SOURCE CAPTURE AS THE RECOMMENDED METHOD TO CONTROL DIESEL EXHAUST EMISSIONS AT THE FIRE HOUSE

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The Issue

Today's fire fighter faces an ever growing number of hazards. Many of these hazards are obvious--the direct contact with fire, the excessive amounts of heat, and the enormous physical burden that fire fighters accept in the course of their duties. In past times, fire fighters were sometimes known as "**smoke eaters**," as tradition dictated a cadre of individuals that could undertake rescues under the worst of fire conditions with little or no protection. However, as technology advances, fire fighting has become more of a science than an art. This fire science teaches us that we must approach fire fighting in a smarter and safer way. *Paramount in this approach is to reduce those hazards which the fire fighter can control.*

Fire fighters wear protective clothing and self contained breathing apparatus (SCBA) to limit their exposure to various hazards on the fire ground. Yet, fire fighters can equally be exposed to hazards *off the fire ground.* **Fire fighter exposure to diesel fuel emissions from fire apparatus within the fire station** represents a significant hazard within the fire service. Continued exposure to diesel fuel emissions has been **linked to cancer and other serious health disorders.** Fire departments must take active measures to reduce this exposure. While several solutions may be apparent to remedy this problem, ***only "proven" source capture methods offer an economic and practical means to virtually eliminate fire fighter exposure to diesel fuel emissions.***

Background

Diesel engines, used in fire apparatus, produce a mixture of toxic gases and particulates as the result of the combustion process. The composition of this exhaust product depends on several factors such as the specific fuel used, temperature of the engine, condition of the engine, cleanliness of the air intake filter, among others. Analyses of general diesel engine exhaust have revealed a variety of extremely toxic substances at significant concentrations[1,2], including:

- ***nitrogen oxides***; any combustion in air will produce various nitrogen oxides. Short term exposures can cause respiratory tract irritation and infections. Long term exposures result in lung tissue damage and difficulty in breathing.

- ***carbon monoxide***; this chemical is always produced as a by-product of combustion. Exposure to high levels of carbon monoxide causes death by tying up the hemoglobin in blood and preventing oxygen intake by the body. Exposure to carbon dioxide at lower concentrations causes headaches, dizziness, weakness, and neurological problems.

- ***volatile organic compounds*** (VOCs); these compounds are a class of carbon-based chemicals such as benzene, toluene, phenol, and chlorinated solvents. Many of these chemicals cause a variety of adverse health effects such as headaches, nausea, neurological disorders, respiratory irritation, and liver damage. Many VOCs are known or suspected carcinogens.

- ***polynuclear aromatic hydrocarbons*** (PNAs); PNAs are a class of relative large, complex chemicals principally formed during combustion processes. In diesel exhaust, these chemicals may adhere to the soot particles or adsorb onto materials they contact. Most PNAs are documented carcinogens.

Much of the ***diesel exhaust is invisible*** consisting of toxic gases and the smallest soot particles. This means that exposure cannot always be detected. Furthermore, ***diesel exhaust can penetrate into and adsorb onto clothing, furniture*** and other items with which fire fighters have routine contact, where it can be later released after the initial exposure or absorb into the fire fighters' skin. Some chemicals within diesel exhaust can remain adsorbed on surface where it can continue to come into contact with fire fighters' skin.

Many studies over the past several years point to an alarmingly high rate for the incidence of cancer and other health problems among fire fighters:

- The International Association of Fire Fighters (IAFF) list cancer as one of the major occupation hazards facing fire fighters today.[3]

- A study of Seattle fire fighters shows a high level of mortality from diseases such as lung cancer, non-malignant respiratory disease, and cardiovascular disease.[4]

- An analysis of fire fighter deaths in the Boston area indicated a 3 to 1 increase in fire fighter cancers when compared to the general population.[5]

- In Los Angeles, cancer mortality among surviving fire fighters is elevated for all lung and circulatory system cancers.[6]

Concerns over repeated diesel exhaust exposures at the fire station are well founded. Both the National Institute for Occupational Safety and Health (NIOSH) and the U. S. Occupational Safety and Health Administration (OSHA) have declared **human exposure to diesel exhaust as a potential occupational carcinogenic (cancer-causing) hazard** through toxicological studies.[7] A 1985 study commissioned by IAFF involved the measurement of diesel exhaust emissions at selected fire stations in New York, Boston, and Los Angeles.[8] This study indicated that the most significant source of fire fighter exposure to diesel exhaust was from the exhaust remaining in the station after the engine start. Some variations in the study results were identified, based on differences in climate, station design, number of runs per tour, and whether the fire fighters smoked or not. From these findings, the IAFF study concluded:

> *"Even with the uncertainties in the reported studies, apparent prudent public health practices would require that steps be taken to limit fire fighter exposure to diesel emissions."*

Later studies substantiated this problem to even show significant diesel exhaust emissions at smaller, less busy fire stations.[9,10] As early as 1986, the New Jersey Department of Health distributed a bulletin alerting fire departments within the state of this problem.[11]

Available Solutions and Their Merits

Various methods have been suggested for reducing diesel exhaust emissions at fire stations.[12-15] These possible solutions take three different forms:

1. ***Engineering controls*** involve methods which reduce the amount of toxic substances released by the diesel engine.

2. ***Ventilation*** increases the flow of clean air to affected areas by adding apparatus room exhaust fans and make up air sources and may, in some cases, provide "positive pressure" make up air in the living and work areas.

3. ***Source capture*** entails placing hose collection devices directly on the apparatus tail pipe and venting the emissions harmlessly into the atmosphere.

Some research has indicated that ***engineering controls*** offer the best method to reduce diesel exhaust emissions since this approach eliminates much of the hazard before it is generated.[16] This solution is based on the use of cleaner burning fuels, better fuel ignition, and improved particulate traps. In addition, diesel engines built after 1995 will have to meet more stringent emission standards as mandated by the U.S. Environmental Protection Agency in accordance with the 1993 Clean Air Act.[17] ***Currently, technology is not available and will be very expensive*** for the fire service to implement. More importantly, the newer generation of diesel engines will ***still produce some exhaust containing hazardous chemicals***. Furthermore, as these newer diesel engines remain in service, their effectiveness in reducing exhaust will diminish as the engine no longer operates at its optimum performance levels. Interim solutions such as ***after market diesel exhaust filters*** added to the apparatus exhaust system may appear to clean exhaust by removing visible particulates, but ***still allow hazardous gases to pass through*** and remain within the fire station. Without monitoring of the atmosphere, there is no way for the fire fighter to determine if the hazardous condition has been removed.

Ambient "general" ventilation is the ***least desirable solution***.[18] Strategies include diluting diesel exhaust gases with fresh air and keeping contaminated air from entering living or work spaces within the station. There are three general approaches to general ventilation:

1. In its simplest form, the apparatus bay doors are left open for several minutes after the diesel-powered apparatus has left, allowing fresh air to enter the apparatus room. Typically, this approach also uses large capacity fans to exhaust diesel emission, creating a negative pressure within the apparatus bay, thus allowing clean air to rush in. The activation of these fans may be linked with the apparatus doors such that the fans are turned on when the doors open.

2. Additional ventilation control can be provided by the station's heating, ventilation,

and air conditioning system to "over" pressure living or work areas. This approach requires the use of mechanical make up air systems to provide equal amounts of outside air to replace apparatus bay air which is exhausted. Some systems employ air distribution ducts for moving air into the desired areas as well as supplemental cooling and heating to temper outside air before it is released within the fire station.

3. Self-contained general ventilation filters may be used in combination with each of the two approaches above. These filters are strategically placed over the apparatus in an effort to pick up free floating diesel exhaust and are intended to remove contaminants by passing the air through mechanical particulate traps and sometimes activated carbon adsorbents. As with the diesel exhaust filters mentioned previously, this technology does not remove all contaminants.

General ventilation approaches have several disadvantages:

- First of all, they ***do not guarantee removal of all diesel exhaust*** because of "dead" air spaces within the station.

- Furthermore, ***the rate of air exchange within the apparatus bay does not always keep pace with the generation of diesel exhaust.*** In other words, significant quantities of diesel exhaust can remain in the apparatus bay before general ventilation systems can remove most of it.

- ***There are often no precautions in place to know when the system is not performing as designed.***

- Proper design of a ventilation system usually ***requires extensive modifications to the station*** at a very high cost.

- Moreover, this approach does not keep exhaust from absorbing into clothing and equipment (which may be stored in or near the apparatus bay) or other textile/plastic materials within the station.

Exhaust source capture is considered the ***most reliable means to significantly reduce or eliminate exposure*** of fire station occupants to diesel exhaust emissions. This solution consists of a collection tube attached to the apparatus tail pipe with a high powered fan used to draw the exhaust gases through the tube to be discharged harmlessly to the outside atmosphere. Just as truck and engine manufacturers are required to design and provide exhaust systems which are air-tight for eliminating the chance of toxic exhaust contamination from spreading into the vehicle passenger compartment, exhaust source capture systems must be similarly designed. Therefore, it is important that the design of these systems entail:

- ***air-tight exhaust duct work*** using sealed connections that start at the exhaust tailpipe and extend through the entire exhaust ventilation system until it exits exterior to the building (The tailpipe connection as well as other seals should be sealed in such a manner that prevents leakage when the apparatus is operating);

- a ***spark-resistant exhaust system*** since significant concentrations of volatile organic hydrocarbons are often present in the exhaust stream (This can usually be achieved by using a "Class A" spark-resistant exhaust fan and grounded duct system);

- ***automatic activation via an in-line sensors*** which monitor when the apparatus engine is started or stopped thus ensuring that the exhaust system is always running during the period that the apparatus is operating (Sufficient time should also be given so that exhaust gases can be purged from the exhaust system after engine shutdown); and

- an ***automatic disconnect nozzle*** allowing vehicles to drive into and out of the fire station with the hoses still attached to the exhaust system (the pick up hose safely disconnects from the vehicle and is retracted into the building permitting automatic doors to close).

Compared with other properly implemented solutions for reducing diesel exhaust emission, source capture versus filter-type systems are the ***least expensive, easiest to achieve, and are currently available***.

Recommendations

Fire service studies and statistics bear out a significant problem for continued fire fighter exposure to diesel exhaust emissions. Given the high incidence of cancer among fire fighters, each fire department should take immediate steps to reduce the level of diesel exhaust emissions within their fire stations as urged by the IAFF. ***A "proven" source capture system remains the only viable option for effectively dealing with diesel exhaust emissions.*** These systems are capable of eliminating nearly all exhaust from the apparatus and can be easily implemented in different fire station facilities.

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