



PPE REIMAGINED

A DISCUSSION ON THE FUTURE OF STRUCTURAL FIREFIGHTING PPE

Houston Fire Department IAFF Input Meeting
March 2025



We need to rethink what our bunker gear looks like. We need to rethink what PPE is to a firefighter. And we need to have a real conversation about tactical decision-making on the fireground.

— **Edward Kelly**, General President, IAFF



At the end of the day, I will tell people I wake up for two reasons: My family and this fire department. And it is my job to ensure that both are taken care of. The biggest task I have, and we have, is to make sure that our members, our brothers and sisters, go home. This is why this is so important.

— **Thomas Muñoz**, Chief, Houston Fire Department



Let's set some standards and let's find out what's going to be the safest way for us to make sure that we take care of the citizens that we serve, that we rescue as many people as we can that need to be rescued, but let's also make sure that we're going home to our families.

— **Michael Glynn**, 11th District Vice President, IAFF



It isn't a one size fits all. What works for somebody up north doesn't necessarily work for somebody on the West Coast or the East Coast. I think it all has to do with training and tactics and it all has to do with what it is that you're dealing with as a department.

— **Marty Lancton**, President, Houston, TX Local 341



Fire fighter safety is an investment, and it's an investment not just from labor but from management. And it takes a partnership between labor and management to achieve fire fighter safety.

— **Sean DeCrane**, Assistant to the General President for Health & Safety, IAFF



CURRENT SITUATION



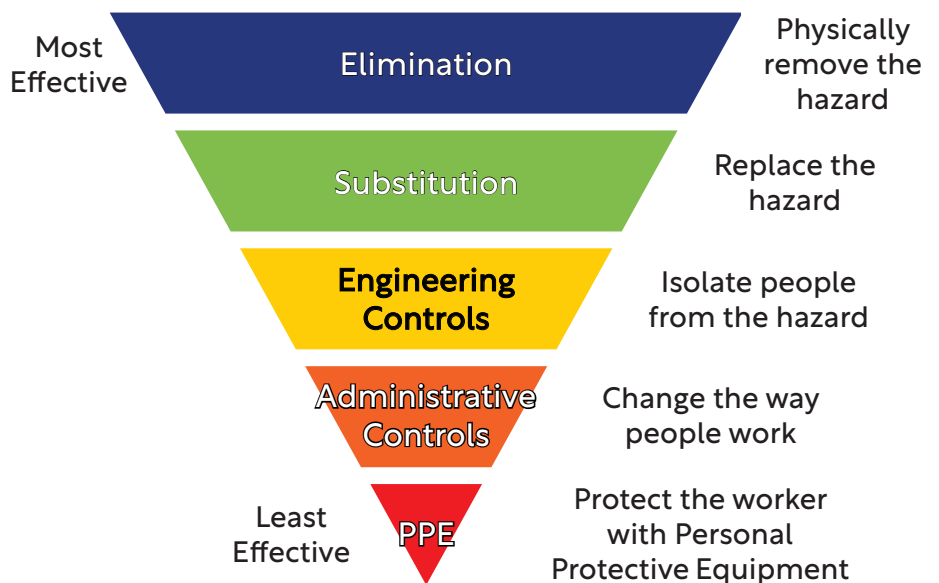
NIOSH HIERARCHY OF CONTROLS IN FIREFIGHTING

Fire and smoke can't be eliminated, but risks can be reduced with exhaust systems, clear procedures, and gear care.

PPE = LAST LINE OF DEFENSE: proper fit, use, and care/maintenance are critical.

Using the hierarchy shifts the fire service from reactive to proactive risk reduction.

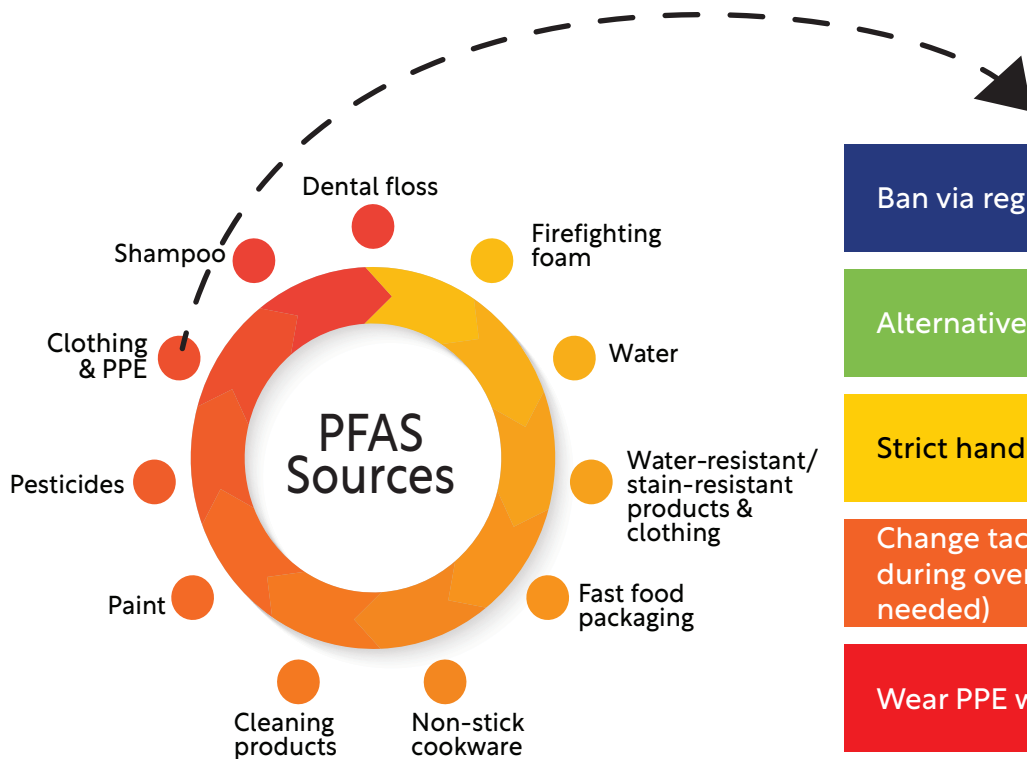
HIERARCHY OF CONTROLS: NIOSH



As you move through the following pages, you'll notice the use of color coding based on the **NIOSH Hierarchy of Controls**. Each color marks a level of protection — from eliminating hazards to relying on PPE — making it easier to see how each subject fits into the hierarchy.



APPLYING NIOSH HIERARCHY OF CONTROLS



Ban via regulations & standards*

Alternative finishes & films**

Strict handling & cleaning procedures

Change tactics to reduce exposure (SCBA during overhaul, wear PPE only when needed)

Wear PPE when handling dirty gear

* Get the chemicals out of the gear — but how do we make up for the impact on performance?

**Adding or changing chemicals may (e.g. PFAS, DWR) result in a chemical “whack-a-mole” (regrettable substitutions)

#1 HEALTH & SAFETY

- Health & Wellness
- **Physicals**
- **Behavioral Health**
- **NFPA 1710**



DECON

GEAR:

On-scene PER +
Advanced Cleaning =
Reduced exposures

PERSON:

Shower within the hour!

50–60% of PAHs on skin are
absorbed within five hours

Cleaning gear isn't enough
— wash your body early to
cut PAH absorption.

Use an impermeable gear
bag for transport

CURRENT STATE OF PPE

1800s – Minimal

- Wool clothes and leather helmets
- Little/no fire or smoke protection

Mid-1900s – Basic Gear

- Rubber coats, metal helmets, boots
- Some water resistance, still low fire safety

1970s – Major Upgrades

- SCBA added for breathing protection
- Fire-resistant materials introduced

1980s–1990s

- Moisture barriers introduced
- Increased metrics on thermal & liquid protection

2000s–2010s – Heat Stress & Cancer Risk Focus

- New breathability requirement
- Improved gear fit for more body types
- Particulate blocking criteria

2020s–Present – Smarter Gear

- Lighter, cooler materials
- Sensors & tech for safety
- Gear matched to specific jobs

Fire fighter PPE has evolved gradually — one risk, one update at a time.

Departments often meet minimum standards, adding features as needed.

But this piecemeal approach leaves some standards outdated, overlapping, or misaligned with today's realities.

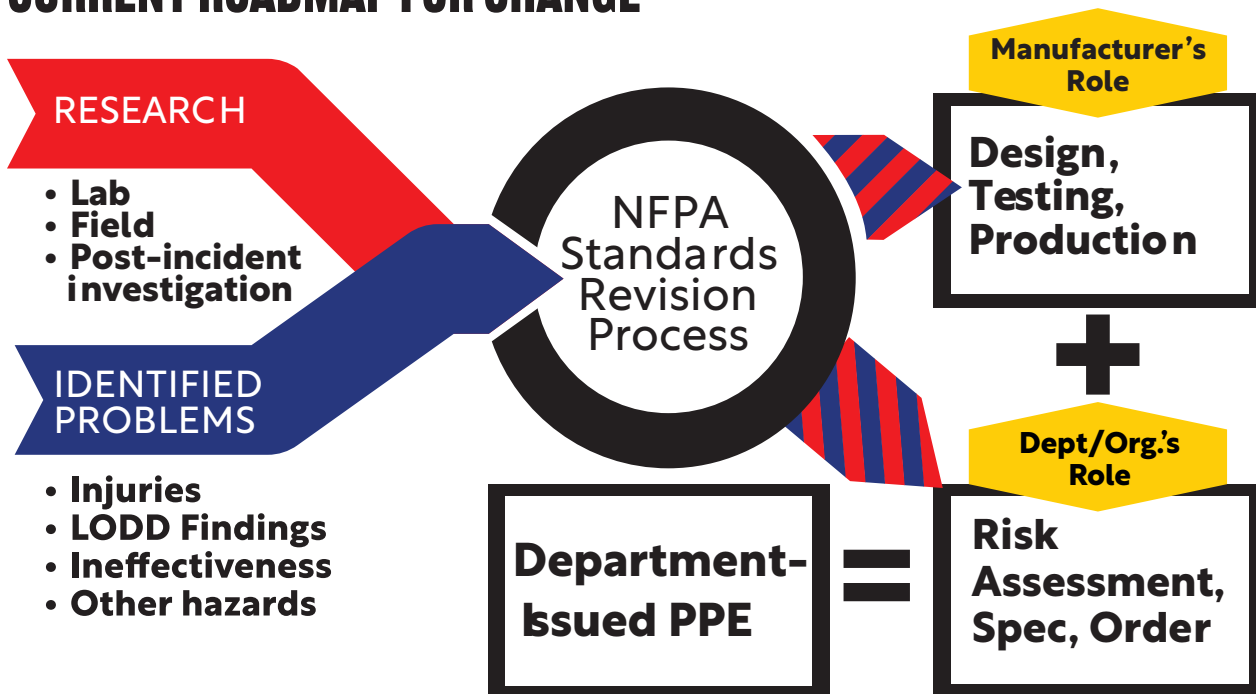
As fire fighter roles expand — fires, medical calls, technical rescues — gear must evolve, too.

The next step: step back, reset priorities, and modernize PPE standards with a forward-looking approach.



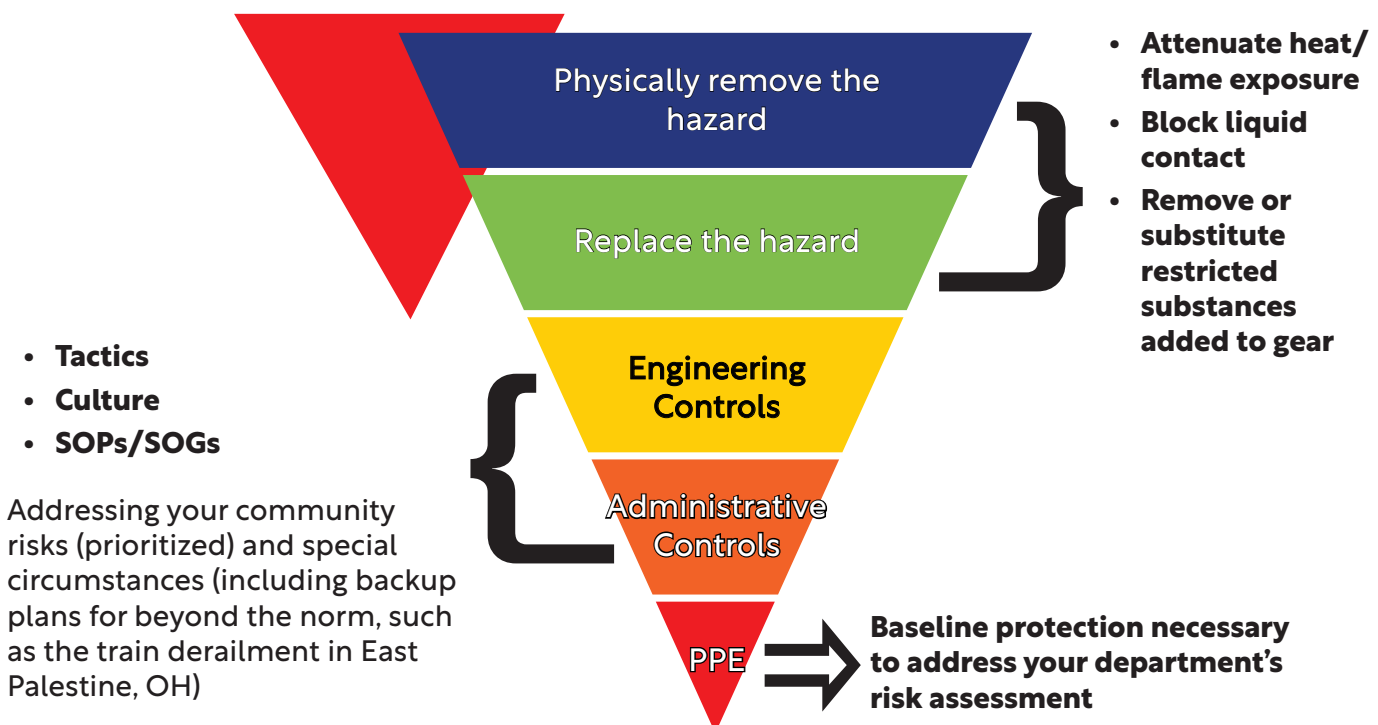
CURRENT STATE OF PPE

CURRENT ROADMAP FOR CHANGE



RETHINK PPE

We can apply the Hierarchy of Controls system within the hierarchy itself.
In this case, it is applied to the "PPE" level.

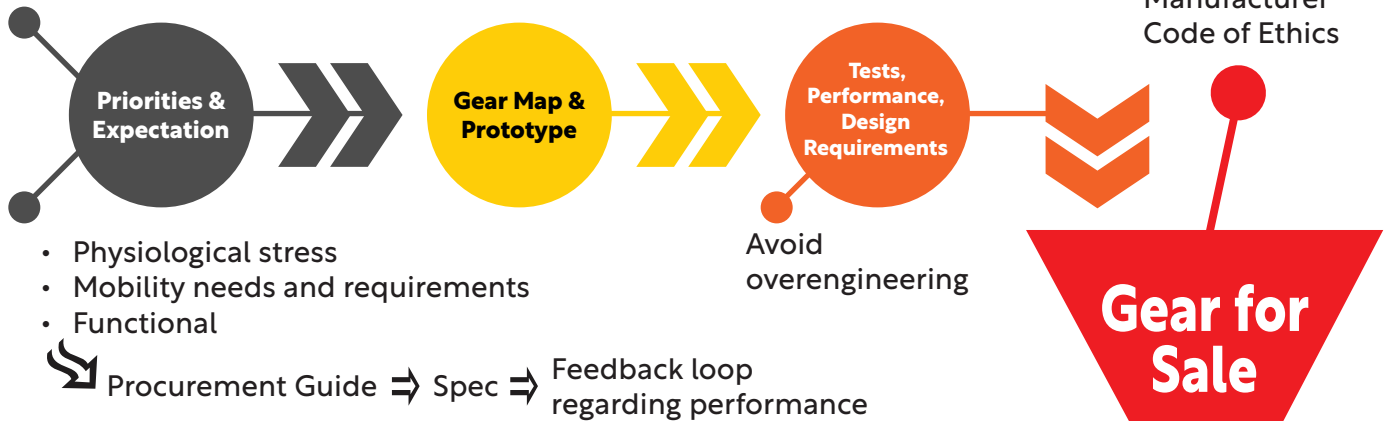


RETHINK PPE

DEPARTMENT PERSPECTIVE:

Risk Assessment:

- Call data
- Burn and injury data
- Tactics and goals



STANDARDS PERSPECTIVE:

Steps 1–4: Led by the fire service with support from hazard and protection experts



Steps 5–7: Technology companies and manufacturers join to design, test, and certify PPE

IAFF HAZARD/RISK ASSESSMENT SURVEY

Why: Gather data related to steps 1 and 2 in the proposed sequence leading to product outcomes

Who: 585 respondents representing over 200 unique departments, with an average of 19 years of experience (range: 1–45 years)

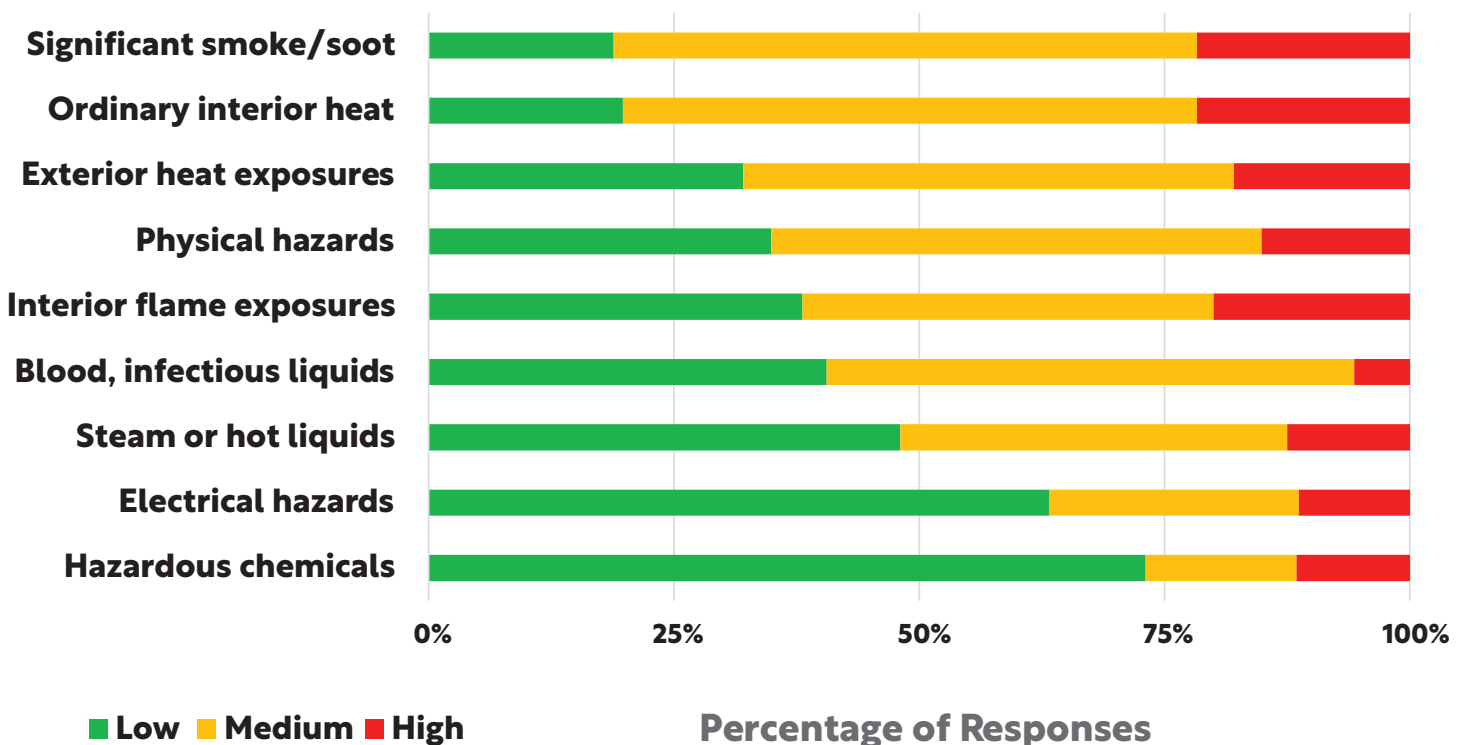
When: December 2024 – May 2025

What:

- Identify gear performance priorities
- Assess acceptability of various trade-offs
- Establish frequency rates of various hazards

SURVEY RESPONSES: FREQUENCY OF HAZARDS

How would you rate the frequency of the following exposure hazards in fire or other calls where you wear your primary PPE?



Nearly three-quarters of the fire fighters surveyed stated that they needed high levels of radiant heat protection from turnout gear less than 10% of the time.

IAFF HAZARD/RISK ASSESSMENT SURVEY

Most frequently encountered hazards:

1. Significant fireground smoke/soot/particles
2. Ordinary (interior) fireground heat/flame exposures
3. Exterior fireground heat exposures

Top Categories:

- Smoke/soot/particles
- Heat/flame/thermal
- Physical hazards
- Liquids (human & fireground)



WHAT ARE RESPONDENTS' PERFORMANCE PRIORITIES?

RATING OF BROAD ATTRIBUTES

Rank desirable performance attributes and impacts of PPE on a scale from 1 (lowest) to 7 (highest).



RATING OF SPECIFIC ATTRIBUTES

Medium/High Concern:

- Hand function
- Ability to hear and communicate
- Range of motion
- Ability to see

Highest Concern:

- Ability to clean and keep free of fireground contamination
- Exposure to hazardous substances present in clothing materials

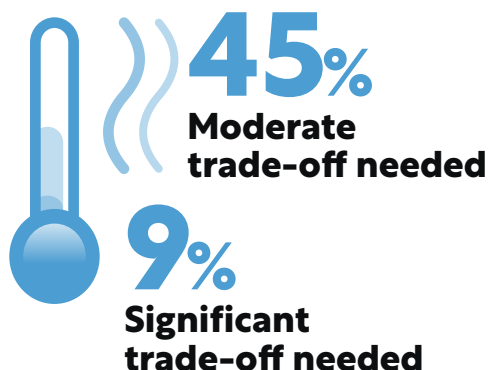
TRADE-OFFS FOR PPE – PHYSIOLOGICAL STRESS

Reported regular heat stress or related physiological stress while wearing turnout gear



Regular heat stress

When asked if they would trade-off thermal protection for lower physiological stress



When asked if they would trade-off barrier protection (against liquids) for lower physiological stress



SOLUTIONS

- Spec gear to reduce physiological impact
- Refine and improve tactics, especially related to high heat load events
- Refine related standards to allow more flexibility when spec-ing gear to meet tactical approach

TRADE-OFFS FOR PPE – MOBILITY

- When asked if mobility in turnout gear is an issue, responses were mixed
- When asked if they would trade-off thermal protection for increased mobility:
 - 53% said a moderate trade-off is needed
 - 8% said a significant trade-off is needed
- When asked if they would trade-off barrier protection (against liquids) for mobility:
 - 46% said a moderate trade-off is needed
 - 10% said a significant trade-off is needed

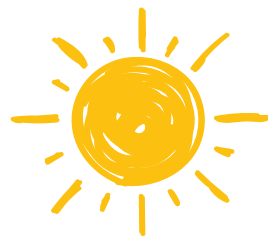
MORE RESEARCH IS NEEDED.



FOCUS ON THERMAL THREAT/TACTICS

Thermal hazards — heat and flame — are the main acute risk.

- NFPA 1970 sets minimum PPE requirements
- More thermal protection = less burn risk, but more heat strain
- PPE is only part of the protection system
- Fire fighters also generate heat through exertion
- Encapsulation means strong rehab is critical for cooling and recovery



Sunny Day
1kW/m²

Too close to BBQ grill
3–5kW/m²



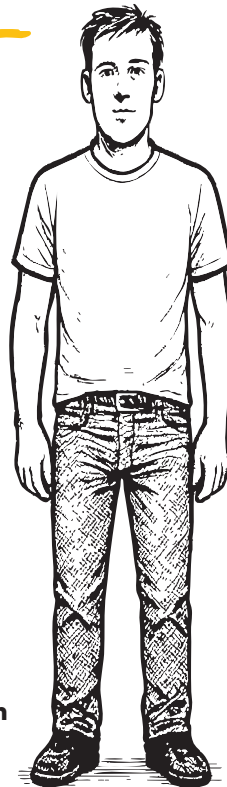
Skin pain
40°C/104°F

2nd Degree Burn
55°C/131°F

Water boils/creates steam
100°C/212°F



Gear starts to char at 316°C/600°F and is not intended for prolonged flame exposure.



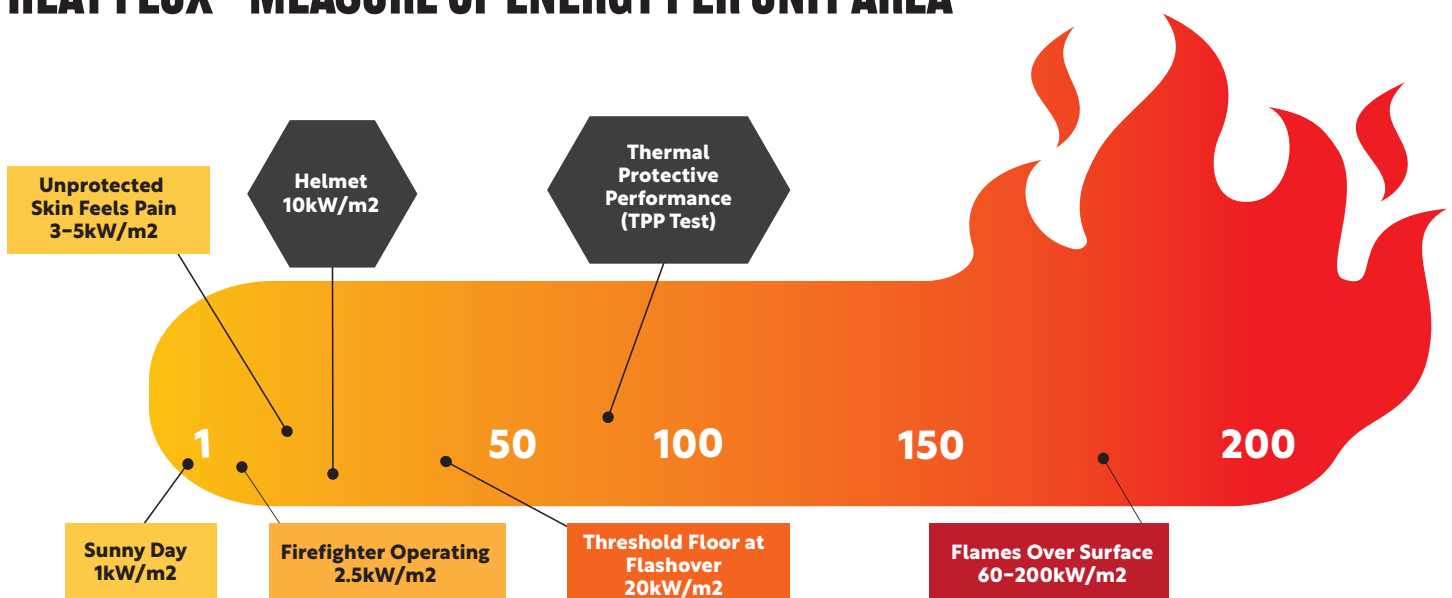
Helmet-Test condition
10kW/m²

Bunker Gear-Test condition
84kW/m²



Flames
60–200kW/m²

HEAT FLUX - MEASURE OF ENERGY PER UNIT AREA



FOCUS ON THERMAL THREAT/TACTICS

CONSIDER THIS:

- Flashover conditions one foot above the floor is zone of PPE protection (500°F)
- Hitting the floor with water, then venting to trapped heat, flattens the heat gradient throughout the home

REMEMBER:

- Heat always moves from hotter to colder (PPE loaded with heat will move that heat to your skin - the coldest thing - fast)

APPLY TO GEAR:

- Gaps between layers, air, and layer fluffiness (e.g. fresh from laundry) slows heat down

APPLY TO TACTICS:

- Outer shell cools fast, but thermal liner and your shirt have stored energy that can't go anywhere quickly – get to PER and rinse gear, get to rehab and open it up
- Fire officers and fire chiefs must consider the thermal protection that their fire fighters have when determining the strategies and tactics of a fire attack
- Fire fighters must maintain situational awareness at all times (smoke is fuel + ventilation = flames developing very rapidly)
- Consider tactics that will keep the gear within the designed operating environment and maintain the protection it provides in case of emergency
 - Choose a different entry point isolated from the exhaust portion of the flowpath (If you can't see and are getting beaten by the fire – you will not be effective in the space anyway.) – take tactical pause to ID a different entry.
 - Get in and close the door
- Exterior fire control (prior to or coordinated with entry)
- Flow and move
 - Straight stream, solid stream bounce off ceiling
 - NEVER use a fog nozzle through window
 - Train to this

BE MORE EFFECTIVE FIRE FIGHTERS



WHERE TACTICAL CONSIDERATIONS MEET YOUR GEAR

Using gear for multiple response types



To fully encapsulate or not fully encapsulate (or is your gear engineered appropriately for your response needs and tactics)?

- Burning ears used to signal when it was time to get out
 - Have we created a false sense of security?
 - Can we even feel our ears (rely on our senses)?
 - Are we relying too much on our gear to save us when we've gone too far?
- Does it make sense to get back to basics, tactically – especially as everything moves faster in fires now – so our gear supports our work rather than drives it?
- Can we do all this while allowing departments that want to exceed the minimum requirements to do so?



DID YOU KNOW?

You can meet the standards with no pockets, elbow pads, or other reinforcements



ZOOMING IN ON TPP AND THL

- NFPA 1970 tests fabric layers, not full gear in use
- Gear must meet minimum TPP (burn protection) and THL (breathability). These are pass/fail tests; results aren't shared as specific values.
- Small changes ($\pm 3 \text{ cal/cm}^2$ for TPP and 70 W/m^2 for THL) are barely noticeable in the field
- TPP and THL are not measured on reinforced composites
- Reinforced areas include extra layers beyond standard composite, pockets, trim, and closures
- TPP is higher (more protective) for reinforced composites
- THL is lower (less breathable) for reinforced composites



WHY “FULL SYSTEM” TESTING MATTERS FOR FIREFIGHTER PPE

1. Real-world performance can't be captured by fabric swatches

- Current NFPA 1970 tests only composite layers of turnout gear
- These lab samples don't reflect how gear performs when worn — fit, seams, closures, and movement all affect protection

2. PPE works as a system, not as isolated pieces

- Turnout coat, pants, gloves, hood, helmet, and boots function together
- Gaps, overlaps, and mobility trade-offs influence actual safety and comfort in the field

3. Lab numbers don't always match field outcomes

- Example: A fire fighter can be burned under clothing with no warning and no apparent damage, while no injuries can occur when gear is severely degraded
- This gap reveals that passing the standard doesn't guarantee protection on the fireground. It also shows that the incidence of burns is affected by a wider range of factors than those addressed in testing.

4. Full system testing = better balance of protection and wearability

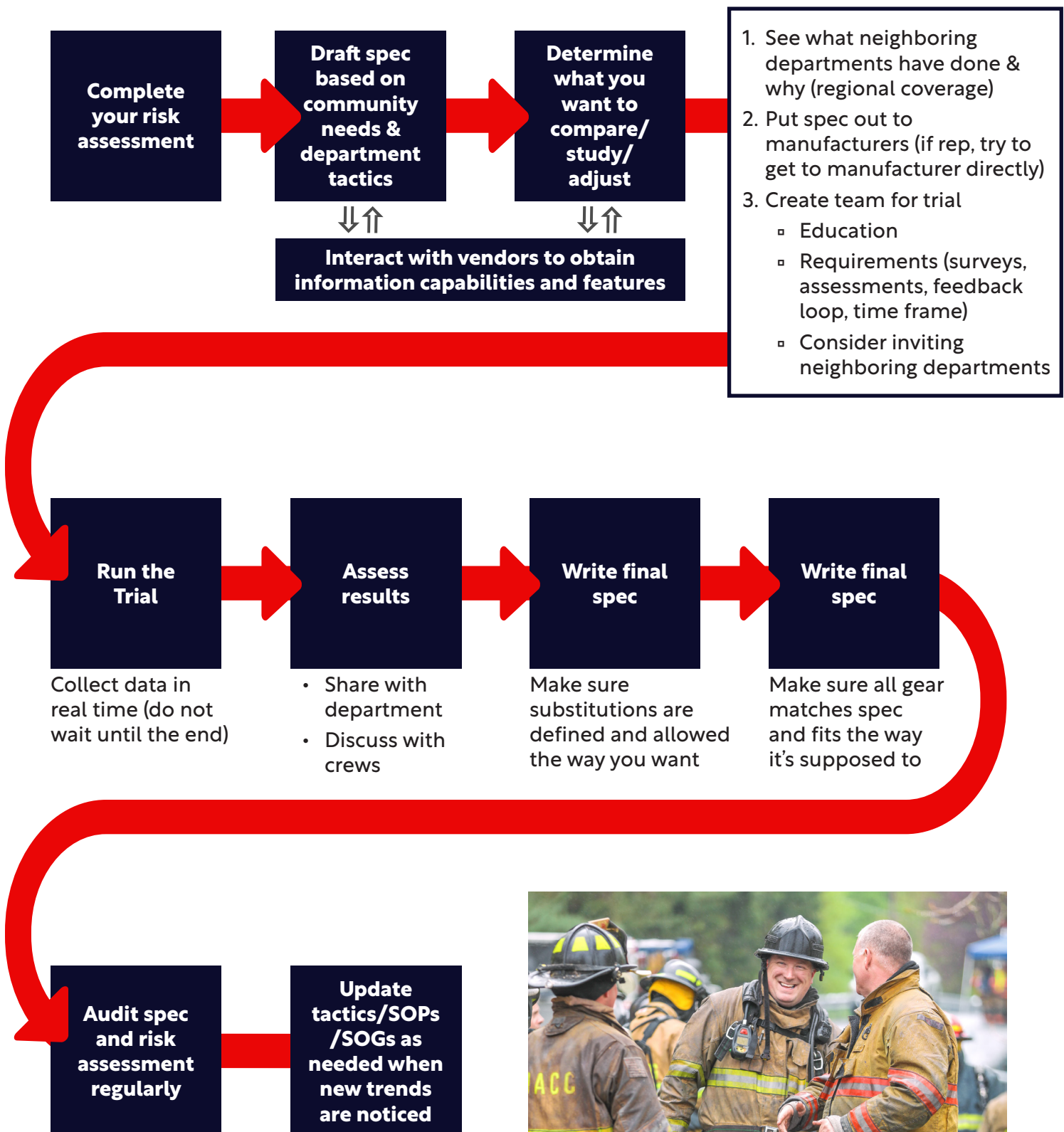
- Evaluates thermal protection, breathability (THL), mobility, and heat stress together
- Provides departments and firefighters with data that mirrors operational reality, not just lab benchmarks

HEAVILY REINFORCED COAT

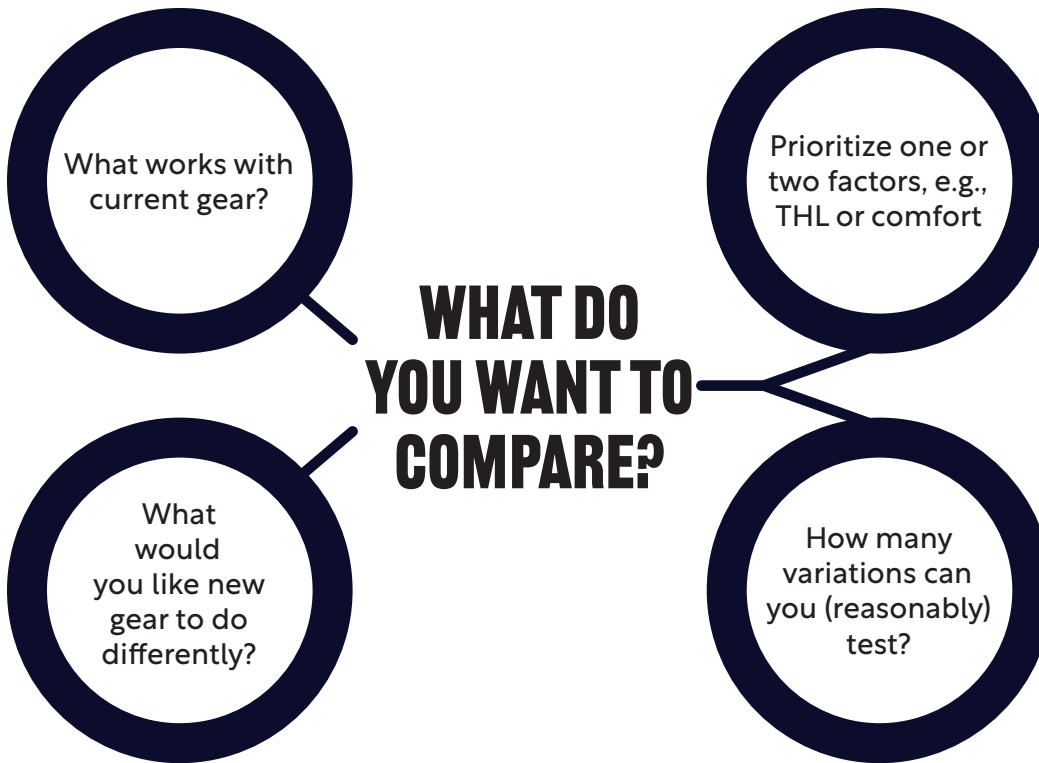
70% =
Goes above and
beyond what
is needed for
protection

30% =
Tested in
Standard
(composite-
based) Testing

HOW TO CONDUCT A WEAR TRIAL



HOW TO CONDUCT A PPE WEAR TRIAL - HOUSTON EXAMPLE



Lab tests give us a baseline — but comparing gear in real-world conditions is

what makes those results something firefighters can actually use.

- Test different THL rating vs. comfort
- Can compare four variations (i.e., four sets per participant)
- All other factors remain the same (TPP, CCHR, trim, layout, reinforcements, etc.)
Four different THL ratings

3. Measure Temperature

- Record skin temperature at five spots inside the gear, including key burn-risk areas: genitals, face, and hands
- Record temperature at one spot outside the gear
- Collect temperature data from the thermal tree inside the structure

4. Get User Feedback

- After every test and gear setup, each participant fills out a survey
- Ask focused questions to understand:
 - Differences in how the gear feels and performs
 - Perceived pros, cons, and overall gear value

2. After the Scenario

- Leave the building but stay on air and keep all gear on for three more minutes

1. Run Each Scenario

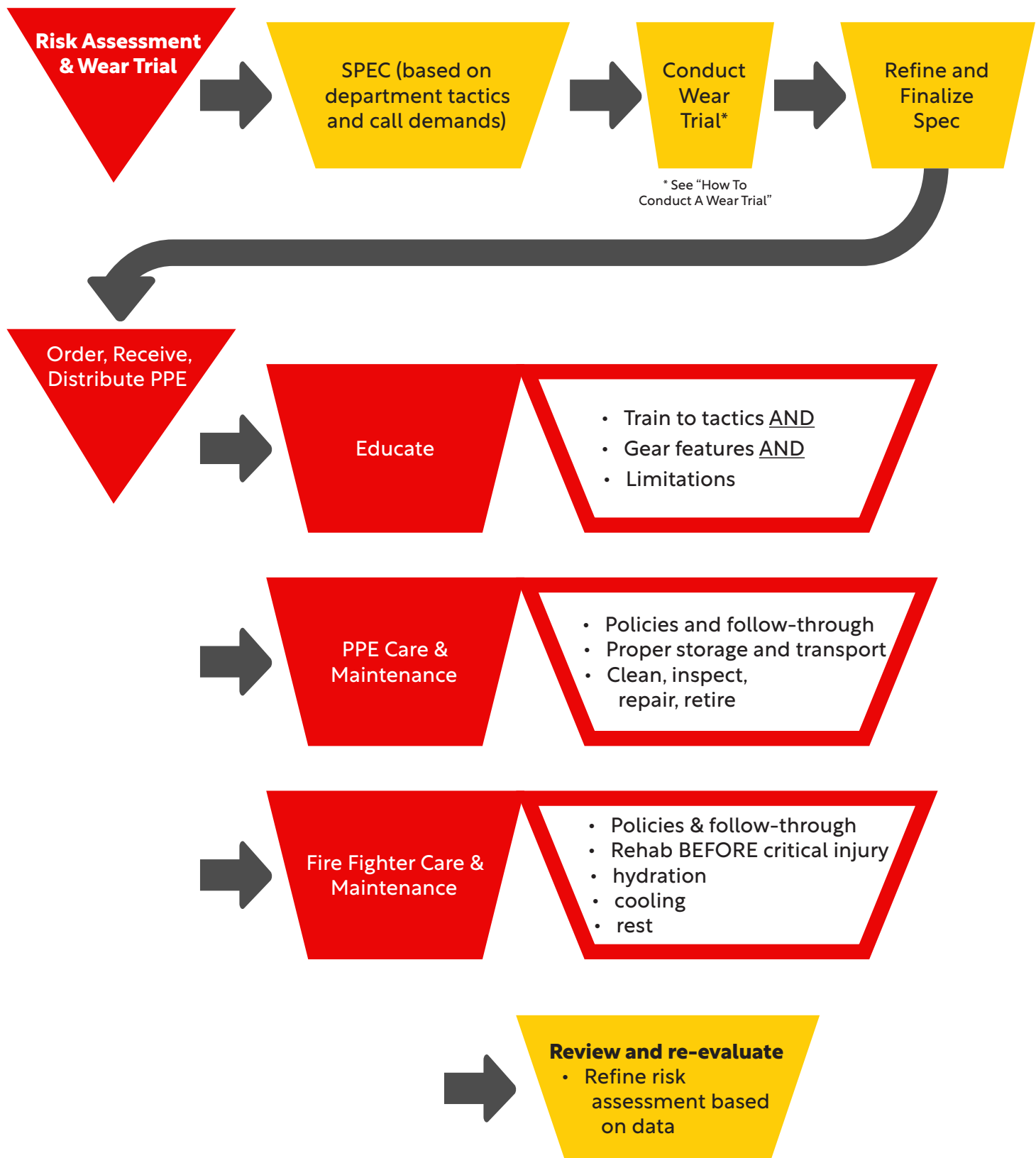
- Do the planned rotations inside the building
- Stay in each assigned spot for the set amount of time



5. Analyze the Report

- Combine what users report with the temperature data
- Look at the results based on comfort, safety, and priorities
- Use what you learn to improve gear design, standards, and health and safety practices

APPLYING THE HIERARCHY OF CONTROLS TO PPE



1. Engage and hold PPE manufacturers accountable
2. Update need assessment to correspond with modern firefighting hazards and risk (covered on pages 8–9)
3. Select and apply appropriate test methods (pages 19–20)
4. Create short-term criteria to supplement current NFPA 1970 standard (page 21)
5. Lay out long-term master blueprint for gear requirements commensurate with protection needs
6. Provide educational materials to inform department PPE selection
7. Offer tools for better surveillance of PPE problems and limitations

PROPOSED MANUFACTURER CODE OF CONDUCT

- **Principal priority:** Protection of fire fighters
- **Design philosophy:** Products should do no harm
 - **Adjunct:** Where trade-offs exist, decisions are to be made to minimize adverse impacts of products on fire fighters
 - **Action:** When hazards are discovered, they are reported immediately and updates on progress toward remedies are given frequently
- **Fire service interaction philosophy:** Full disclosure
 - **Premise:** Any information used in evaluation of product must be available to fire service
 - **Prevailing theme:** Communicate hazards when known

TEST METHODS HAVE A HISTORY THAT AFFECTS IMPACT ON PRODUCT QUALIFICATION:

- Conditions of exposure
- Types of measurements made
- Interpretation of results
- Acceptance criteria

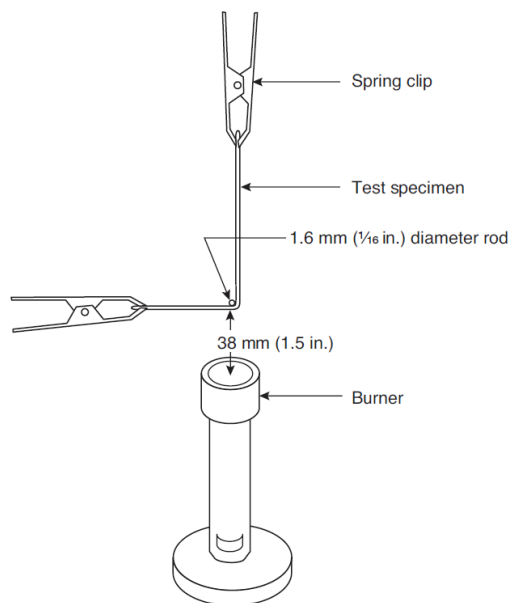


Equipment used to measure heat resistance of helmets, gloves, boots, hoods, and garment materials

Turnout gear is the way it is today not necessarily based on the needs of the fire service, but rather because of how test methods and their associated criteria define performance.

EXAMPLE: DIFFERENT WAYS TO EVALUATE GLOVE FLAME RESISTANCE

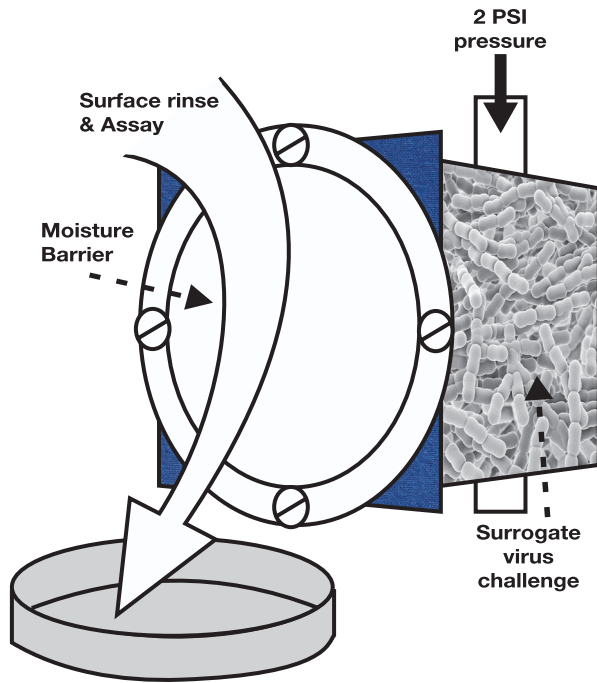
- **Relevance:**
Measures property of interest
- **Precision:** Provides repeatable results
- **Discrimination:**
Relates performance to “meaningful” field use
- **Access:** Testing capabilities are available



Glove composite test



Whole glove test



EXAMPLE OF LESS FIELD RELEVANT TEST: VIRAL PENETRATION RESISTANCE

Evaluates products for bloodborne pathogen protection

- Uses surrogate virus (similar to Hepatitis C) at high concentration (10 million viruses per mL)
- One hour contact with moisture barrier only, some time at high pressure
- Biological assay can detect single virus
- NFPA defines a passing result as fewer than 10 viruses getting through

QUESTION: How does this test relate to liquid pathogens passing through three layers of garment and causing disease transmission?

KEY STUDIES TO INVESTIGATE TEST AREAS

Study 1: Barrier Tradeoffs

- **An examination of moisture barrier testing is needed**
 - Impact of requiring less “barrier” performance
 - Impact of applying more realistic flame resistance test
- **Presumed solutions**
 - Probable improvement of garment breathability
 - Less likelihood for use of restricted substances

Study 2: Systems Level Training

- **Better promotion of full garment testing to assess**
 - Heat and flame performance
 - Garment insulation
 - Physiological impact
 - Fit and function



Moving manikin evaluates physiological impact of gear on fire fighter

IAFF EFFORTS: PROPOSED SUPPLEMENTAL CONTENT

- Short explanation of NFPA 1970 standard
 - Basic understanding of requirements
 - What is included and not included
- Specific requirements from department to manufacturers
 - Certification details
 - Disclosure of key information
 - Warranty provisions
- Additional criteria to be applied to product
- Example criteria
 - Application of restricted substance criteria to other materials in gear
 - Overall thermal manikin testing
 - Overall physiological manikin testing
 - Dynamic fit testing
 - Mandatory cleaning effectiveness information
- Provision of PPE limitation and training information

WHAT DOES THE SUPPLEMENT LOOK LIKE?

As procurement guide:

- Intents inform fire department in purchasing turnout clothing
- Establishes requirements to give control in specifying their gear
- Requires ethical manufacturer conduct

As specification:

- Offers additional criteria
- Set options for departments to set supplemental tests and criteria to understand limitations of products
- Create means of enforcing manufacturer compliance
- Additional requirements can be verified through UL Solutions or Safety Equipment Institute

**Verification
through Respected
Certification
Organizations**



Safety Equipment Institute

PROCUREMENT GUIDANCE

- **Checklist for selecting/evaluating PPE Supplemental Modules:**
 - Suggested approach for carrying out hazard/risk assessment
 - Questions to manufacturers in reviewing products
 - Recommendations for carrying out field trials
 - Examples of successful department procurement processes

PPE SURVEILLANCE PROGRAM

EMPHASIS ON NEAR-MISSES AND SEVERE INJURIES

- **Checklist for collection and gathering of information**
 - Documentation of incident
 - Injury information details
 - PPE examination and testing procedures
 - Analysis approach
 - Documentation of findings
- **PPE “Hotline” to report issues**
 - Communications channel to provide feedback to NFPA and supplemental criteria
- **Road map for next 10 years of PPE evolution**
 - Recommended research direction
 - Development of new PPE concepts
 - Critique of NFPA 1970 performance/requirements and adequacy
 - Targeted criteria for reevaluation/alignment with firefighter needs



AVAILABILITY OF PROJECT INFORMATION ON IAFF WEBSITE

OVERARCHING QUESTIONS

- 1. Does the diversified fire service mission warrant a one-size-fits-all approach to PPE?**
- 2. Is the level of PPE capabilities commensurate with fire fighter expectations, tactics, and training?**
- 3. How can fire departments be more empowered over their PPE selection and use decisions?**
- 4. Are adaptable PPE solutions an appropriate solution that can be implemented and accepted within the fire service?**
- 5. Does the fire service need a more robust program of PPE surveillance to monitor its adequacy?**

Frequency

 High

 Medium

 Low

The IAFF is using the discussion at its PPE workshop and the PPE Reimagined project to answer these questions and revolutionize the direction of PPE for its members and the fire service.

This event was undertaken with support from a grant awarded by the
U.S. Department of Homeland Security (DHS).

Summary brochure design by the International Association of Fire
Fighters, with graphics and layout support from Jeanne Barnhill,
Senior Graphic Designer - NDRI-USA



INTERNATIONAL ASSOCIATION OF FIRE FIGHTERS

1750 New York Ave., NW

Washington, D.C. 20006

(202) 737-8484

www.iaff.org • [@IAFFofficial](https://twitter.com/IAFFofficial)