BENZENE VAPOR CONCENTRATIONS DURING A SIMULATED CRUDE OIL SPILL[1]

Lt. Cdr. Donald S. Delikat and Lt. Michael Zustra
U.S. Coast Guard First District (M)
408 Atlantic Avenue
Boston, Massachusetts 02210

Lt. Cdr. Chris P. Rennix
U.S. Navy Environmental Prevention Medical Unit 2
Building 336
Norfolk, Virginia 23511

Lt. Denise L. Matthews
U.S. Coast Guard Reserve Training Center
Marine Safety School (T-MER)
Yorktown, Virginia 23690

Lt. Cdr. Joseph J. Ocken
U.S. Coast Guard Fifth District
431 Crawford Street
Norfolk, Virginia 23704

Objective

Benzene vapor concentrations during a simulated crude oil spill were measured to quantify the potential to exceed the Permissible Exposure Limits (PELs). The main concern was benzene vapor concentrations in worst-case situations. Vapors were measured using a variety of methods, including sample badge monitors, which are readily available for use by first responders.

Methodology

Standard National Institute for Occupational Safety and Health (NIOSA) sampling methods for pumps and passive badges were used, as well as colorimetric tubes and nonspecific direct-reading meters. Different densities (API gravities) of crude oil were evaluated during hot weather conditions. Samples were taken in open areas and underneath a simulated wharf with three of the four sides blocked (Figure 1). Benzene levels ranged from about 7 ppm (parts per million) to below detectable limits under the simulated wharf. In open areas, the highest recorded level was about 0.4 ppm.

Discussion

Various toxic compounds are present in crude oil, but few studies have been made of personnel exposures to these vapors during the first hours of a spill.[3,5] Worst-case conditions include rapid evaporation of high vapor pressure components (such as benzene) during the first hours of a spill; hot weather; enclosed areas; spreading surface area; and high API gravity crude oil (i.e., rich in high vapor pressure components). Under these conditions the time-weighted average benzene concentration exceeded 1 ppm during the first half hour of the simulation. Results several hours later, in open areas, or using lower API gravity crude oils were much lower. Calculated as an 8-hour average, exposures did not exceed the PEL of 1 ppm, although the 5 ppm short term exposure limit (STEL) was exceeded under the simulated wharf.

Results from passive badge samples correlated well with those from

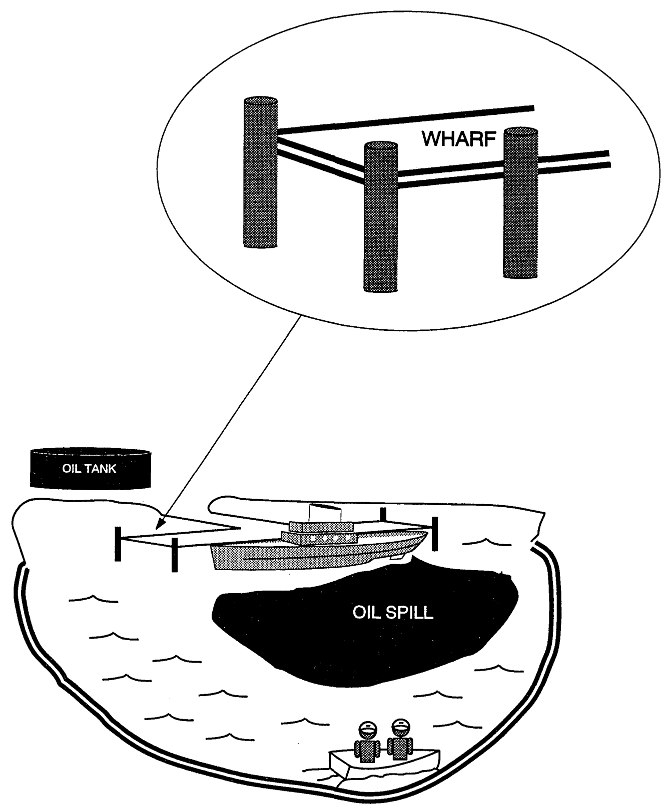

Figure 1. Schematic drawing of sampling methods

1. Opinions expressed in this paper are solely those of the authors and do not represent the views of the U.S. Coast Guard, U.S. Navy, or Department of Defense.

industrial hygiene pumps. Other investigators report similar findings, indicating that this method should be considered for collecting exposure data during the first hours of a real spill, when more difficult procedures are not available.[2,4,6]

Although the PEL was not exceeded over an 8 hour period in this simulation, the potential exists for real spills that may be larger or more prolonged, especially if personnel do not follow safe work practices. If new limits for benzene exposure are adopted, the potential for overexposure will be much greater.[1] First responders should be aware of this exposure potential, the worst-case conditions to be avoided, and the personal protective equipment that can be used to reduce exposures if needed.

References

1. American Conference of Governmental Industrial Hygienists, 1990. Notice of intended changes—Benzene. *Applied Occupational Environmental Hygiene*, v5, n7, pp453–465
2. Bartolucci, G. B., L. Perbellini et al., 1986. Occupational exposure to solvents: Field comparison of active and passive samples and biological monitoring of exposed workers. *Annals of Occupational Hygiene*, v30, n3, pp295–306
3. Eley, W. D., R. J. Morris, L. L. Hereth, and T. F. Lewis, 1989. Is overexposure to benzene likely during oil spill response? *Proceedings of the 1989 Oil Spill Conference,* American Petroleum Institute, Washington, D.C., pp127–129
4. Gregory, E. D. and V. J. Elia, 1983. Sample retentivity properties of passive organic vapor samples and charcoal tubes under various conditions of sample loading, relative humidity, zero exposure level periods and a competitive solvent. *Journal of the American Industrial Hygiene Association*, v44 (February), pp88–96
5. National Research Council, 1985. Oil in the Sea: Inputs, Fate and Effects. National Academy Press, Washington, D.C., pp472–482
6. Pristas, R., 1991. Benzene in air-organic vapor monitors versus charcoal tubes. *Journal of the American Industrial Hygiene Association*, v52, July

LOCATION OF LEAKS IN PRESSURIZED UNDERGROUND PIPELINES[1]

Eric G. Eckert and Joseph W. Maresca, Jr.
Vista Research, Inc.
100 View Street, P.O. Box 998
Mountain View, California 94042

Millions of underground storage tanks (UST) are used to store petroleum and other chemicals. The pressurized underground pipelines associated with USTs containing petroleum motor fuels are typically 2 in. in diameter and 50 to 200 ft in length. These pipelines typically operate at pressures of 20 to 30 psi. Longer lines, with diameters up to 4 in., are found in some high-volume facilities. There are many systems that can be used to detect leaks in pressurized underground pipelines. When a leak is detected, the first step in the remediation process is to find its location. Passive-acoustic measurements, combined with advanced signal-processing techniques, provide a nondestructive method of leak location that is accurate and relatively simple, and that can be applied to a wide variety of pipelines and pipeline products.[1]

Approach

Figure 1 shows a simple representation of a passive-acoustic leak location system in which three transducers simultaneously sample the acoustic signal. The output of each transducer is digitized and stored as a time series. These time series, recorded by spatially separated sensors, serve as input to a leak location algorithm. The main function of the location algorithm is to estimate the time delay between acoustic leak signals received by pairs of sensors. The measured time delay can be used to estimate the source location (for signals received by sensors bracketing the leak) or the propagation speed of the acoustic waves (for signals received by nonbracketing sensor pairs).

Location algorithms that measure the time delays by means of cross-correlation analysis work well provided that the signal is very strong or that background noise is not excessive. When the acoustic signal is weak in relation to the level of background noise or has a finite frequency bandwidth, more sophisticated signal-processing techniques are available. One such technique is coherence function analysis. If the correspondence between received signals is frequency-dependent, or if the phase-dependence of the correspondence is a nonlinear function of frequency, the application of coherence function analysis is the means by which the source of the signal is best located. For the purpose of signal estimation and source location, coherence function analysis represents a significant improvement over correlation analysis.[2] Advanced signal processing is required for the successful application of this technology to the problem of leak location in UST pipelines.

Two criteria must be satisfied for the location algorithm to yield accurate estimates: the received signals must originate primarily at a single, localized source and propagate as plane waves along (or within) the pipeline, and the received signals must maintain a reasonable degree of similarity over the maximum sensor separation. If the first criterion is satisfied, the difference in phase between received waves of a given frequency is simply related to the time delay between signals that arrive at the different sensor locations. The accuracy with which the time delays can be measured is related to the second criterion. The similarity between signals emitted from a localized source and received at separate locations is determined by the signal strength relative to ambient noise (the signal-to-noise ratio) and the difference in propagation path between the source and each sensor. Due to the complex manner in which the acoustic leak signal is produced (turbulent flow

1. Much of this work has been published as part of E. G. Eckert, J. W. Maresca, Jr., Robert W. Hillger, and James J. Yezzi, 1992, Location of leaks in pressurized petroleum pipelines by means of passive-acoustic sensing methods. *in* Leak Detection Monitoring for Underground Storage Tanks, Philip B. Durgin and Thomas M. Young, eds., ASTM STP 1161. American Society for Testing and Materials, Philadelphia