Health Implications of Deployment Exposures: Diesel and JP-8 Engine Exhaust

FACT SHEET 64-024-0414

Purpose:

To summarize what is known about the health implications of engine exhaust exposures in deployed settings to include: sources of exposure, mitigation tactics, significance of military exposures in terms of immediate and potential long term health implications, persons at potentially higher risk of effects, and general medical guidance.

General Description:

Engine exhaust is the mixture of small particles and gases that are released during the burning of fuel in internal combustion engines in vehicles, aircraft, generators, and furnace engines. The fuel types include gasoline and diesel fuels, including JP-8 ("jet propellant-8"). The exhaust released when these fuels are burned is made up of small carbon particles, unburned hydrocarbons (such as benzene, toluene, and xylene), carbon dioxide, carbon monoxide, nitrogen oxides, sulfur oxides, water vapor, and small amounts of metals and other chemicals like formaldehyde. Some compounds are adsorbed onto the particulate matter (PM), while others may be released as fumes or a gas. The PM can be visible as "soot." The actual composition of exhaust (particle sizes and chemical make-up) depends on fuel type and purity, engine type, and operating conditions, especially the temperature at which it is burned.

Exposure to exhaust is not unique to deployment settings. Engine exhaust is a large part of the air pollution in the US and other industrialized countries, especially urban settings. Certain occupations such as truckers, railroad workers, and miners have been found to have higher and more continuous exposures to diesel exhausts.

Types of Exposures in Deployment:

JP-8, the primary fuel in military deployments, is mostly "kerosene," is thicker than diesel, and contains less benzene--a known cancer-causing chemical. It evaporates more slowly, and so the liquid fuel itself can be a skin hazard. Exposure to the exhaust occurs through inhalation (breathing) rather than ingestion and skin absorption. Since studies show that diesel and JP-8 exhaust are generally similar; the term "diesel exhaust" (or "DE") in this factsheet includes exhaust from JP-8.

Because of the deployed military's heavy reliance on diesel engines (e.g., transport and combat vehicle and aircrafts generators for heating, cooling, power), exposures to DE may be more frequent and somewhat higher than experienced by the general public in typical U.S. urban settings. For most personnel, these exposures would be much less than those experienced by persons in particular occupational settings and would not require specific medical surveillance. However, certain military occupations (e.g., vehicle or engine maintenance) could place personnel in areas such as motor pools that do not have adequate ventilation and thus could resulting in higher and or more frequent exposures. Frequent or continuous low level exposure to DE from generators that are inappropriately vented near work areas or life support areas could also be a concern. It is also important to recognize that, depending on the deployment location, and individual's exposures to the PM and other chemicals in DE may be *in addition to* other PM and chemical exposures from other sources. For example, in Southwest Asia, personnel may be exposed to ambient PM from windblown dust, burning trash, and industrial sources. When the general precautions for its handling are followed, JP-8 can be used to ignite and help burn human and other solid wastes in a burn pit, burn-out latrine or burn-barrel latrine. So, even if a person's DE exposures alone are not associated with acute or long term effects, they could present an additive component of that person's overall inhalation exposure experience – which may cumulatively result in risk of acute or long term effects.

Exposure Mitigation/Risk Reduction Measures:

While use of personal protective skin and eye equipment is warranted to protect those working directly with the diesel or especially JP-8 *fuels*, protective equipment is not necessary for typical exposures JP-8 or diesel *exhaust* (DE) in deployment settings. The following actions are routine recommendations to minimize exposure to DE:

- Ensure adequate ventilation wherever motor vehicles are operated
- Do not operate vehicles in enclosed areas for extended periods unless exhaust is vented to the outside
- Reduce or eliminate unnecessary engine idling
- Do not place generators near building doors, windows, or intake vents for air handling systems; and direct the generator exhausts away from the buildings
- Ensure engines are properly maintained and operated
- Avoid troop formations in close proximity to idling or stationary engines

Acute Effects Potentially Associated with Deployment Exposures:

Short term or one time acute exposures to DE can cause irritation to the eyes, nose and throat, headache, light-headedness, dizziness, and chest tightness. The greatest acute concern from engine exhaust during deployments in the past has been due to carbon monoxide (CO) from inappropriately vented heaters in tents and working quarters. Guidance on proper fuels and venting procedures has mitigated this problem.

Some of the exhaust (larger particles) can be expelled from the body by coughing or sneezing and some soot may be visible in expelled sputum. The smallest particles may reach the lung. In deployments, particulate matter (PM) exposure from DE is often experienced in conjunction with other sources of PM – to include windblown dust and sand and industrial smokes. Measured levels of PM in Southwest Asia (Iraq, Afghanistan) indicate that some persons – especially those with existing respiratory conditions (e.g., asthma) or possible cardiovascular conditions - may experience more serious acute effects or aggravation to their condition.

Long-Term Effects Potentially Associated with Deployment Exposures:

Occupational studies have been unable to specifically quantify individuals' DE exposures since the durations, frequency, and mixture of components are so variable. As such, the results of studies are not always clear. However, while short term DE exposures have not been attributed to long term effects, some studies of workers routinely exposed to DE provide evidence of increased risk of some long term health effects. Truck drivers, bridge and tunnel workers, mineworkers, forklift drivers, railroad and dock workers, and garage workers have been identified with highest exposures. Farm workers and vehicle maintenance workers may also experience heavy exposures. Several animal studies also show relationships between repeated exposures to DE and certain long term effects. Since most deployed military personnel are not expected to experience DE exposures like in the high occupational exposures, they are not expected to have associated long term health conditions. However, military duties associated with repeated DE, other excessive sources of PM exposure, pre-existing health conditions, and smoking history, may put some personnel at greater risk of chronic symptoms or conditions:

Respiratory: Coughing, allergies, chronic bronchitis, asthma, fibrosis causing obstruction and inflammation to airflow (reduced lung function).
Cardiovascular: Heart conditions including abnormal heart rhythms, changes in heart rate variability, heart attacks, atherosclerosis, and increased incidence of stroke.
Cancer: Studies of highly exposed workers indicate that prolonged exposure to DE appears to increase the risk of lung cancer, even accounting for smoking which is a much higher risk factor. Evidence is less clear for other cancers.

Persons Potentially at Higher Risk of Effects:

- Persons with existing respiratory conditions (e.g., asthma) or possible cardiovascular conditions
- Persons with routine and/or higher exposures occupational DE exposure (e.g., vehicle/aircraft maintenance)
- Persons who smoke

Medical Evaluations

In addition to basic medical history and physical exam, providers should ask questions relevant to the exposure of concern as well as any potential associated risk factors or susceptibilities. Some suggested questions:

Questions for Medical Professionals to Ask Regarding Suspected Exposure

1. Have you experienced any specific exhaust exposures that caused acute effect(s) or symptoms? If yes:
   - What symptoms?
   - How often or how many times did this occur?
   - How long did the exposure(s) last?
   - Was/Were the exposure(s) experienced in an enclosed space?
2. What type of occupation or tasks were you assigned while deployed?
3. What are your garrison/stateside occupational duties and types of exposures?
4. Describe other potentially relevant exposures and/or medical conditions to include:
   - Other hobbies, Smoking habits, Allergies, Asthma or respiratory conditions, Medications

For Acute Symptoms.

Diagnostics: There are no medical tests to identify or quantify DE exposure. Single or occasional exhaust exposures that result in mild to moderate acute effects do not generally warrant any specific diagnostic tests. However, for individuals with unique conditions or significant acute signs/symptoms, some tests may be clinically indicated to assess, document, and treat the individual's condition. If a patient has significant breathing difficulties or lower airway signs and symptoms, a pulse oximetry, a pulmonary function test, and/or chest x-ray may be warranted

Treatment: There is no antidote for this exposure, so treatment consists of supportive care and reassurance. Particularly given the low level exposures experienced in deployment settings, minimal treatment, if any, is anticipated to be needed. Certain underlying health conditions (e.g., asthma) may be considered aggravated by this exposure and should be treated accordingly and documented. Avoidance of further exposure is the primary course of action.

Documentation: If seeing a patient with acute symptoms associated with a diesel exhaust exposure, providers should include the specific ICD-9 code of 987-"*Toxic effects of other gases, fumes, vapors*" and include information regarding the exposure scenario include levels, frequency, and duration.

For Long-Term Health and Medical Monitoring

Based on the current evaluation of exposure data relevant to U.S. military deployments, there are no specific medical surveillance, follow up diagnostics, or treatments recommended for any population of concern pertaining to this type of exposure. Providers with questions regarding specific individual' patient's concerns can contact the USAPHCs Environmental Clinical Consult Service (EM-CCS).

Key References:

1. USAPHC Factsheet – Summary of Evidence; Chronic Respiratory Conditions and Military Deployments, Nov 2011
2. EPA 600/8-90/057F Health Assessment Document for Diesel Engine Exhaust., 2002. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=29060
3. Frumkin, Howard and Michael Thun; Diesel Exhaust; *A Cancer Journal for Clinicians*; Volume 51, Issue 3, pages 193–198, May/June 2001. http://onlinelibrary.wiley.com/doi/10.3322/canjclin.51.3.193/full
4. NIOSH Publication No. 2005-151: NIOSH Pocket Guide to Chemical Hazards, September 2005. http://www.cdc.gov/niosh/npg/
5. J Natl Cancer Ins (2012) 104(11): Studies Show Exposure to Diesel Exhaust May Increase Lung Cancer Mortality - http://jnci.oxfordjournals.org/

If you need additional information please contact:
U.S. Army Public Health Command
Environmental Medicine Program (EMP) usarmy.apg.medcom-phc.mbx.emp@mail.mil – Environmental Clinical Consult Service (EM-CCS)
5158 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5403
DSN 584-2714; COMM (410) 436-2714; FAX Extension-4117