Clean Cab, Decontamination, and Exposure Risk Reduction for Wildland Firefighting Vehicles

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Background

In the course of their duties, firefighters are exposed to a complex suite of hazardous, toxic, and carcinogenic materials that are inhaled and deposited on the skin and personal protective equipment (PPE) of firefighters (1-3). Advances in decontamination procedures and exposure protections in structure firefighters began as early as the 1970s (4). However, a long-term myth that firefighting in the wildland was less dangerous—because the smoke was made up primarily of plant materials and not building or artificial materials—has suppressed the urgency to develop better safety practices for wildland firefighters. Moreover, today's wildland urban interface (WUI) fires have structures, vehicles, infrastructure and vegetation all burning simultaneously, with responding agencies that can come with a diversity of vehicles, PPE, experience, and training, yet the protection standards are still far behind the growing risk and need.

Although significant advancements in PPE have helped keep firefighters safe from burn, chemical, biohazard, and physical injuries, the gear also absorbs a significant amount of smoke, ash, and various hazardous, toxic, and carcinogenic substances resulting in sustained exposures as their PPE continues to off-gas in the engine cabs of their vehicles, and toxins transfer to skin, upholstery, and other surfaces (5-6). As a result, many fire agencies have adopted "clean cab" protocols and policies, making the vehicle's cab a "clean zone" for reducing total exposure.

In contrast, wildland firefighters do not wear or carry SCBA, can work 24 hour or longer shifts in the same PPE, and often sleep on the ground during rest periods—also in the same PPE, with limited opportunities for showering or laundering (7-8). While there is some encouragement for decontamination post incident, there are no comprehensive standards or procedures that have been universally adopted by wildland firefighting agencies (9).

Firefighting in the wildland and WUI, requires a completely different set of tactics that preclude the use of external storage for PPE, and strategies such as "bump and run" require firefighters to climb in and out of the vehicle as fires progress, often during chaotic and fast-moving events – where little time if any exists to limit contamination into the cab's interior. Today we experience an average of 70,600 wildfires with well over 8 million acres burned each year (10), and as the frequency and intensity increases, exposure risk now endangers a rapidly growing workforce. Implementing best practices including some version of "clean cab" is paramount in reducing occupational exposures and risk.

Objectives

Little is known about cross-contamination and potential high-risk exposures on vehicles and apparatus used in the wildland/WUI context. The purpose of this project was to:

1) Understand and identify high-risk/high-contaminated areas within the wildland/WUI apparatus;
2) Identify other novel factors involved with exposure risk, including in-cabin air quality and PPE off-gassing; and
3) Provide general recommendations and solutions to reduce occupational exposure risk based on these results

Methods

In Phase 1 of the project, we evaluated how contaminants can be introduced to the wildland/WUI vehicles, by covering firefighters with UV powder to observe surface exposures, contamination, and transference. We worked with CAL FIRE and other fire agencies (Austin Fire Department, and diverse agencies responding to wildland/WUI incidents in California) to track firefighter movement and transference on a variety of apparatus and incidents. Phase 2 included an analysis of 10x10cm swab samples collected on key areas of potential contamination within the apparatus (identified from the results from Phase 1), with an emphasis on detecting PAHs, volatile, and semi-volatile organic compounds.

The final assessment performed on wildland/WUI incidents and controlled burns (with CAL FIRE), evaluated respiratory firefighter exposure risk inside the vehicles, and the role that the PPE and firefighters themselves play in the overall exposure and contamination risk in the apparatus. This was done using a suite of air quality monitoring sensors developed in partnership with the National Institute of Standards and Technology (NIST), focused on particulates, VOCs, benzene, airborne acids, nitrogen and sulfur oxides, cyanide, and other compounds. Both active incidents (with firefighters) and simulated incidents were monitored. During the simulated incidents, wildland PPE (four sets of jackets and pants) were exposed to simulated wildland/WUI smoke (consisting of wood, tar paper, straw, and PVC) for one hour, and then used inside a Type 3 engine to evaluate off-gassing and airborne contaminants.

Tracking firefighters using UV reactive powders and identifying the transfer of the materials onto various parts of the apparatus and equipment.

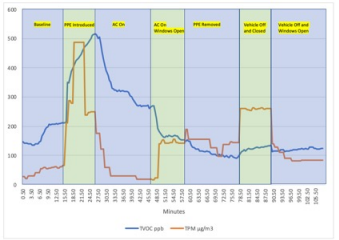
Tracking firefighters during active incidents, training, and simulated WUI incidents, and using smoke-exposed PPE inside the apparatus to measure off gassing

Results

We were able to determine high touch areas within the apparatus and on the equipment with the highest rates of potential contamination from the firefighter's tools, hands, boots, and body. Various material types and locations tended to show higher levels of contamination and exposure. In Phase 2, while no PAHs were detected using swab sampling, a total of 29 unique volatile and semi-volatile organic compounds were detected, many of which carry health risks, demonstrating that indeed these areas were contaminated during actual incidents. A relative ranking of identified locations is provided in the adjacent table. Our assessment also provided a relative ranking and potential exposure risk by material type, that included: cloth (4.06), hard plastic (textured; 3.2), rubber (2.95), metal (2.6), vinyl (2.57), hard plastic (smooth; 2.28), and mixed materials (1.29).

Location	Relative Ranking	Location	Relative Ranking
Floor	8.67	Grab Handles	2.5
Cloth Seats	4.71	Coolers	2.33
Door Handles	4.52	Door Gasket	2
Steering Wheel	4.17	Entry Sill/Steps	1.51
Communications/Headsets	3.25	Computers/Tablets	1.5
Vinyl Seats	2.77	Tools	1.29
Seat Belts	2.69	Ignition	1.17
Switches/Knobs	2.54	Window Sill/Arm Rests	0.46

During the assessment inside the cab, we observed that over fifty percent of the time, the air quality within the apparatus showed significantly higher levels of key constituents including PM and VOCs than what was recorded outside the apparatus as ambient air quality (even when the apparatus was surrounded by heavy smoke). We determined that this was largely the result of off gassing of the firefighters and their PPE, gear, and tools. The use of various mitigation measures significantly lowered the levels of PM, VOCs, benzene, sulfur and nitrogen oxides, and other compounds. This included turning on the air conditioning, rolling down the windows, and removing the PPE from inside the apparatus.



Conclusions

Clean Cab strategies can be an effective tool for avoiding, minimizing, and mitigating exposure risk for wildland/WUI firefighting. Key features of a clean cab programs should consider the following recommendations.

Apparatus Cleaning Protocols
- Periodic gross decontamination
- Regular replacement of filters
- Thorough decontamination protocols post incident

Firefighter Practices
- Remove PPE when possible
- Regular gross decontamination
- Storing gear outside cab
- Not using "dirty" PPE at the start of the shift
- Avoid any contamination of water/food
- Training programs for awareness
- Robust and standardized full decontamination

Apparatus Features/Design:
- Update materials to reduce transfer/absorption
- External storage for PPE and gear/tools
- Improved in-cab filtration
- Facilitate vehicles to off gas
- Install washing stations on vehicle

Other Key Findings
- Develop scalable solutions for all industries
- Clean PPE is not always "clean"
- Firefighters are unaware of the issues or underestimate them
- Institutional challenges for change exist

A COMPLETE LIST OF INTERIM RECOMMENDATIONS IS PROVIDED IN THE DRAFT DOCUMENT

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