

NFPA 1970 UPDATE

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CHAIR OF NFPA 1970 AND 1850 TECHNICAL COMMITTEE

ORIGIN OF NFPA 1970

NFPA 1970 CONSOLIDATES FOUR PREVIOUS STANDARDS:

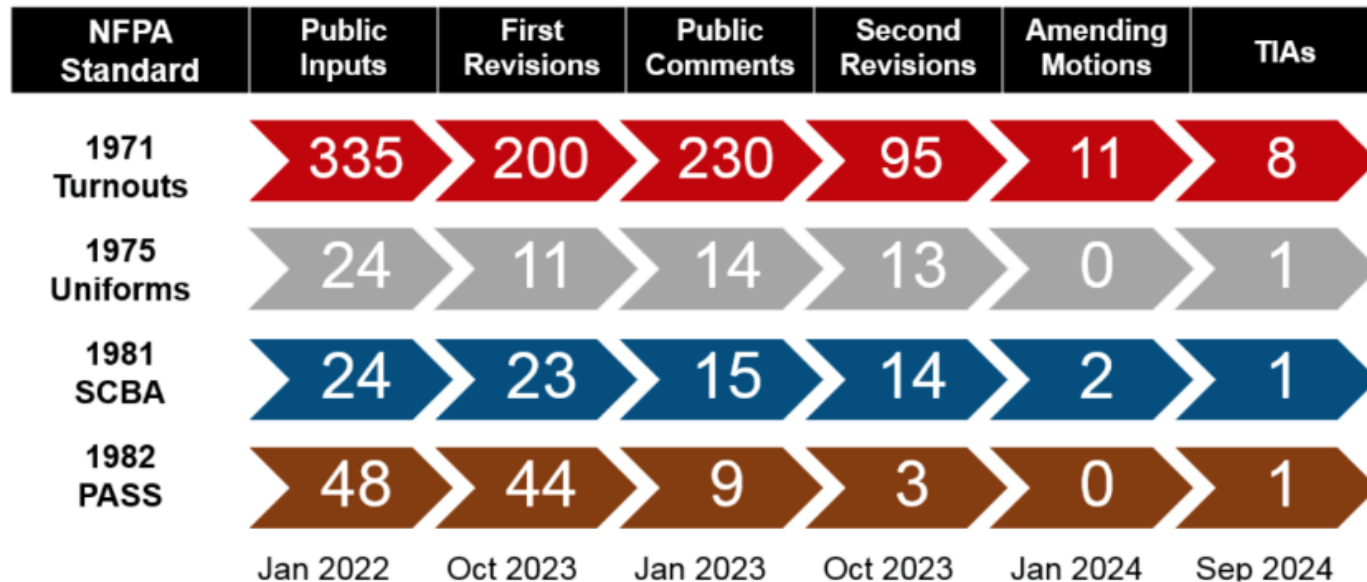
- **NFPA 1971 (2018) – STRUCTURAL FIREFIGHTING ENSEMBLES**
- **NFPA 1975 (2019) – EMERGENCY SERVICES WORK APPAREL**
- **NFPA 1981 (2019) – OPEN-CIRCUIT SCBA**
- **NFPA 1982 (2018) – PASS SYSTEMS**

SIMPLIFIES MAINTENANCE, IMPROVES CONSISTENCY, AND ALIGNS RELATED ADVANCEMENTS.



Stull Figure 1

THE DEVELOPMENT OF NFPA 1970



Stull
Figure 2

NFPA 1970 FINISHED PRODUCT

- **Common chapters are provided for referenced documents, terminology, and general certification requirements (Chapters 2 through 4).**
- **Chapters 5-9 apply to NFPA 1971.**
- **Chapters 10-14 apply to NFPA 1975.**
- **Chapters 15-19 apply to NFPA 1981.**
- **Chapters 20-24 apply to NFPA 1982.**

IMPLEMENTATION SCHEDULE & FIRE SERVICE IMPACT

NFPA 1970 IS EFFECTIVE SEPTEMBER 29, 2024, REPLACING PREVIOUS STANDARDS.

- NEW PRODUCTS MUST BE CERTIFIED TO NFPA 1970.**
- EXISTING TURNOUT GEAR CERTIFICATIONS ARE VALID FOR UP TO 12 MONTHS.**
- SCBA AND PASS DEVICES HAVE AN 18-MONTH GRACE PERIOD.**
- MANUFACTURERS MUST TRANSITION PRODUCTS TO THE NEW STANDARD.**

KEY CHANGES IN TURNOUT GEAR CLOTHING

- **MANDATORY PARTICULATE-BLOCKING HOODS.**
- **PFAS (TOTAL FLUORINE) CONCENTRATION LABELING AND RESTRICTED SUBSTANCES.**
- **ENSURING GEAR MAINTAINS PERFORMANCE OVER SERVICE LIFE.**
- **ADJUSTED MOISTURE BARRIER REQUIREMENTS FOR NON-PFAS OPTIONS.**
- **NEW BREATHABILITY TEST METHODS.**
- **IMPROVED GLOVE SIZING AND PRODUCT LABELING.**
- **CLEANING EFFECTIVENESS STANDARDS.**
- **OPTIONAL SYSTEM-WIDE ENSEMBLE PERFORMANCE CRITERIA.**

NEW HOOD REQUIREMENTS & IMPACT

- **STRUCTURAL HOODS MUST BE PARTICULATE-BLOCKING; PROXIMITY HOODS ARE EXEMPT.**
 - **FULL PARTICULATE-BLOCKING LAYER COVERAGE.**
 - **EXCEPT FOR A SMALL PORTION AROUND THE HOOD OPENING AND HEMS OF THE HOOD BIB**
 - **TESTING APPLIED TO HOOD SEAMS.**
 - **PREVIOUSLY, TESTING WAS ONLY APPLIED TO THE MATERIAL SURFACE AREA**
 - **MUST WITHSTAND LAUNDERING AND HEAT EXPOSURE.**
 - **10 WASHINGS AND ONE 10-MINUTE HEAT EXPOSURE AT 285° F**
 - **A MINIMUM NUMBER OF SIZES IS REQUIRED TO ENSURE THE SIZING OF THE MAJORITY OF THE FIRE SERVICE**
 - **HOODS ARE NOW TESTED FOR STORED ENERGY AS A REPORTABLE VALUE BY MANUFACTURERS**
 - **DECONTAMINATION EFFECTIVENESS MUST BE REPORTED FOR PERCENT REMOVAL OF VOCs AND HEAVY METALS**

NFPA 1970 & PFAS/RESTRICTED SUBSTANCES

OPTIONAL PFAS (TOTAL FLUORINE) LABELING FOR CERTIFICATION.

- *THIS [TYPE OF PROTECTIVE ELEMENT] UPON CERTIFICATION HAS A PFAS (TOTAL FLUORINE) CONCENTRATION OF NO MORE THAN 100 PPM.”*
- **MANDATORY INDEPENDENT TESTING FOR RESTRICTED PFAS CHEMICALS.**
- **LIMITS TOTAL FLUORINE CONCENTRATION TO 100 PPM.**

Table 1. Materials Tested for PFAS and Restricted Substances by Element Apparel		
PROTECTIVE ELEMENT	MATERIALS TESTED FOR RESTRICTED SUBSTANCES	MATERIALS EXCLUDED FROM RESTRICTED SUBSTANCES TESTING
Garments	Outer shell, moisture barrier, thermal barrier, and wristlet/garment-glove interface components	Leather, reinforcements, high visibility trim, labels, thread, and hardware
Helmets	Ear cover fabric material layers, textile-based suspension material, and textile-based retention materials	Leather, shell materials, eye and face protective device materials, brackets, hardware, and labels
Gloves	Principal textile-based fabric materials (shells, moisture barriers, linings, and wristlets); includes all moisture barriers and fourchettes	Leather, reinforcements, thread, elastic, and labels
Footwear	Upper principal textile-based fabric material layers (any exterior layers, barrier layers, and linings)	Leather, laces, zippers, removable insoles, reinforcement layers, thread, and labels
Hood	Outer layer, inner layer, particulate-blocking layer	Thread and labels

Stull Table 1

NFPA 1970 & PFAS/RESTRICTED SUBSTANCES

INTRODUCTION OF A RESTRICTED SUBSTANCES LIST (RSL)

- **MODELED FROM WIDELY ACCEPTED REGULATORY AUTHORITIES**
 - **OEKO-TEX, AFFIRM, REACH, CALIFORNIA PROP 65, AAFA**

Table 2. Major Categories of Restricted Substances Applied to Apparel

CATEGORIES OF RESTRICTED SUBSTANCES

• Acidity/alkalinity	• Monomers
• A kyl phenols and ethoxylates	• Nitrosamines
• Chlorinated benzenes and toluenes	• Organotin compounds
• Chlorinated paraffins	• PFAS
• Chlorinated phenols	• Phthalates
• Dyes	• Polyaromatic hydrocarbons
• Flame retardants	• Solvent residues
• Formaldehyde	• UV stabilizers
• Heavy metals	• Volatile organic compounds

Stull Table 2

NFPA 1970 & PFAS/RESTRICTED SUBSTANCES

APPLICATION OF RESTRICTED SUBSTANCES REQUIREMENTS

- **MATERIAL AND COMPONENT SUPPLIERS SUBMIT THEIR MATERIALS TO INDEPENDENT LABS (ATTESTATION ORGANIZATION)**
- **ATTESTATION ORGANIZATION REPORTS TEST RESULTS OF RELEVANT RESTRICTED SUBSTANCES**
- **A CERTIFICATE ATTESTING TO RESTRICTED SUBSTANCE LIMITATIONS REQUIRED BY NFPA 1970**

Table 3. Examples of Restricted Substance Limits in NFPA 1970

CHEMICAL CLASS OR GROUP	RESTRICTED SUBSTANCE(S)	TEST METHOD	MAXIMUM LEVEL
Acetophenone and 2-Phenyl-2-propanol	Acetophenone and 2-Phenyl-2-propanol	Extraction in acetone or methanol, sonification for 30 minutes at 60°C (140°F); analysis by GC/MS	10 mg/kg
Chlorinated phenols	Pentachlorophenol	All materials: EN 17134-2	0.5 mg/kg
	Tetrachlorophenols		0.5 mg/kg
	Trichlorophenols		2.0 mg/kg
	Dichlorophenols		3.0 mg/kg
	Monochlorophenols		3.0 mg/kg
Dyes	Specific dyes identified in separate table	All materials: DIN 54231	50 mg/kg
	Navy blue	All materials: DIN 54231	Not present
Heavy metals, extractable	Antimony	All materials: EN 16711-2	
	30.0 mg/kg		
	Arsenic		1.0 mg/kg
	Barium		1000 mg/kg
	Cadmium		0.1 mg/kg
	Chromium		2.0 mg/kg
	Cobalt		4.0 mg/kg
	Copper		50.0 mg/kg
	Lead		1.0 mg/kg
	Mercury		0.02 mg/kg
	Nickel		4.0 mg/kg
Heavy metals, total content	Selenium	Textiles: EN 16711-2 with ISO 17075-1 if chromium is detected All materials: EN 16711-2	100 mg/kg
	Chromium VI		0.5 mg/kg
	Arsenic		100 mg/kg
	Cadmium		40.0 mg/kg
	Mercury		90.0 mg/kg
	Lead		0.5 mg/kg
Monomers	Styrene	Extraction in methanol; GC/MS, sonication at 60°C (140°F) for 60 minutes	0.005 mg/m³
	Vinyl chloride	All materials: ISO 6401	0.002 mg/m³

Stull Table 3

OUTER SHELL PERFORMANCE & DURABILITY

NFPA 1970 INTRODUCES NEW DURABILITY TESTING (MULTI-CONDITIONING):

- **20 LAUNDERING CYCLES.**
- **HIGH HEAT EXPOSURE (285°F FOR 10 MIN).**
- **3,000 FLEXING CYCLES.**
- **UV AND DIESEL FUEL RESISTANCE TESTING INTRODUCED.**

INTENDED TO BETTER DEMONSTRATE DURABILITY OF FABRICS

ADDRESSING PHYSIOLOGICAL STRESS IN TURNOUT GEAR

INTRODUCTION OF NEW TESTING FOR HEAT STRESS IMPACT.

- **NEW RET REQUIREMENT:**

- **MEASURES EVAPORATIVE RESISTANCE OF GARMENTS (≤ 45 PASCAL M²/WATT).**
- **TESTED IN WARMER CONDITIONS (95°F, 40% RH) FOR HEAT STRESS EVALUATION.**
- **EXPECTED TO HELP PROVIDE SOME BETTER INSIGHT INTO FIREFIGHTER HEAT BUILDUP INSIDE GARMENTS.**

IMPACT:

- **HELPS BALANCE HEAT LOSS & INSULATION.**
- **FIREFIGHTERS CAN BETTER MANAGE CORE TEMPERATURE DURING OPERATIONS.**

MOISTURE BARRIER CHANGES IN NFPA 1970

NEW TESTING APPROACH FOR MOISTURE BARRIERS:

- **EVALUATED AS PART OF FULL GEAR COMPOSITE INSTEAD OF A SINGLE LAYER.**
 - **MOISTURE BARRIERS ARE NOW TESTED AS A SANDWICH BETWEEN THE THERMAL BARRIER AND THE OUTERSHELL.**
 - **INTENDED TO BETTER REPRESENT HOW GEAR IS WORN ON THE FIRE GROUND.**
- **THE VIRAL PENETRATION TEST WAS REPLACED WITH THE HYDROSTATIC TEST (LEVEL 3 STANDARD).**
 - **THE HYDROSTATIC TEST IS WHAT IS IN THE MEDICAL INDUSTRY FOR TESTING LEVEL 3 SURGICAL GOWNS.**
- **MORE REALISTIC LIQUID PENETRATION TESTING USING MINERAL OIL-BASED FLUIDS.**
 - **PREVIOUSLY, AN ESTER-BASED HYDRAULIC FLUID WAS USED, WHICH WAS CONSIDERED TO BE RELATIVELY AGGRESSIVE.**
- **UV DEGRADATION TEST REVISED TO REFLECT FIELD EXPOSURE.**

THESE CHANGES ENCOURAGE NON-EPTFE BARRIER TECHNOLOGIES AND BALANCE FIREFIGHTER PROTECTION.

ADDRESSING ENSEMBLE ELEMENT SIZING CONCERNS

PROTECTIVE HOODS:

- **PARTICULATE-BLOCKING HOODS REQUIRE LESS ELASTIC MATERIALS.**
 - **WILL CONFORM LESS TO A FIREFIGHTER'S HEAD THAN A TRADITIONAL KNIT HOOD**
- **NEW SIZING REQUIREMENTS ENSURE PROPER FIT.**

PROTECTIVE GLOVES:

- **A NEW SIZING APPROACH CONSIDERS FIREFIGHTER HAND DIMENSIONS.**
 - **MANUFACTURERS HAVE THE OPTION TO USE ANTHROPOMETRIC DATA FOR DEMONSTRATING THAT THEIR SIZING SYSTEM WILL FIT THE 5TH TO 95TH PERCENTILE OF HAND DIMENSIONS.**

CONTAMINATION CONTROL FOR PROTECTIVE CLOTHING

TESTING REQUIREMENTS HAVE BEEN ADOPTED FROM NFPA 1851 (1850)

- **APPLY TO OUTER-SHELL, THERMAL LINER, MOISTURE BARRIER, AND HELMET TEXTILES, AND HOODS**
 - **DETERMINE CLEANABILITY OF SVOC'S AND HEAVY METALS**
 - **MANUFACTURERS AND SUPPLIERS ARE REQUIRED TO REPORT THIS INFORMATION IF REQUESTED**

PRODUCT TYPE	PRODUCT/MATERIAL DESCRIPTION	AVERAGE DECONTAMINATION EFFICIENCY	
		SVOCs*	HEAVY METALS
Protective garment outer shell	Aramid Blend no PFAS	53	73
	Aramid Blend with PFAS	60	56
	PBI/Aramid Blend no PFAS	54	59
	PBI/Aramid Blend with PFAS	60	61
Protective garment moisture barrier	Nonwoven Aramid with PTFE A**	37	Not tested
	Nonwoven Aramid with PTFE B**	47	Not tested
	Woven Aramid with PTFE A**	37	Not tested
	Woven Aramid with PTFE B**	54	Not tested
Protective garment thermal barrier	Aramid/FR Rayon blend with PBI spunlace	77	76
	p-Aramid/ FR Rayon blend with Aramid spunlace	82	80
	Aramid/ FR Rayon blend with Aramid spunlace	81	77
	Aramid/FR Rayon/Nylon with Aramid spunlace	85	73
Protective hood	2-layer PBI FR Rayon knit 1 with PTFE A**†	81	92
	2-layer PBI FR Rayon knit 1 (knit only)	79	98
	2-layer PBI knit with Polyimide*†	93	83
	2-layer Carbon fiber (knit only)	74	82
	2-layer Carbon fiber with PTFE B**†	73	63

Stull Table 4

SIGNIFICANCE OF OPTIONAL TESTS IN ANNEX G

ANNEX G INTRODUCES OPTIONAL FULL ENSEMBLE TESTING.

TESTS ASSESS:

- **THERMAL PROTECTION**
- **HEAT STRESS IMPACT**
- **SMOKE PARTICULATE & FIRE GAS PROTECTION**
- **FUNCTIONALITY**
- **HELPS DEPARTMENTS EVALUATE PPE PERFORMANCE & GEAR INTEROPERABILITY.**

OTHER CONSEQUENTIAL CHANGES IN NFPA 1970

ADDITIONAL UPDATES INCLUDE:

- **NEW CRITERIA FOR ELECTRONIC COMPONENTS (E.G., RFID CHIPS) IN TURNOUT GEAR.**
- **REQUIREMENTS FOR INTRINSIC SAFETY OF INTEGRATED ELECTRONICS.**
- **STRICTER TESTING FOR DRAG RESCUE DEVICES (DRDS).**
- **MORE EXPLICIT IDENTIFICATION OF MATERIALS IN TURNOUT GEAR CONSTRUCTION.**

ENHANCES FIREFIGHTER SAFETY AND IMPROVES TRANSPARENCY IN PRODUCT MATERIALS.

THANK YOU...

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Research Update: PFAS in the Fire Service

***NFPA PPE Workshop
April 2, 2025***

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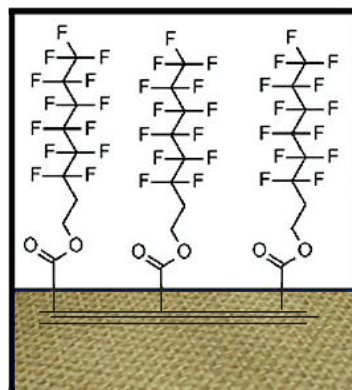
Fundamental Background on PFAS



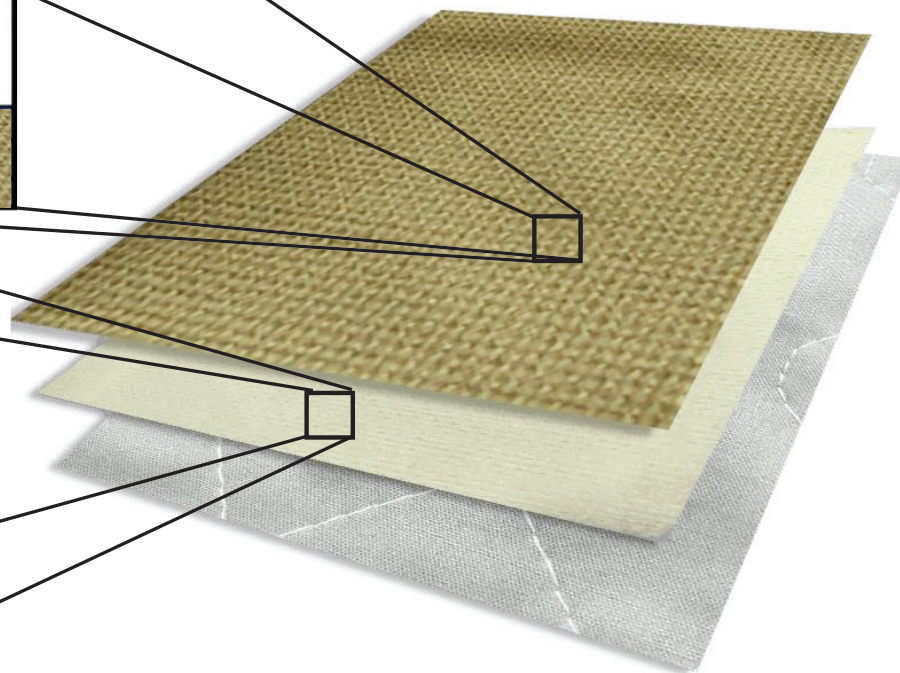
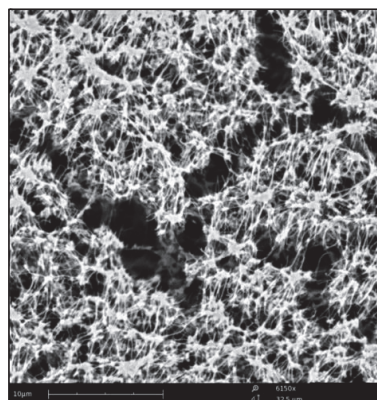
- Per- and polyfluoroalkyl substances
- Synthetic chemicals used since the 1940s
- Resistant to heat, water, and oil
- Used in many consumer and industrial products, including firefighter gear
- Persist in the environment and human body for long periods
- Associated with various health effects, including certain cancers and immune system issues
- Bioaccumulate in humans and wildlife

Intentionally-Added PFAS Chemistries

Water and Oil Repellents
Side Chain Fluoropolymers
FTMAC, FTOH, FTS



Membrane
Fluoropolymers (PTFE)
Bicomponent with PU



Complexity of PPE Transition

- PPE is the study of trade-offs
- There are available **alternatives** but not direct **replacements**
- Performance of non-PFAS PPE is expected to be different from traditional PPE in numerous ways
 - Limited information on the magnitude of the difference for each property



Performance Trade-Offs of Interest

- Alternative non-PFAS Finishes
 - Repellency of water, biological fluids, oils, fuels
 - Potential flammability hazards following exposure to flammable liquids
 - Durability of materials following aging process
 - Ability of the materials to resist fireground contamination
 - Ability of the materials to be cleaned effectively
- Alternative non-PFAS Barriers
 - Barrier less protected from flammable liquids
 - Durability of materials following aging process
 - Breathability and thermal burden (total heat loss or evaporative resistance)

PFAS, Firefighting, and Essential Use?

- Question #1:
 - Are PFAS essential to meet the PPE performance standards?
- Question #2:
 - Do performance standards accurately reflect firefighter needs?
- Question #3:
 - Do the performance standards need to be revised to better reflect firefighter needs so that PFAS are no longer essential?



**- New Claim -
- New Measurement -**



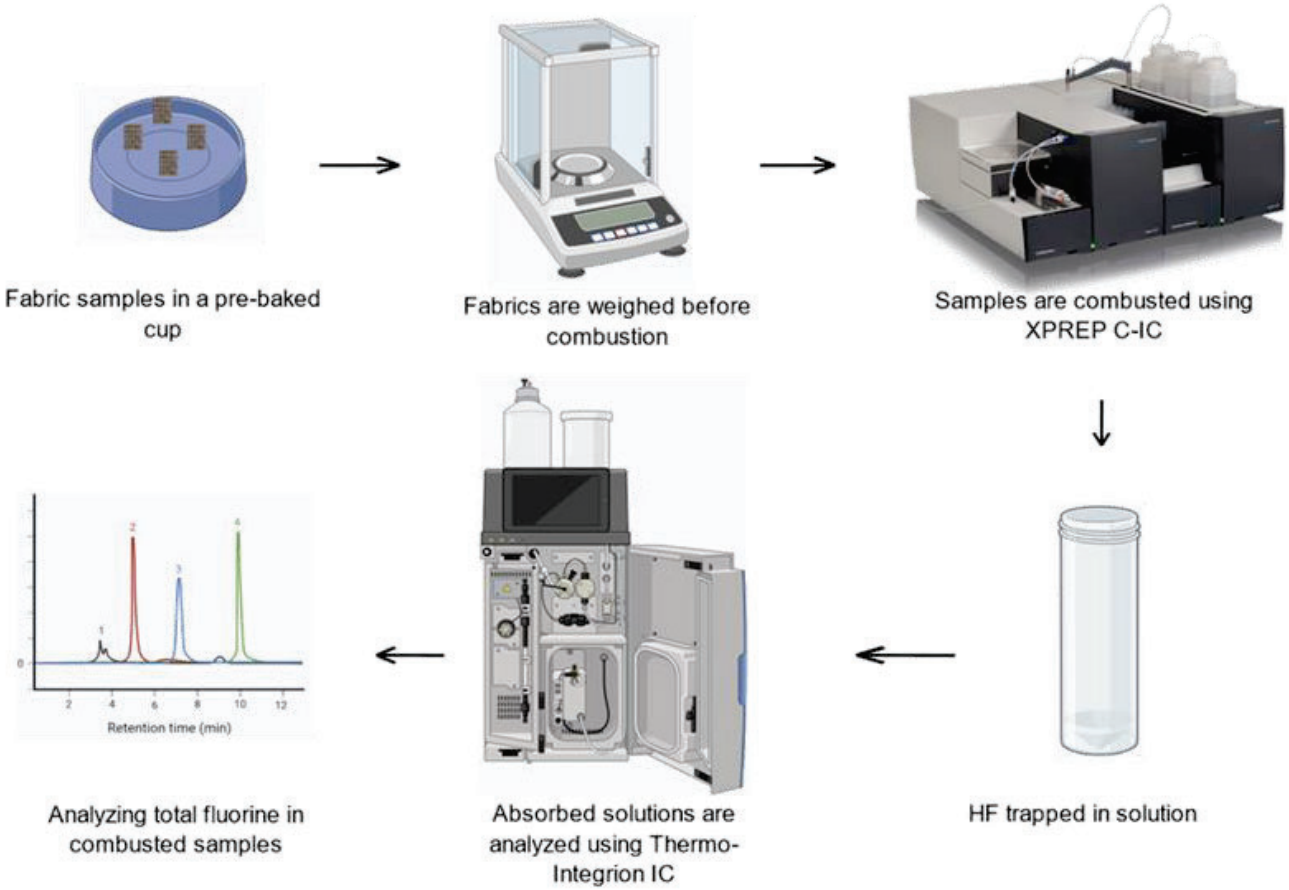
New Measurement for Total Fluorine

- For manufacturer's that want to claim their product was not manufactured with intentionally added PFAS

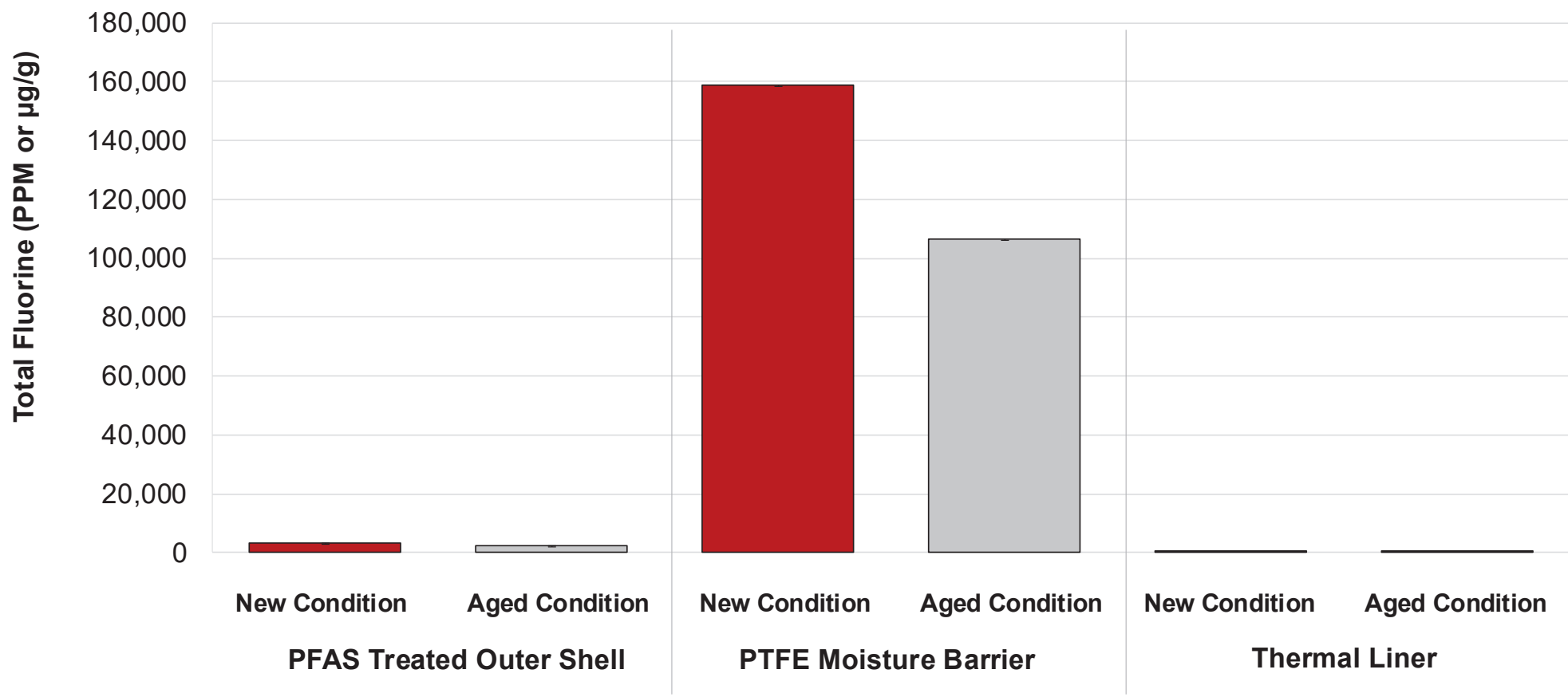
THIS [type of protective element] UPON CERTIFICATION HAS A PFAS (TOTAL FLUORINE) CONCENTRATION OF NO MORE THAN 100 PPM.

- This Total Fluorine measurement can be made with a combustion ion chromatograph or other comparable instrument/technique
- What do the results look like for common turnout materials?

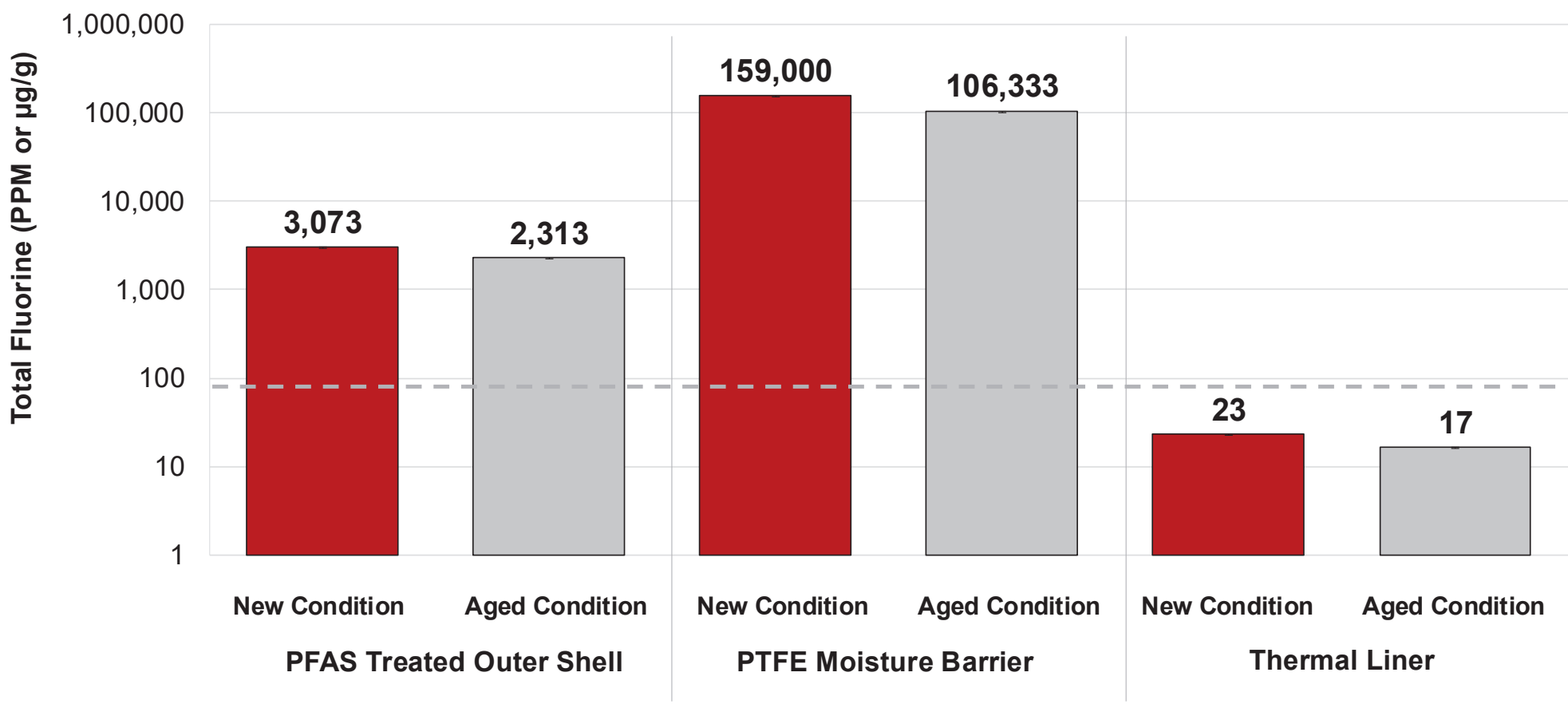
Analysis of Total Fluorine in CIC



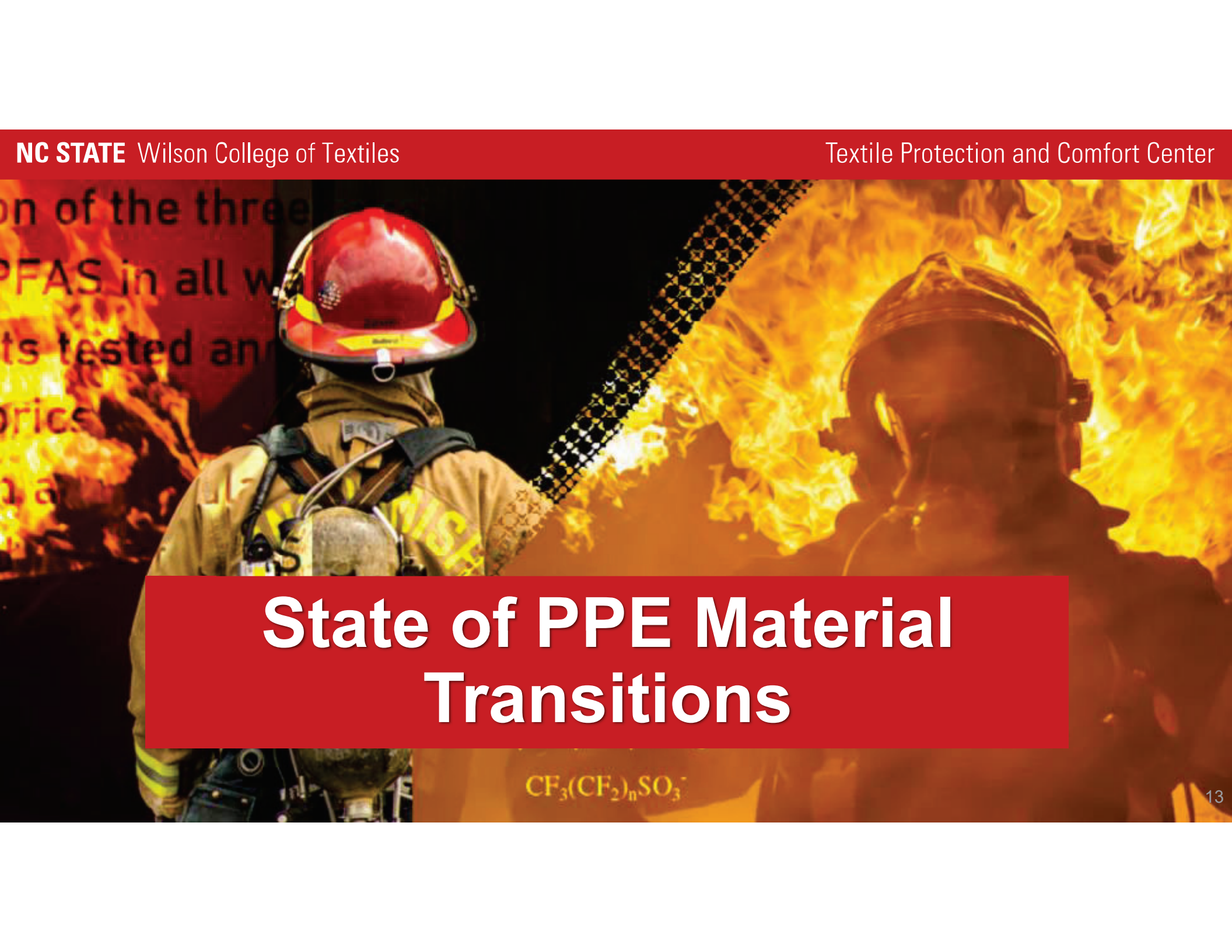
Analysis of Total Fluorine in CIC



Analysis of Total Fluorine in CIC



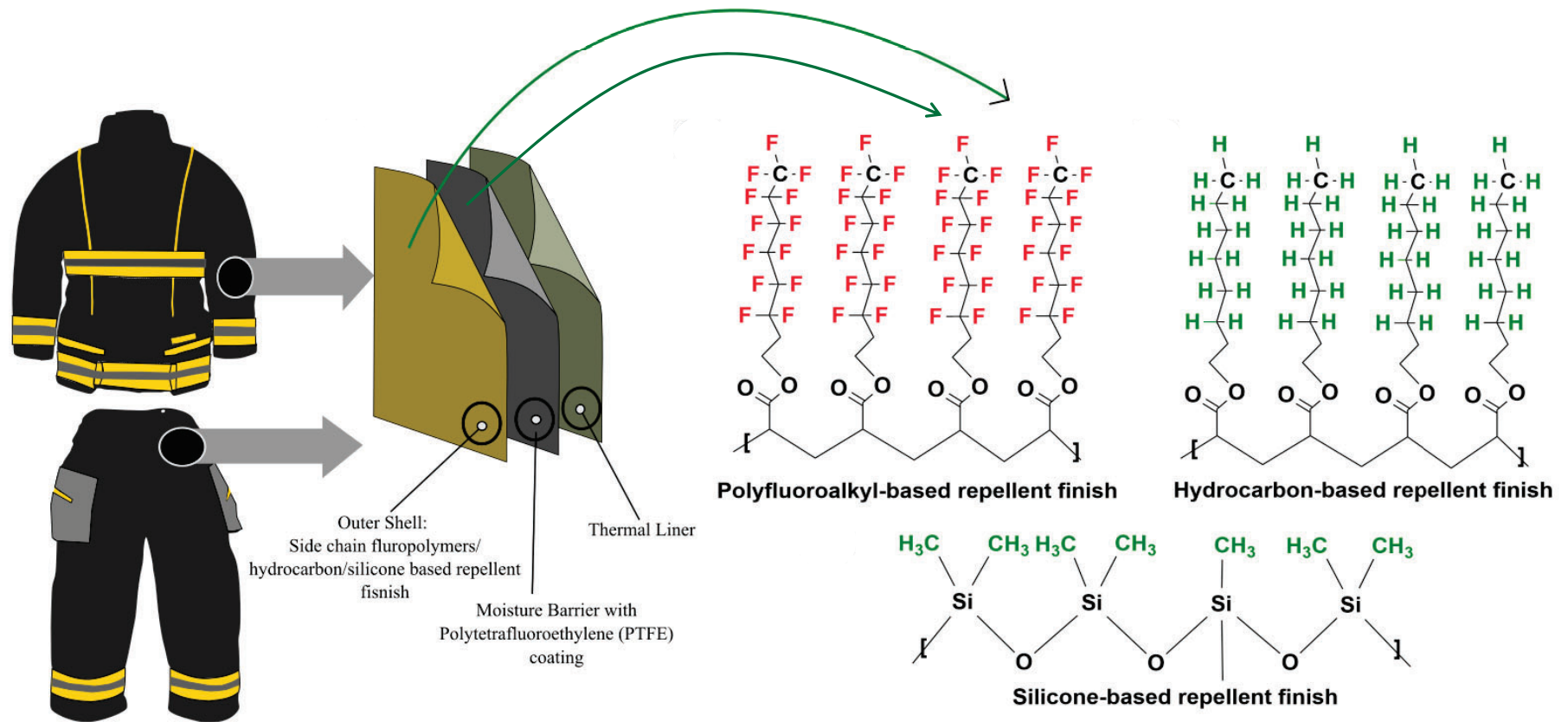
For a 30 mg sample, LOD is ~0.35 µg/g (PPM)

A photograph of two firefighters in full protective gear, including helmets and oxygen tanks, standing in front of a large fire. The scene is illuminated by the bright orange and yellow flames. A red banner is overlaid on the bottom half of the image, containing the title text.

State of PPE Material Transitions



State of Transition to Non-PFAS Finishes



Impact of Alternative Finishes on Wicking

- Expected loss of oil repellency
- Most commercially available alternative finishes are hydrocarbon wax-based
- Finish is very similar to hydrocarbon fuels
- Increases the wicking of diesel fuel across a larger surface area



**PFAS-Treated
Outer Shell**



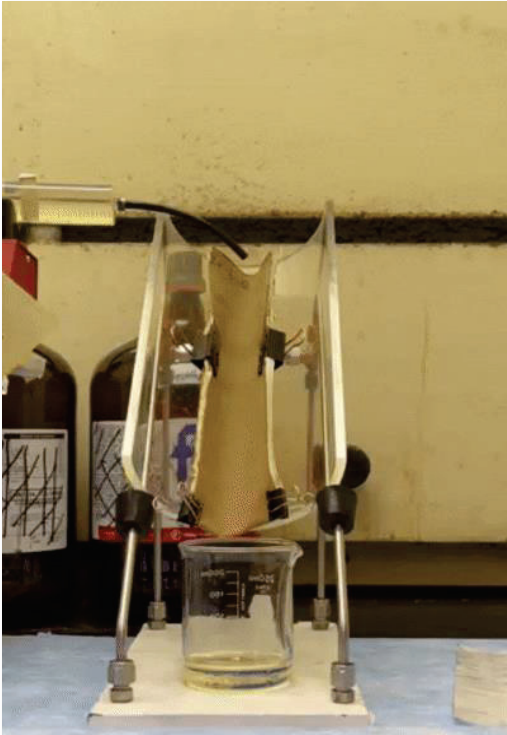
**Non-PFAS
Outer Shell**

**Traditional
PFAS-Treatment**

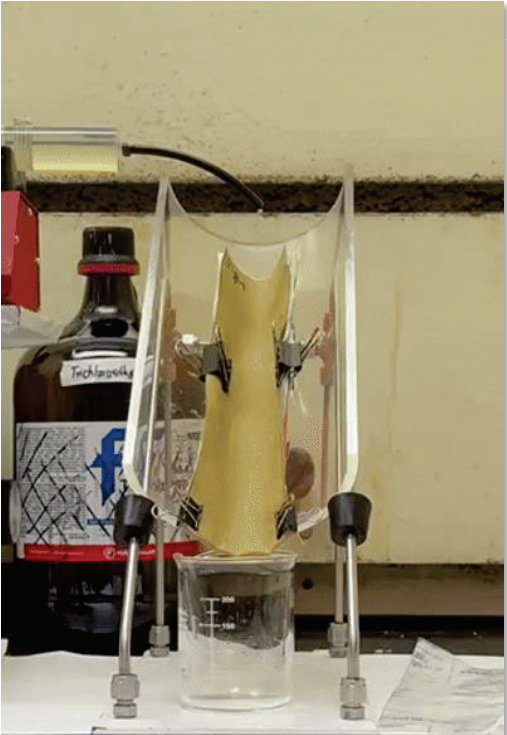
**PFAS Alternative
Hydrocarbon Wax**



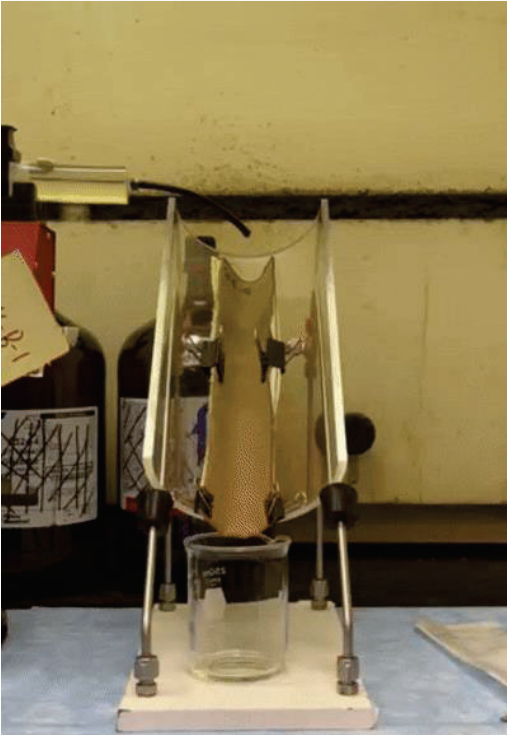
New



**Aged-
Contaminated**

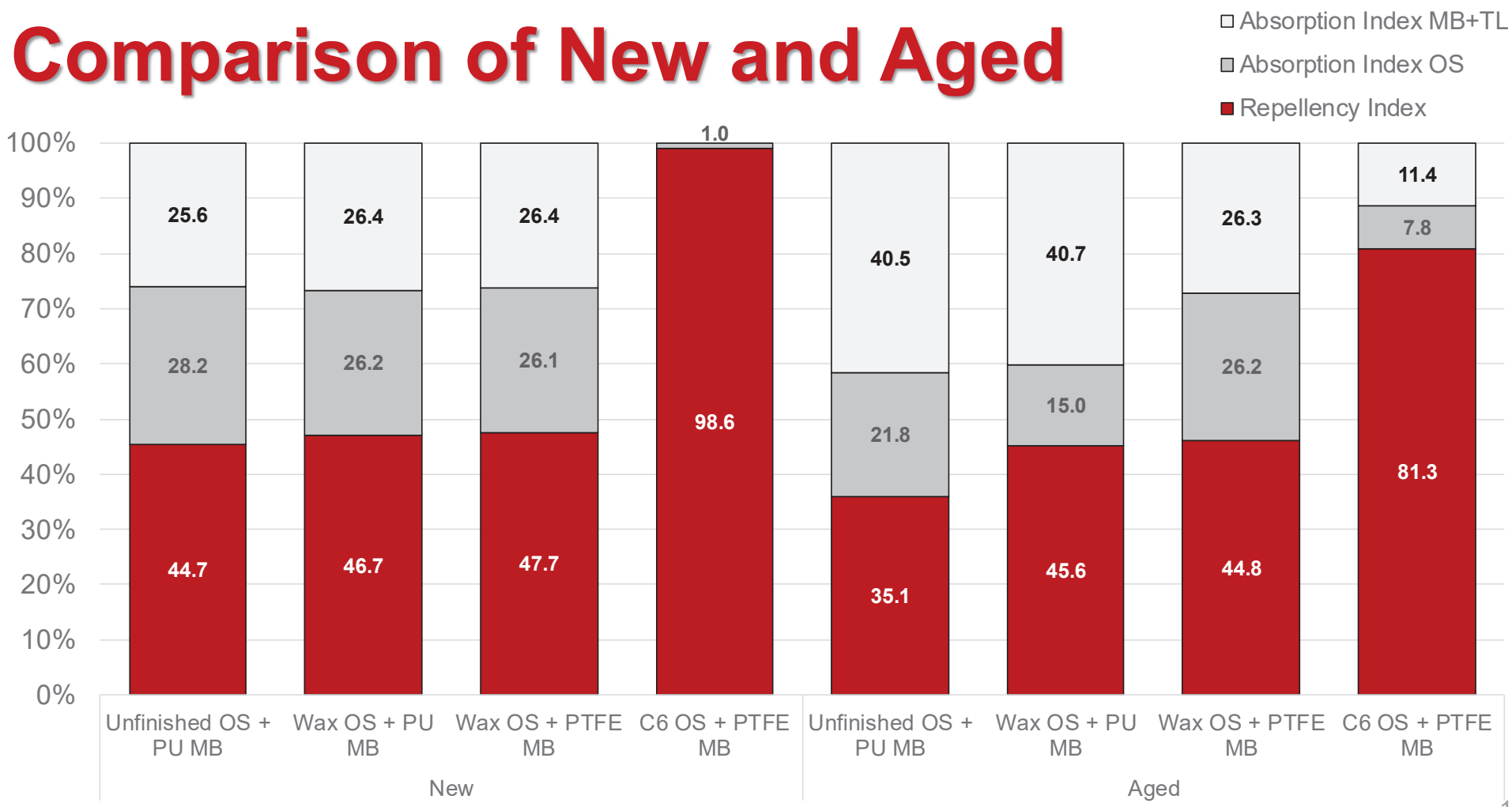


New



**Aged-
Contaminated**

Comparison of New and Aged



Outer Shell Non-Fluorinated

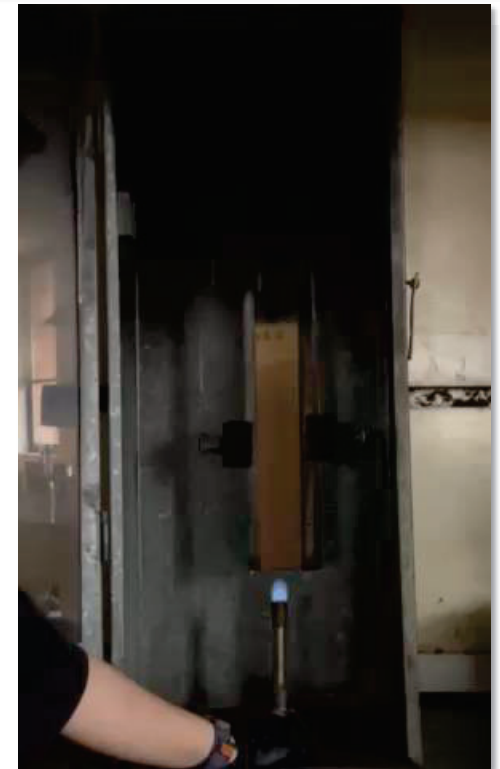
New (Single layer OS)



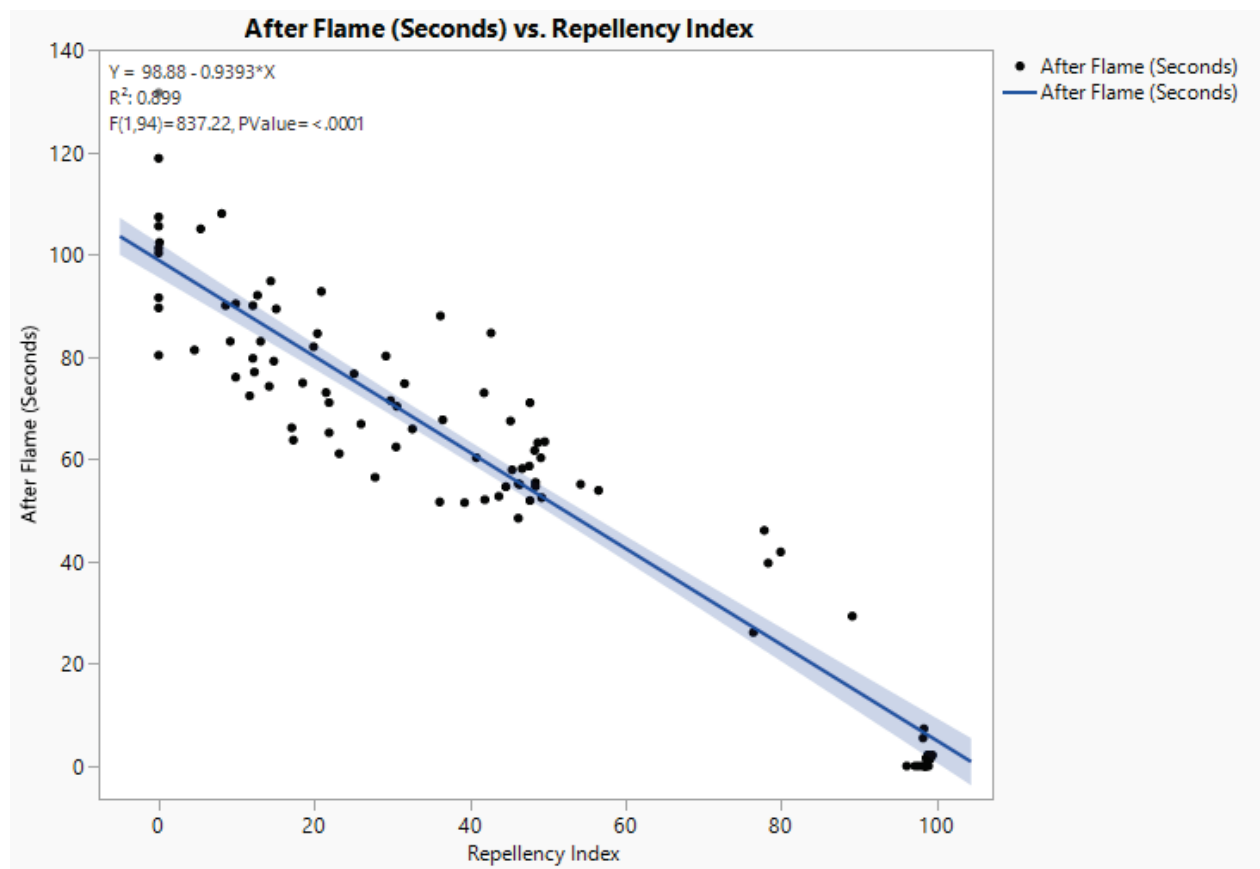
New (Composite)



Aged-Contaminated (Composite)



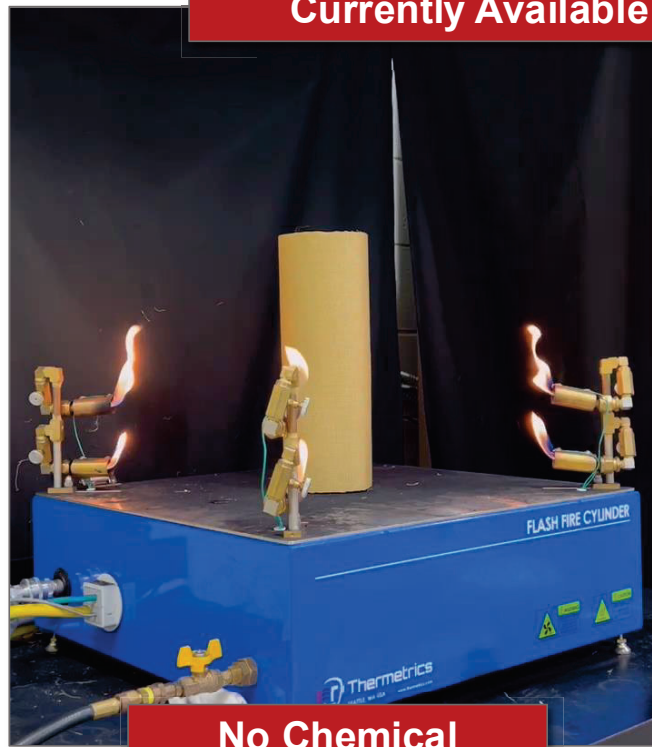
Relationship between Repellency and Flammability



Impact on Flammability and Burn Injury

- Fully non-PFAS composite “sleeve” on cylinder
- Exposed to 10 mL of diesel fuel ~5 minutes before test
- Record heat flux and energy transmitted through composite
 - Burn injury due to after-flame
- Diesel may represent a worse-case scenario
 - Spreads across fabric
 - Burns slowly

Currently Available Non-PFAS Composite



No Chemical
Splash



Splashed with 10mL
of Diesel Fuel

Outer Shell Fluorinated Composite

New



Aged-Contaminated

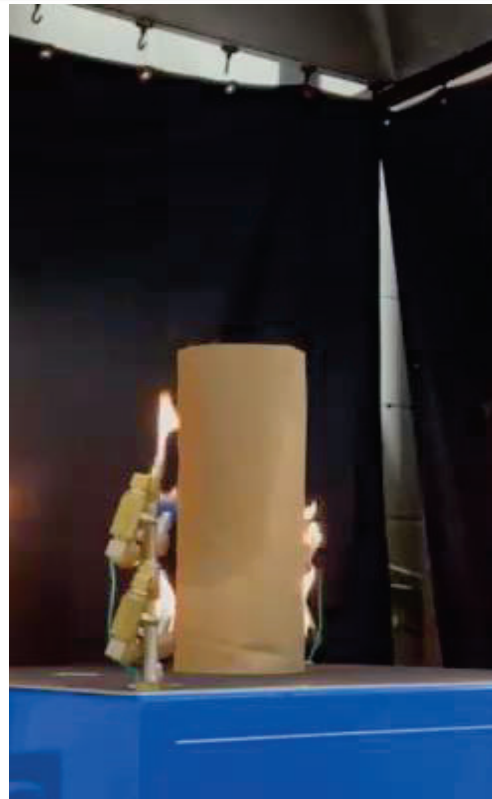


Outer Shell Non-Fluorinated Composite

Outer Shell Aged



Outer Shell New-Contaminated



Outer Shell Aged-Contaminated



State of Transition to Non-PFAS Barriers

- Remove PTFE from the moisture barrier
 - Alternatives could be based on polyurethane, polyester, polyethylene
- Multiple critical standard tests
 - *Light degradation*
 - Total heat loss and evaporative resistance
 - Water vapor transmission rate
 - Liquid and chemical penetration resistance
 - Viral penetration resistance
 - Heat and thermal shrinkage
 - Flammability
- Many changes for NFPA 1970 revision

Regular inspection of new barriers is critical



Critical Considerations

- There are available **alternatives**, but they are **not direct replacements** for traditional gear performance
- **Every firefighter must be trained on the differences** in non-PFAS gear performance before being issued the gear or wearing in emergency response
- As new gear is fielded, it is imperative to inspect and monitor its performance and durability regularly
- Re-evaluate expectations for turnout gear performance
 - It may not be possible from a material or chemistry perspective to replace the performance of PFAS materials
 - May impact work limits, rehab protocols, exposure guidelines



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PFAS & BFRs in Firefighter Turnout Gear: Which chemical class is the bigger concern?

Heather M. Stapleton¹, Nick Herkert¹, Derek Urwin², Bryan Ormond³

1. Duke University, Durham, NC

2. University of California Los Angeles, Los Angeles, CA

3. N.C. State University, Raleigh, NC



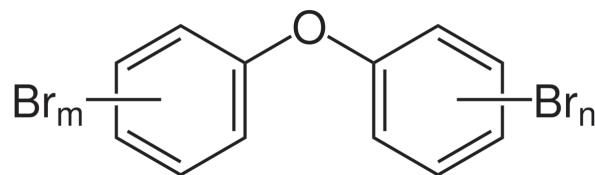
Source: <https://www.nist.gov/image/firefighter-turnout-gear-layers-new-textiles>

- PFASs are traditionally a component of the durable water repellent finish (DWR) of the Outer Shell (OS).
- Fluoropolymers (e.g. ePTFE) historically used in the moisture barrier (MB).
- Chemical treatments not typically applied to the thermal barrier/layer (TL), which serves as a heat barrier.

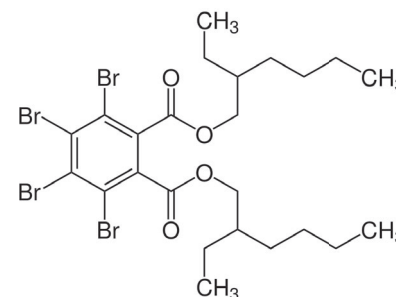
Research Question

If PFAS are no longer used, will other chemicals be used in their place? Are there BFRs present in turnout gear textiles?

- **Additive**

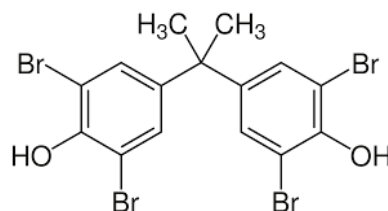


Polybrominated diphenyl ethers (PBDEs)

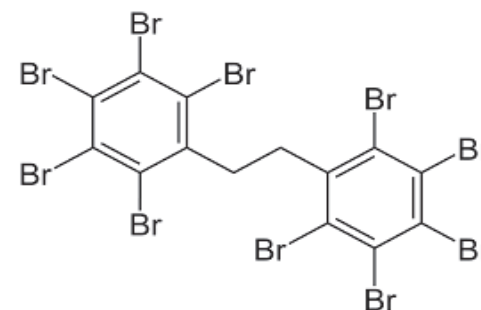


Bis (2-ethylhexyl) tetrabromophthalate

- **Reactive**

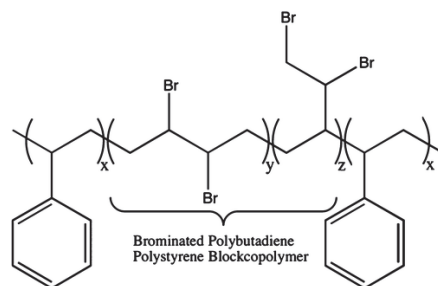


Tetrabromobisphenol A (TBBPA)



Decabromodiphenyl ethane (DBDPE)

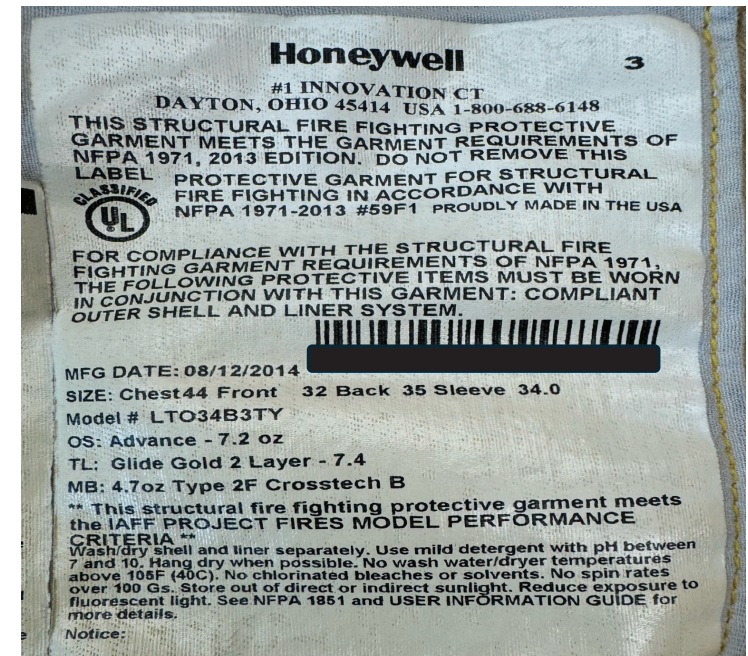
- **Polymeric**



METHODS

Turnout Gear Samples

- 12 used turnout gear garments were collected from fire service partners in California, Maryland and North Carolina.
- Separately tested each layer of each garment; Outer Shell (OS), Moisture Barrier (MB) and Thermal Liner (TL)
- Also tested two different versions/formulations of a new (from factory) moisture barrier advertised as non-PFAS treated (Stedair Clear)



Turnout Gear Samples

Group	Sample #	Type	Year of Manufacture	Outer Shell	Moisture Barrier	Thermal Liner
A	1	Jacket	06/2015	Advance, Tan	Crosstech Black 2F	Defender M SL2
	2	Jacket	10/2013	Gemini XT, Gold	Crosstech 3-Layer, 4A	Caldura NPi
	3	Jacket	08/2014	Advance	Crosstech Black 2F	Glide Gold 2 Layer
B	4	Pants	02/2016	Kombat Flex	Stedair Gold	Glide PBI G2
	5	Jacket	02/2016	Kombat Flex	Stedair Gold	Glide PBI G2
	6	Jacket	06/2016	Kombat Flex	Stedair Gold	Glide PBI G2
C	7	Jacket	10/2020	Gemini XT	Stedair 4000	Glide Ice 2 Layer
	8	Jacket	12/2020	Gemini XT	Stedair 4000	Glide Ice 2 Layer
	9	Jacket	05/2020	Gemini XT	Stedair 4000	Glide Ice 2 Layer
D	10	Jacket	03/2024	PBI Quilt	Stedair Clear	Glide Ice 2L PBI
	11	Pants	03/2024	PBI Quilt	Stedair Clear	Glide Ice 2L PBI
	12	Jacket	03/2024	PBI Quilt	Stedair Clear	Glide Ice 2L PBI

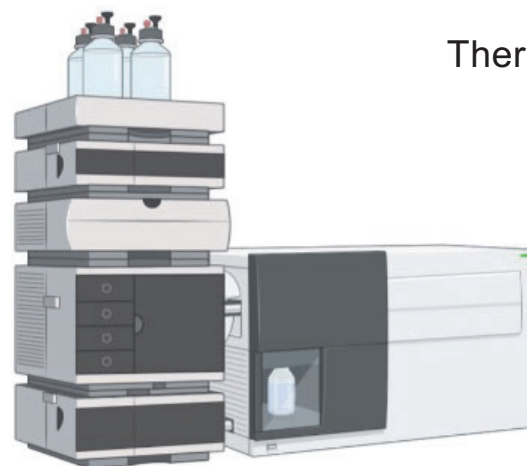
Non-PFAS Treated Gear

Methods

- Separated and individually tested the outer shell (OS), moisture barrier (MB) and thermal liner (TL) from each garment
 - Extracted 1 cm² of each fabric sample for 19 brominated flame retardants (BFRs) using GC-HRMS
 - Extracted 1 cm² of each fabric sample for 15 volatile PFAS using GC-HRMS
 - Extracted 1 cm² of each fabric sample using methanol for 43 non-volatile PFAS using LC-MS/MS



Thermo Orbitrap GC-HRMS

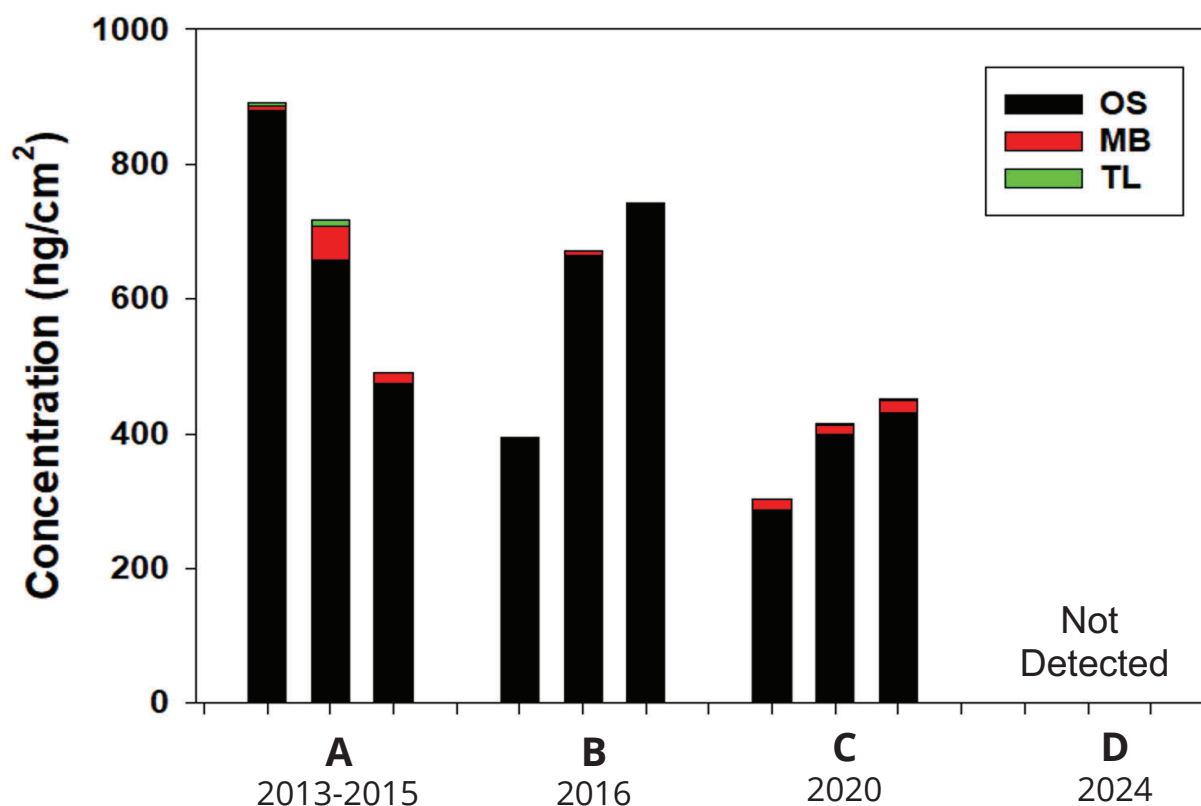


Agilent LC-MS/MS

PFAS Results

Total PFAS by Garment

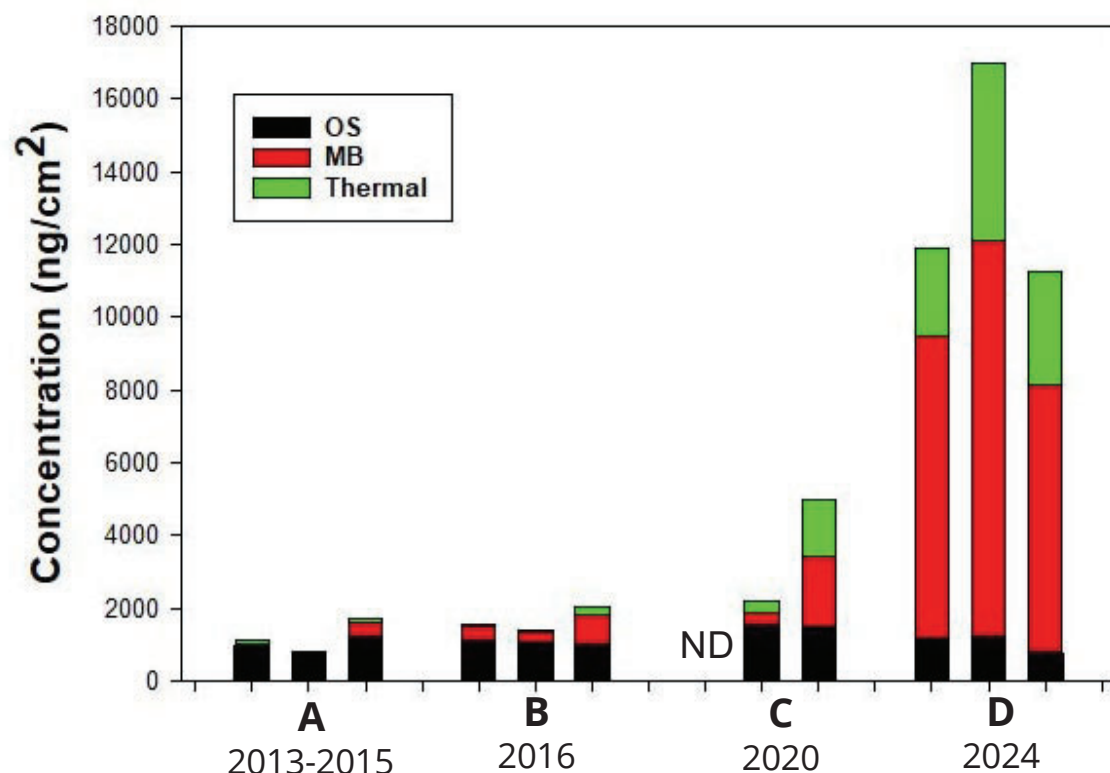
- PFAS detected & quantified in all garments except the non-PFAS treated samples
- Extractable PFAS was primarily in the Outer Shell of all garments, ranging from 305-900 ng/cm²
- 6:2 FTMAC dominated PFAS in the Outer Shell textiles
- Types of PFAS in moisture barriers varied; included PFAAs, FTMACs and MeFBSE



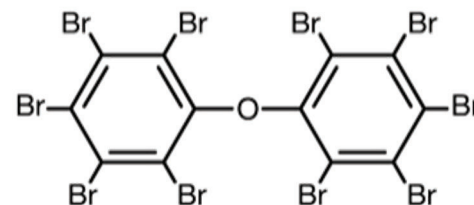
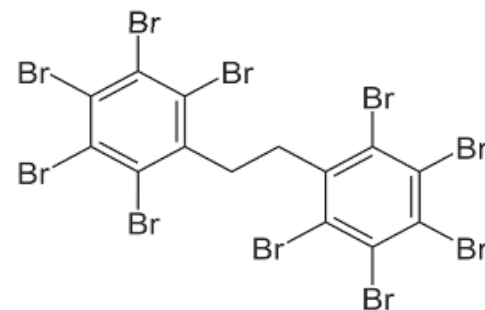
BFR Results

Total BFRs by Garment

- BFRs detected & quantified in all garments but one
- Older garments had more BFRs in the outer shell
- Non-PFAS treated gear had the highest amount of BFRs in the moisture barrier and thermal liners (>90% was all DBDPE)
- BFRs in moisture barriers of Groups A, B and C were significantly lower and varied in composition



- **BDE-209** is a brominated flame retardant (BFR)
 - Phased out due to toxicity¹
 - Serum levels of BDE-209 were elevated in a 2012 study of CA firefighters²
- **DBDPE** is a BFR that replaced BDE-209 in many applications
 - Molecular structure similar to BDE-209
 - Similar toxicity concerns regarding DBDPE³
 - No studies have measured DBDPE in firefighter serum

BDE-209**Global Restrictions****DBDPE**

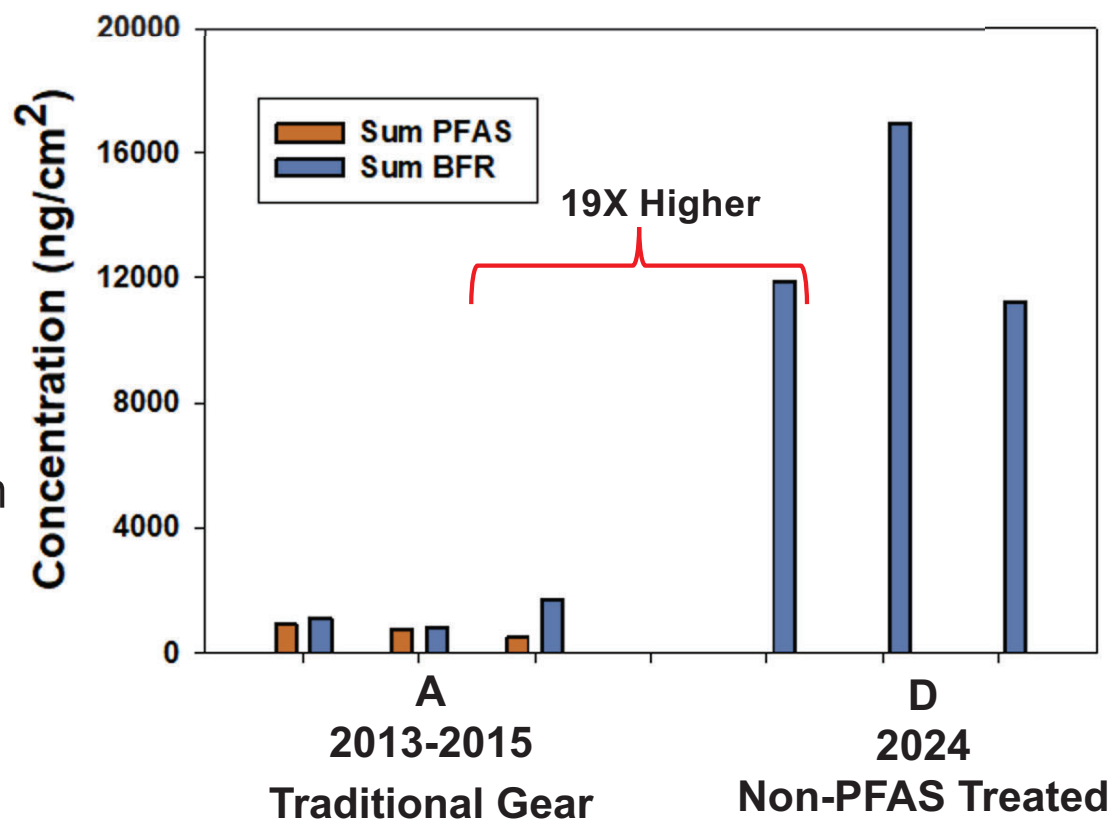
[1] Sun, Yuqiong, et al. "A critical review on BDE-209: Source, distribution, influencing factors, toxicity, and degradation." *Environment International* (2023): 108410.

[2] Park, June-Soo, et al. "High exposure of California firefighters to polybrominated diphenyl ethers." *Environmental science & technology* 49.5 (2015): 2948-2958.

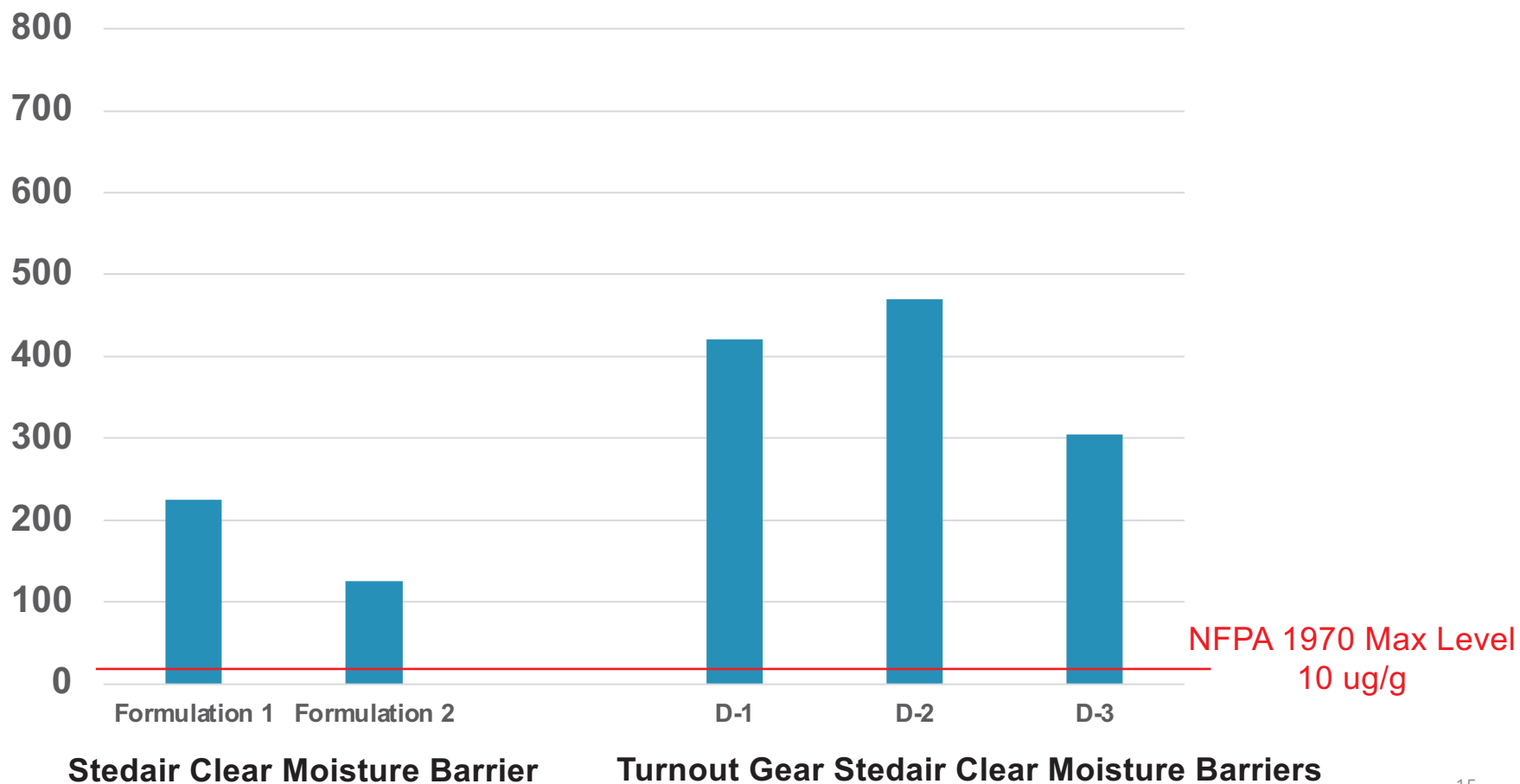
[3] Wang, Rui, et al. "New brominated flame retardant decabromodiphenyl ethane (DBDPE) in water sediments: A review of contamination characteristics, exposure pathways, ecotoxicological effects and health risks." *Environmental Pollution* (2023): 122121.

Older vs New Turnout Gear

- Traditional turnout gear contains both intentionally added PFAS & accumulated BFRs from use/exposure
- Current non-PFAS treated gear using a Stedair Clear moisture barrier contains an intentionally added BFR at levels that are higher than intentionally added PFAS in the traditional gear



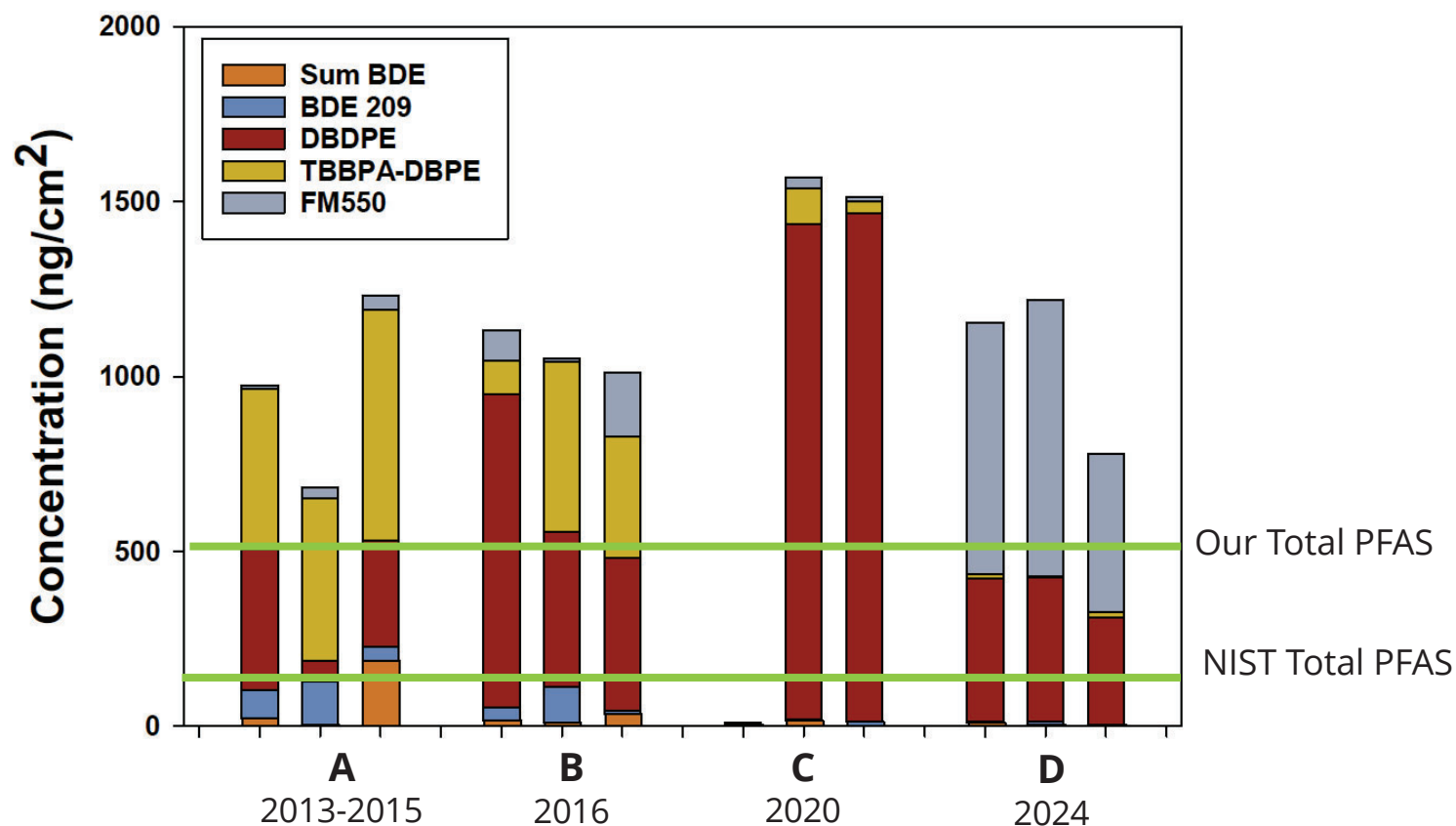
DBDPE Levels in Micrograms per Gram (ug/g)



BFR Levels in Outer Shell of Used Gear

BFRs in Outer Shell

- What is the source of the BFRs?
- These BFRs are among the more hydrophobic BFRs
- May reflect chemicals that accumulate over time and are NOT washed off



Source: Maizel et al. 2023
<https://doi.org/10.6028/NIST.TN.2248>

Implications & Future Areas for Study

- We were limited to testing one type of non-PFAS treated gear; other manufacturers are planning to roll out more options in the near future which may look very different than Stedair Clear.
- These results do not tell us whether firefighters are receiving exposure to these chemicals directly from the turnout gear; more research is needed

Acknowledgements

- **NC Collaboratory**
- **Duke Cancer Institute**
- **Annie & Michael Falk Foundation**

Duke University:

- Kate Hoffman, PhD
- Lee Ferguson, PhD
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- Alex Beste
- Duncan Hay
- Sharon Zhang

University of Arizona

- Jeff Burgess, PhD
- Shawn Beitel
- Olivia Healy
- James Hollister
- Krystal Kern

NC State University:

- Jane Hoppin, PhD

Fire Service Partners:

- Corey Miller (Durham)
- IAFF





Questions?

PPE Research

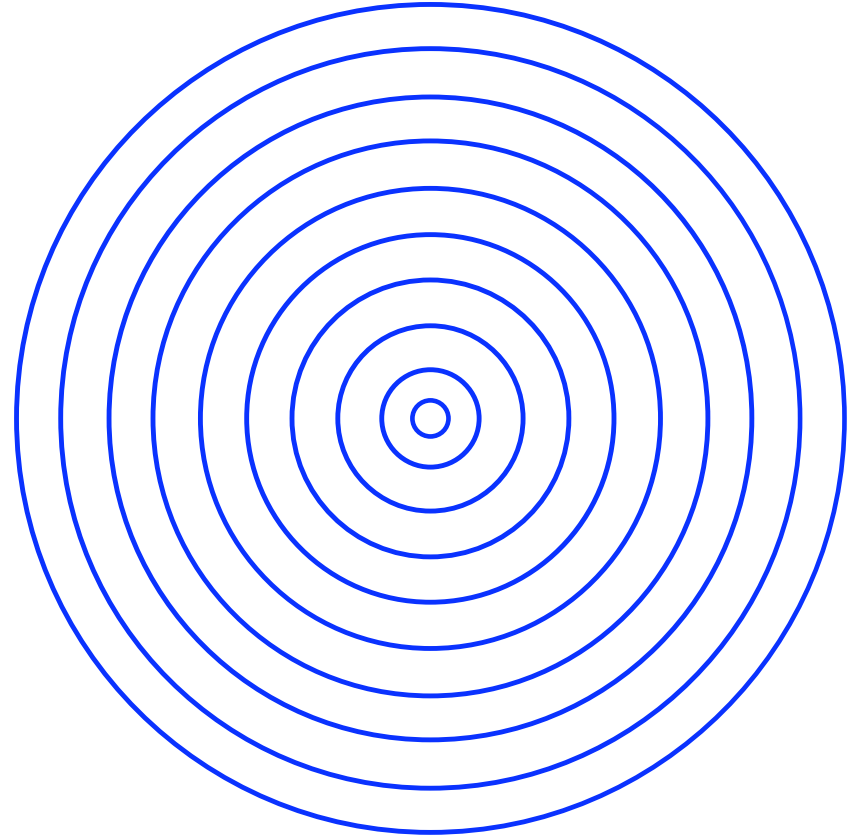
Updates on FSRI's PPE related research

Richard Kesler
April 2, 2025

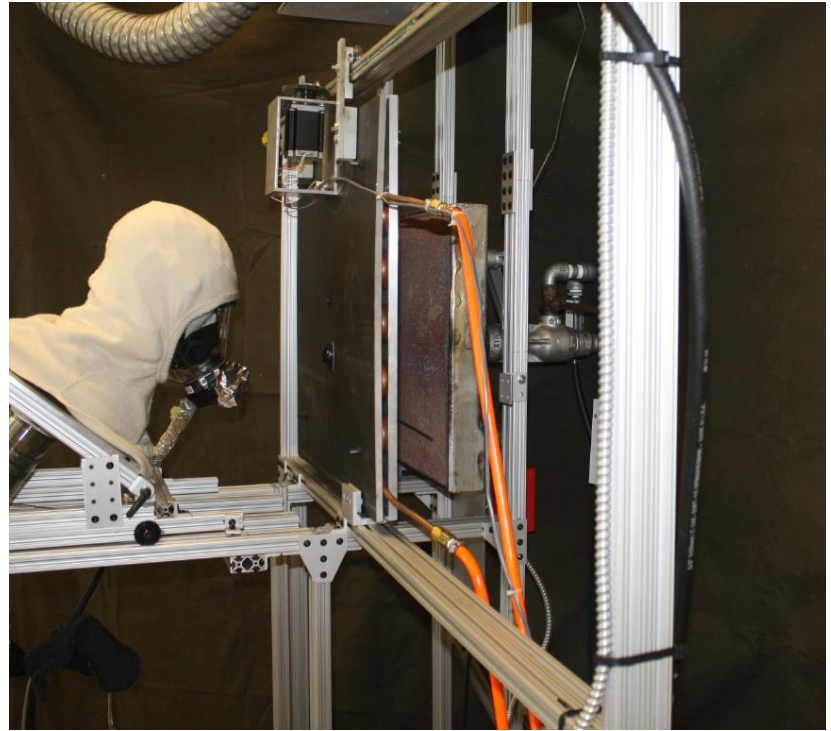


**Fire Safety
Research Institute**

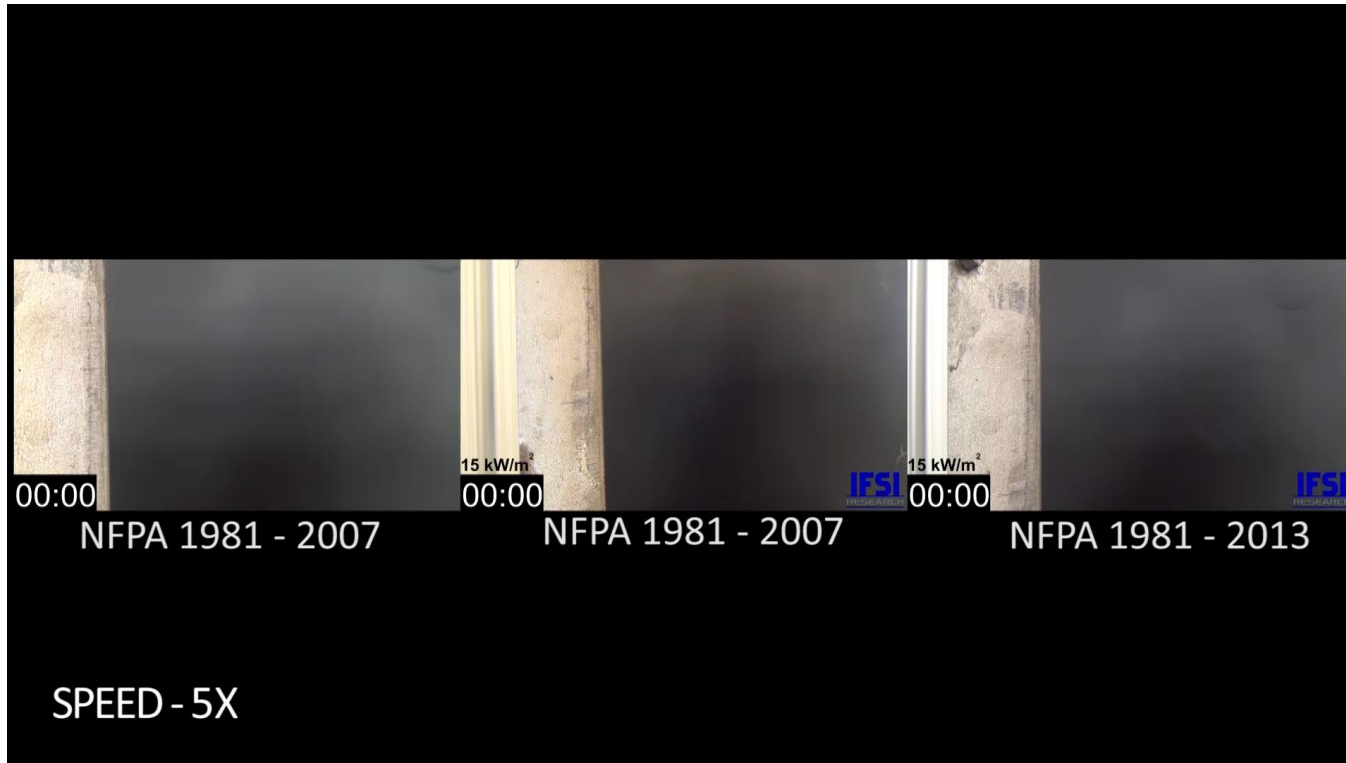
SCBA Facepiece Thermal Properties



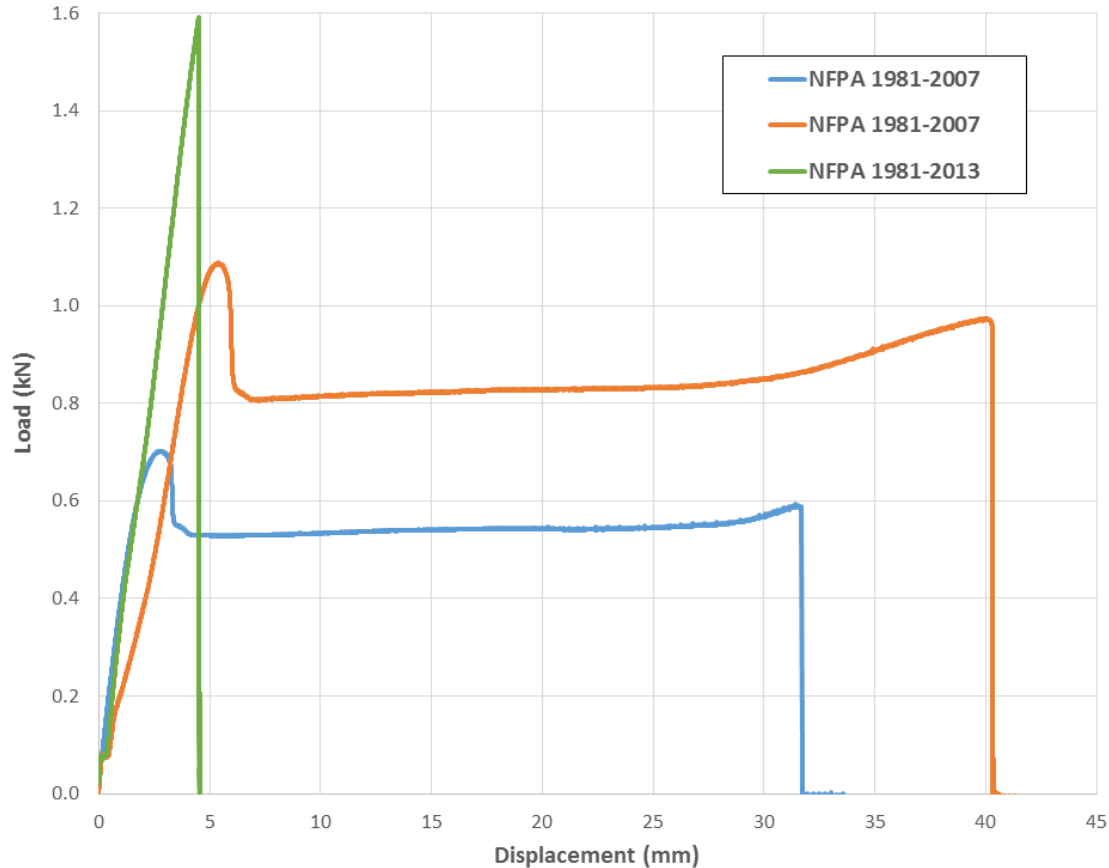
Thermal Exposure to SCBA Facepiece



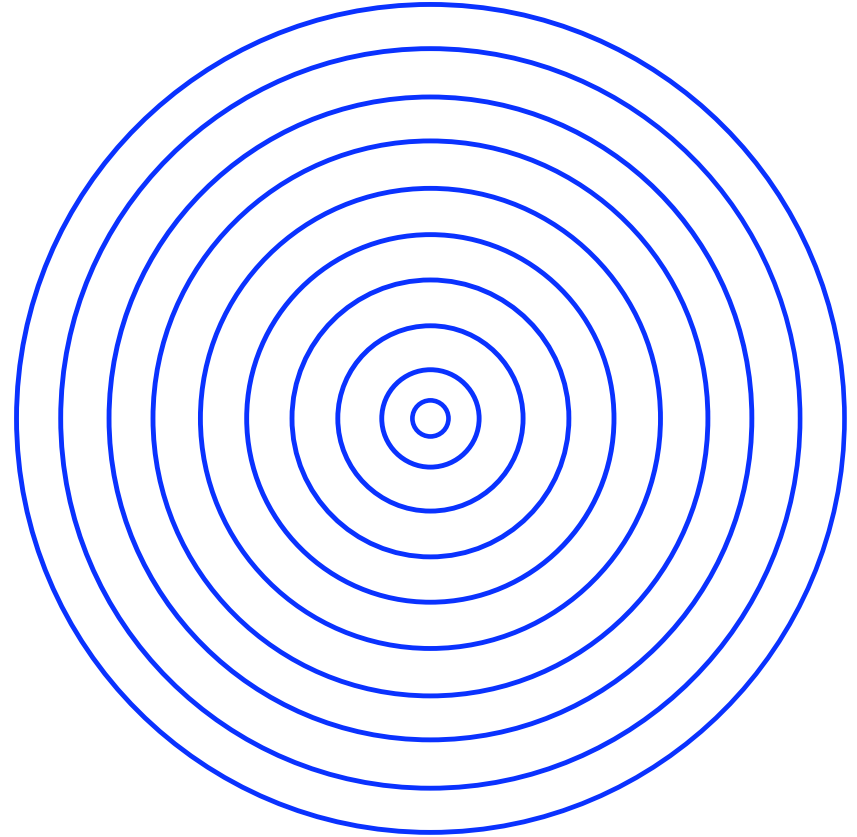
Thermal Exposure to SCBA Facepiece



Tensile Testing of SCBA Facepieces



Assessments of Particulate Blocking Hoods

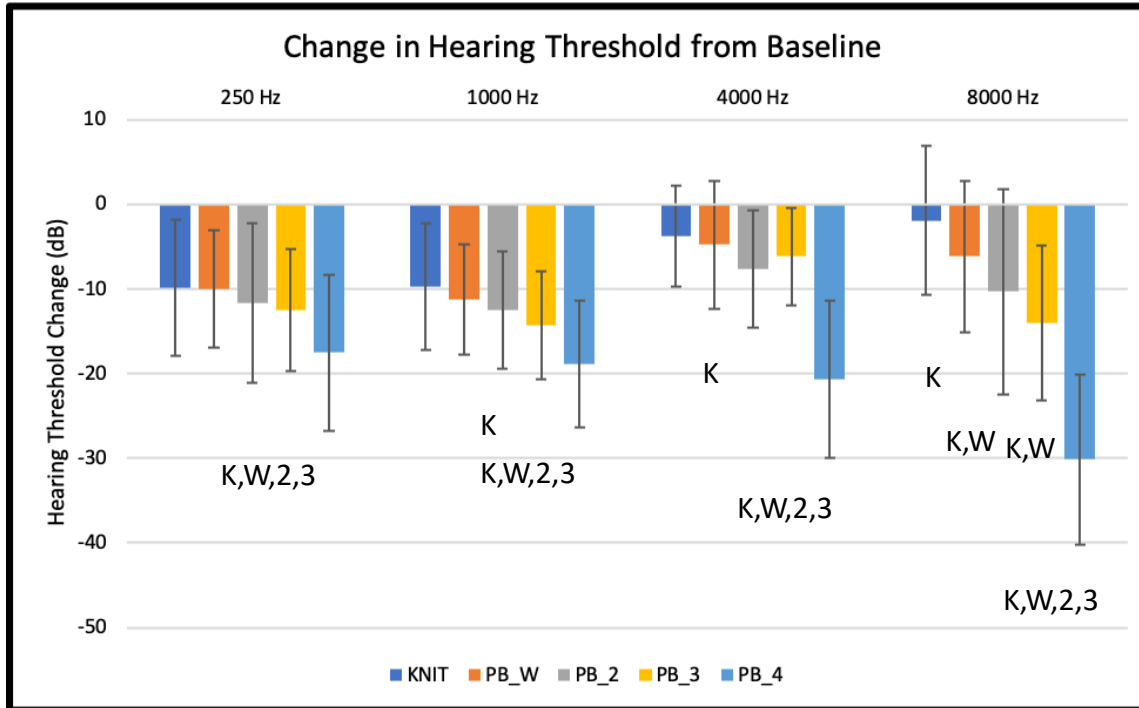


Phase I - Laboratory Based Measures

Hoods	Construction	Particulate Blocking Technology
Control	Control, no hood worn	None
Nomex	Nomex blend, 2-ply	None
PB_W	Particulate blocking, PBI/Lenzing	Quilted Barrier
PB_2-ply	Particulate blocking, Nomex, 2-ply	Bonded blocking layer
PB_3-ply	Particulate blocking, Nomex blend, 3-ply	Non-bonded blocking layer
PB_4-ply	Targeted Particulate Blocking, Ultra CG/Melange/CG Heavy Weight Twill, 4-ply	Non-bonded blocking layer

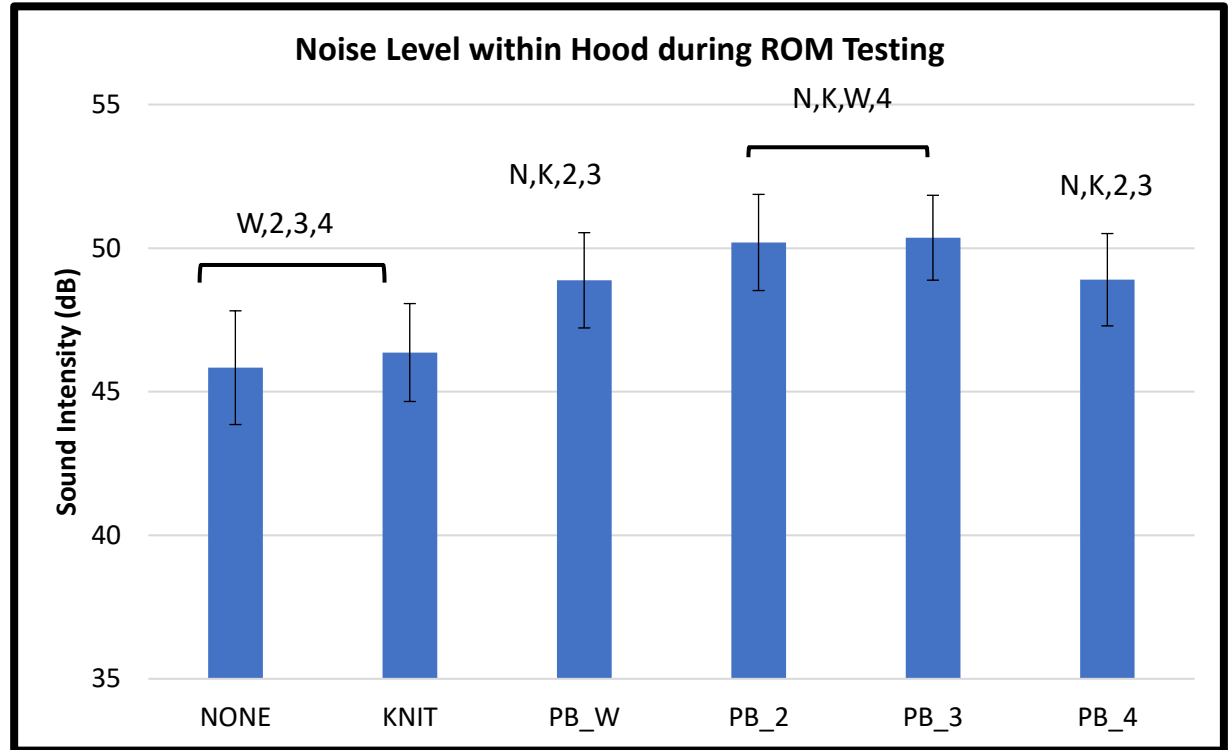
Laboratory Based Measures- Communication

Hearing Reduction

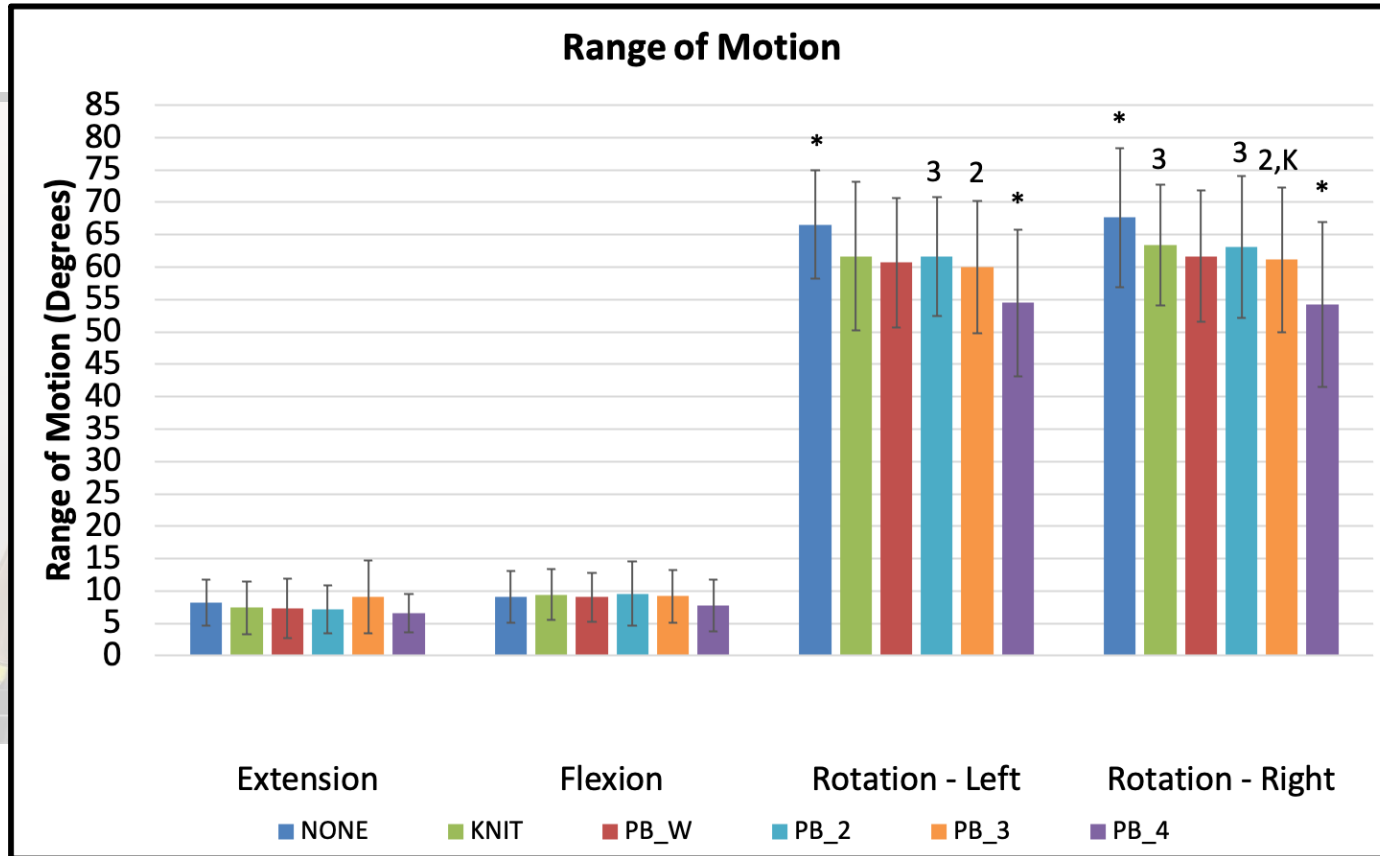


Laboratory Based Measures- Communication

Noise Production



Laboratory Based Measures – Range of Motion



Phases II - Fireground Activity

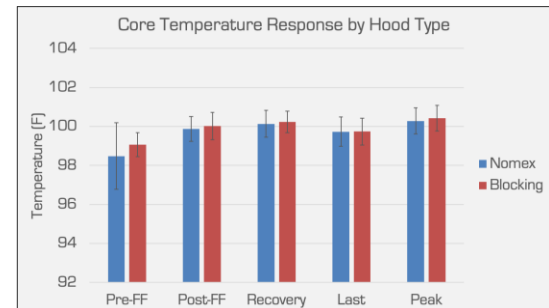
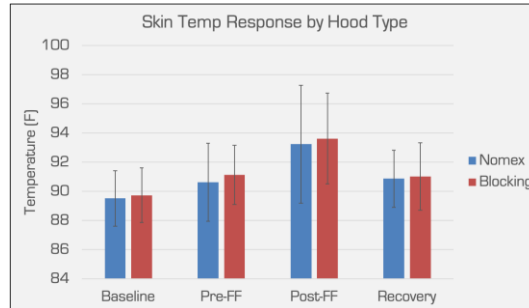
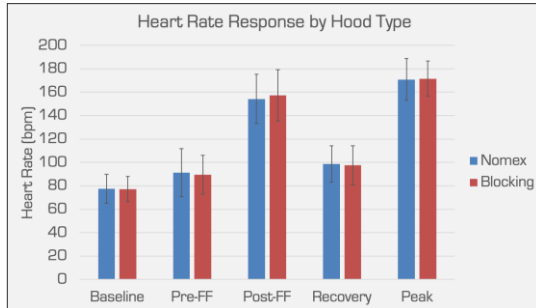


Phase II - Fireground Activity/Physiological

Measures of:

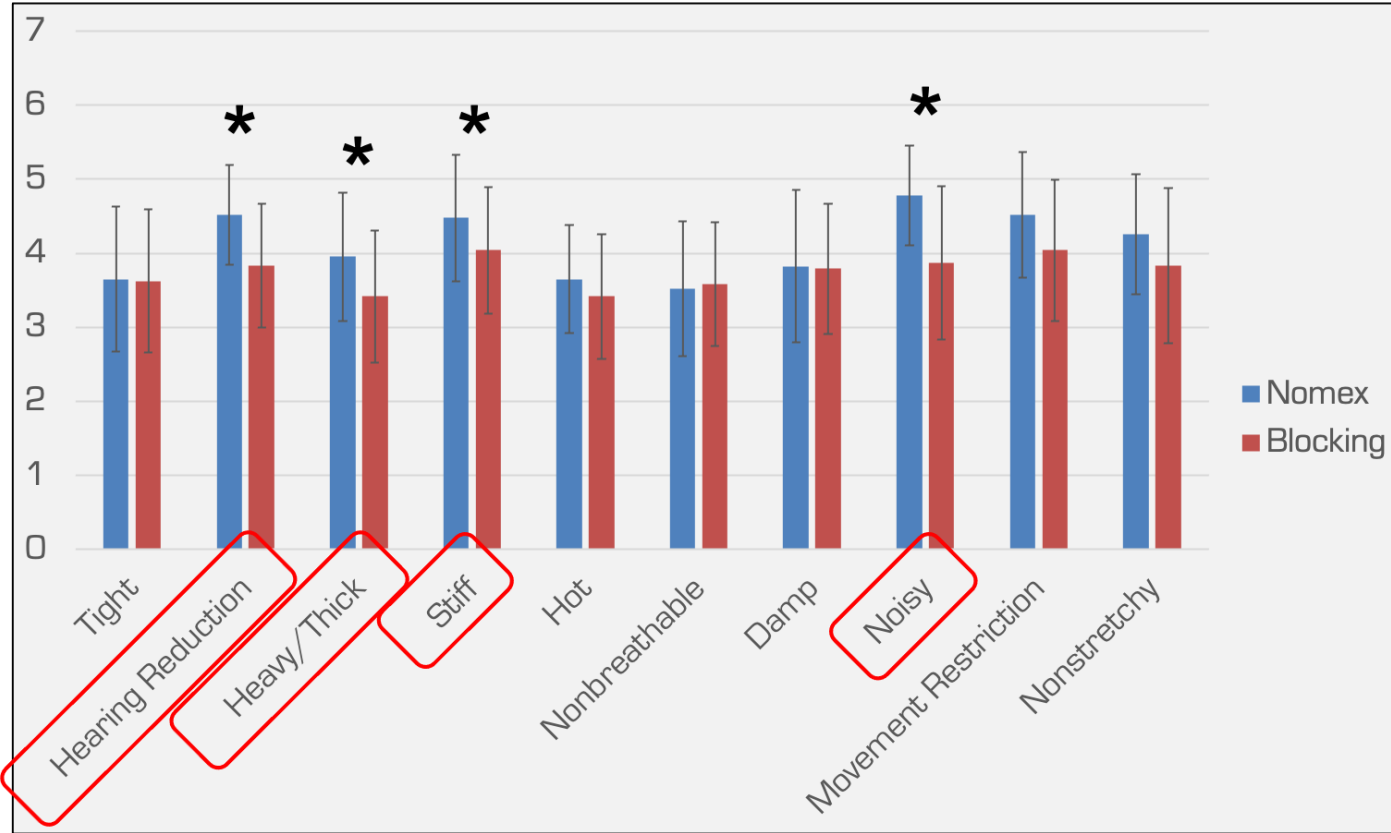
1. Heart Rate
2. Skin Temperature
3. Core Temperature

Hoods	Construction	Particulate Blocking Technology
Nomex	Nomex blend, 2-ply	None
PB_3-ply	Particulate blocking, Nomex blend, 3-ply	Non-bonded blocking layer



Property Perceptions (Post 1-bout Firefighting)

More negative perception



Hood Contamination

Hood Design	Location	N	% non-detects ^A	Median	Mean	Range
New-Knit (K)	Inner					
	Outer	3	0%	1,800	1,440	560 – 1,970
New-Blocking (B)	Inner					
	Outer	9	0%	1,500	2,600	570 – 7,710

K - Outside



K - Inside



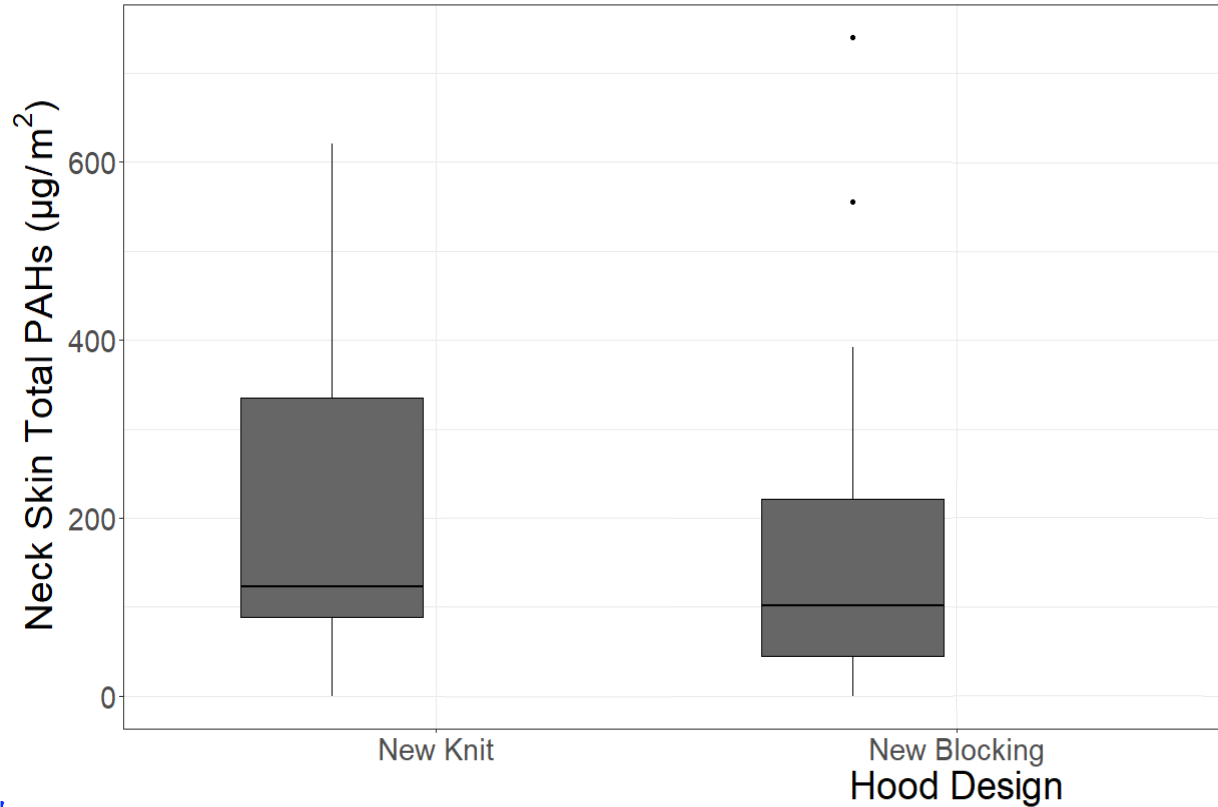
B - Outside



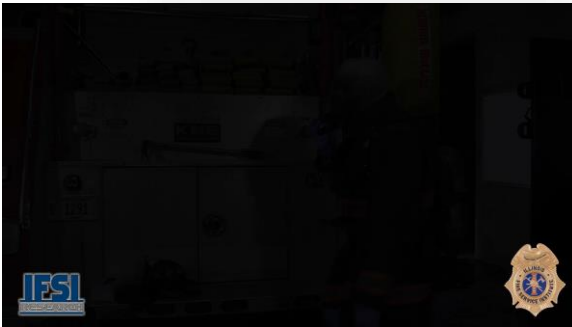
B - Inside



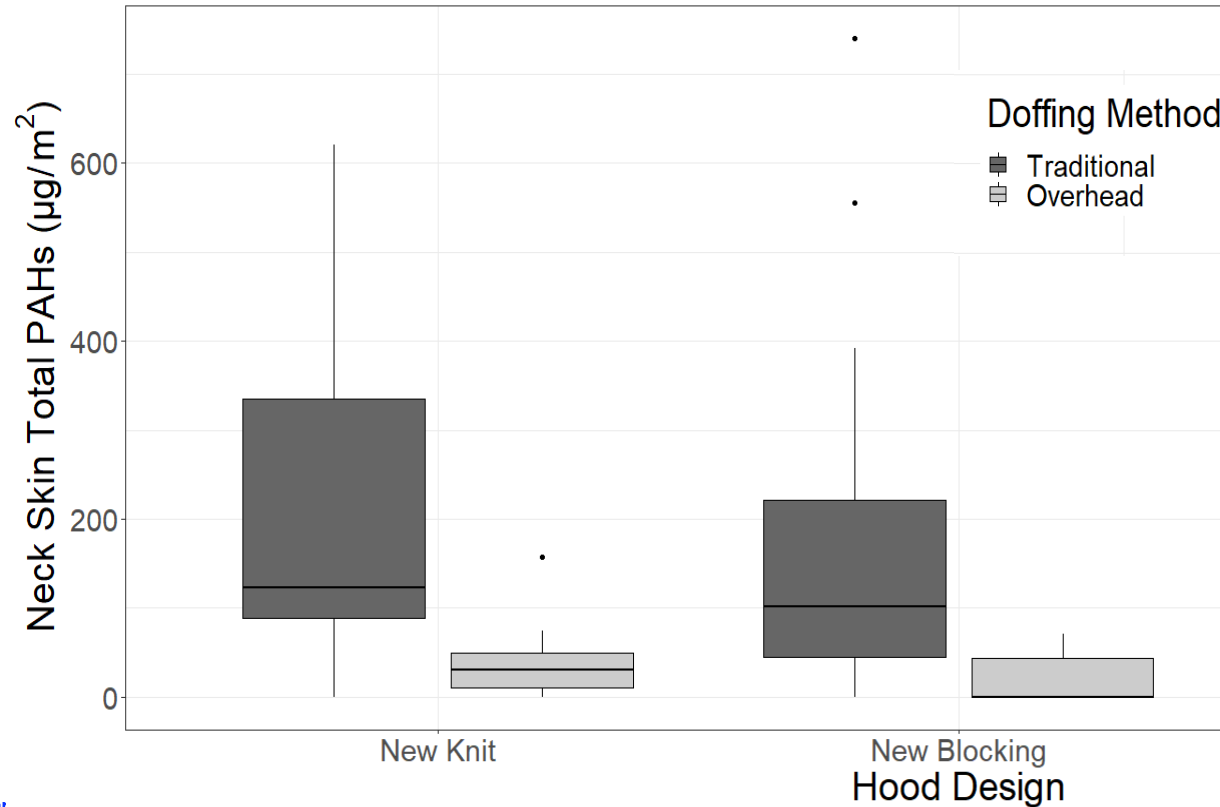
Neck Skin Contamination



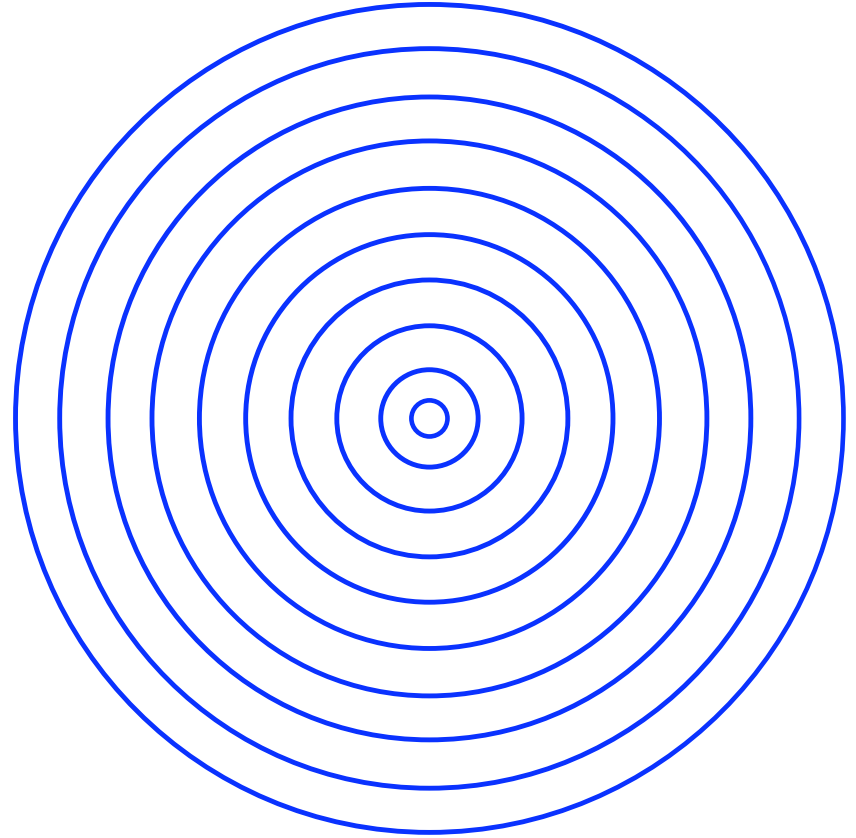
Traditional vs Overhead Doffing



Traditional vs Overhead Doffing



Repeated Exposure and Cleaning Cycles



The Fireground Exposure Simulator (FES)

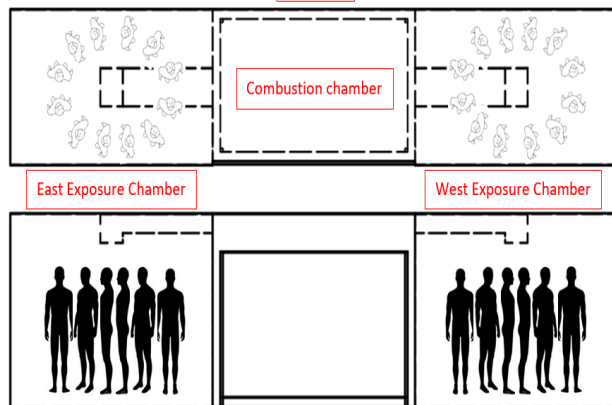
Fire Technology
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Manufactured in The United States
<https://doi.org/10.1007/s10694-020-00981-3>



Development of Fireground Exposure Simulator (FES) Prop for PPE Testing and Evaluation



Top view



Front view

FES produces...

Thermal conditions similar to
Search & Rescue teams from
Fireground Study

PAH & Benzene concentrations
at and above upper range
measured from Fire Attack
teams from Fireground Study

IFSI
RESEARCH

National Institute for
Occupational Safety and Health
NIOSH



PPE Cleaning Methods



Machine Laundering



**Wet Soap Decon/
Preliminary Exposure
Reduction (PER)**



Dry Brush Decon

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RESEARCH

National Institute for
Occupational Safety and Health
NIOSH



PPE performance testing

Samples from

- New PPE
- Post-10, 20, 40 exposure/cleaning cycles

NFPA standard tests

- Tear strength
- Seam strength
- Char length
- THL
- TPP
- Liquid penetration



Fire Technology
© 2020 The Author(s)
Manufactured in The United States
<https://doi.org/10.1007/s10694-020-01021-w>

Check for updates

Impact of Repeated Exposure and Cleaning on Protective Properties of Structural Firefighting Turnout Gear

**Gavin P. Horn, Richard M. Kesler, Hannah Newman, Jacob W. Stewart and Denise L. Smith, Illinois Fire Service Institute, University of Illinois at Urbana-Champaign, MC-675, 11 Gerty Drive, Champaign, IL 61820, USA
Gavin P. Horn and Steve Kerber, UL Firefighter Safety Research Institute, Columbia, MD, USA
Jessica Andrews, UL LLC, Research Triangle Park, NC, USA
Kenneth W. Fent, National Institute for Occupational Safety and Health, Cincinnati, OH, USA
Denise L. Smith, Skidmore College, Saratoga Springs, NY, USA*



After only 5 exposures



IFSI
RESEARCH

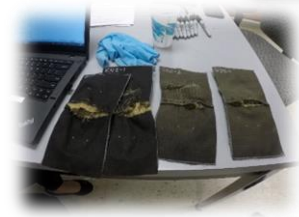
National Institute for
NIOSH Occupational Safety and Health



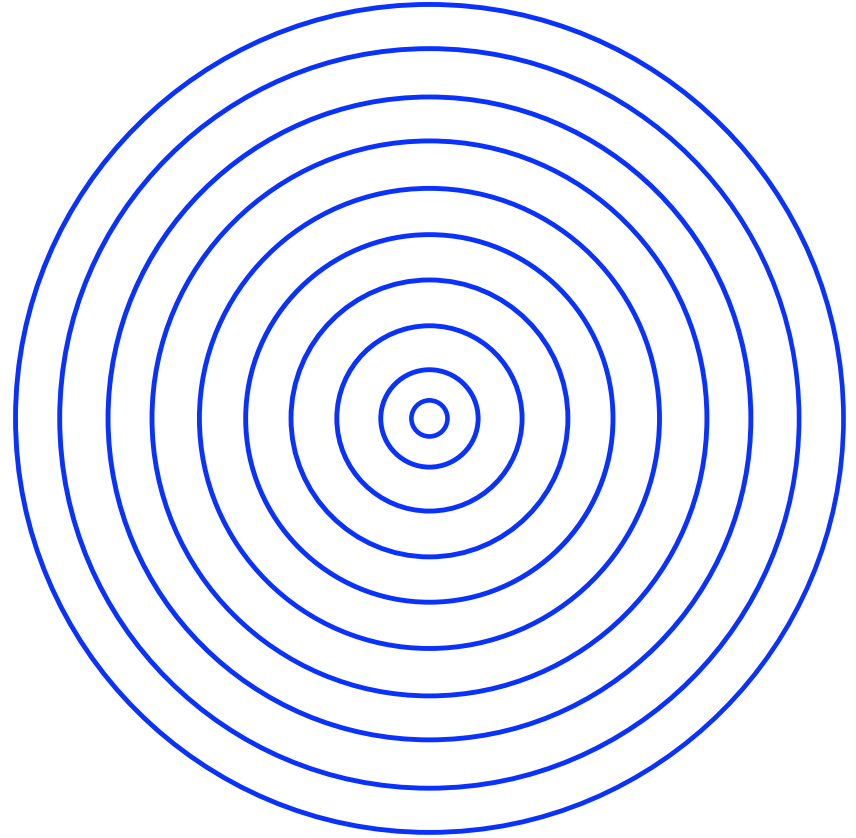
PPE Protection & Repeated Cleaning

Important take home messages :

1. Repeated laundering reduced tear strength of the outer shell and thermal barrier compared to the new samples and more so than wet or dry decontamination.
2. After 40 laundering cycles, outer shell tear strength and seam strength drops below NFPA 1971 required levels set for new PPE.
3. Wet soap decontamination was negatively associated with moisture barrier seam strength but did not increase char length.
4. THL was reduced for all samples with a cleaning treatment while TPP was only increased in the treatments that included a laundering treatment.
5. PPE built with hook & dee closures had lower outer shell tear strength and reduced performance in the liquid penetration test.



On-going PPE and Contamination Research



Material Properties

– Thermal Response of PPE

- Convective Exposures
- Time to $T_{\text{skin}} = 55^{\circ}\text{C}$
- Exposure $>100^{\circ}\text{C}$ resulted in decreased safe operational time

– Materials and Products Database

- Repository of materials properties
- Adding PPE components



EV Suppression Tests

- Firefighting Techniques
 - Standard firefighting equipment
 - EV specific techniques
- Contamination
 - Chemical Concentrations in Air
 - Water Run-off
 - Turnout Contamination and Laundering
 - Worker Protection Factors



PPE Contamination and Protection

- **Turnout Swatches**

- PAH and Heavy Metal Contamination
- Contamination Removal
 - Traditional vs CO₂ Cleaning

- **Air Sampling**

- Active Air Sampling
- Passive Air Sampling
 - Inside vs Outside PPE





Fire Safety
Research Institute

Thank you

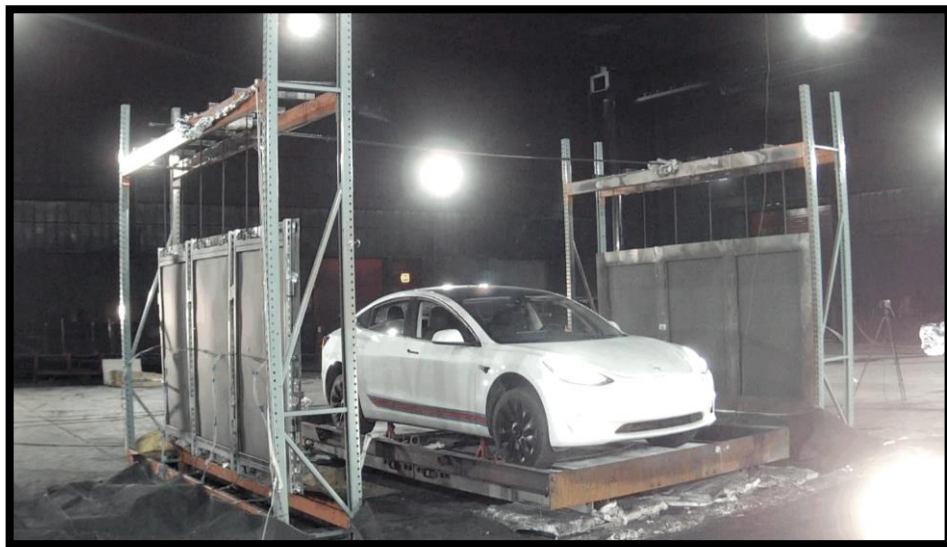
Richard Kesler

Richard.Kesler@ul.org

UL.org

Discoveries in Safety™

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ASTM INTERNATIONAL

Safety Equipment Institute

NFPA 1970 Workshop

April 2-3, 2025
Benjamin Hanna
SEI Program Manager
bhanna@seinet.org

www.seinet.org

What is SEI?



- Non-profit charitable organization which operates a voluntary certification program open to all manufacturers
- Established in 1981 from interest among users and manufacturers due to concerns over the potentially poor-quality products being sold in North America
- Became an affiliate of ASTM International in 2016
- Accredited to ISO 17065, *General Requirements for Bodies Operating Product Certification Systems*, by A2LA



SEI's Mission



Initially established to assist government agencies, users, and manufacturers in meeting their mutual goals of protecting those who use safety equipment to protect from potential hazards, both occupationally and recreationally

To aid advancements in protective equipment technology, using recognized standards and state-of-the-art test facilities

To support manufacturers and users by providing an easily recognized mark for certified products



SEI Certification Programs



Fire & Emergency Services

- Structural and Proximity Firefighting
- HazMat
- Wildland & Urban Interface
- Emergency Medical Operations
- Technical Rescue
- Station/Work Uniforms
- SCBA & PASS Devices
- Thermal Imagers
- Radios

Sports & Recreation

- Helmets & Faceguards (Football, Baseball, Softball, Lacrosse, Polo)
- Soccer Shin Guards
- Baseballs & Lacrosse Balls
- Baseball & Lacrosse Chest Protectors
- Equestrian Helmets & Body Protectors
- Eyewear for Women's Lacrosse & Field Hockey
- Head Protectors for Women's Lacrosse

Law Enforcement

- Bomb suits
- Less Lethal Aerosol Devices
- Restraints

Industrial & Occupational Safety

- Head Protection
- Eye/Face Protection
- Fall Protection
- Protective Footwear
- Industrial Flash Fire
- Emergency Eyewash/Shower Equipment

How Does the Certification Program Work?



Use of the SEI Mark



- Products certified by SEI are permitted to display the SEI Mark on the certified product
- In addition to the SEI Mark, some standards, such as NFPA 1970, require written compliance statements

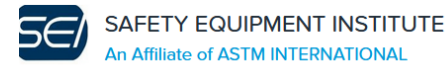


Verifying an SEI Certification



seinet.org/search.htm

- Online Certified Product List
 - Search field or use drop down navigation
- Email info@seinet.org



CERTIFIED PRODUCTS | PROGRAMS ▾ | SAFETY ALERTS | NEWS | ABOUT

Certified Products

Search the SEI Certified Product List

Search

Search Program, Product, Organization, Brand Name, Model Number



Clear Filter

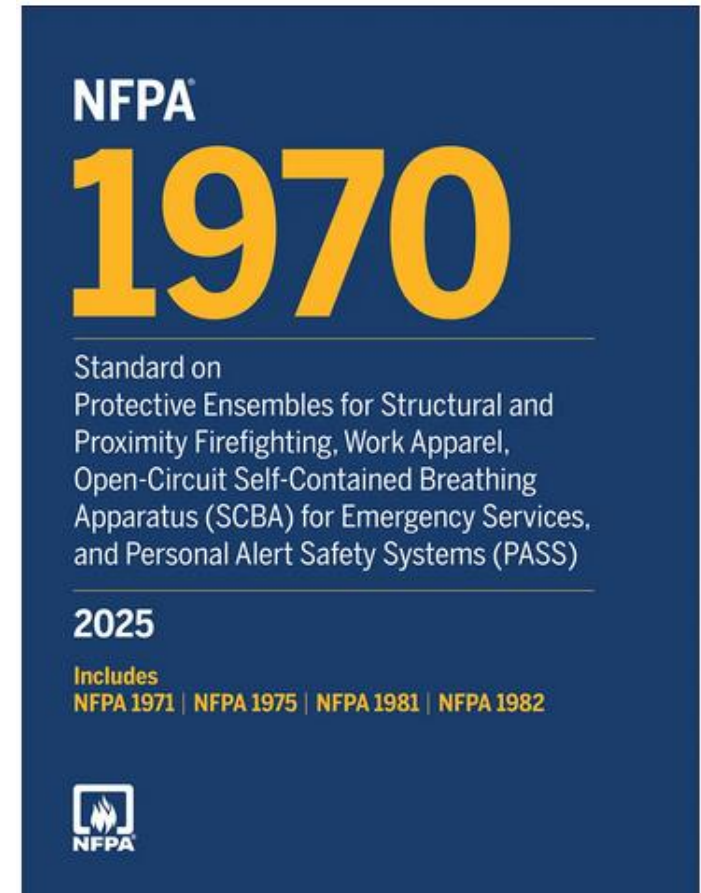
Showing 5201 Results

Fire and Emergency Services			
Bomb Suit			
Public Safety Bomb Suits (NIJ CR-0117.01)			
Bomb Suit			
Med-Eng			
Brand Name	Model #	Size/Class/Configuration	
Med-Eng	EOD 10		Open Certification Details
Med-Eng	EOD 10	(Berry Compliant Model)	Open Certification Details
Med-Eng	EOD 10E		Open Certification Details

NFPA 1970-2025



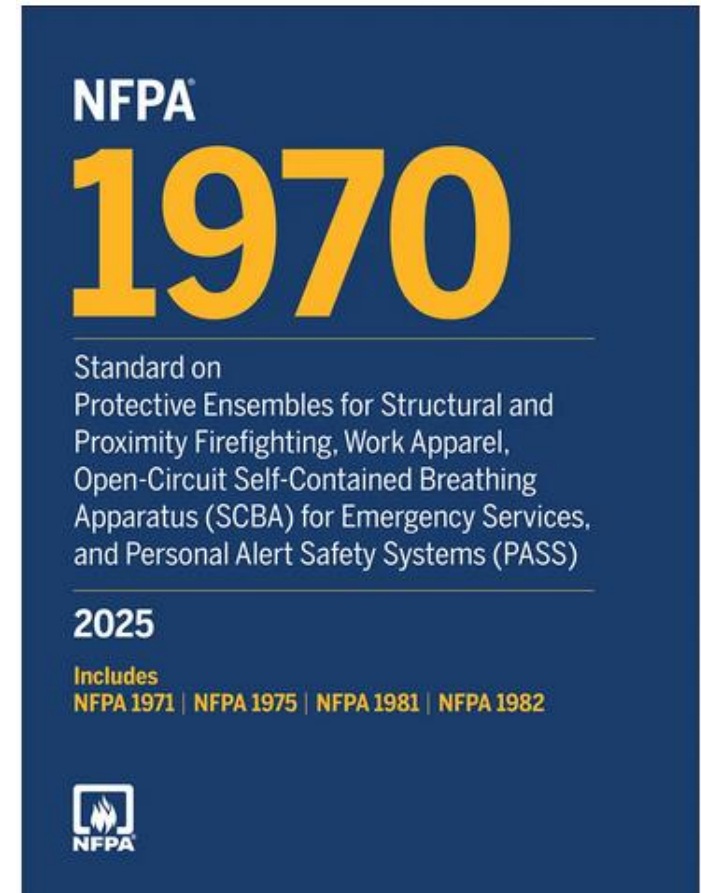
- SEI is accredited to certify all NFPA 1970 product types
 - Structural and Proximity Ensembles (NFPA 1971)
 - Work Apparel (NFPA 1975)
 - SCBA (NFPA 1981)
 - PASS Devices (NFPA 1982)
- SEI administers the certification program and permits the use of the SEI Mark on products that are found to meet all applicable requirements
- SEI partners with ISO 17025 accredited laboratories who conduct the required testing



NFPA 1970-2025 Transition



- SEI has been working closely with many manufacturers to transition from previous editions to the new NFPA 1970
- Priority is NFPA 1971 & 1975 products due to shorter 12-month transition period, compared to 18-month for NFPA 1981 & 1982 products
- Products are at various stages of the process from preparing samples for testing, to nearing completion of testing
- Most questions we receive are in relation to the new Restricted Substances List (RSL) requirements
 - SEI does not directly coordinate the RSL testing
 - Manufacturers must perform the RSL testing independently and submit documentation to SEI showing compliance with the NFPA 1970 requirements
 - Documentation required includes:
 - Certificate from a certification body or attestation organization
 - Test report that corresponds with the issued certificate
 - Documents must clearly indicate the products that are tested/certified



SEI's NFPA 1970 Team



Steve Sanders

SEI Technical Director
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- SCBA (NFPA 1981)
- PASS Devices (NFPA 1982)
- TC Member FAE-RPE
- CC Member FAE-AAC

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- Hoods (NFPA 1971)
- Garments (NFPA 1971)
- Work Apparel (NFPA 1975)
- TC Member FAE-SPF
- TC Member FAE-SCE

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- Footwear (NFPA 1971)
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- Prospective TC Member FAE-SPF

General SEI Questions

info@seinet.org



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Thank you

www.seinet.org



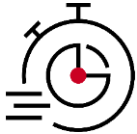
Current state of certification and testing

NFPA 1970 (1971)

Amanda Newsom
April 2, 2025

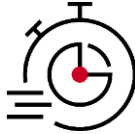
NFPA 1970 certification timeline

**Standard issued
September 2024**



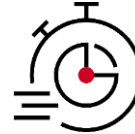
Review of requirements and
sampling required

**Twelve-month
implementation***



Evaluation of all product to
existing and new requirements

**Certifications complete by
September 2025**



Any product that is not
certified to NFPA 1970
must be withdrawn.

Starting a file review



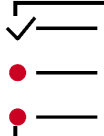
Standard issued

- Standards council approval
- Issue date 20 days later



Standard available

- Approximately 1-2 months after issuance



Customer information

- Review current file
- Customer responds with revisions needed



Quoting

- Review customer information
- Customer accept quote



Sample collection

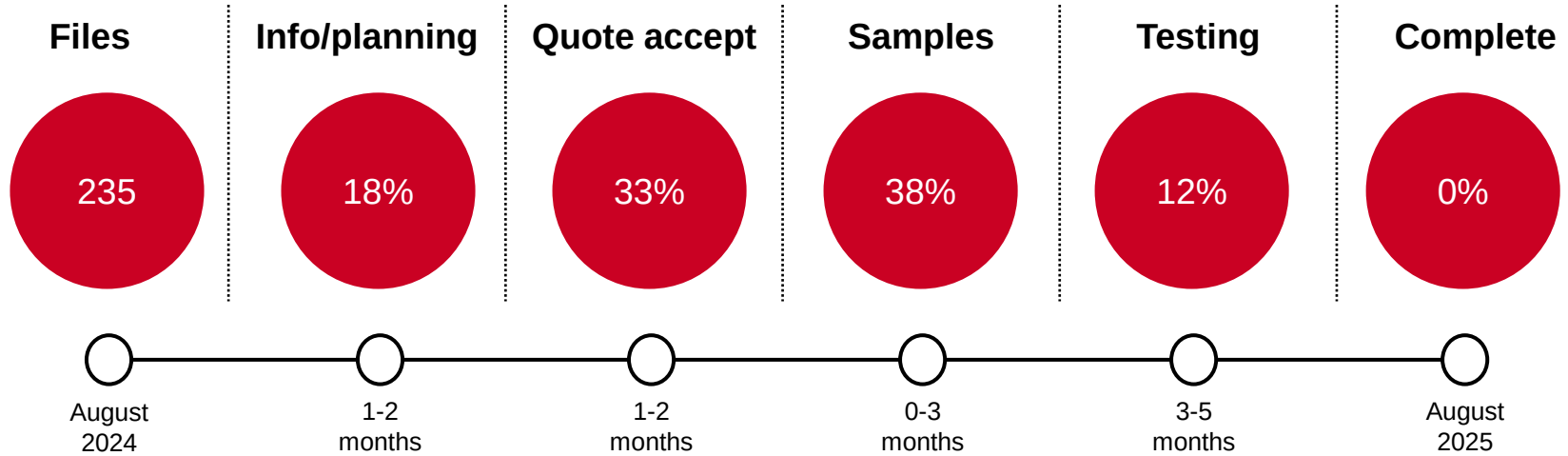
- Based on quoting, customer submit samples



Testing

- Testing of all samples

Current state of UL Solutions' projects



Evaluation components

Finished products



Components



Composites



Restricted
substances



Labeling



QA review



Restricted substances

Testing

- Requirements in NFPA 1970 (1971)
- Conformance statement from laboratory
- Test report supplied to certification organization for reference

Certification

- Third party attestation organization
- Certificate with product identification
- Test report supplied to certification organization for reference

Other

- Testing to alternate restricted substance list
- Letter or certificate

Restricted substances

- Impacts every step in the supply chain
- Includes manufacturing processes
- Mandatory for certain components



Testing for PFAs

- Total fluorine test is performed in-house at UL Solutions
- Special packaging required to prevent contamination
- Can be performed by component suppliers





Thank you

UL.com/Solutions



Urban Fire Forum Position Statement

Advancing Firefighter Safety Research and Training on Non-PFAS PPE

April 3, 2025, Otto Drozd III, Executive Secretary, Metro Fire Chiefs - NFPA

IT'S A BIG WORLD. LET'S PROTECT IT TOGETHER.®

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Introduction
Understanding PFAS Risk
Research: The Path Forward
Training Considerations
UFF Position Summary

Introduction



In 2022, firefighting was classified as a Group 1 carcinogen by IARC.

This underscores the urgent need to reduce firefighter exposure to carcinogens.



Urban Fire Forum advocates for safer alternatives and robust training.

Understanding PFAS Risks

PFAS: synthetic chemicals used for water and heat resistance.

They accumulate in the human body, wildlife, and the environment.

Exposure linked to increased cancer risks for firefighters.

Call to action: prioritize Non-PFAS PPE solutions.



ITRC, Naming Conventions and Physical and Chemical Properties of Per- and Polyfluoroalkyl Substances (PFAS), <https://pfas-1.itrcweb.org/fact-sheets/>

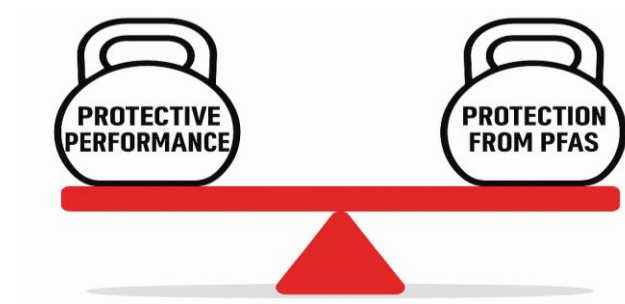


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Research: The Path Forward

- Studies show that PFAS levels vary across PPE layers.
- NCSU and FEMA AFG are investigating non-PFAS alternatives.
- Need to balance protection with reduced toxicity.
- Ongoing research is essential for safer innovation.





New gear may have different thermal, absorption, and moisture behavior.



Training should address limitations, fit, and comfort.



Protocols must adapt to maximize safety and performance.

Training Considerations

Pre-Deployment Evaluation

1

Simulate high-risk conditions for performance testing.

2

Assess durability and wear in controlled trials.

3

Use pilot programs to gather real-world feedback.

Ensuring Suitability

- Identify changes in thermal, chemical, and moisture resistance.
- Develop risk compensation strategies (e.g., heat channels, exposure limits).



Operational Risk Assessment



Reassess hazards with new gear capabilities in mind.



Establish rules of engagement for PPE limitations.



Adjust exposure times, workload, and environmental conditions.

Operational Risk Assessment

Incident Type	Primary PPE Required	Additional Notes
EMS (Medical Response)	EMS/Rescue uniform, Medical gloves, Eye protection, Mask (N95/surgical), Gown (as needed)	PPE level may increase for infectious diseases or biohazards.
Structure Fire	Turnout gear, SCBA, Firefighting gloves and boots	Full NFPA 1970-compliant gear is required for IDLH environments.
Vehicle Extrication	Extrication gear, Eye protection, Helmet with face shield, Cut-resistant gloves, Steel-toe/rescue boots	SCBA not typically used unless fire or hazardous materials present.
Wildland Fire	Wildland fire PPE, Helmet with shroud, Goggles, Leather gloves, Fire shelter, Wildland boots	NFPA 1950-compliant gear; SCBA not typically used.
Hazardous Materials	Level A/B/C suits depending on threat, SCBA or APR, Chemical-resistant gloves and boots	PPE level depends on material and exposure risk.
Active Shooter / Hostile Event	Ballistic vest and helmet, Rescue task force uniform, Gloves, Eye protection, Medical kit	PPE coordinated with law enforcement; focus on casualty care.



Training and Adaptation

Provide targeted in-service training on PPE limitations.

Teach adaptive behaviors to reduce risk



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NFPA®

1580

Standard for
Emergency Responder
Occupational Health and Wellness

2025

Includes

NFPA 1581 | NFPA 1582 | NFPA 1583 | NFPA 1584



Firefighter Rehabilitation

- Revise protocols for work/rest cycles and heat recovery.
- Provide access to cooling equipment and hydration.
- Include nutritional support during rehab periods.

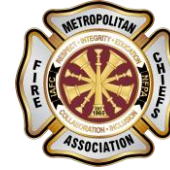


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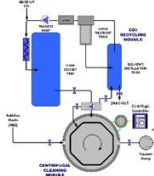
Decontamination Procedures

- Develop thorough on-site and post-incident cleaning protocols.
- Implement routine deep cleaning of PPE.
- Clean gear enhances protection and reduces toxicity.



2024 Urban Fire Forum (UFF) Position Statement

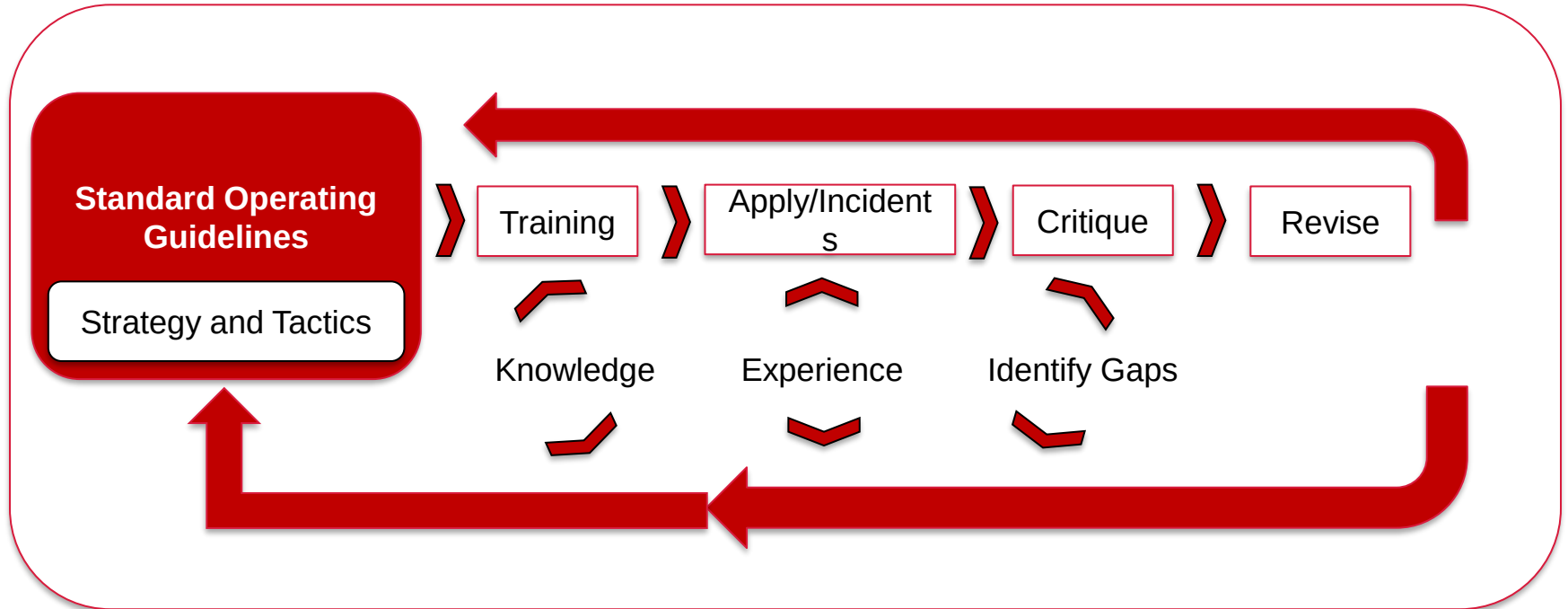
Statement in Support of Considering Enhanced Decontamination Methodologies of PPE Following Exposure to Lithium-Ion Battery Fires

Advanced Cleaning (Normal)	Specialized Cleaning (Soaking Approach)	Liquid CO2 Dry Cleaning	Enhanced Liquid CO2 Dry Cleaning
			

Post-Deployment Review

30 Days	60 Days	90 Days
• Conduct Initial Audit	• Perform Secondary Audit	• Final Audit
• Gather user impressions	• Use feedback to refine training	• Evaluate gear durability
• Identify immediate training gaps	• Adjust operational protocols	• Determine PPE lifecycle

Fire Service Improvement Model



References

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