Protective Undergarment for hazardous fire gases

Summary of

Tests, Studies and Certifications

In collaboration with the Swedish Firefighters' Cancer Foundation

Skin's exposure to PAHs in fire smoke

The protective undergarment's ability to protect against Polycyclic Aromatic Hydrocarbons (PAH) - in both gas and particulate format - has been tested on four different occasions. These independent studies have been carried out at the Rescue Service's training site Guttasjön outside Borås, Sweden under the guidance of Chalmers Industriteknik in Gothenburg, Lund University and the IVL Swedish Environmental Institute.

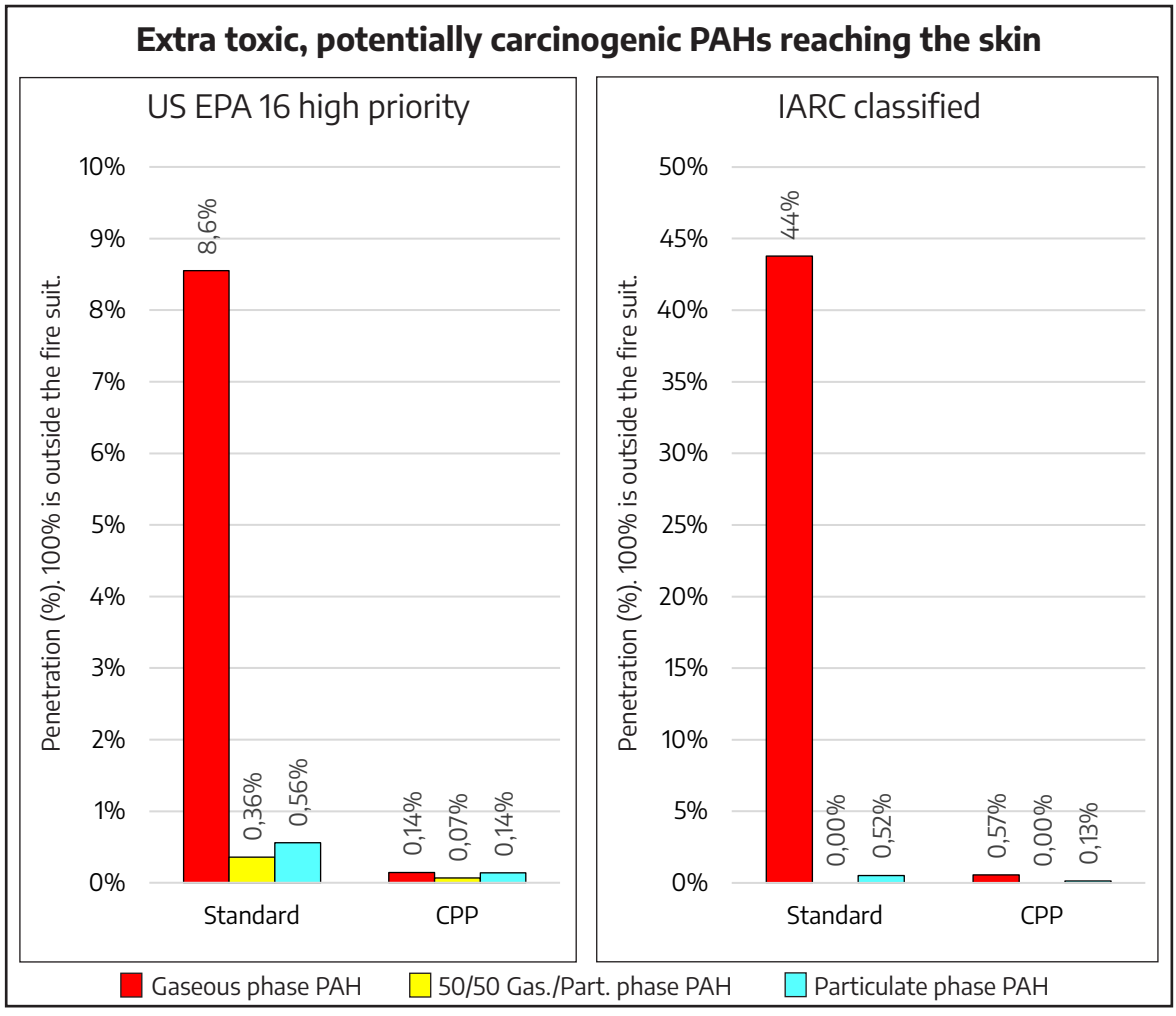
Tests/Research	Test Design and Objectives	Penetration with fire suit and standard undergarment	Penetration with fire suit and CPP undergarment	Penetration standard versus CPP
Material test October 2019.	The amount of PAH that penetrated through samples of fabrics from fire suit and undergarment.	approx. 10%	approx. 0,1%	approx. 100 times higher.
Two Swedish smoke divers September 2020.	The amount of PAH that penetrated through fire suit and undergarment at a live fire exercise after 1 smoke dive 25 minutes	approx. 10%	approx. 0,1%	approx. 100 times higher.
Two Swedish smoke divers December 2020.	The amount of PAH that penetrated through fire suit and undergarment at live fire exercises after 10 smoke dives of 25 minutes each (250 min total) with washing after each exercise	approx. 6,4%	approx. 0,09%	approx. 70 times higher.
Four Swedish smoke divers August 2021.	The amount of PAH that penetrated through fire suit and undergarment at live fire exercises after 24 smoke dives of 25 minutes each (600 min total) with washing after each exercise	approx. 15%	approx. 0,76%	approx. 20 times higher.

The 35 PAHs found on the firfighters' skin:

acenaphthene[1]
acenaphthylene[1]
anthracene[1]
biphenyl
2,3-dimethylnaphthalene
fluorene[1]
1-methylanthracene
1-methylfluorene
1-methylnaphthalene
2-methylnaphthalene
1-methylphenanthrene
2-methylphenanthrene
3-methylphenanthrene
naphthalene[1,2]
phenanthrene[1]
2-phenylnaphthalene
2,3,5-trimethylnaphthalene
fluoranthene[1]
1-methylfluoranthene
1-methylpyrene
pyrene[1]
retene
benzo[a]anthracene[1,2]
benzo[a]pyrene[1,2]
benzo[b]fluoranthene[1,2]
benzo[e]pyrene
benzo[g,h,i]perylene[1]
benzo[k]fluoranthene[1,2]
chrysene[1,2]
coronene
dibenz[a,h]anthracene[1,2]
indeno[1,2,3-c,d]pyrene[1,2]
2-methylchrysene
5-methylchrysene
perylene

Gaseous phase PAH
50/50 Gas./Part.
Particulate phase PAH
Those in bold font are extra toxic, probable carcinogenic by US EPA[1] and IARC[2].

Throughout the tests a total of 35 different PAHs were identified on the skin of the firefighters and the values in the table above are for those 35 PAHs.
There are more than 100 different PAHs of which:
-USA Environmental Protection Agency (US EPA) has identified 16 of high priority, extra toxic and classified as carcinogenic at different levels.
-International Agency for Research on Cancer (IARC) has also classified a number of PAHs as confirmed, probable or possible carcinogenic.
The extra toxic, probable carcinogenic (US EPA and IARC) are in bold font in the table on the left.
Totally 15 extra toxic and potentially carcinogenic PAHs were found on the firefighters' skin during the tests, that is they penetrated both the fire suit and the underwear and the graphs below illustrates the penetration.



Tests during the CE-certification

The protective undergarment is in conformity with the provisions of the Regulation (EU) 2016/425 of the European Parliament and of the Council. The undergarment complies with the standard EN ISO 13982-1:2004, Protective clothing for use against solid particulates – Chemical protective clothing providing protection to the full body against airborne solid particulates (type 5 clothing). The certification is Category III, which is the highest possible.

Following tests were performed during the certification:

1. Leakage test, inward leakage. Approved according to EN ISO 13982-2:2004 $L_{jmn,\ 82/90} \leq 30\%$ and $L_{s,\ 8/10} \leq 15\%$
2. Physical material performance according to EN 14325:2004
   - Abrasion resistance class* 1 of 6
   - Flex crack resistance class* 5 of 6
   - Tear resistance class* 3 of 6
   - Puncture resistance class* 2 of 6
   - Resistance to flame class* 3 of 6
   - Seam strength class* 4 of 6

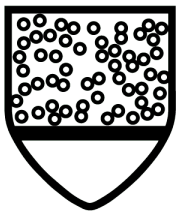
   *EN-classification specified in EN 14325:2004. The higher the classification number, the better the performance, and everything from 1 and above is approved.

CPP's undergarment is the only protective garment for smoke diving with this CE-certification.

CE 0200

EN ISO 13982-1:2004

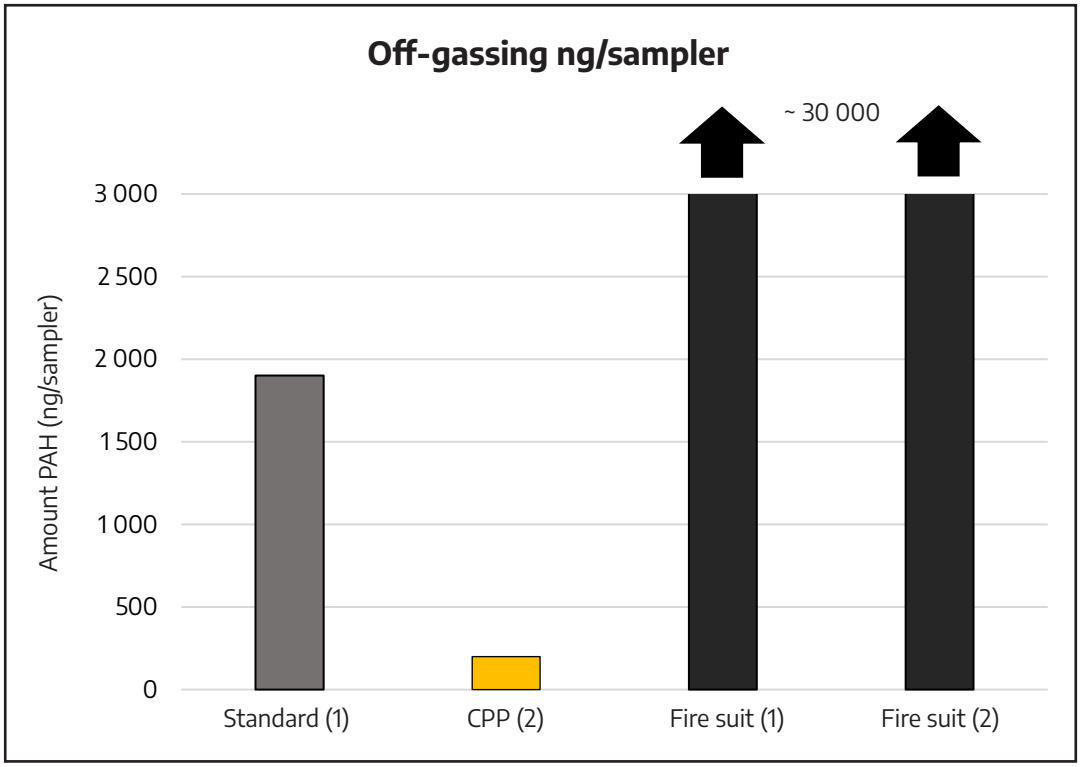
Category III



Type 5

Off-gassing tests

The research studies "Skin exposure to PAH in fire smoke" also examined the degree of off-gassing from an undergarment, e.g. how much PAH the undergarment releases after smoke diving. The results are interesting both from a health perspective as well as measuring the effectiveness of the activated carbon.
Off-gassing adds an additional risk of exposure to hazardous PAH to the skin since undergarments normally continue to contaminate the skin even after a completed smoke dive. With CPP's undergarment the off-gassing exposure to the skin is 1/10 compared to standard undergarments meaning that it could be sufficient to remove only the fire suit when getting into the truck at the fire scene.
The limited off-gassing of the CPP protective undergarment illustrates how effectively the activated carbon binds and retains the hazardous PAHs.



On July 1st, 2022, WHO's Cancer Agency, IARC, classified occupational exposure as a firefighter as carcinogenic to humans according to their highest degree of certainty. IARC mentions in their decision both PAHs ("... complex mixture of combustion products from fires, e.g. polycyclic aromatic hydrocarbons,...") **as well as skin absorption** ("Dermal exposure, inhalation, and ingestion are common routes of exposure...") **as probable causes.**

The protective undergarment, which is the world's first providing protection for firefighter's skin against carcinogenic fire gases and particles, is a Swedish invention developed by CPP Garments and requested by the Swedish Fire Fighters' Cancer Foundation.

The protective undergarment, based on military technology and research, consists of a patented fabric with a thin particle filter, and, more importantly, a thin layer of micro spheres of activated carbon. It provides the same level of comfort and functionality as today's standard undergarments, that is, it is air permeable with the possibility for perspiration and body heat to pass through.

Regular fire suits provides an effective protection against heat and fire whilst lacking sufficient protection against carcinogenic fire gases. Our new protective undergarment replaces existing undergarment making it the indispensable complement to the firefighters' fire suits.

Tests, Studies, and Certifications can be downloaded on www.cppgarments.com

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