Reducing Cancer Risks for the Fire Service

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Cancer Risks for the Fire Service

- Awareness of cancer risks is increasing
- Challenges to fully characterize the risk and impacts
  - IAFF LODD database - 864 members between 2005-15
  - Mounting epidemiological evidence
    - Increased risk for cancer incidence & mortality

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Excess Cancer Risk[1]

Outcome	Obs	Mortality SMR[3] (95% CI)	Obs	Incidence SIR[4] (95% CI)
All mortality	12,028	0.99 (0.97, 1.01)	NA	NA
All Cancers	3,285	1.14 (1.10, 1.18)	4,461	1.09 (1.06, 1.12)
Esophagus	113	1.39 (1.14, 1.67)	90	1.62 (1.31, 2.00)
Intestine	326	1.30 (1.16, 1.44)	398	1.21 (1.09, 1.33)
Lung	1,046	1.10 (1.04, 1.17)	716	1.12 (1.04, 1.21)
Kidney	94	1.29 (1.05, 1.58)	166	1.27 (1.09, 1.48)
Oral cavity[2]	94	1.40 (1.13, 1.72)	174	1.39 (1.19, 1.62)
Mesothelioma	12	2.00 (1.03, 3.49)	35	2.29 (1.60, 3.19)

1. Cancers with statistically significant excesses in mortality and incidence with U.S rates referent (Daniels et al. Occup Environ Med 2014; 71(6): 388-397).
2. Oral cavity includes lip (excluding skin of the lip), tongue, salivary glands, gum, mouth, pharynx, oropharynx, nasopharynx, and hypopharynx
3. SMR = standardized mortality ratio
4. SIR = standardized incidence ratio

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Occupational Exposure to Fireground Chemicals

- Awareness of cancer risks is increasing
- Challenges to fully characterize the risk and impacts
  - IAFF LODD database - 864 members between 2005-15
  - Mounting epidemiological evidence
    - Increased risk for cancer incidence & mortality
- Need to characterize our 'risk' to positively impact outcomes

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Complex Exposure Pathways

- Source: where the chemicals originate
- Composition: makeup and physical state of the chemicals
- Transport / contact: how the chemicals come into contact with the firefighter
- Intensity: exposure concentration
- Duration: length of the exposure time
- Absorption route: how the chemicals enter the firefighter's body (inhalation, dermal absorption, or ingestion)
- Dose: amount of chemical deposited in the firefighter's body

* Slide prepared by LCDR Kenny Fent, NIOSH

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Potential Sources of Exposure

Residential fire (photo by IAFF.org)

Dumpster fire (public domain)

Vegetation fire (photo by Physics.org)

Industrial fire (photo by Eastern Daily Express)

Car fire (photo by NIOSH)

Training fire (photo by NIOSH)

* Slide prepared by LCDR Kenny Fent, NIOSH

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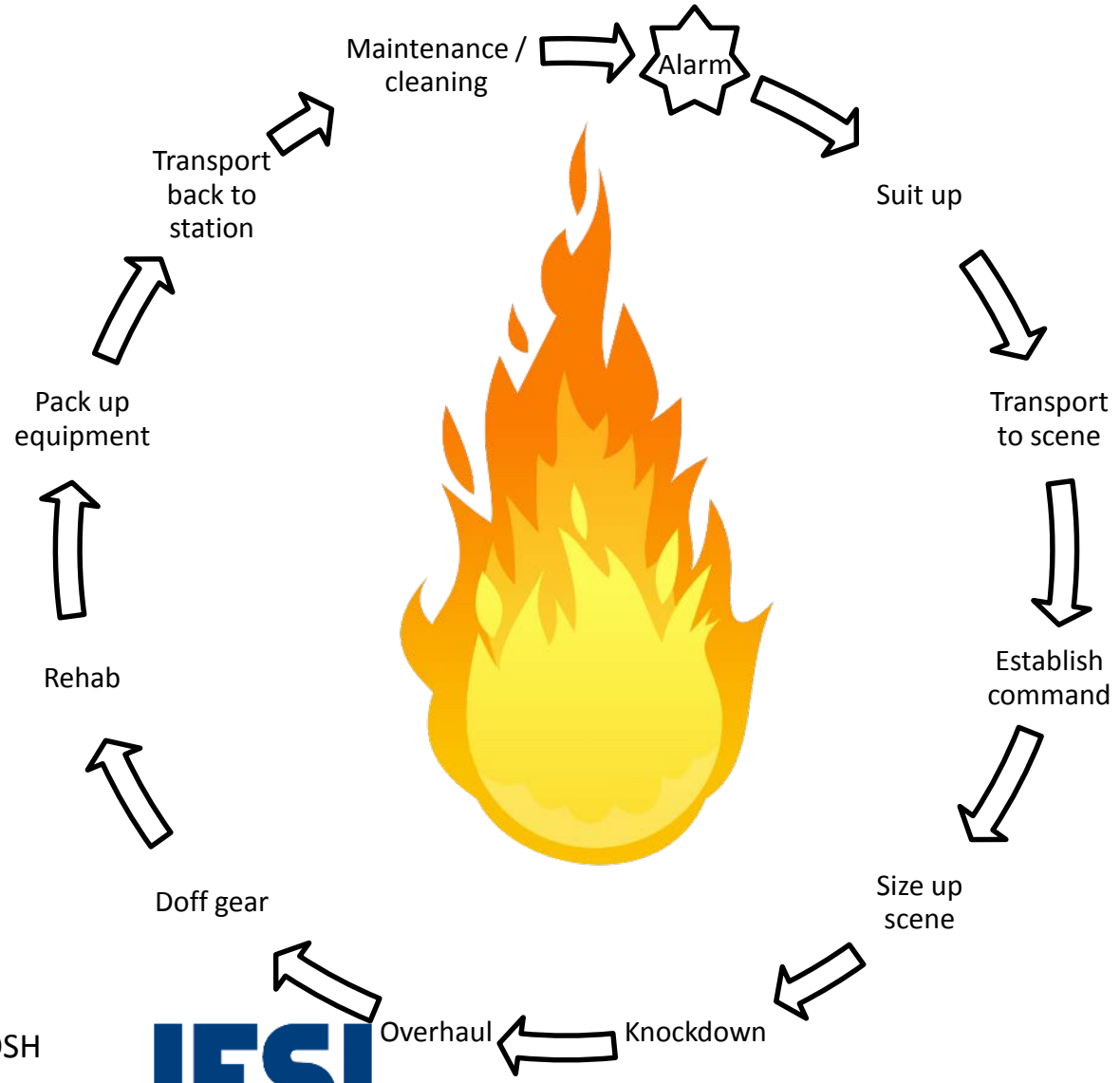
Potential for Chemical Contact



*** Also during live-fire and simulated smoke training**

* Slide prepared by LCDR Kenny Fent, NIOSH

NIOSH HHE Study 2010

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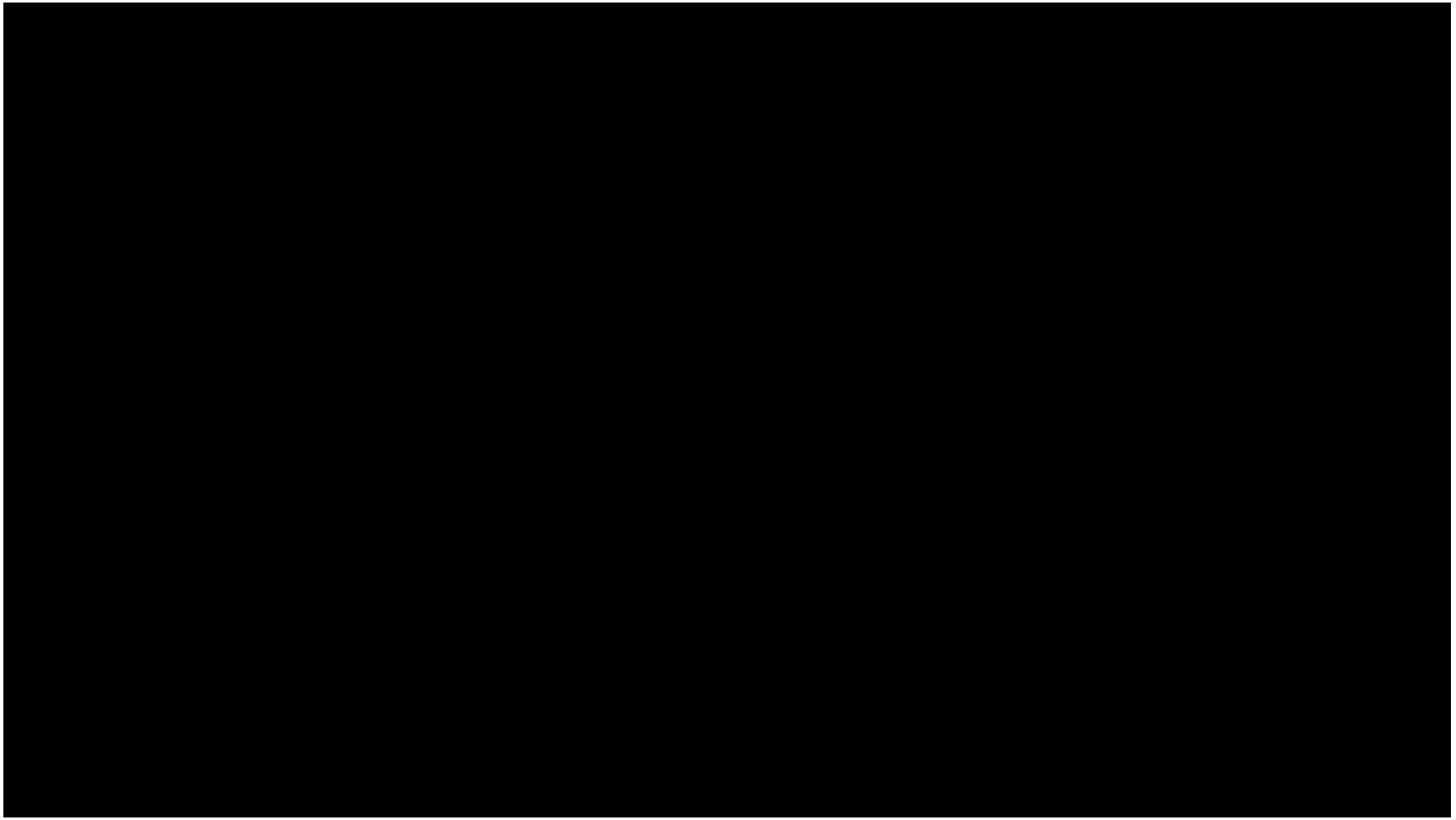
IFSI-UL FSRI-NIOSH Fireground Study



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Interim Report

Cardiovascular & Chemical Exposure Risks in Modern Firefighting

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IFSI Research; UL FSRI; NIOSH; UIC

Interim Report

Cardiovascular & Chemical Exposure Risks in Modern Firefighting

Interim Report – Summary

Full Report can be downloaded from:

https://www.fsi.illinois.edu/documents/research/CardioChemRisksModernFF_InterimReport2016.pdf

Purposes of the Study

This DHS/FEMA AFG funded study was designed to better understand how operating in a modern fire environment is related to the two leading health issues facing firefighters; namely cardiovascular events and chemical exposures related to carcinogenic risk. We investigated the impact of different tactics (traditional interior attack vs a transitional attack) and different firefighting location/assignment (interior attack, outside operations, outside command, overhaul) as well as measures such as skin cleaning and gross on scene decon to affect these risks.

Motivation for Study

Significant advances have been made in our understanding of the hazards associated with structural firefighting.

- Research has provided a greater understanding of the development, propagation and dangers of modern residential fires. The fire service has been provided with important tactical guidance that may potentially increase firefighter effectiveness while decreasing risk.
- Sudden cardiac events are the leading cause of duty-related deaths among firefighters and they are far more likely to occur after fire suppression activity. Substantial evidence suggests that firefighting leads to significant cardiovascular strain.
- Firefighters have an increased risk for several types of cancer. Fires produce hundreds of toxic compounds. Some are carcinogenic like benzene and certain polycyclic aromatic hydrocarbons (PAHs).

Despite these advances in understanding, important questions remain.

- What is the physiological and chemical impact of the different exposures experienced by firefighters employing differing tactics and conducting various job assignments on the fireground?
- How do factors related to firefighting effect cardiovascular responses under realistic modern fire environments? How effectively does the body recover over the 12 hours following a response?
- How - and at what levels - do toxic combustion products get into a firefighter's body? How much of the absorbed dose comes from skin absorption versus inhalation?

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https://www.fsi.illinois.edu/content/research/reports.cfm

Top Considerations

Chemical Exposure Risk

1. Know what's in the air – may end up on PPE, skin and in the body
2. Contamination on Firefighting PPE – job assignment and decon
3. Skin contamination – job assignment and decon

Concentrations of flame retardants (µg/g)* in burn room furnishings

Compound measured	Carpet padding (n = 3)	Curtain liner (n = 1)	Foam from inner spring mattress (n = 2)	Foam topper for bed (n = 2)	Head-board padding (n = 1)	Chair cushion (n = 2)	Liner for chair cushion (n = 1)	Flat screen TV plastic (n = 1)
Polybrominated diphenyl ethers								
BDE 47	< 0.1 - 0.41	0.19	< 0.1	< 0.1 - 0.74	5,600	< 0.1 - 4.1	< 0.1	< 0.1
BDE 85	< 0.1	< 0.1	< 0.1	< 0.1	840	< 0.1 - 1.6	< 0.1	< 0.1
BDE 99	0.11 - 0.56	0.25	< 0.1 - 0.44	< 0.1 - 2.9	15,000	< 0.1 - 25	< 0.1	< 0.1
BDE 100	< 0.1	< 0.1	< 0.1	< 0.1 - 0.6	2,500	< 0.1 - 3.8	< 0.1	< 0.1
BDE 153	< 0.1 - 5.6	< 0.1	< 0.1	< 0.1 - 2.0	2,000	< 0.1 - 13	< 0.1	< 0.1
BDE 154	< 0.1	< 0.1	< 0.1	< 0.1 - 0.69	1,400	< 0.1 - 5.0	< 0.1	< 0.1
BDE 183	< 0.1 - 1.1	< 0.1	< 0.1	< 0.1 - 2.0	67	< 0.1	< 0.1	< 0.1
BDE 206	< 0.1 - 14	2.8	< 0.1 - 6.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
BDE 209	0.41 - 102	440	< 0.1 - 61	< 0.1	< 0.1	< 0.1 - 0.68	< 0.1	< 0.1
Other brominated flame retardants								
TBBPA	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TBB	0.38 - 3.2	910	< 0.1 - 0.5	< 0.1 - 7.5	< 0.1	18,500 - 26,750	68.5	< 0.1
TBPH	0.22 - 5.7	340	< 0.1 - 1.2	< 0.1 - 3.7	< 0.1	5,800 - 6,380	19.6	< 0.1
DBDPE	< 0.1 - 0.53	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Organophosphate flame retardants								
TCEP	< 0.1	1.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TCPP	59 - 630	5.4	< 0.1	< 0.1	8.4	< 0.1 - 1.3	< 0.1	< 0.1
TDCPP	240 - 9,100	1.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
TPP	0.43 - 3.8	4.0	0.16 - 0.23	< 0.1 - 1.3	1,690	1,400 - 7,380	22.6	19
TCP	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

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Example Data: Flame retardant in the Air (µg/m^3)

Compound measured	Fire period – Living Room	Overhaul period – Bedroom
BDE 47	9.6	< 0.04
BDE 85	< 0.17	< 0.04
BDE 99	7.4	< 0.04
BDE 100	< 0.17	< 0.04
BDE 153	< 0.17	< 0.04
BDE 154	8.7	< 0.04
BDE 183	< 0.17	< 0.04
BDE 206	< 0.17	< 0.04
BDE 209	14	< 0.04
TBBPA	12	< 0.04
TBB	9.2	< 0.04
TBPH	1.2	< 0.04
DBDPE	< 0.17	< 0.04
TCEP	< 0.25	< 0.06
TCPP	< 0.25	< 0.06
TDCPP	< 0.25	< 0.06
TPP	2000	14
TCP	220	1.9

Potential source of:

- Contamination in cab
- Contamination in station dust

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Particulate on Fireground

06/30

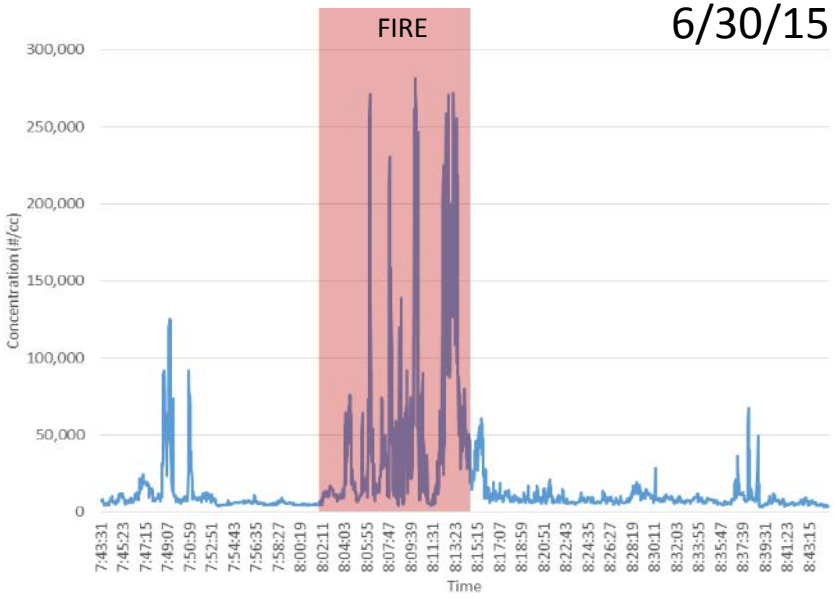
Potential source of:

- Contamination in cab
- Additional exposure to outside firefighters

06/27

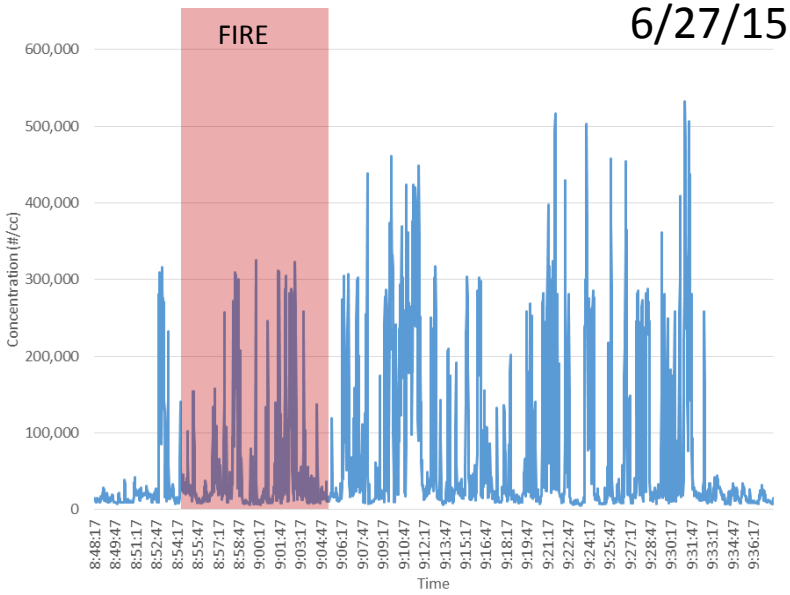
Downwind of smoke plume

6/30/15



Downwind of diesel exhaust

6/27/15



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Top Considerations

Chemical Exposure Risk

1. Know what's in the air – may end up on PPE, skin and in the body
   - Flame retardants – in the fuels and air born
   - VOCs inside and outside structure
   - Particulate – from the fire and operating apparatus

Top Considerations

Chemical Exposure Risk

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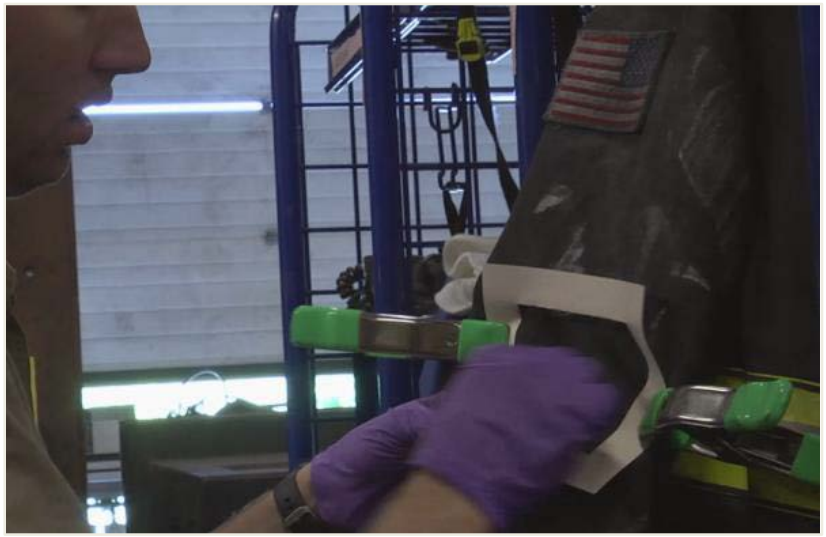
2. Contamination on Firefighting PPE – job assignment and decon

Example Data: PPE Surface Contamination with FR (ng/100 cm^2)



Next Innovation?

How do we best decon gloves?
Need same attention as hoods!!

Compound Measured	Post-fire (jacket)*	Post fire (right glove)
BDE 47	48	35
BDE 85	< 1	< 1
BDE 99	< 1	40
BDE 100	< 1	12
BDE 153	< 1	< 1
BDE 154	< 1	< 1
BDE 183	< 1	< 1
BDE 206	< 1	< 1
BDE 209	1,200	1,200
TBBPA	< 1	30
TBB	22	30
TBPH	11	14
DBDPE	140	290
TCEP	5.5	< 1.5
TCPP	< 1.5	200
TDCPP	190	460
TPP	2	3,100
TCP	< 0.2	360

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Gross On-Scene PAH Decontamination

Thoughts for Innovation:

Air Brush – No Effect

Dry Brush - ~25%

Wet Soap - ~85%

Can we do better?

Fent et al. **Contamination of firefighter personal protective equipment and skin and the effectiveness of decontamination procedures**, in review *JOEH*

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Example Data: Air Concentrations of VOCs off-gassing from PPE (ppb)

Same approximate volume as apparatus cab

Fireground Operations:

Allow PPE to off-gas outside of the cab

Compound Measured	Wet decon		
	Pre-fire	Post-fire*	Post-decon
Benzene	< 0.6	75	< 0.6
Toluene	< 0.5	19	< 0.5
Ethyl benzene	< 0.4	3.3	< 0.4
Xylenes	< 0.4	2.2	< 0.4
Styrene†	< 0.4	120	0.42

HCN follows similar trend

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Top Considerations

Chemical Exposure Risk

1. Know what's in the air – may end up on PPE, skin and in the body
2. Contamination on Firefighting PPE – job assignment and decon
   - Significantly depends on job assignment
   - Gloves may be more contaminated than bunkers
   - Gross decon using water, soap and brush can remove 80-90% of contamination
   - Offgassing in cab can provide additional exposure to firefighters
3. Skin contamination – job assignment and decon

Skin Contamination

- Hands may be more heavily contaminated than neck
  - Interior firefighters!
  - Water/sweat may carry contaminants through interfaces
- Neck heavily contaminated for Inside firefighters
  - Also outside vent and overhaul
  - Contamination found even if entry is never made!

- Skin cleansing wipes
  - Reduced contamination by 54% (when present)

Options from Manufacturers?

Healthy In, Healthy Out; Washington State; Beth Gallup

Top Considerations

Chemical Exposure Risk

1. Know what's in the air –
   - Flame retardants – in the fuels and air born
   - VOCs inside and outside structure
   - Particulate – from the fire and operating apparatus
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   - Significantly depends on job assignment
   - Gloves may be more contaminated than bunkers
   - Gross decon using water, soap and brush can remove 80-90% of contamination
   - Offgassing in cab can provide additional exposure to firefighters
3. Skin contamination – job assignment and decon
   - Contamination on the hands appears more significant than the neck
   - Skin wipes can remove ~50% of contamination on skin

Coming Soon …

- Initial academic papers – coming weeks/months
  - Open Access
- Final report and toolkit – End 2017
- Biological uptake (?) of contaminants
- Training ground study
- Repeated cleaning of PPE
- Impact of new hood design
- **Next questions…**

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