QUEENSLAND FIRE and EMERGENCY SERVICES FIREFIGHTER EXPOSURE STUDY

“COME TO WORK CLEAN GO HOME CLEAN”

WHY THE INTEREST-A SAFER COMMUNITY!

Science

Inform about PPE performance

understand sources of exposure and consequence

when is it dirty? Can we determine in field?

Inform development and application risk based decision making tools

Occupational Health and Safety

Challenge and improve operational doctrine

Inform the debate about sources of exposure and consequence

health impacts on emergency responders

Inform selection of risk control measures and minimising opportunities for exposure at fireground, vehicle and station

Predict the likely exposures of fire fighters, emergency responders and the community at any fire

COMBUSTION

Combustion products reflect

- structure/type/quantity/mix
- temperature and oxygen content
- decomposition pathways
- fire type and fire evolution stage
- other hazardous materials
- extinguishing agents

FIRE PRODUCTS

Combustion products include

- Inorganic oxides – carbon monoxide, carbon dioxide;
- Hydrocarbons – saturated/unsaturated- methane/benzene and polyaromatic hydrocarbons (PAHs);
- Partially oxygenated hydrocarbons- like acrolein;
- Partially nitrogenated/halogenated/sulfurated organics;
- Undecomposed/partially decomposed products;
- Simple inorganic molecules like hydrogen cyanide, sulfur dioxide;
- Volatile metal/non metal oxides like “zinc oxide”;
- Volatile inorganic compounds like arsine;
- Particulates including PAHs; and
- Non volatile products such as copper oxide

Combustion product distribution and concentration varies

Combustion product toxicity varies

HOW DOES IT GET TO US-EXPOSURE

Source	→	Pathway	→	Receptor
Fire -heat Particulates Airborne Contaminants		Air contact		Person lungs/skin

Most effective entry route is the lungs

if fire-fighters don self contained breathing apparatus then
the route of entry with greatest significance? skin!!!

fire fighter ensembles are designed to withstand heat, but little if anything is known about whether protective clothing affords protection against airborne contaminants

research generally focused on understanding environment outside the firefighter protective clothing or thermal performance

STUDY STRUCTURE

Literature Review ✓ ongoing

Measure the concentrations of the combustion products;

- Simulated room burns ✓ completed (5/5) report
- Wildfires ✓ completed draft report
- Simulated office burns ✓ completed (5/5) report
- Simulated petrochemical burns ✓ completed (5/5) report
- Simulated industrial fires ✓ completed (5/5) report
- Operational fires ✓ to commence
- Instructor Exposure-repeated entry ✓draft report
- FESA/QFES study Stage I- report complete stage 2 commenced
- Bushfire extension -to commence

Establish relationships between contaminant concentrations and Fire-fighting practices; ✓ underway
Implement changes at QCESA –Live Fire ongoing
Inform QFES fire-fighters and wider audience ongoing
Trial at select stations in preparation
Broad implementation across QFES in preparation

EXAMPLE OBJECTIVES

Characterise fire fighter exposures during activities within simulated fires and fires within the community

Establish relationships between:

- fire fighting and other work practices;
- external fire fighter exposures;
- fire fighter exposures adjacent to the skin;
- deposition of polyaromatic hydrocarbons (PAH) on the protective clothing; and
- deposition of PAHs onto the skin

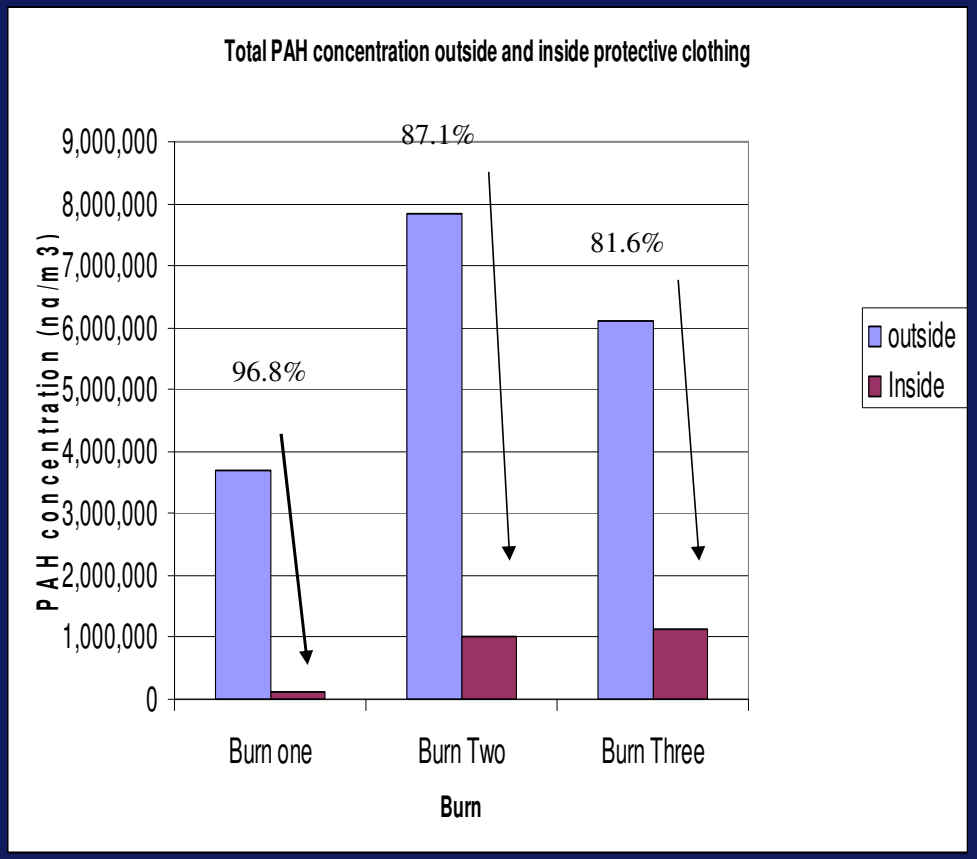
Focus on instructors during hostile attack three repeats four fires

- deposition of PAH onto clothing sequentially; and
- off-gassing off garments after these activities

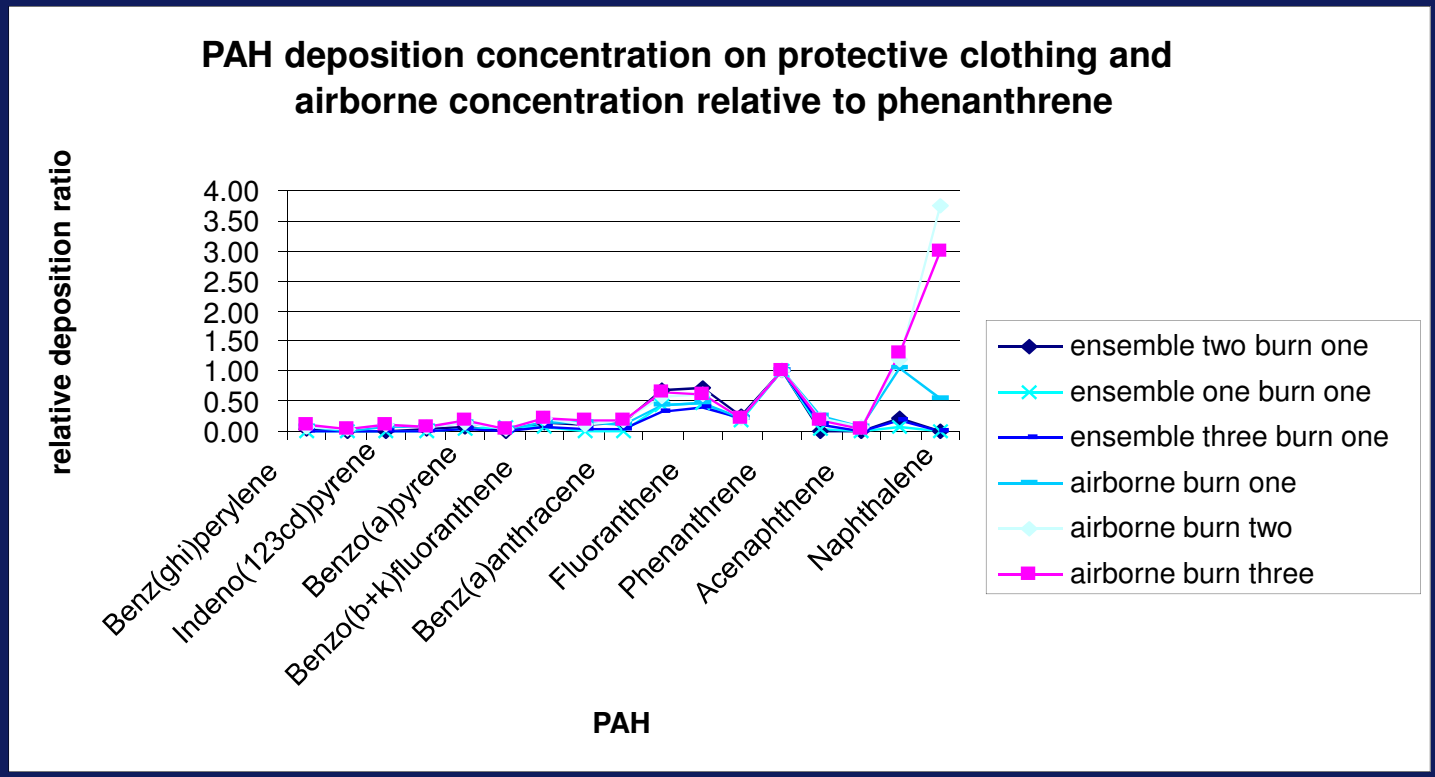
EXAMPLE RESULTS POLYAROMATIC HYDROCARBONS (PAH)

airborne PAH exposures much higher than other fire simulations

Protection factors inside are similar to those observed from simulated fires



ANOTHER VIEW
PAH CONCENTRATION ON CLOTHING COMPARED WITH AIRBORNE RELATIVE TO PHENANTHRENE



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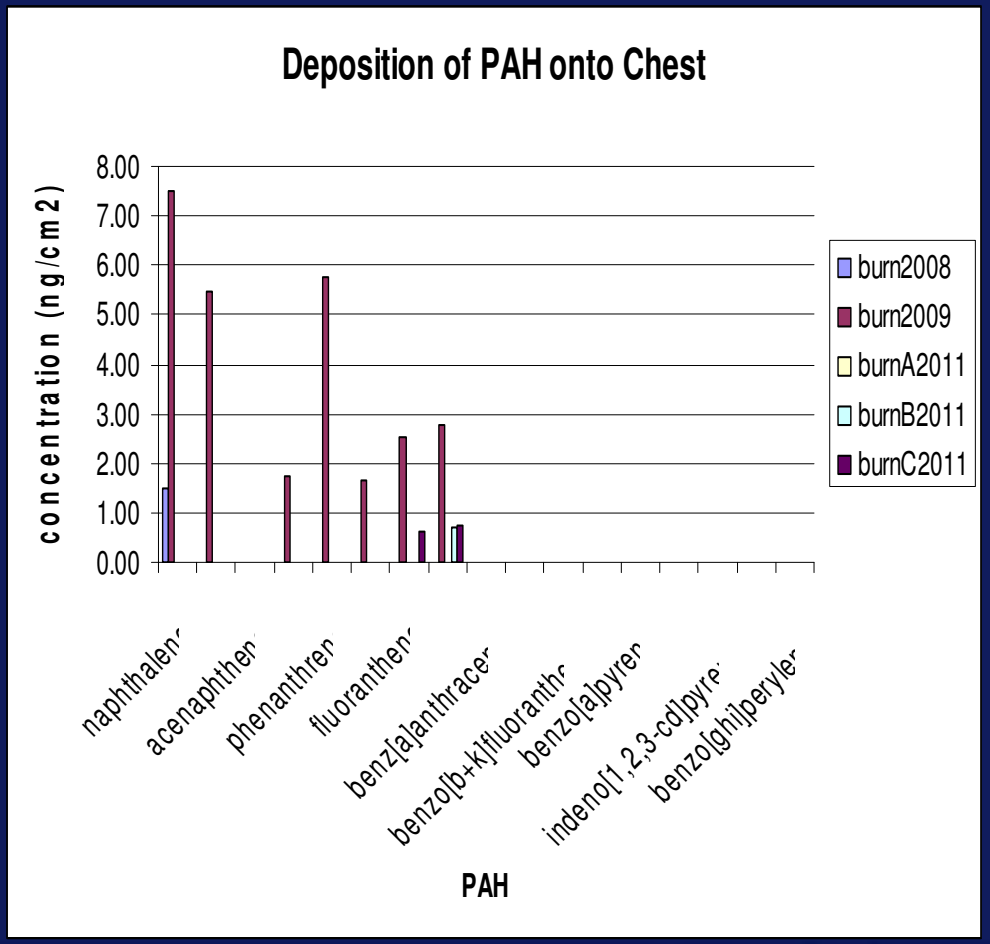
A FURTHER VIEW: PAH DEPOSITION ON SKIN- CHEST

Deposition occurs onto the skin
- not detected on all occasions
- naphthalene, etc

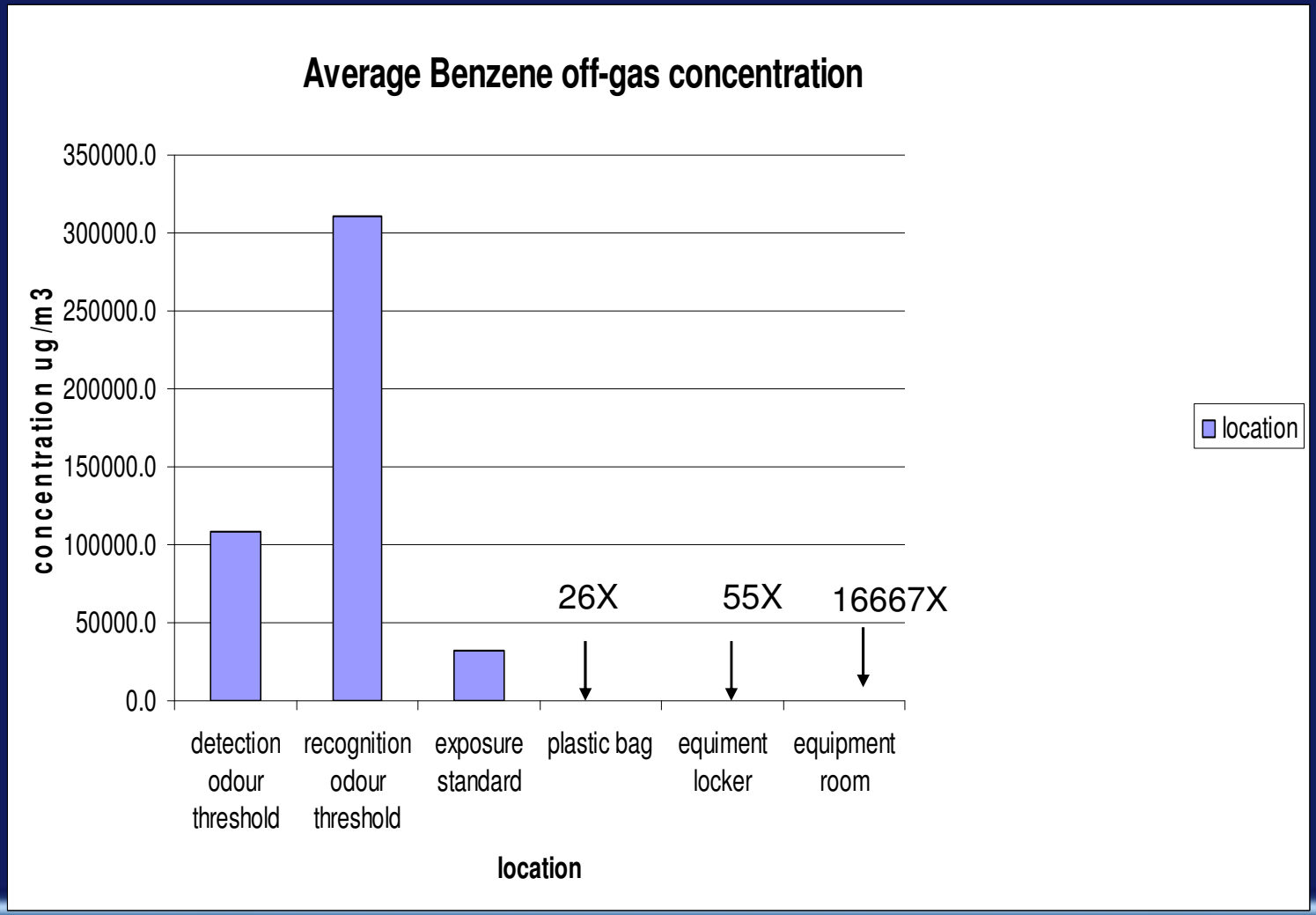
Some variance between values
- exposure times differ
- airborne PAH concentrations differ

?relationship between time and extent of deposition

Reinforces message about managing exposures, and shower after a fire.



AVERAGE BENZENE OFF GASSING RELATIONSHIP



Data Explanation

Recognition 97 ppm
Detection 34 ppm
WES 1 ppm
Av benzene 0.038 ppm
Locker 0.018 ppm
Room 0.00006 ppm

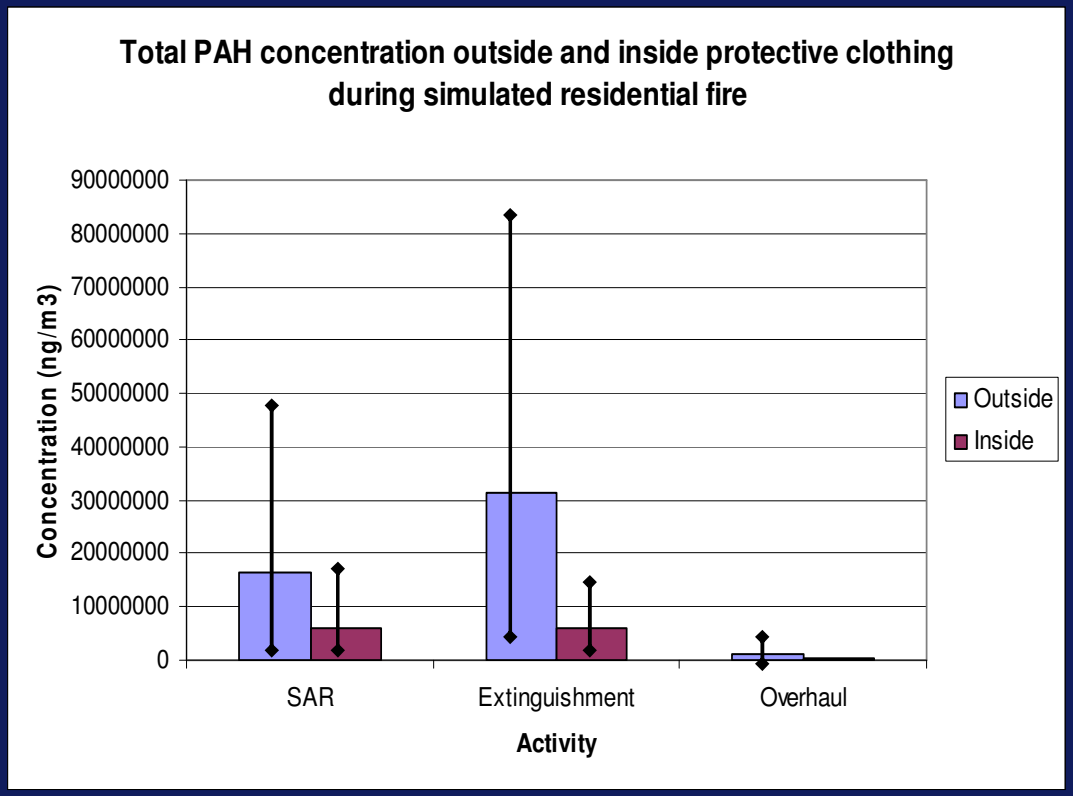
Assumes no air exchanges locker closed- equilibrium

Ratio against WES

SECOND EXAMPLE-TOTAL PAH DURING SIMULATED RESIDENTIAL BURN-SAR/EXTINGUISHMENT/OVERHAUL

Simulated residential burn
Search and Recue (SAR), extinguishment and overhaul.

Differences SAR/Extinguishment and overhaul
95 % reduction from extinguishment to overhaul
Significant variation
(upto ca. 130 X) during same extinguishment activity)
(upto ca. 300 during same SAR activity)
(upto ca. 30 X during overhaul)

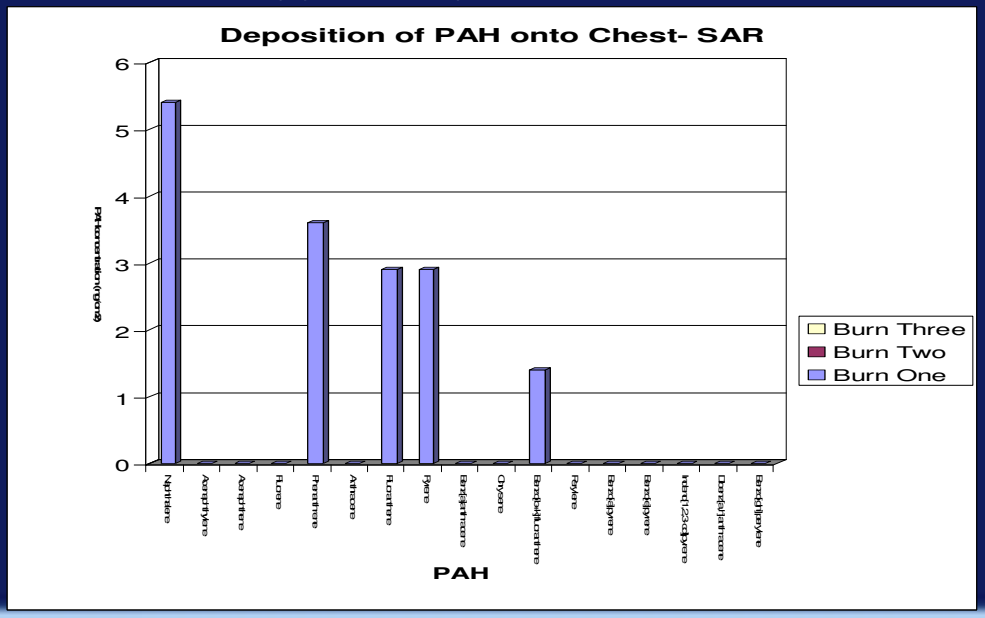


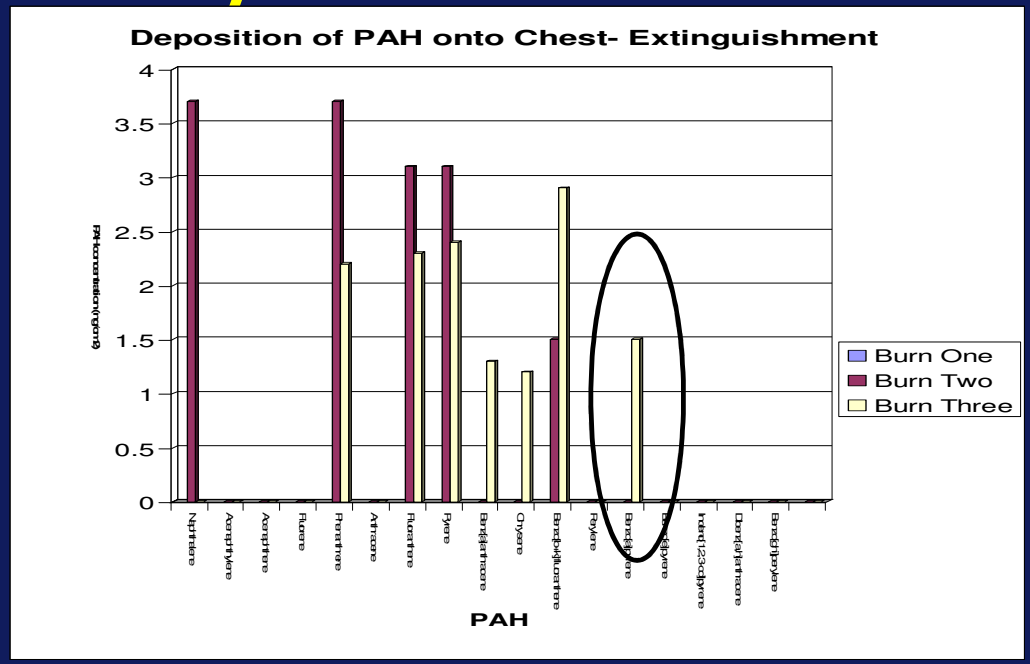
greater variation and higher exposures in residential/office/industrial simulated burns than earlier work undertaken by QFES only during extinguishment (< 6 X)

TOTAL PAH DEPOSITION DURING SIMULATED RESIDENTIAL BURN-SAR/EXTINGUISHMENT/OVERHAUL

PAH deposition onto skin surrogate

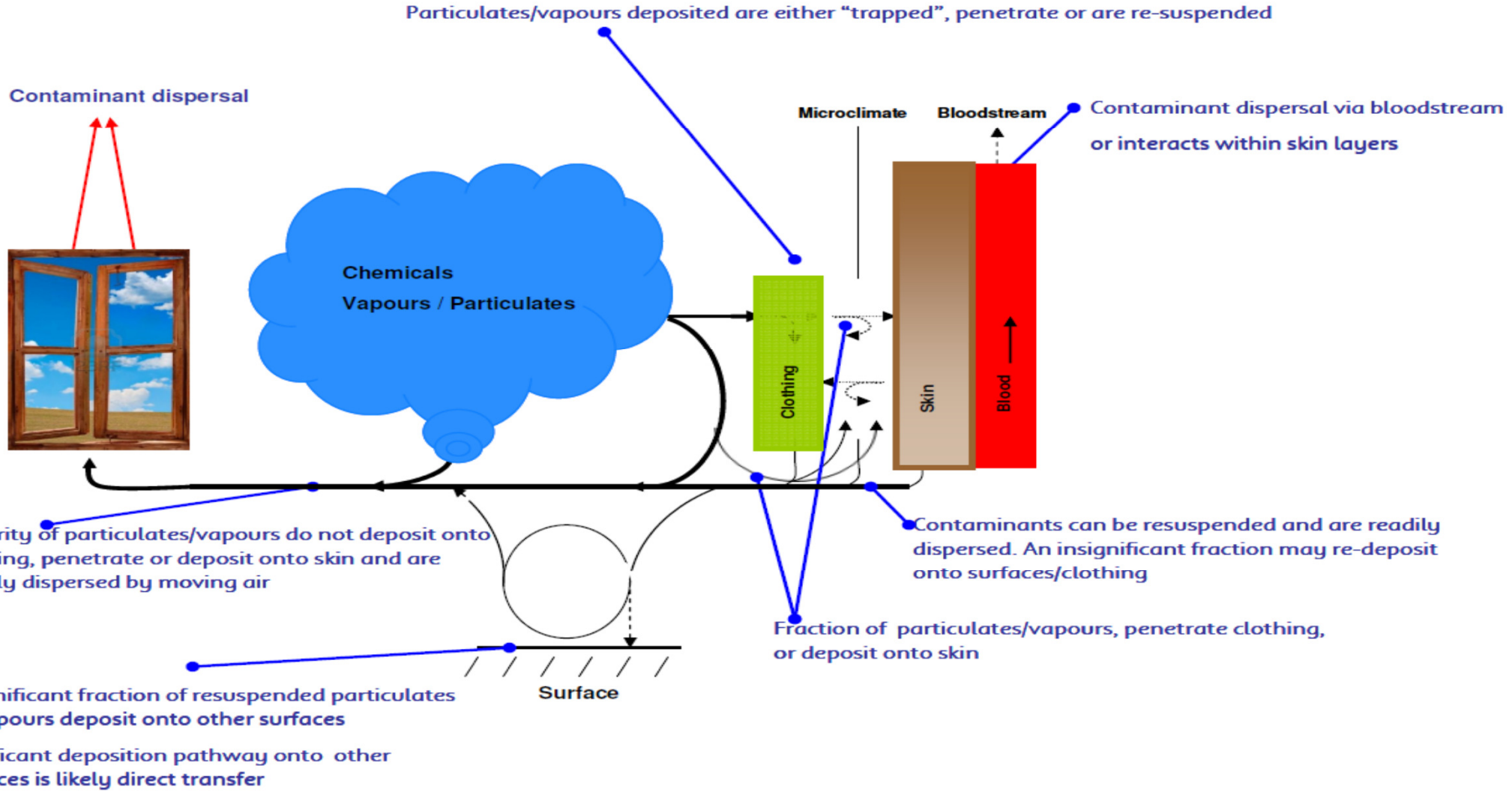
deposition onto arm/chest during SAR/extinguishment
<Limit of Reporting (LOR) during overhaul and on legs
variation between same activity
Naphthalene/phenanthrene most common
Note first time benzo[a]pyrene deposition measured





BEHAVIOUR OF AIRBORNE CONTAMINANTS ON CLOTHING AND SKIN

Qualitative description



WHAT DOES IT MEAN SO FAR?

Fire- fighter exposure varies according to activity

MUST don SCBA and establish control zones around smoke egress

Don't stand in smoke - immediate deposition onto protective clothing and penetration of clothing

- deposition distribution similar to PAH smoke composition

PPE offers some protection against ingress of airborne contaminants especially PAHs

PAH deposition shown to occur on skin surrogate

Have a shower after fire response!!! –limits the dose

Positioning/Tactics influence on exposure yet to be resolved but

- stay low and use positions below neutral plane
- also minimises heat exposure
- stay behind water curtain if possible

Challenge approaches to

how uniforms/workwear are applied and managed.

how vehicles/stations and "inside" are managed

QFRS FIRE-FIGHTER DECONTAMINATION AND LAUNDRY

Chemical Fire
Fire where quantities hazardous materials stored/used,
eg. garden shed, plastics warehouse, pesticide factory

Residence/Office Fire
Typical furnishings expected to find
Eg. apartment, bookstore, office
If storing hazmats or large quantities materials
Seek Expert Advice

Petroleum Gas Fire
Eg. LNG, or propane

Laundry Frequency
consider situation/advice, upto number nominated, or every 6 months which ever is first
If in doubt launder

Station Shower
shower back at station as soon as practicable

	Decontamination	Station Shower	Laundry
Chemical Fire			
Interior Operations	✓	✓	✓
Exterior Operations within smoke	✓	✓	✓
Flammable liquid			
Interior Operations		✓	✓
Residence/Office/Transport Fire			
Asbestos/other fibre	✓	✓	✓
Chemical Fire			
Exterior Operation –no smoke/runoff	X	✓	X ?Activities
Flammable liquid			
Exterior Operations -smoke			✓ X activities
Residence/Office Fire			
Interior Operations	X	✓	✓ 3 entries (45 mins Total)
Chemical Fire			
Cold Zone	X	✓	X 20 activities
Residence/Office Fire			
Exterior Operations	X	✓	X 20 activities
Cold Zone	X	✓	X 20 activities
Petroleum Gas Fire			
Exterior Operations	X	✓	X 20 activities
Transport Fire			
Exterior Operations	X	✓	X ?Agency Policy
Bush Fire	X	✓	X ?Agency Policy