VII. INDUSTRIAL HYGIENE FIELD SURVEY

Introduction

The work of the industrial hygienist depends on the recognition and evaluation of hazards in the workplace. Based on carefully executed field surveys, the monitoring, prevention and control of the hazards can yield a safe and healthful workplace.

Goal:

The purpose of this experiment is to practice and demonstrate the principles of a thorough and accurate IH survey. The field survey will take place at the Northlake Diesel Exhaust Exposure Facility, located just off campus (see description below). Your survey will begin with a walkthrough during which the facility engineer will describe the operation of the diesel exposure facility; you should be observant of possible IH hazards, and be prepared to ask questions of the facility engineer as required to help you design your sample collection strategy to evaluate chemical hazards in this workplace.

The Northlake Diesel Exhaust Exposure Facility

The Northlake Diesel Exhaust Exposure Facility is used for conducting controlled exposures of humans and animals to diesel exhaust. The facility includes office space with finished interiors in the front of the building. The rear of the building contains unfinished warehouse space, in the center of which is a chamber where the diesel exhaust exposures are conducted. The diesel engine (part of a diesel engine-electric generator set), a tank containing diesel fuel and an electric load bank are located adjacent to the rear of the building.

A schematic diagram of the diesel exhaust generation and dilution system is shown in the attached figure. (Also described in the paper by Gould, et al cited below). You may use this to indicate the locations of sampling, to be decided after the walkthrough. Exhaust from a stationary diesel power plant is drawn into the duct entering the building and is diluted with air streams from a compressor and from a larger air handling unit that uses filtered outside air. After two or three dilution stages, including adjustment of the air temperature and relative humidity, the diesel exhaust is directed to the exposure chamber where human volunteers or animals can be given controlled exposure.

The system is intended to produce a particle concentration in the exposure room of approximately 400 $\mu g/m^3$, with a size distribution such that most of the mass will be in particles with aerodynamic diameters less than or equal to 1.0 μm.

The instrumentation already installed on site includes equipment for monitoring air temperature and relative humidity within the ducts and in the exposure room, and several direct-reading instruments in the exposure room: particle concentration, inorganic gases, and perhaps others.

Excess diesel exhaust is vented at the rear of the building. Clean air intakes are inside the rear of the building. High capacity galvanized steel duct work (with multiple joints) transfers air/diesel exhaust from the diesel engine, inside the warehouse and delivers it to the exposure chamber. Additional ducting takes the air/exhaust mixture from the exposure chamber and discharges it through the roof at the rear of the building.

Volatile hydrocarbon exposures are likely to be highest in the region of the diesel fuel tank, especially during refueling operations. Exhaust exposures (including particulate matter, CO, sulfur oxides, NO_X, volatile and semi-volatile organics) are likely to be highest in the exposure chamber itself, but may also be important near the engine (where excess exhaust is ventilated). Potential leaks in the ductwork (prior to dilution) would contaminate the indoor environment with diesel exhaust. Other potential indoor air concerns would be formaldehyde and VOC emissions from particle board and new carpeting in the office area, leakage of calibration gases (NO_2) in the warehouse area, and animal allergen exposures when experiments with rats and mice are transferred to or from the exposure chamber.

Typically, neither the workers, nor the exposure volunteers, wear personal protective equipment.

Diesel Exhaust

The health hazards of exposure to diesel exhaust have been recognized for some time – diesel exhaust has irritant and allergenic properties, and it contains many carcinogens. However, exposures to diesel exhaust have not always been effectively controlled or regulated. MSHA established in 2001 an interim allowable occupational exposure standard for diesel exhaust of 0.4 mg/m^3, and this was revised to a final standard of 0.16 mg (total carbon)/m^3 effective in May, 2008. USEPA has established a reference concentration for diesel particulate of 0.005 mg/m^3. OSHA has yet to adopt a standard for diesel particulate matter. The attached paper from McDonald et al has some useful tables detailing chemical concentrations present in diesel exhaust emissions. You can use the particle mass concentrations from McDonald's tables, and the expected particle mass concentrations in the Northlake facility (0.4 mg/m^3 in chamber, approx. 4 mg/m^3 in duct before secondary dilution) to scale McDonald's chemical data to estimate the levels you might expect to find in the Northlake facility, and hence choose appropriate sampling methods and sample collection times (maximum 1.5-2 hrs!).

EXPERIMENTAL SURVEY

All of your previously used, direct reading and sampling equipment could be needed and they should be checked and calibrated before starting the surveys. All instruments and equipment that have been used so far in the course can be applied, as you see fit.

The class will be divided into teams; first, everyone will undertake a walkthrough survey of all facility operations. During the walkthrough, the facility engineer will describe and demonstrate a number of instruments that are used by the diesel facility to monitor the atmosphere in the exposure chamber. Next, team 1 will make particulate measurements and take samples at appropriate locations, and team 2 will make measurements and/or collect samples for volatile (gaseous) contaminants. In session two, the two teams will exchange roles. Sampling of diesel exhaust can take place in the exposure chamber, in the adjoining warehouse space (assumed to be a low-exposure area) and inside a section of the exhaust ductwork before secondary dilution of the exhaust (contaminant levels here are approx. 20x higher than in the chamber itself). The attached figure outlines the diesel exhaust dilution system at this workplace. Particle levels in the exposure chamber are typically about 0.4 mg/m^3. You should also be alert to potential non-diesel exhaust chemical exposures in this facility.

As with all IH surveys, a minimum disruption of the staff is desired. Instead of placing instruments on the personnel, please plan to place fixed-site samplers to evaluate the system at

appropriate locations or critical points. Samplers and instruments should be charged and calibrated in the lab before leaving for the site. It is advisable to prepare and take equipment for all predicted measurements even though some may not be used.

Notes, descriptions and data should be recorded in your notebooks to prevent loss while visiting an unfamiliar site. Observations, diagrams, layouts, time sequences, and flow patterns are helpful later, in recreating the extent of hazard or determining if personnel would be exposed. Some data logging may be possible. As with all work sites it is not always possible to find typical operations in progress at the time of the visit, so that some conjecture may be needed to describe significant, potential hazards.

SURVEY REPORT/LAB REPORT

The report for this experiment will consist exclusively of the survey results and analysis, described as follows. Address your report of the survey to the Diesel Exhaust Study Facility, University of Washington. Include a summary of your observations and tables of the data that you collect. Your data should include appropriate QC measures including calibration data for pumps and direct reading instruments, media blanks and collection/analysis of replicate samples, as appropriate. Where you have used different approaches to measure the same variable (e.g. particulate mass by gravimetric analysis or direct-reading monitor) you should compare the two measures, discuss the advantages/disadvantages of each method, and if the methods gave different results discuss why, and which result is most accurate or appropriate in this instance. You will also be provided with data from an array of characterization instruments the diesel facility uses to monitor the chemical composition in the chamber. These data should be compared with the data that you have obtained, and differences between the two sets of data should be discussed.

Conclude with any significant findings and suggestions that you can support with your data. Relating your measurements to the relevant standards will provide objective support for any assessments you make about the hazards (or lack thereof) of the chemical exposures in this workplace. Positive reinforcement of previous corrective action and listing of non-hazards could also be useful. Comparisons of different sampling locations would be helpful.

Attachments:

1. Figure 1: Schematic of diesel exhaust dilution system and exposure chamber
2. McDonald et al., Design characterization and evaluation of a small scale diesel exhaust exposure system. *Aerosol Sci. Technol.* **2004, 38:62-78**
3. Gould, T. et al. A Controlled Inhalation Diesel Exhaust Exposure Facility with Dynamic Feedback Control of PM Concentration. *Inhalation Toxicol.* **20:49–52, 2008.**

2 step process for primary dilution
Vacuum pump: motive air (filtered) supplied by compressor (0.5-1.6 ft^3/min at sufficient pressure); diesel exhaust sample pulled from engine exhaust pipe and discharged from vacuum pump in approximate 1:1 mixing step.
Fan and filtered air: Balance of primary dilution air added concentrically through mini-air blender to mix rapidly with exhaust stream.

Variable diversion prior to secondary dilution
Feedback-control system enables different concentrations to be created following secondary dilution, where remaining filtered and conditioned air is added to system.