Arlene Kidd

Arlene Kidd is the Technical Director at Ardmel Group UK, bringing over two decades of experience in the technical textiles industry.

Throughout her career, she has demonstrated a strong commitment to innovation and product development, contributing significantly to the advancement of high-performance textile technologies. Under her technical leadership, Ardmel Group has continues to uphold its reputation for excellence in quality, functionality, and technological innovation.

Arlene has also developed a focused interest in the area of Moisture vapor transfer barriers, dedicating several years to the study of breathable materials used in firefighting gear and outdoor apparel.

Membranes in Motion

Realising toxins through Breathable membranes

Introduction

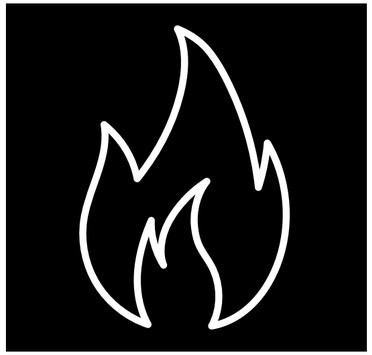
Understanding the Risks

Exposure

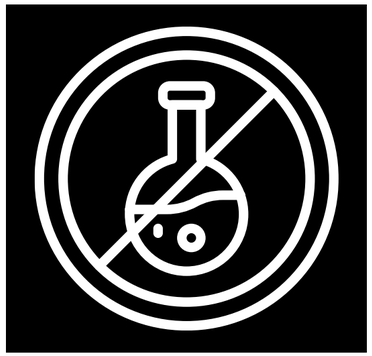
Standards

Safer Alternatives

Why It Matters



Firesuits protect against heat and flames



They all contain harmful chemicals

Growing concerns over long-term health risks for firefighters

Materials

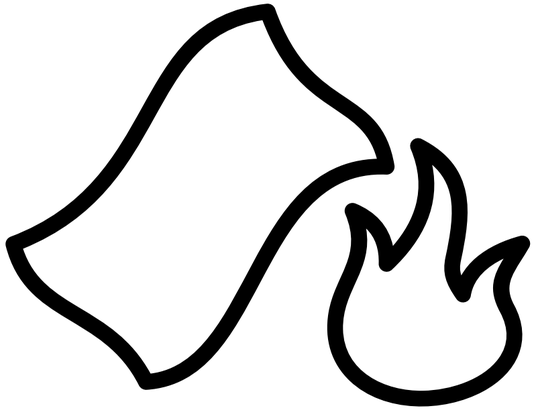
Common fabrics

- Nomex
- Kevlar
- PBI (Polybenzimidazole)

Barriers

- Moisture barriers (PTFE membranes)
- Flame Retardants (FRs)

All treated with PFAS



PFAS: The Hidden Danger

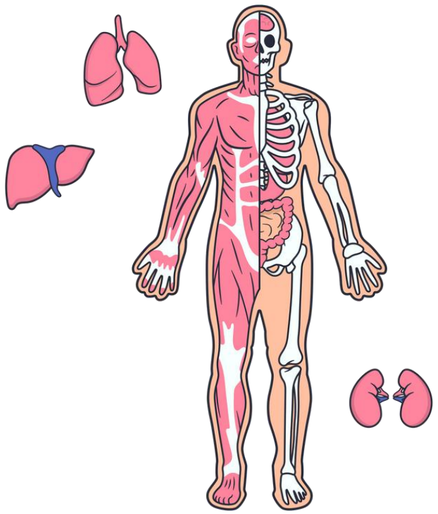
What are PFAS?

- PFAS are forever chemicals that don’t break down in the environment or body.

- They are used for water, oil and stain resistance in gear.

Health Risks

- They are linked to cancer, liver damage, immune system suppression.



How Exposure Happens

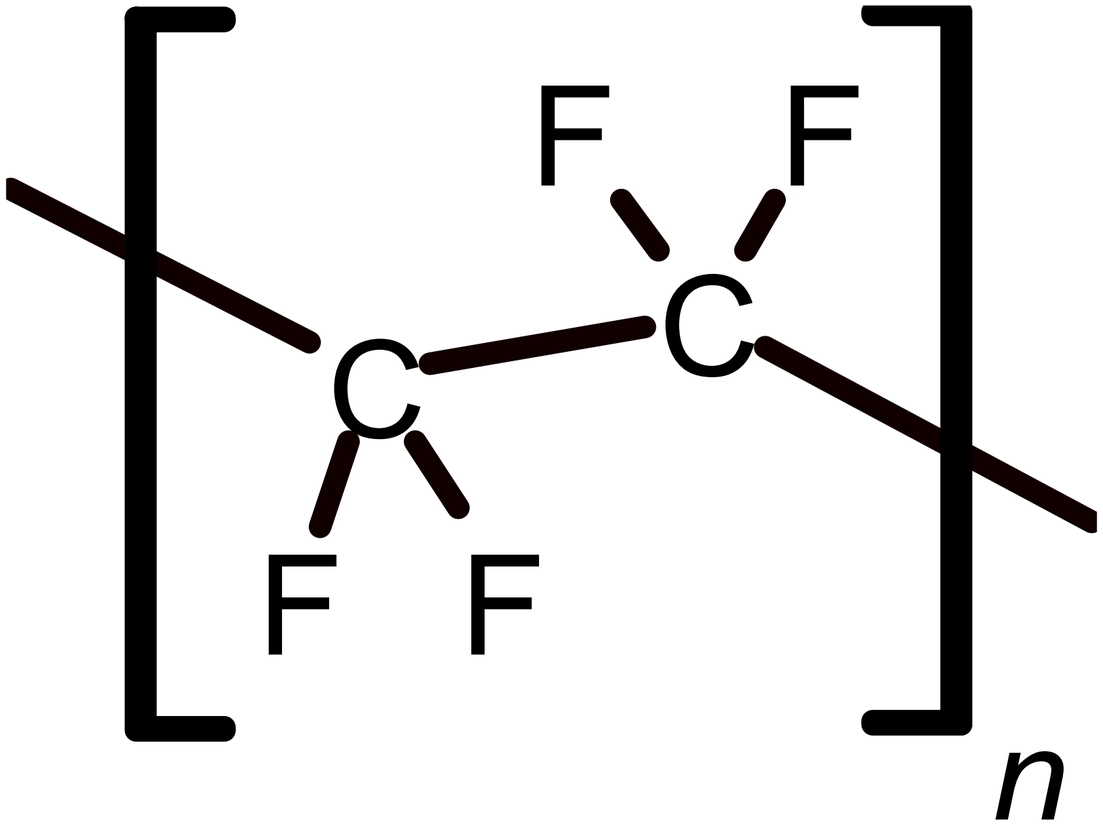
Dermal Absorption

- Chemicals penetrate skin through sweat, open pores, and hair follicles.
- Can happen during and after exposure

Inhalation

- Toxic vapors and particles breathed in through masks, gaps, or when gear is removed.
- Especially high-risk in overhaul and smouldering phases

Firesuits Should Protect, Not Expose.



The Real Risk

The absorption of toxins through breathable membranes.

Testing Firefighter Gear Breathability ISO 11092

Understanding Real-World Conditions

Not Fit For Purpose

ISO 11092: Standard lab test for breathability and thermal resistance.

- Designed for mild, steady conditions (35°C, 65% RH, no radiant heat or water.
- Real fireground environments vary from the lowest of 120˚C, are much harsher, hotter and more complex.
- Need more fit for purpose advanced tests to simulate real firefighter challenges.

Firefighters typically endure:

Firefighters typically endure:

100–300 °C heat near fires

600–1000+ °C in extreme flashover or ceiling-level conditions

Limitations of ISO 11092

- No radiant heat exposure.
- Mild temperatures and humidity. Does not correlate to extreme fire temperatures.

- Controlled steady sweat rate (not variable heavy sweating).
- Does not account for moisture accumulation and steam risk.

Breathability is overvalued in High Hazard Fire Scenarios

Why Breathability Fails in Real Life Fire Conditions

Breathable membranes (PTFE) are not effective in real fire conditions where:

- The ambient environment is saturated with heat, smoke, steam and toxins.
- Moisture vapour gradients collapse or reverse, rendering breathability ineffective or dangerous.

Critical Flaws in Breathable Membranes in Fire Suits – Reverse Breathability

Vapor transport requires a gradient

Breathable membranes work when the inside humidity is greater than the outside and dry. (Outward diffusion) This is not the case in Firefighter scenarios.
Fire environments , exterior air is more humid and hotter, reversing this gradient and driving contaminants and hot steam inwards. (Inward diffusion)

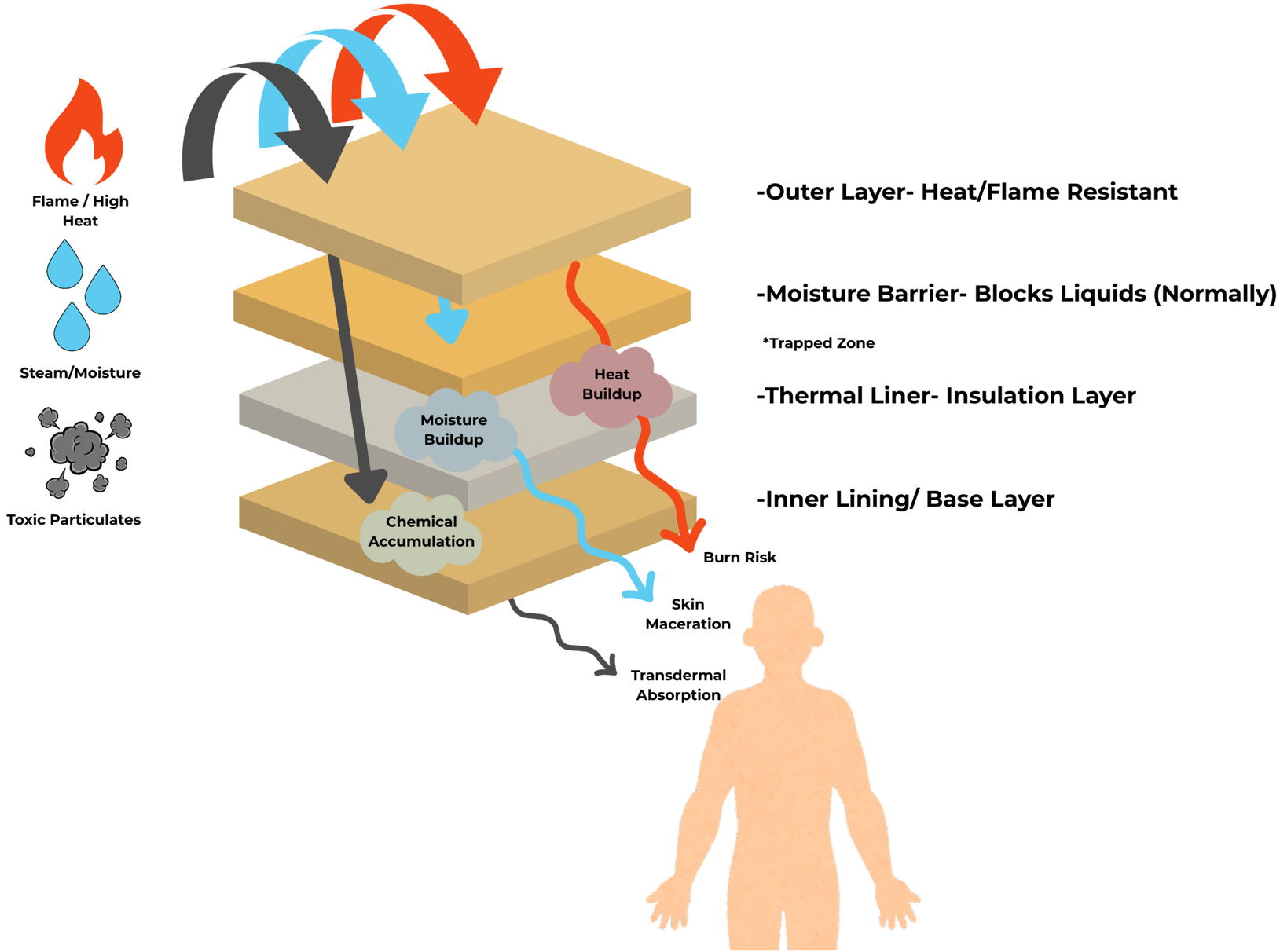
Thermal Load > Moisture Load

Breathability becomes irrelevant when heat is extreme and work duration limited.

Hot Zone Challenges

- Internal suit temperatures can rise due to **heat conduction**, especially if sweat vapor cannot escape (which relates back to **reverse breathability**).
- **Steam burns** and **scalding** are common due to moisture inside the suit vaporising.
- Heat stress can begin at body temperatures of **>38.5 °C**, reducing performance and decision-making.

Explaining Reverse Breathability



-Outer Layer- Heat/Flame Resistant

-Moisture Barrier- Blocks Liquids (Normally)

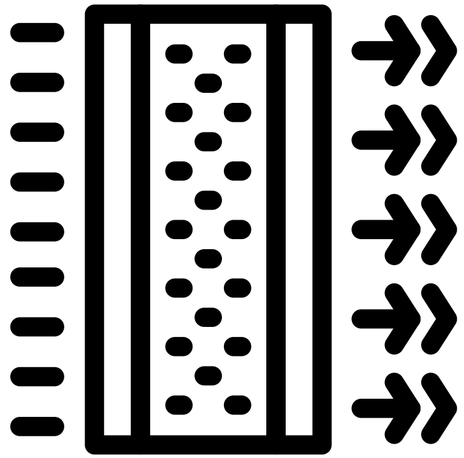
*Trapped Zone

-Thermal Liner- Insulation Layer

-Inner Lining/ Base Layer

Routes of Toxic Entry

The unwanted inward passage or toxins through breathable membranes in firesuits.



Dermal Absorption: A Major Pathway

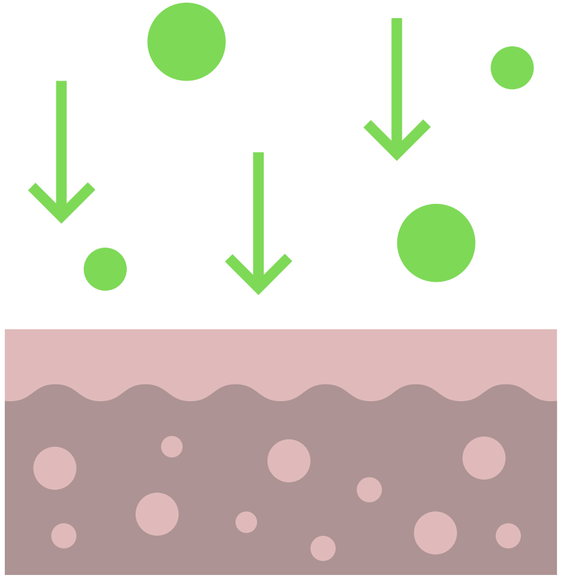
Absorption through skin is a major route of exposure for firefighters.

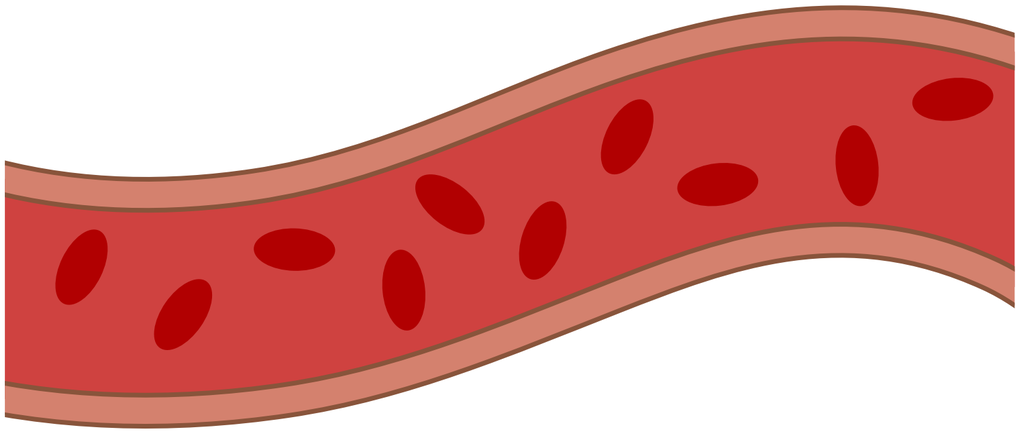
Heat opens the pores, increasing permeability to chemicals.

Studies show certain toxins are absorbed more readily through skin than lungs under firefighting conditions.

Lipophilic toxins (like benzene) easily pass through skin.

Dermal absorption bypasses liver detoxification, unlike inhalation.





Absorption into the Bloodstream

Toxic chemicals absorbed through skin enter directly into the bloodstream.

A 2020 study showed increased PFAS levels in firefighters’ blood samples.

Key Study on Chemical Vapor Diffusion in Turnout Gear

Study Highlights:

Designed a **passive sampling dosimeter** using firefighter turnout gear as a diffusion membrane.

Captured volatile analytes (including EPA-listed carcinogens) that passed through the gear onto an activated charcoal strip.

Analyses with GC-MS confirmed that **toxic compounds from combustion and pyrolysis did permeate through turnout gear layers**.

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Key to Reducing Risks

Previous studies from Lancaster University and others conclude that decontamination is essential to reduce firefighter exposure to harmful chemicals.

Regular cleaning of gear significantly lowers contamination levels.

Effective decontamination helps protect firefighters’ health by minimizing residual toxins.

Limits of Decontamination

Decontamination is crucial for reducing overall exposure and health risks.

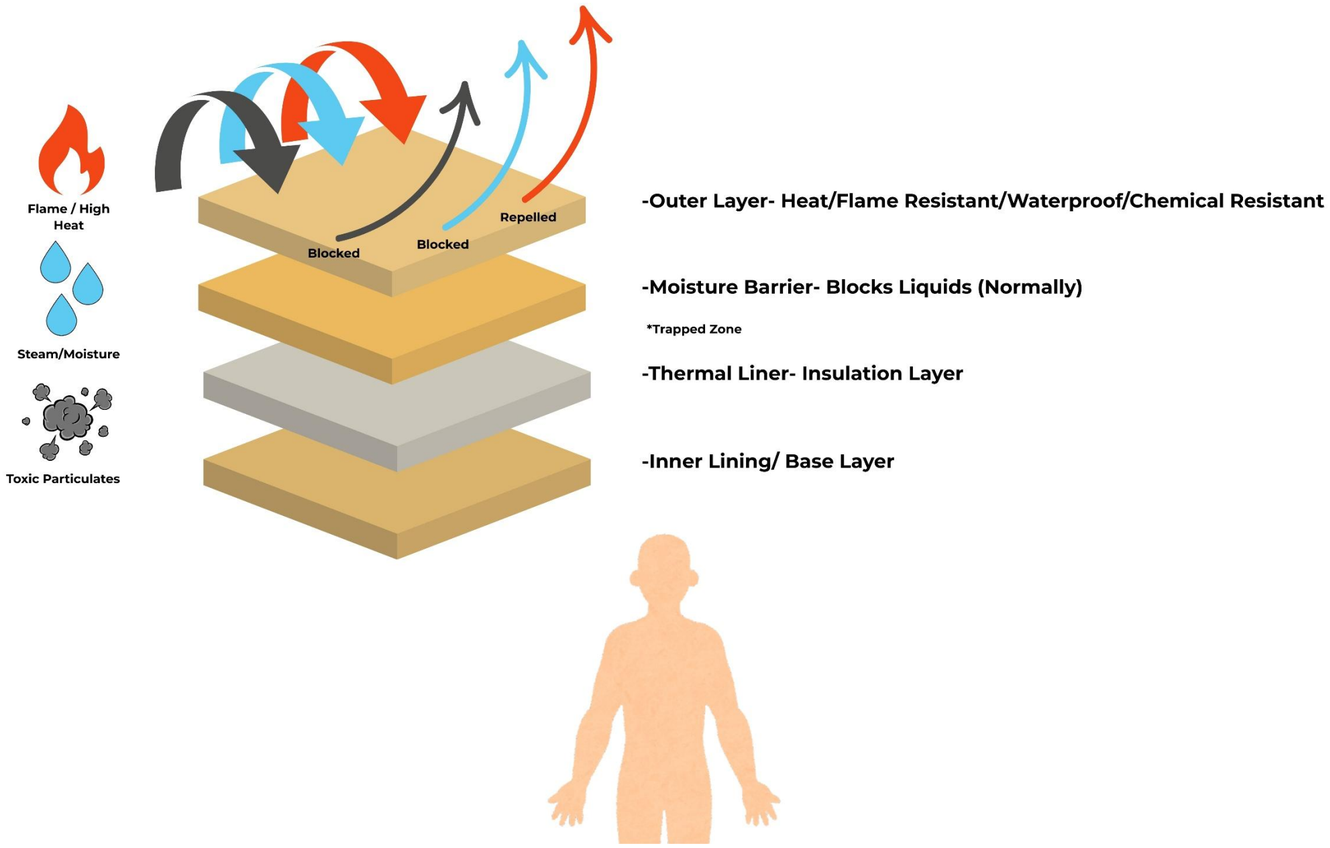
However, it does not reduce toxins already absorbed through the skin and into the bloodstream.

We Need Safer Alternatives

Traditional breathable membranes in fire suits pose major exposure risks.

Using a non-breathable, chemical resistant coating applied to a heat- resistant outer shell with an active cooling system if required you can block harmful particles and toxins completely.

Non-Breathable Impermeable Chemical Resistant Barriers



Completely blocks particle and vapor-phase toxin entry

Prevents reverse diffusion of harmful chemicals

Resists chemical degradation under heat and fire conditions

Key Takeaways

01 Firesuits save lives — but current materials carry major risks

02 Skin is a major route of toxin absorption.

03 Breathable membranes are ineffective and dangerous in real fire conditions.

04 Decontamination is essential but it will not prevent toxic absorption.

05 A safer alternative exists by using non breathable chemical resistant coatings.