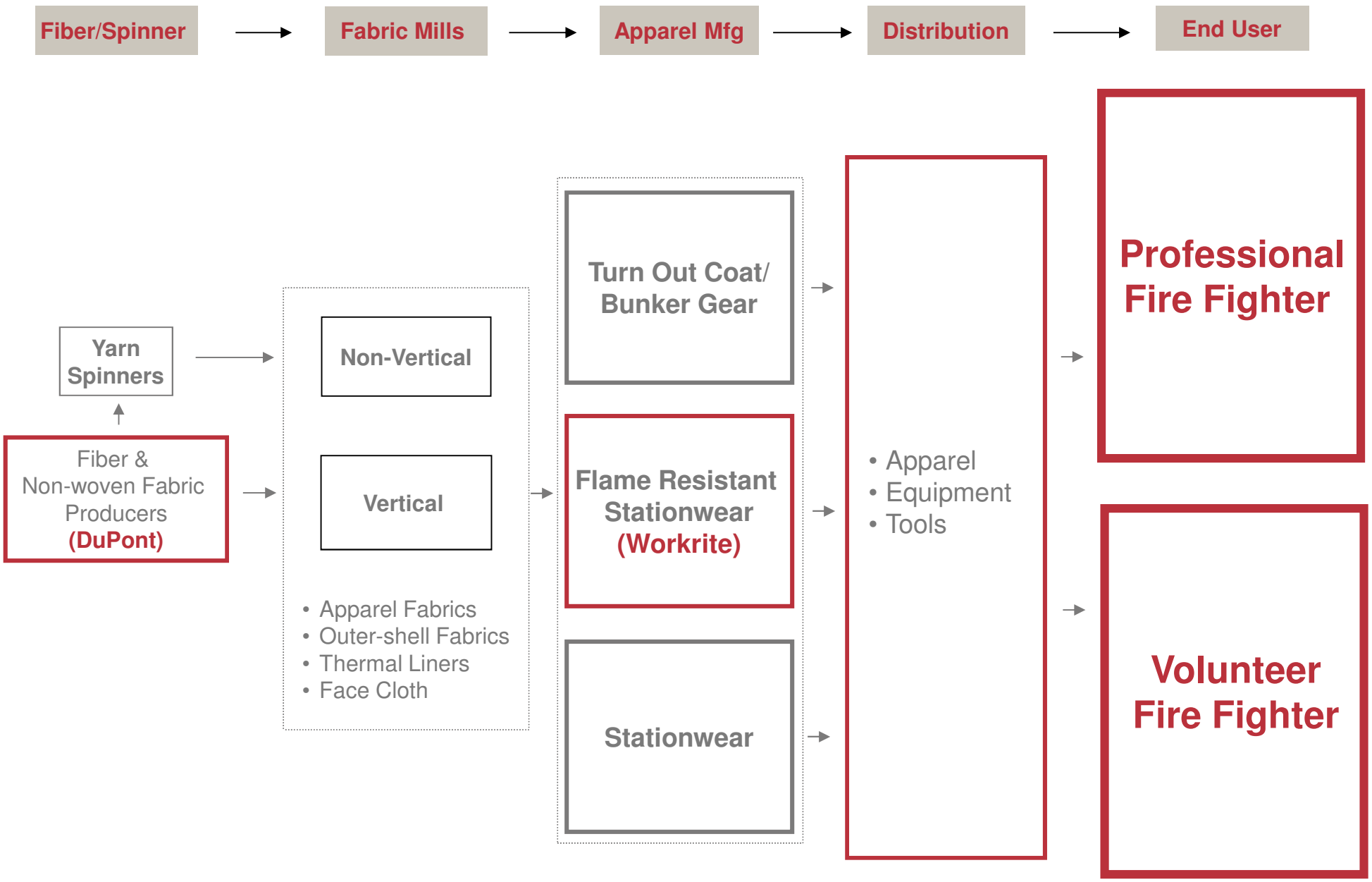
PPE · SCBA · RESCUE · OSHA
SOUTHERN AREA FIRE EQUIPMENT RESEARCH
S.A.F.E.R.
Est. 1976
APPARATUS · EMS · COMMUNICATION

FIRE
ORANGE COUNTY
CALIFORNIA
AUTHORITY

DUPONT®
The miracles of science™

Workrite® UNIFORM

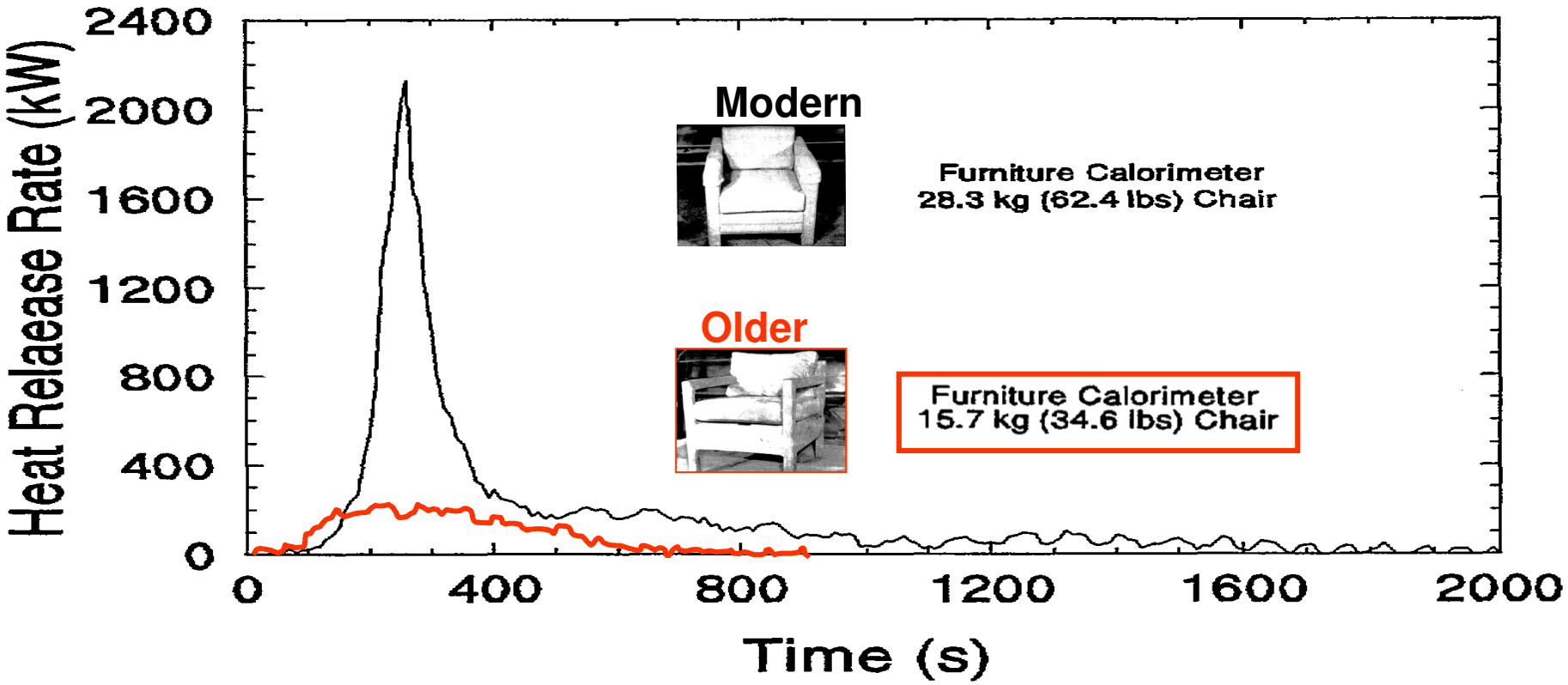
Fire Service - Supply Chain



DuPont™ Nomex® and Workrite

- **Heritage –** 40+ years of protecting against all types of fires, Workrite and DuPont!
- **Proven and predictable –** fire is NOT
- **Experience –**
  - Inherent flame resistance technology leadership
  - Thermo-Man™
  - Standards development / evolution
- **Credibility –**
  - Firefighters
  - Military personnel
  - Auto racing
  - NASA astronauts
- **Durability and cost effectiveness**
- **Comfort without compromising performance**
- **Professional appearance and easy care**
- **Innovation by strong collaboration with channel**
- **Commitment –** NA network of professionals throughout channel

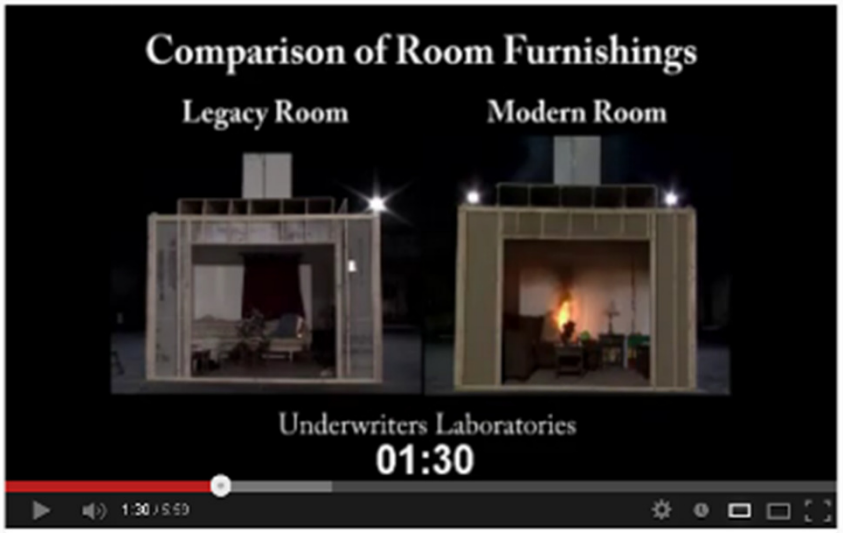
Changing Fire Environment

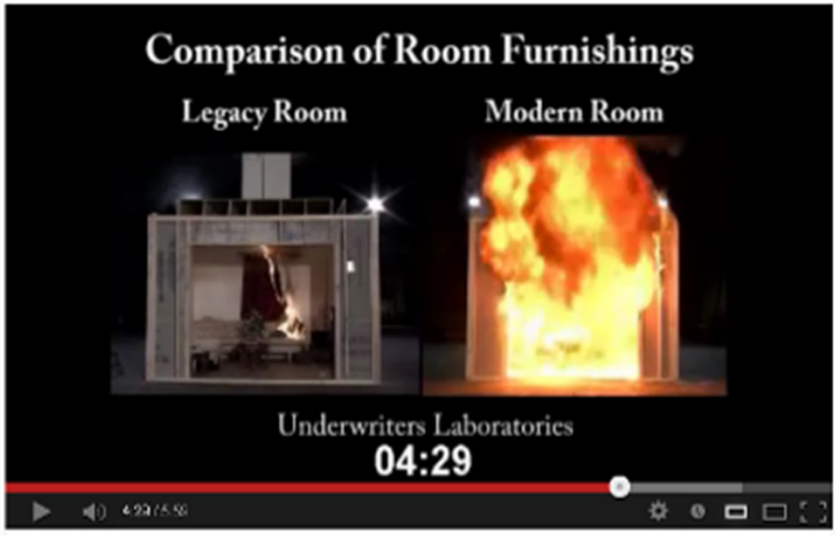


New materials of construction release much higher levels of energy during burning.

Firefighter's Protective Clothing and Thermal Environment of Structural Firefighting, Lawson-NIST

Fire Progression in Modern vs. Legacy Rooms





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

http://www.youtube.com/watch?v=aDNPhq5ggoE

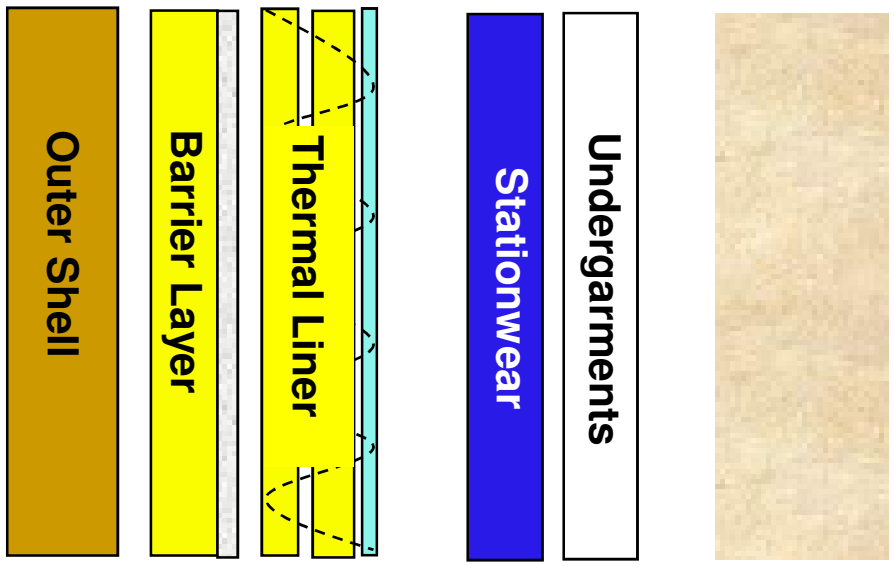
Firefighter PPE Evolution

1900 -1960	1970	1990	2010	2020
	980M FF 	1.02 MM FF 	1.10 MM FF 	?
Cotton, Leather, Rubber Coated	Nomex®	Blends, Breathability	Higher Strength, CBRN Option	
$25/Coat	$100/Coat	$800/Set	$1500/Set	

- Thermal Protection
- Water Resistance
- Bloodborne Pathogens
- Heat Stress Protection
- Compression Burns
- ChemBio Resistance
- Stored Energy
- Multi Threat

Fire Fighter Clothing System

- Composed of multiple layers and garments
- Designed to optimize performance against heat and flame while maximizing mobility and breathability.



Heat Transfer Fundamentals

Heat transfer follows the laws of physics:

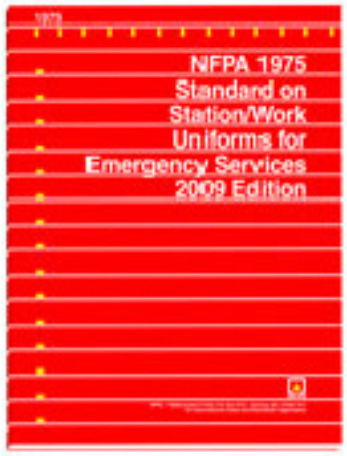
- Heat travels from Hot to Cold
- Heat Energy travels through the path of least resistance
- Systems will move to thermal equilibrium
- The rate of heat transfer is determined by the temperature differential between the two objects

Clothing insulation is a function of the number of layers, weight, and thickness of the composite

- Heavier materials adsorb more heat
- Trapped air within and between layers reduces thermal conductivity
- Impermeable layers reduce convective heat flow

Garment composite insulates by "storing" heat during thermal exposures

NFPA 1975: Station/Work Uniforms



Specifies minimum requirements for design, performance, testing, and certification of station/work uniforms that are non-primary protective garments, so that they will not cause or contribute to burn injury severity.

Material Options:

- Flame Resistant: NOMEX …
- Non Melting: 100% Cotton

Current Edition: 2009

- Clarifies the blocking/sticking performance

New Edition (Pending): 2013

- Antimicrobial
- Water-resistance
- Work vs. Station/Uniform

NFPA 1975 Options

Non Flame Resistant vs Flame Resistant Stationwear

- Non primary protective apparel.
- Needs to be properly worn in conjunction with primary protective garments.
- Compliant materials will not reduce thermal protection of the ensemble.
- Non Flame Resistant materials must be covered during thermal/flame events.

Why FR/Nomex® Stationwear?

- Back-up to primary turnout gear – chimney effect, arms/legs riding up, added insulation/protection.
- Moisture management – weight vs. cotton < heat stress, heat transport (water conducts heat 20x vs. air).
- Durability and appearance – laundering, lifecycle, cost/user (USFS example).

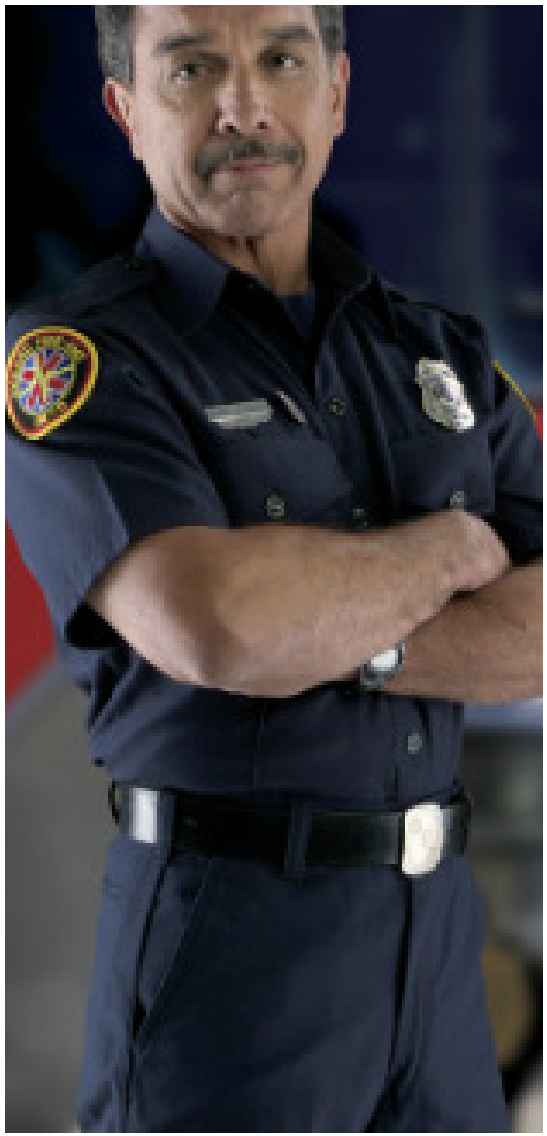
NFPA 1975 Options

Non Flame Resistant vs Flame Resistant Stationwear

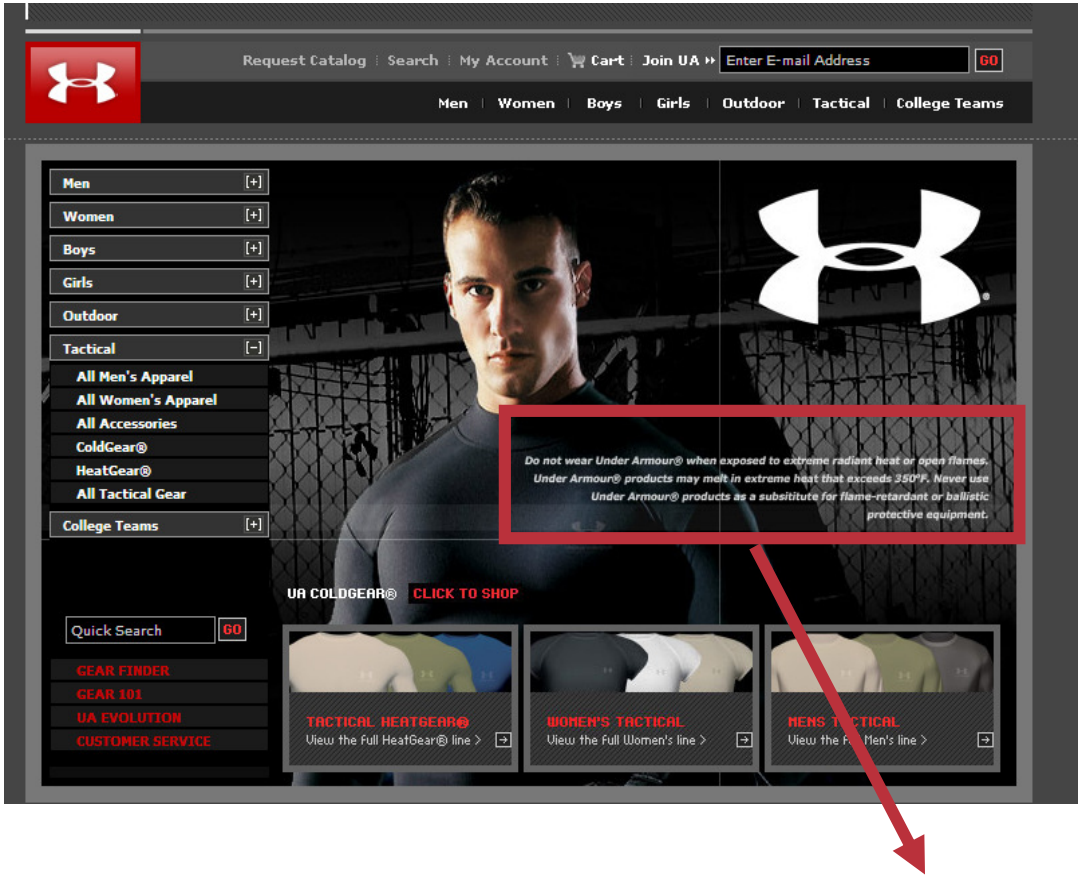
Materials that melt should not be worn under flame resistant garments.

- Materials like nylon, polyester, acrylic and blends can melt during thermal exposures.
- They form high temperature residues which cool slowly and can cause severe injury when they stick to the skin.

Manufacturers of high tech undergarments do not recommend the use of their materials under FR clothing as they can compromise it's performance.



Materials That Melt Can Compromise Performance



In Extreme Heat polyester under garments can melt, increasing severity of burn injuries.

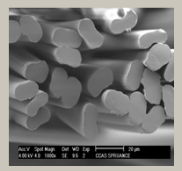
Do not wear Under Armour® when exposed to extreme radiant heat or open flames.

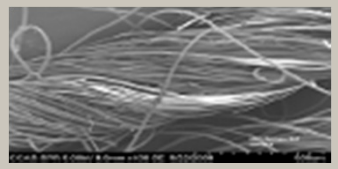
Under Armour® products may melt in extreme heat that exceeds 350°F.

Never use Under Armour® products as a substitute for flame retardant or ballistic protective equipment

Performance Attributes

Fiber/Yarn





Fabric/Finishing

Garment/Design

NOMEX® & KEVLAR®

Inherent Flame Resistance

Thermal Shrinkage **Moisture Regain**

Toughness **Producer Colored**

Thermal Insulation **FR Treatments**

Air Permeability **Dyed Color**

Pilling Resist **Moisture Management**

Thermal Protection **Durability**

Functionality **Fit**

Style

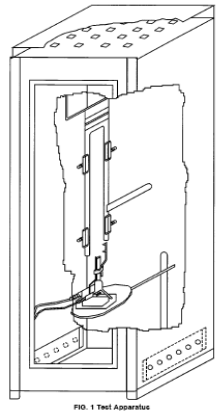
NFPA Thermal Screening Tests

Vertical Flammability material flame resistance

NFPA 1971 specifications:
No Melting or Dripping
≤ 2 sec After Flame,
≤ 4 inch Char Length

NFPA 1975 specifications:
No Melting or Dripping
≤ 2 sec After Flame,
≤ 6 inch Char Length

Impact of DEET on FR Fabrics



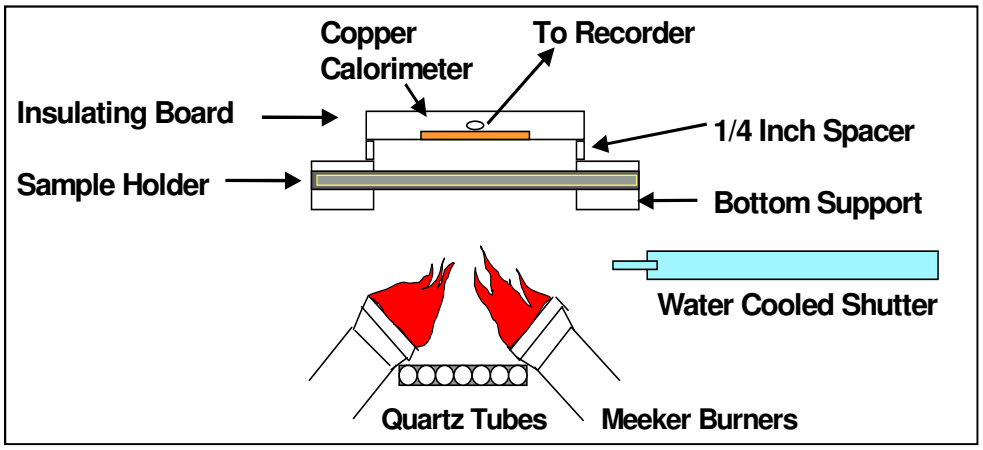
Thermal Stability (500º Oven) material stability

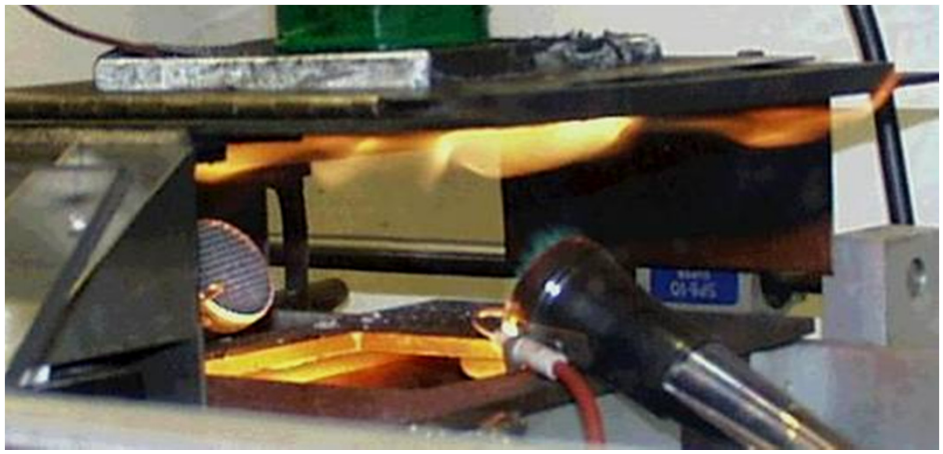
NFPA 1971 specifications:
no Melting, Dripping, Separation or Ignition, < 10% Shrinkage

NFPA 1975 specifications:
no Melting, Ignition or Sticking

Nomex® Polyethylene Polyester

Thermal Protective Performance

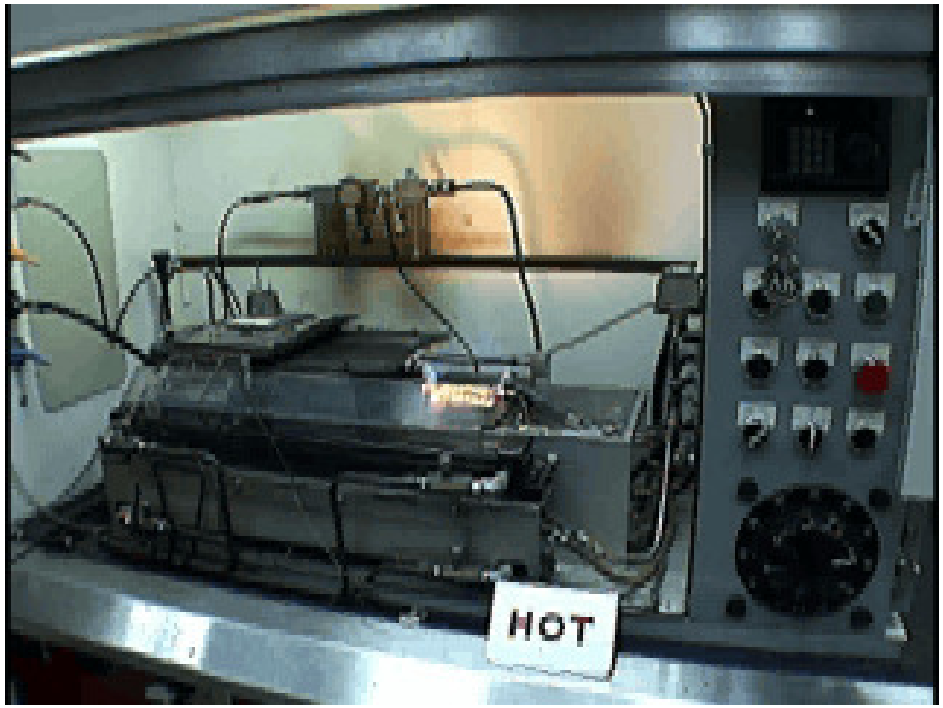




Flame Exposure Simulation

Measures time to 2nd Degree Burn Injury based on Stoll Curve

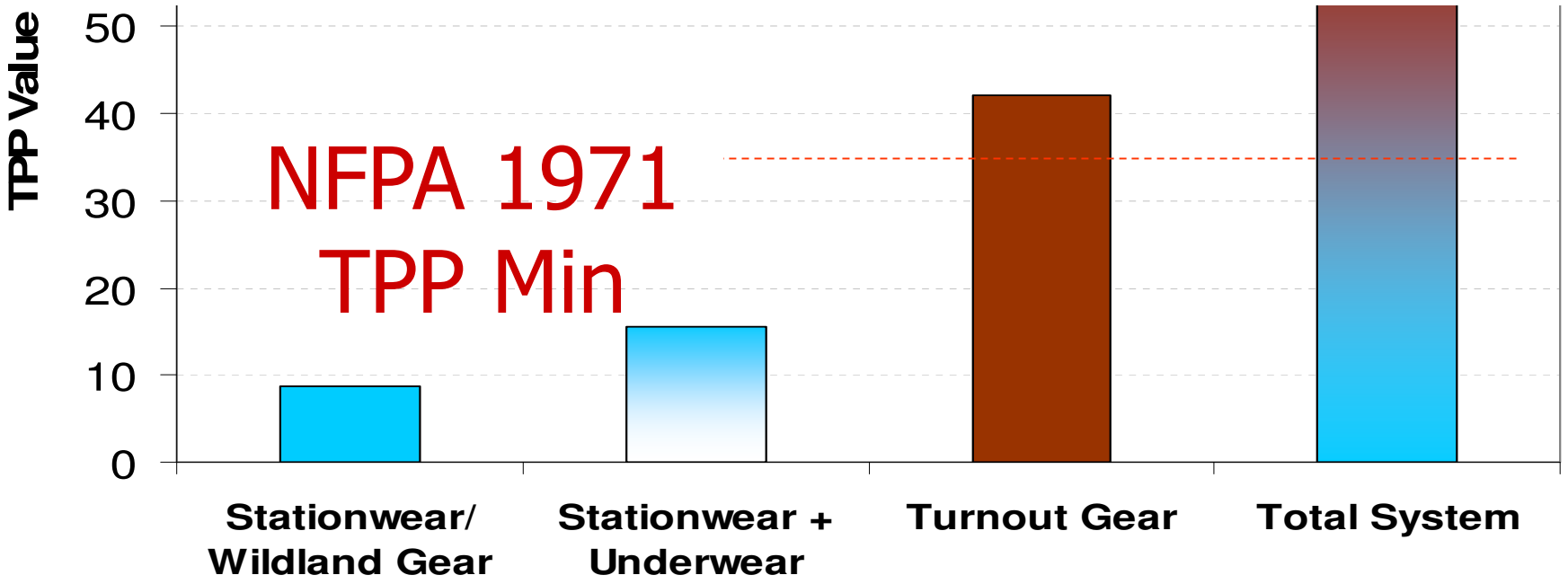
- **50:50 combination of Radiant and Convective Heat**
- **Repeatable 2.0 cal/cm^2 Heat Flux**



Bottom Line: Provides a Relative level of Insulation for materials and composites

Thermal Protective Performance

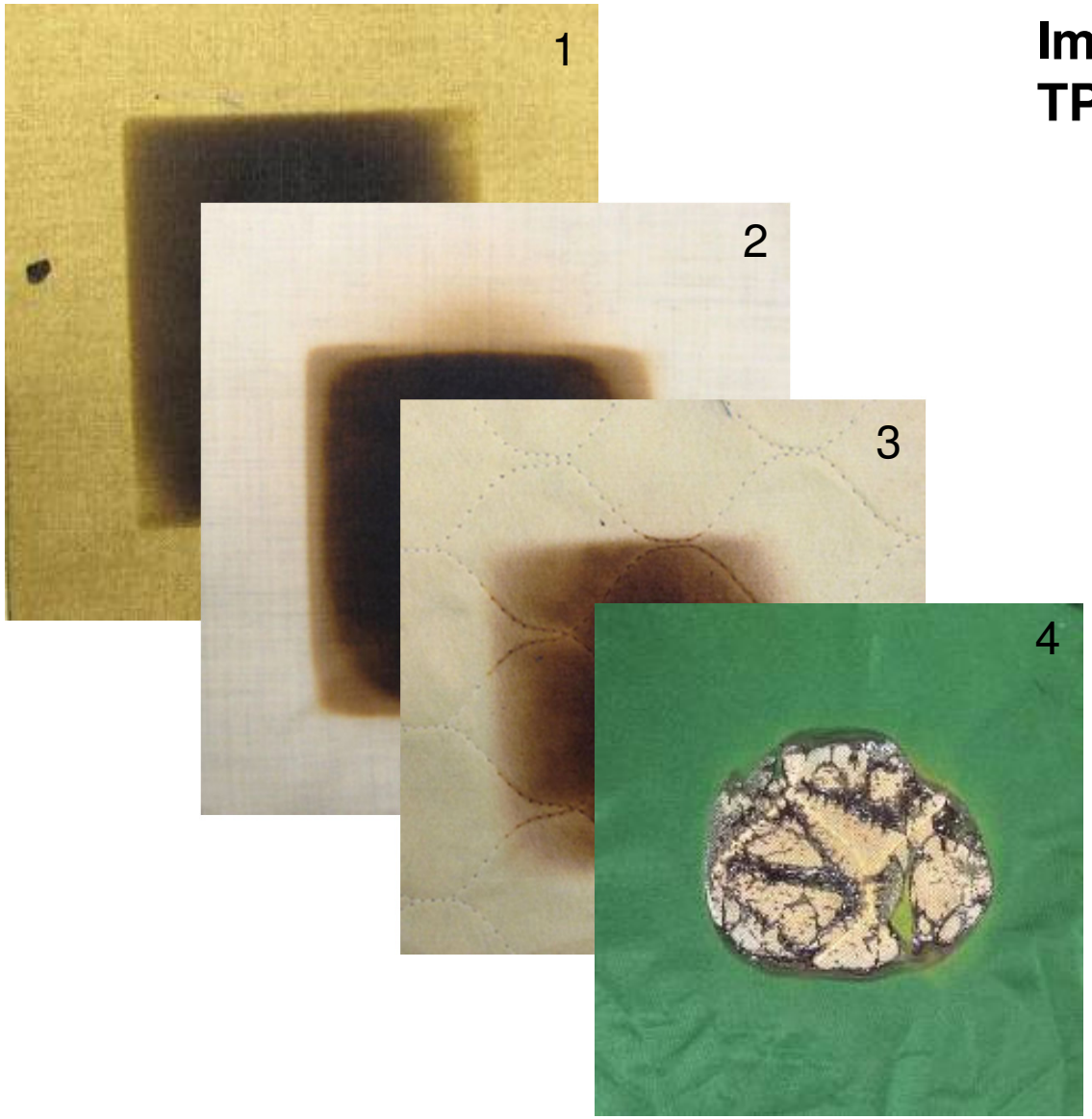
THL: **750 W/m²** **450 W/m²** **250 W/m²** **< 150 W/m²**



Each garment of the firefighter clothing system contributes to the overall thermal insulation and total heat loss.

Thermal Protective Performance

Exposure of Composite with Polyester Filament Underlayers



Images reveal after 30 seconds of TPP Exposure (@ 2 cals/cm^2);

- 100% polyester shirt can melt underneath turnout gear composite.
- Simulates firefighter trapped in emergency event.

Composite Structure:

1. Kevlar®/PBI outershell
2. Crosstech®/Nomex® PJ 2 Layer Nomex® E89™
3. Nomex® Filament/Spun fabric
4. 4.7 oz/yd^2 polyester knit

Stationwear Behind Turnout Composite

4.3 oz 100% polyester

4.5 oz poly/cotton blend

7.4 oz 100% cotton

4.7 oz Nomex® IIIA

Conditions: 25 sec TPP exposure with Turnout Composite
Turnout Composite : 23.1 opsy, TPP of 37.6

Stationwear made from 100% polyester or poly/cotton blends show evidence of melting at the onset of 2nd degree burns during the TPP test. 100% cotton and Nomex® do not melt under the same conditions.

The DuPont™ Thermo-Man® System

- A UL manikin testing facility certified to NFPA 2112 – the first of its kind
- Used for NFPA 2113 clothing performance assessments
- DuPont developed in conjunction with the U.S. Military to help them protect the warfighter from burns
- Utilizes 122 heat sensors and 12 torches on six stands to create a uniform flame engulfment
- Test methodology has become an industry standard – ASTM F1930 (ISO13506 - internationally)

Delivers realistic short duration fire conditions;

- Uses “jet fire” of specific intensity and duration
- Controllable duration (Exposure Time) & intensity (Heat Flux)
- Sensors measure calorimeter values
- 60 second acquisition period

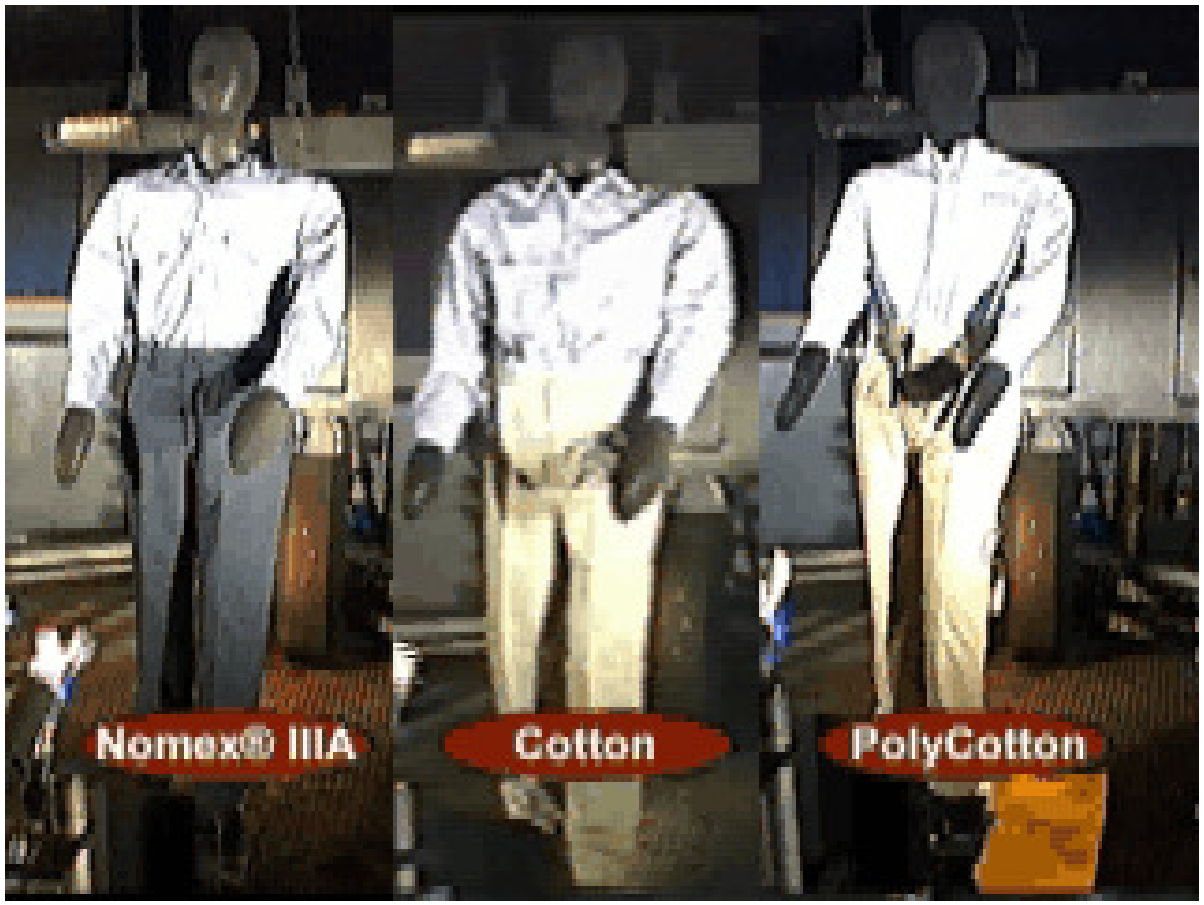
Results Reflect Actual Exposures;

- Amount, degree, and location of predicted burn injury calculated from sensor data
- Estimated probability of survival determined

Bottom Line: Provides a Prediction of Burn Injury for Specific Garments over a Full Range of Flash

ThermoMan™ Manikin Testing

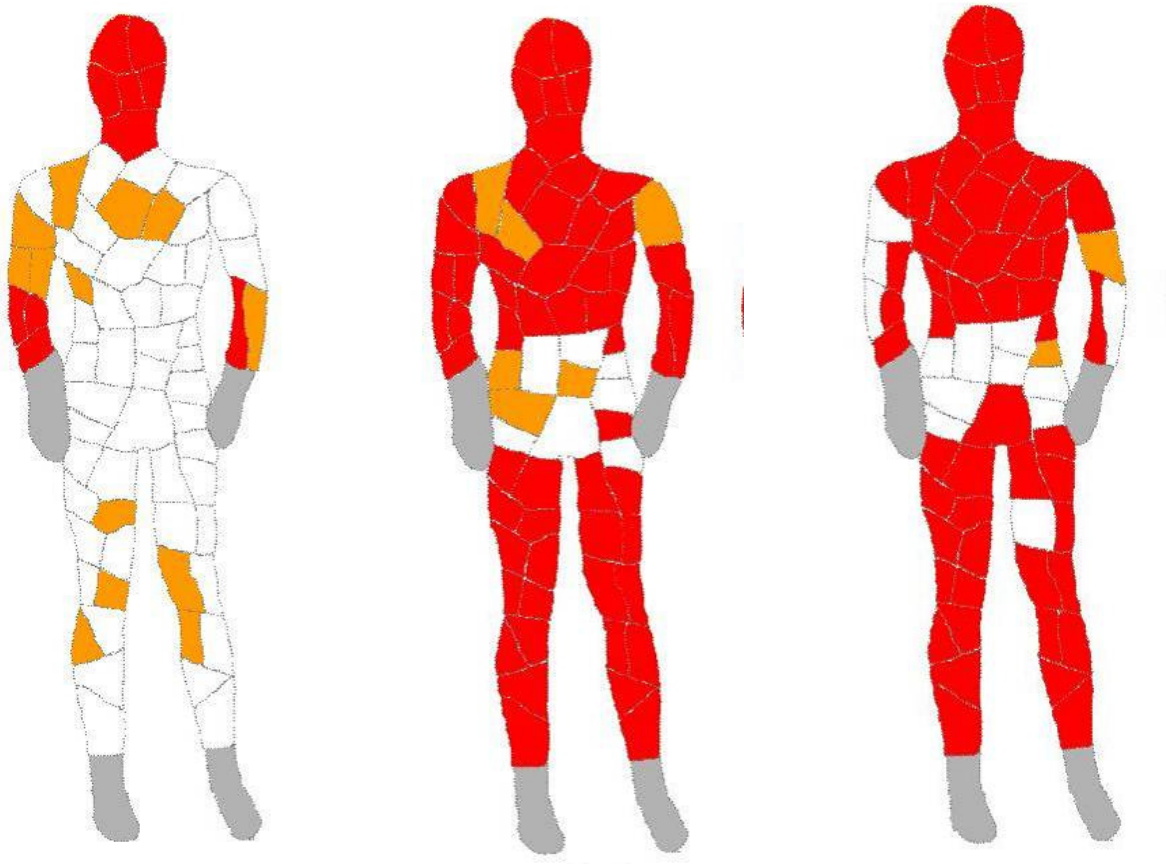
Simulated Stationwear Testing



NOMEX® IIIA Cotton Poly/Cotton

ThermoMan™ Manikin Testing

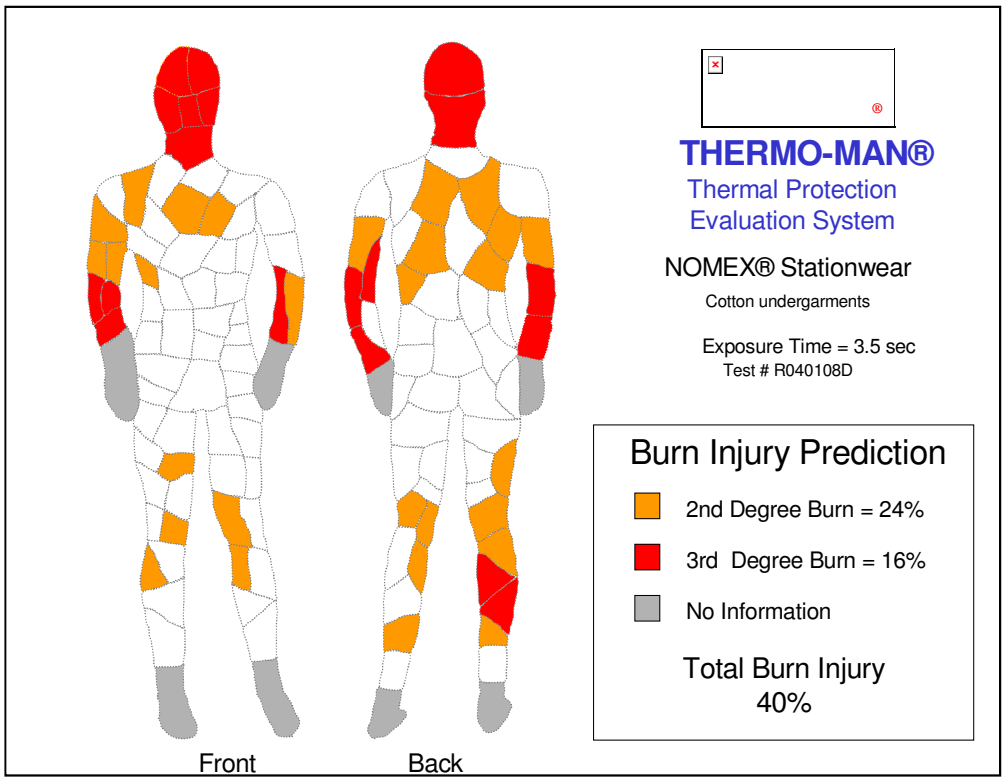
Simulated Stationwear Testing

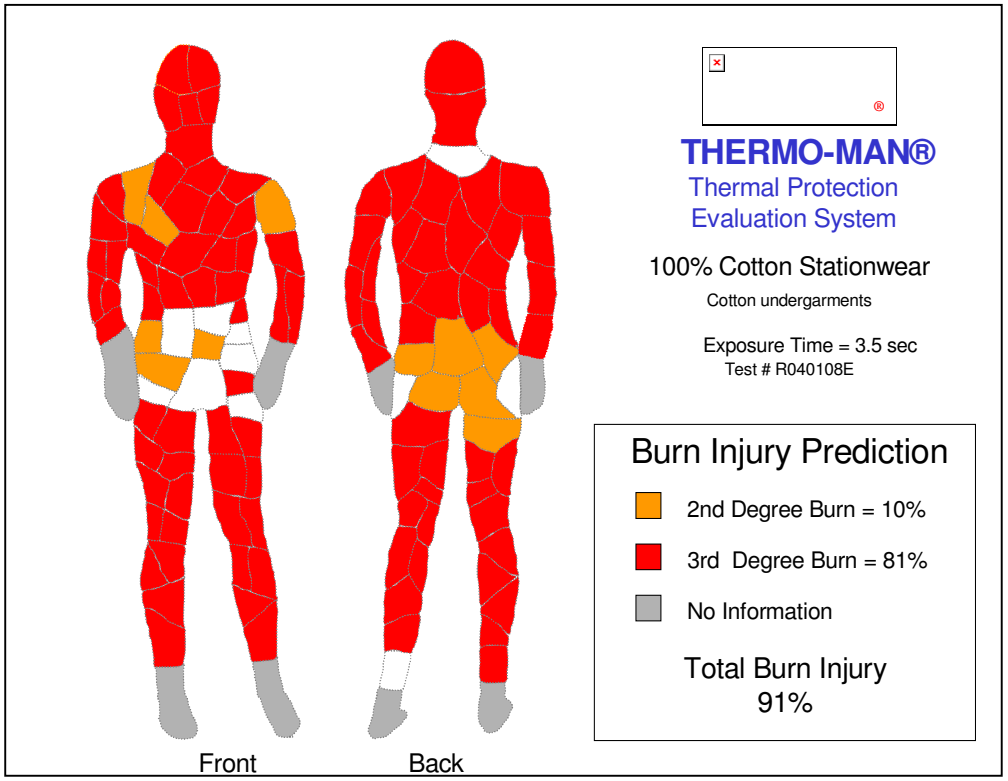


NOMEX® IIIA	Cotton	Poly/Cotton
40%	91%	84% *

ThermoMan™ Manikin Testing

Simulated Stationwear Testing



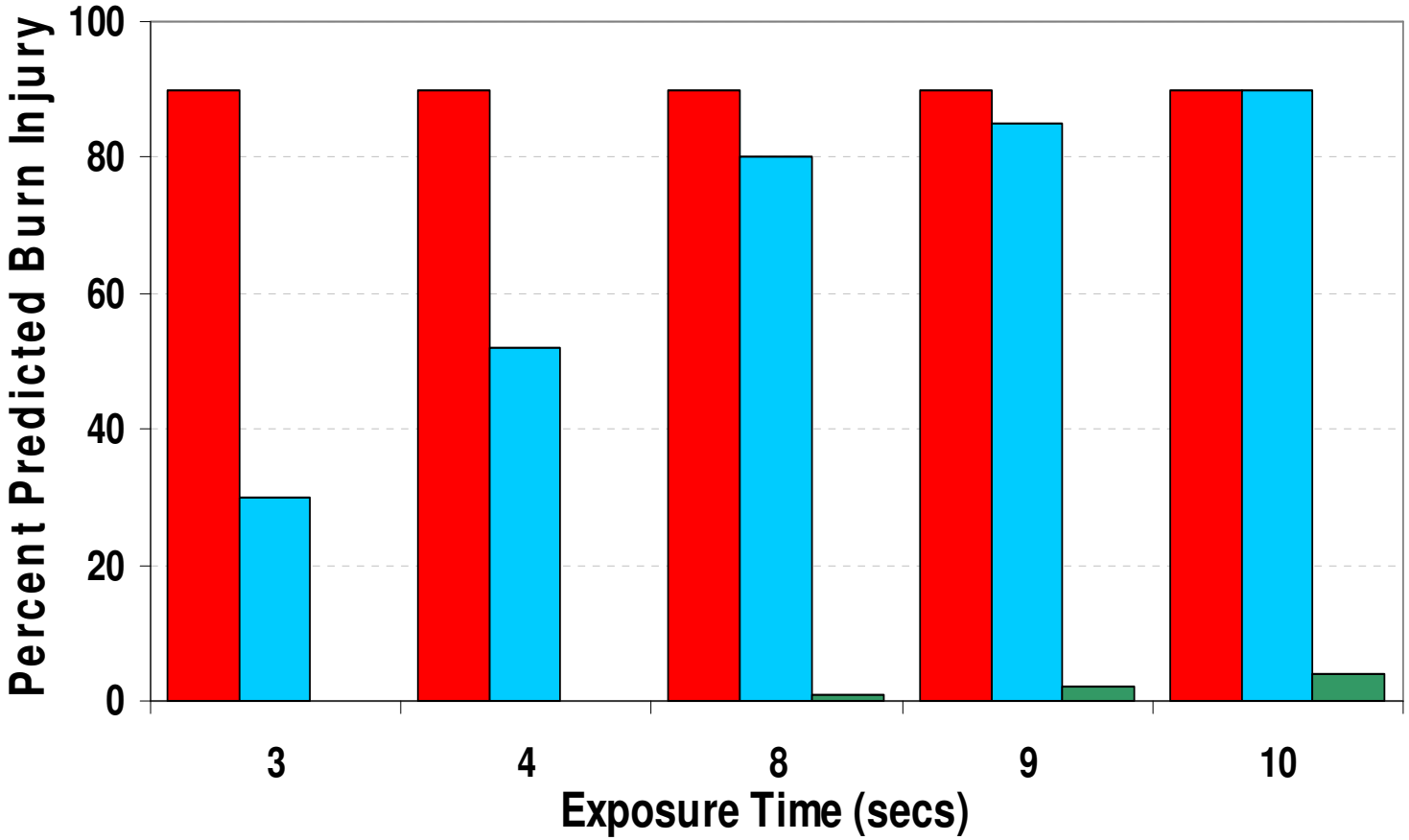


NOMEX® IIIA **100% Cotton**

Flammable cotton fabrics continue to burn long after initial flame exposure. Burning garments continue to expose user to hazardous environment until garment extinguished.

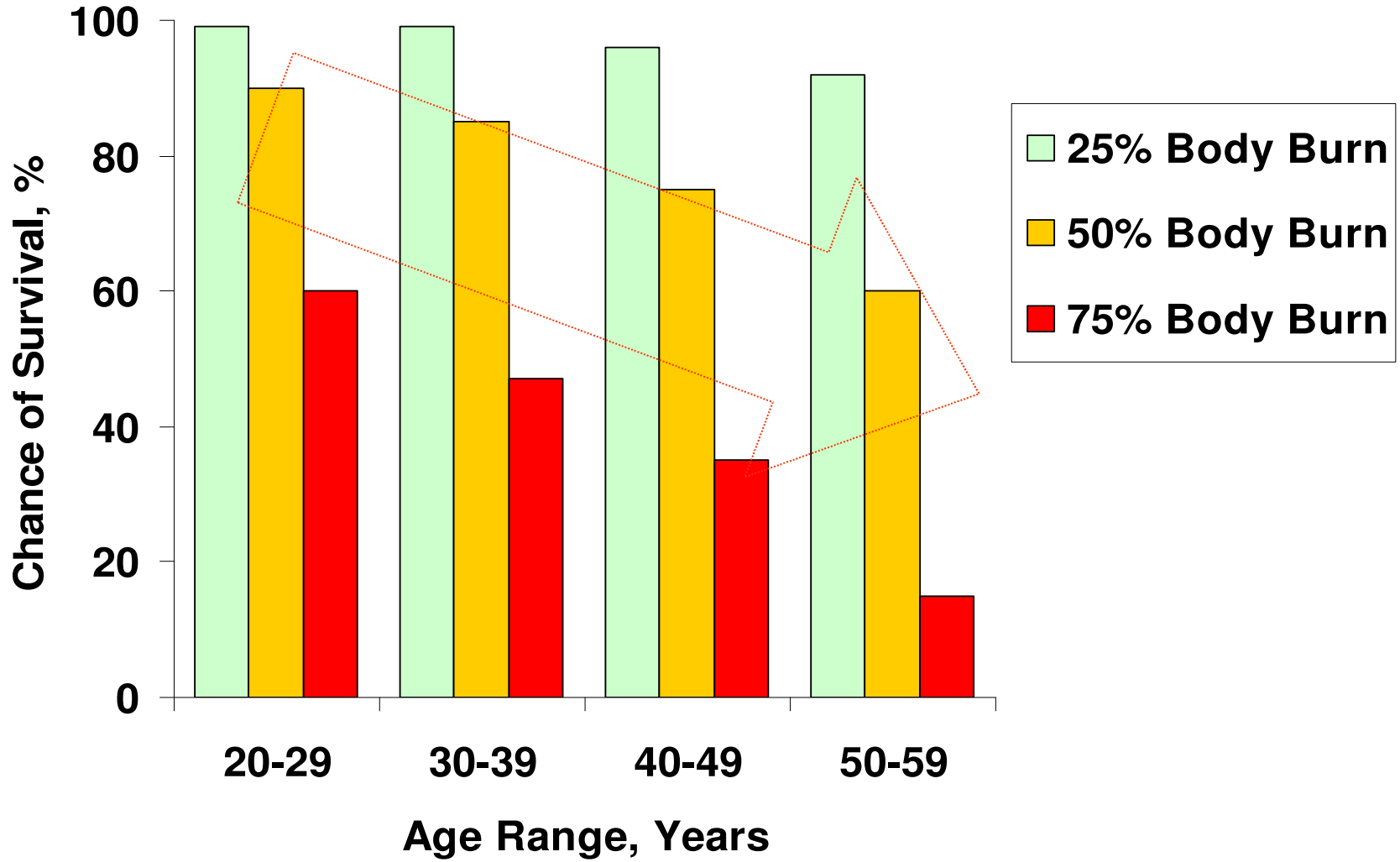
ThermoMan™ Manikin Testing

Predicted Burn Injury vs Exposure Time



ThermoMan™ Manikin Testing

Predicted Survival Rate vs Burn Injury Level



Station/Work Uniforms What to Look For

Mark Saner

Technical Manager

Workrite Uniform Company

Station/Work Uniforms

What to Look For ….

Areas to Consider

- Compliance/Protection
- Appearance /Styling
- Durability
- Value

Compliance/Protection

- NFPA 1975 Compliance
  - Does not cause or contribute to burn injury severity
  - Flame Resistant or Non melting
- Added Layer of Protection with FR

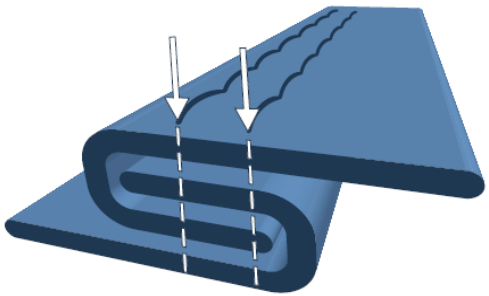
Chief Robert Post, Barrow County FD

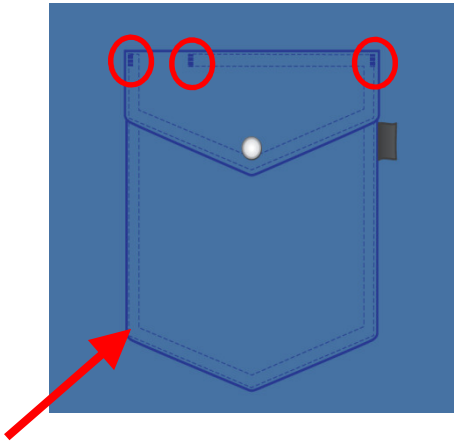
Appearance/Styling

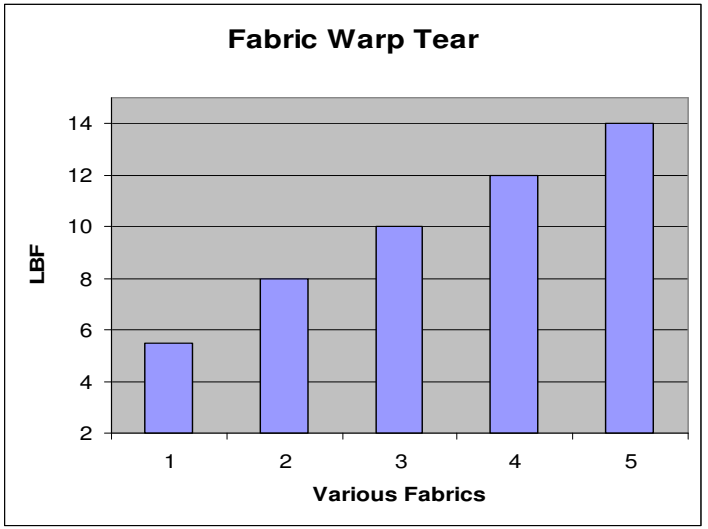
- Professional Image
  - Badge Tab
  - Epaulets
- Permanent Press
- Crease Retention
- Color Durability
- Shrinkage Performance

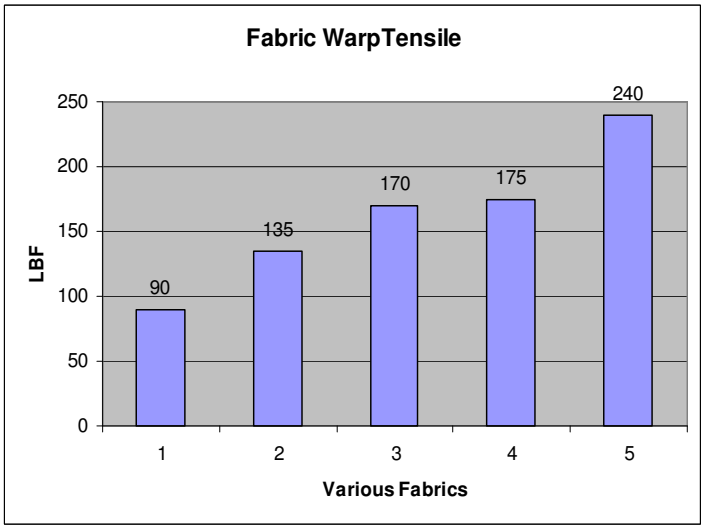
Durability

- Fabric Strength and Tear Resistance
- Garment Seam and Stress Point Construction
- Appearance Retention & Shrinkage Control



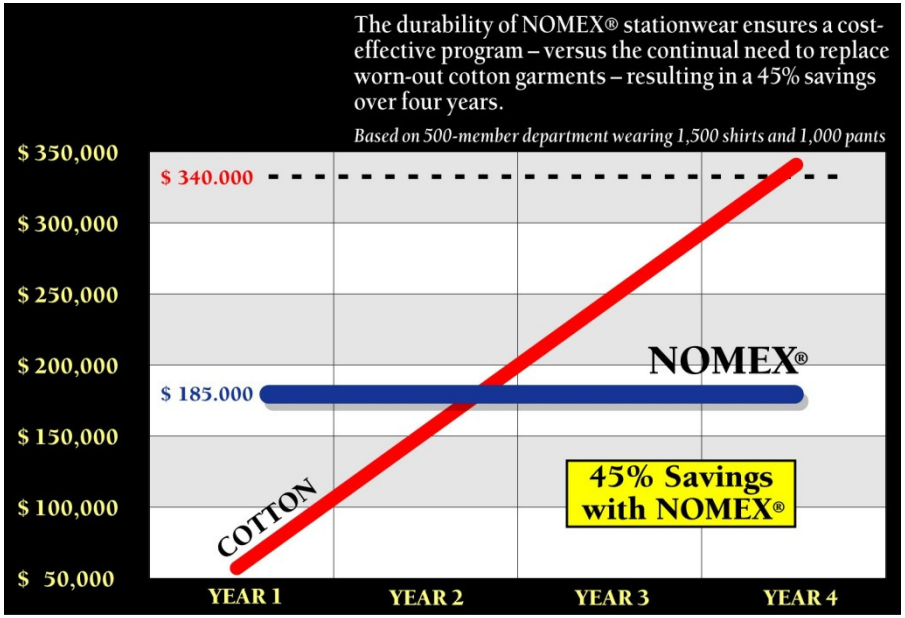






Value

- Initial Cost
- Care & Maintenance Considerations
- Apparel Durability
- Appearance Retention
- Long Term Ownership Costs



Questions ?

Disclaimer Notice

This information corresponds to our current knowledge on the subject and may be subject to revision as new knowledge becomes available. It is your responsibility to investigate other sources of information on this issue that more appropriately addresses your product and its intended use. DuPont™ makes no warranties and accepts no liability whatsoever.

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NIST SCBA Studies

http://www.nist.gov/el/fire_research/scba-120611.cfm

- Temperature and Heat Flow can seriously damage SCBA Face Piece
- Exposure of Firefighter to Toxic Gases and Thermal Damage of Respiratory System
- Simulations involving various Fire Scenarios and Tactics
- Catastrophic failure at 536 deg F, during front entry of a burning building
- Studies underway to understand thermal conditions before material failure