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QUEENSLAND FIRE and RESCUE
FIREFIGHTER EXPOSURE STUDY
“AIR PURIFYING RESPIRATORS DURING OVERHAUL”

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BACKGROUND

QFRS has been undertaking a number of investigations to characterise fire fighter exposures during a number of activities within simulated fires

To determine :

- fire-fighter external exposures;
- fire fighter exposures inside protective clothing;
- deposition of polyaromatic hydrocarbons (PAH) on the protective clothing;
- deposition of PAHs onto the skin; and
- off-gassing from garments after various activities and laundering

To establish

- guidance for fire-fighters to minimise and manage exposures
- post entry management including decontamination, showering, cleaning protective clothing

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BACKGROUND

Studies have also included

determining suitability of respiratory protective devices for use during wildfire operations

included characterisation of airborne contaminants, respiratory rates for work and APR suitability

characterising post fire environment for fire investigators at residential fires

developed respiratory decision logic for use by fire investigators

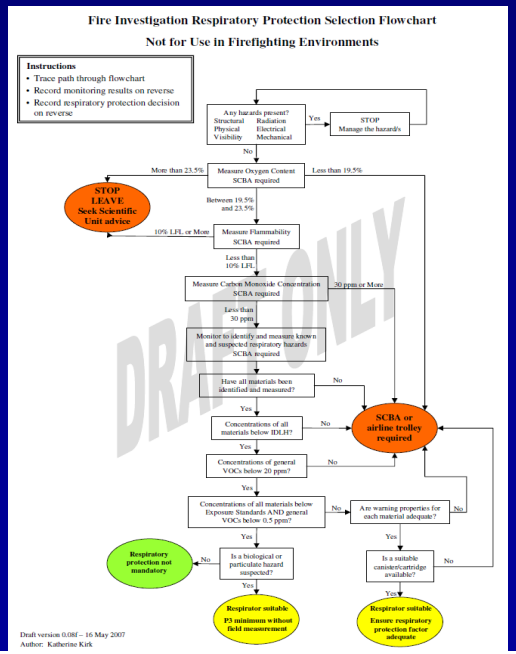

TABLE OF RESPIRATORY PROTECTION SELECTION GUIDANCE FOR VEGETATION FIRES

IF MATERIALS OTHER THAN VEGETATION ARE BURNING, APPLY RELEVANT QFRS INCIDENT DIRECTIVES FOR SELECTION OF PROTECTIVE CLOTHING AND EQUIPMENT

WORK INTENSITY	TYPICAL WORK ACTIVITY	ADJUSTED EXPOSURE STANDARD / EXCURSION GUIDELINE FOR CARBON MONOXIDE BY SHIFT DURATION [See Note 4 on reverse]							RESPIRATORY PROTECTION GUIDANCE [Minimum selection – See Notes 1-3 on reverse]
		15 min	30 min	1 hour	8 hrs	10 hrs	12 hrs	14 hrs	
Sedentary	Driving	200 ppm	100 ppm	60 ppm	30 ppm	21 ppm	15 ppm	11 ppm	If oxygen less than 19.5% use SCBA If CO higher than Adjusted Exposure Standard • Modify work method (e.g. work upwind) if possible and/or • Reduce work duration by rotating personnel and/or • Wear respiratory protection appropriate for CO. P2 charcoal mask (3M 8577) and goggles is the minimum respiratory protection. If available, use full face mask respirator (Promask NP) with MPC Plus cartridge. Work intensity for similar tasks will change with • Temperature • Relative humidity • Terrain (gradient, density of vegetation) • Fatigue
Light	Supervision Pump operation	200 ppm	100 ppm	60 ppm	30 ppm	21 ppm	15 ppm	11 ppm	
Heavy (e.g. work on level or gradual slope)	Ignition Backburning Patrolling Mop-up	200 ppm	100 ppm	60 ppm	30 ppm	21 ppm	15 ppm	11 ppm	
Very heavy (e.g. work on moderate slope)	Ignition Backburning Patrolling Mop-up	150 ppm	75 ppm	45 ppm	22 ppm	15 ppm	11 ppm	8 ppm	
Extremely heavy (e.g. work on steep slope)	Patrolling Mop-up	100 ppm							

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RECENTLY THE INVESTIGATIONS HAVE BEEN EXTENDED TO INCLUDE

Search and Rescue, Extinguishment and Overhaul during

- simulated residential fires
- simulated office fires
- simulated industrial fires

further 3 tests of each simulation with different protective clothing to be completed

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HOW DOES IT GET TO US-EXPOSURE

Source → Pathway → Receptor

Fire -heat
Particulates
Airborne Contaminants

Air

Person

lungs/skin

Most effective entry route is the lungs

This approach describes the exposure
contact of an agent with the outer boundary of an organism

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CONTAMINANTS OF INTEREST

Using a mixture of real-time measurements/ sample collection approaches for laboratory characterisation
Include but not limited to

volatile organic compounds such as
- benzene, xylene, hexane

polyaromatic hydrocarbons such as
- naphthalene, benzo(a)pyrene

oxygenated hydrocarbons such as
- formaldehyde, acrolein

simple inorganics such as
- hydrogen cyanide, hydrogen chloride

The potential airborne contaminant list of interest is almost infinite
prioritise and what is feasible!!!

Be mindful harsh environment

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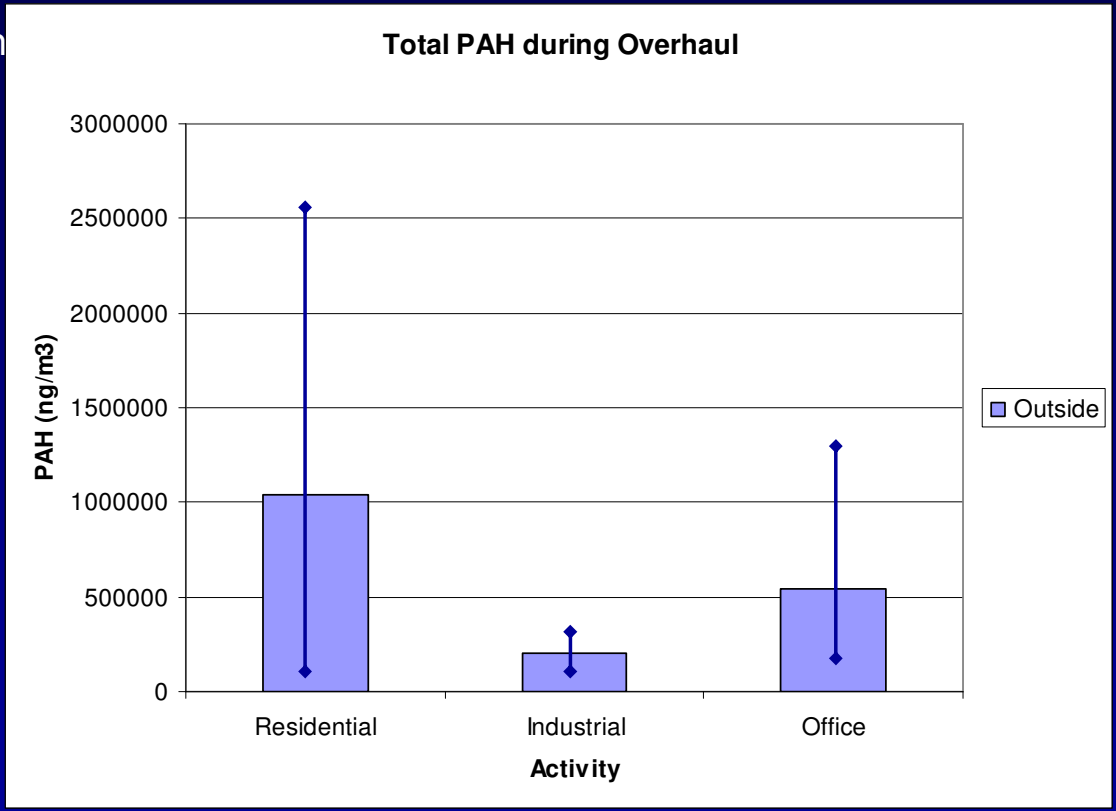
EXAMPLE-TOTAL PAH DURING SIMULATED FIRES RESIDENTIAL/INDUSTRIAL/OFICE-OVERHAUL

Significant changes to distribution/concentration from extinguishment to overhaul

Average differences Extinguishment/Overhaul
Residential 93 % (85-97%)
Industrial 92% (84-96%)
Office 86% (75-97%)



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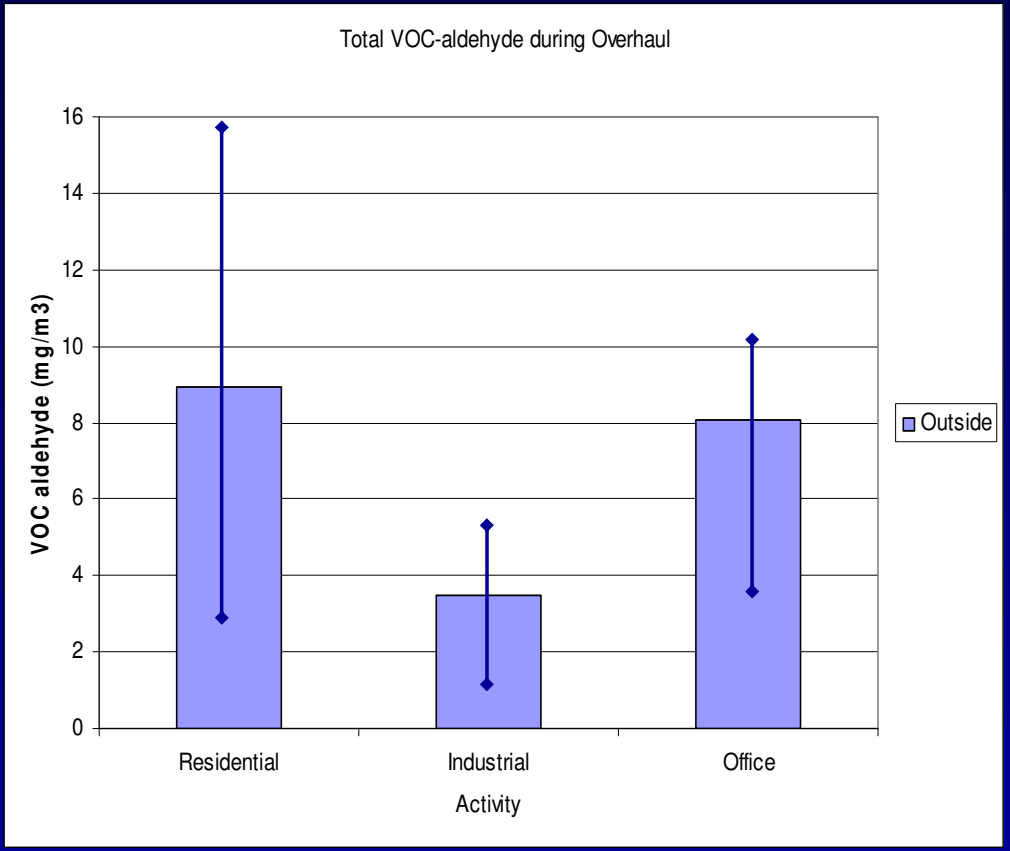
EXAMPLE-TOTAL VOC ALDEHYDES DURING SIMULATED FIRES-RESIDENTIAL/INDUSTRIAL/OFFICE-OVERHAUL

Significant changes to distribution/concentration from extinguishment to overhaul

Average differences Extinguishment/Overhaul
Residential 79 % (77-81%)
Industrial 73% (47-93%)
Office 72% (43-88%)



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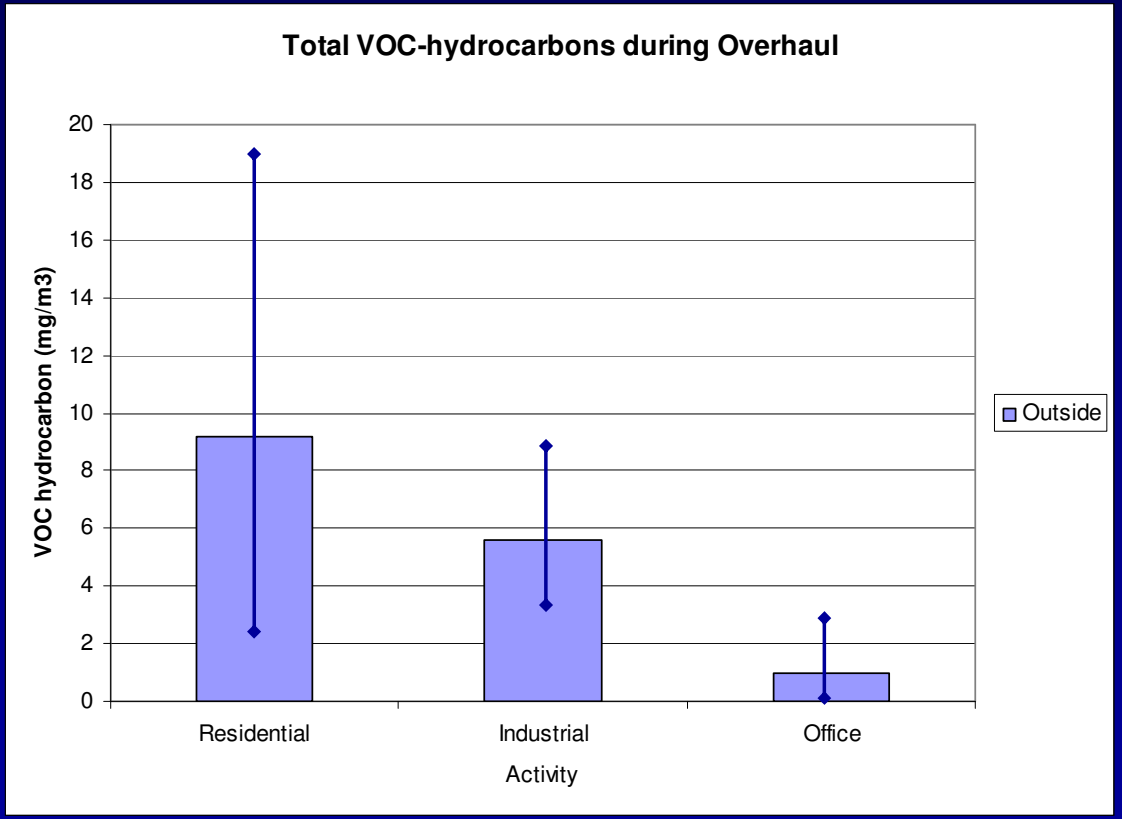
EXAMPLE-TOTAL VOC HYDROCARBONS DURING SIMULATED FIRES-RESIDENTIAL/INDUSTRIAL/OFFICE-OVERHAUL

Significant changes to distribution/concentration from extinguishment to overhaul

Average differences Extinguishment/Overhaul
Residential 86 % (70-95%)
Industrial 27% (18-37%)
Office 94% (82-99%)



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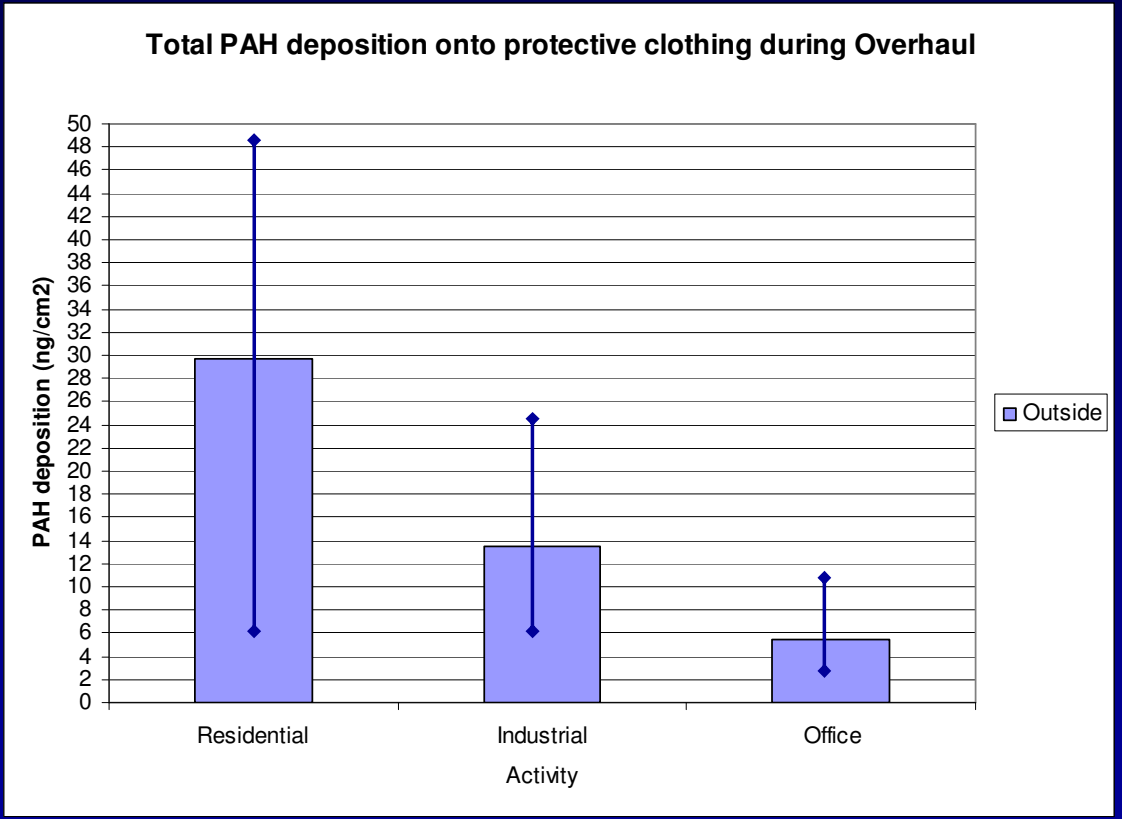
EXAMPLE-TOTAL PAH DEPOSITION DURING SIMULATED RESIDENTIAL BURN-SAR/EXTINGUISHMENT/OVERHAUL

PAH deposition onto protective clothing

Significant variation between same activity
PAH deposition rate also varies
Highest average rate during extinguishment

Average differences Extinguishment/Overhaul
Residential 83 % (60-96%)
Industrial 76% (46-95%)
Office 79% (59-96%)

Evidence of deposition onto skin surrogate patches
Not uniform distribution



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AIR PURIFYING CANISTER CONSIDERATIONS

Air Detection

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Environment
Respiratory Rates
Work/location
Respiratory Protective Device Suitability

SCBA ⟷ APR

There remain many questions to resolve

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AIR PURIFYING CANISTER CONSIDERATIONS

QFRS- fire must be out, not smouldering or evidence of flaming combustion

rationale includes

- complexity of the airborne contaminants and ability to characterise and assess
- location/work and respiratory rates of fire-fighter
- hot combustion gases pose significant issues for canisters
- suitability of alternative forms of respiratory protection

however, fire-fighter can

consult scientific officer about environment, suitability of respiratory protective devices

undertake more detailed assessment of environment

entry through established SCBA control procedures

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AIR PURIFYING CANISTER CONSIDERATIONS

Agree definition of what operational environment and activities constitutes overhaul

Is it ?

Or

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AIR PURIFYING CANISTER CONSIDERATIONS

What are the activities fire-fighters undertake during overhaul?

- characterise tasks, respiratory rates and duration
- do these vary as a function of overhaul environment/department or even season?
- can generalisations be applied

Airborne contaminants

- are these similar across different overhaul environments
- combination of contaminants and impact on the canister- adsorption/capacity
- what guidance values can be applied especially with mixtures

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AIR PURIFYING CANISTER CONSIDERATIONS

Performance issues about canisters are yet to be resolved

these include:

- contaminant concentration and mixtures;
- temperature and humidity effects for some jurisdictions- pressure?;
- end of service life indication;
- absorption phenomena such as competitive absorption or at low concentration; and
- capacity- cycling/respiratory rates.

Relationship to standards and operational value to users