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Project Summary

Measurement and Analysis of Adsistor and Figaro Gas Sensors Used for Underground Storage Tank Leak Detection

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Two different sensor technologies and their properties were analyzed. The analysis simulated a leak which occurs from an underground storage tank. Figaro gas sensors and the Adsistor gas sensor were tested in simulated underground storage tank environments using the Carnegie Mellon Research Institute (CMRI) automated gas testing facilities. This automated system monitored the sensors' responses while dynamically exposing them to various mixtures of methane, butane, and xylene. The sensors were also tested to determine the effects of humidity on their responses. Sensor responses were characterized by sensitivity, selectivity, and speed of response and recovery to select test concentrations of methane, butane, and xylene. The test results are presented as a list of sensor specifications to allow the potential end user a direct comparison of these two different types of sensors.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Over two million underground storage tanks (USTs) are currently being regulated by the EPA. By 1993, the vast majority of these tanks are to be equipped with leak detection monitors to alert tank owners of any problems. Vapor monitoring equipment, housed in a monitoring well surrounding the UST, is a common choice for protecting the environment from gasoline or product spills from a leaky tank.

The concept behind vapor monitoring is that a small liquid leak will generate a large increase in product vapor concentration. By proper placement of the monitor wells, the product vapor will readily migrate to the monitoring wells. There, the vapor sensors will detect the increased vapor concentrations and sound an alarm.

This study was initiated by the EPA Office of Underground Storage Tanks to help the regulators of UST, who use vapor phase product leak detectors, to better understand the capabilities and limitations of commercial vapor sensors used in continuous vapor phase product leak detectors. The study was limited to characterizing two types of commercial vapor sensors: The Figaro sensor and the Adsistor sensor.

Procedures

Four types of Figaro gas sensors, models number 812, 813, 822, 823, and the Adsistor gas sensor were tested in simulated UST environments using the CMRI automated gas testing facilities. The characterization of these sensors resulted in a set of specifications that allows direct comparison between the different sensor types. The Figaro sensors are metal oxide semiconductor devices that operate at elevated

* Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

temperature. The Adsistor sensor operates at ambient temperature, and it works on the principle of gas adsorption in a polymeric material.

The selection of test gases was based on a study performed by Geoscience Consultants, Ltd., in 1988. Based on this study, methane was chosen as a potential interference that may cause false alarms for UST monitors. Also iso-butane and m-xylene were chosen as tags because they represent major chemical constituents in gasoline. The sensors were tested to determine their sensitivity and cross sensitivities to methane, butane, xylene, and humidity.

Three test chambers were built to house the sensors. One chamber was built to test nine Adsistor sensors and two chambers to house 12 Figaro sensors, six of each type. The volume of each test chamber was 1.2 liters. Test chamber temperatures were monitored during testing. The Adsistor test chamber temperature operated at room temperature, about 22 degrees Centigrade. The Figaro test chambers ran hotter at about 33 degrees Centigrade due to the local heating induced by the Figaro sensor's operating power requirements.

Results and Discussion

The Figaro 823 was chosen for illustrating the behavior of Figaro sensors for several reasons. First, the test results document that the Figaro 812, 822, and 823 sensors all have comparable responses, considering the statistical spread in their respective responses. Second, the Figaro 812 sensor has been discontinued, being replaced by the 822 model. The 822 and 823 sensors are described by Figaro as being the same sensor but packaged differently. Finally, the Figaro 813 sensors are very sensitive to methane and are of limited use for monitoring UST product leaks.

The Adsistor sensors tested had model parameters and sensor responses within 11% of each other.

All the Figaro sensors tested showed wide variations in the sensor model parameters and measured responses. For the Figaro 823 sensors, the spread in percent standard deviation ranged from 15% to 100%. Similar variations in sensor behavior were observed for the Figaro 822 and 812 sensors. The Figaro 813 sensors showed a more reproducible response with the spread in percent standard deviation ranging from 3% to 30%.

Gas concentration ramp tests were used to determine the test gas to which the sensors were most sensitive. The sensors were then modeled for this target gas.

The Adsistor sensor clearly responded to xylene at concentrations over 100 ppm as indicated by its increased resistance. The sensor's resistance did not change when exposed to methane and butane at concentrations up to 5000 ppm. The Adsistor sensor was not sufficiently sensitive to the lower xylene concentration range. Readings of 62 and 68 ppm xylene in the presence of 10 and 30 ppm xylene, respectively, reveal the baseline or zero reading for these sensors. Also, the reading of 233 ppm xylene in the presence of 300 ppm indicates the model is insufficient to truly characterize this sensor. However, the small spread of 3.7 ppm among the nine Adsistor sensors indicates that the sensors are responding similarly.

For the Figaro 823 sensor, the resistance decreased with respect to all the test gases. However, it was most sensitive to xylene. The Figaro 823 sensors are sensitive enough to measure 10 ppm xylene and were therefore modeled and calibrated for xylene. This sensitivity to xylene was also observed for the Figaro 812 and 822 sensors. Thus, the Figaro 812, 822, and 823 sensors were all modeled and calibrated for xylene. In the case of the Figaro 813 sensors, they were more sensitive to methane and therefore were calibrated as methane sensors.

Adsistor sensor sensitivity is not affected by changes in the level of humidity. For the Figaro 823 sensor, changes in reading of more than 50% were observed when the humidity varied from wet to dry conditions.

The Adsistor sensors are insensitive to both methane and butane, and they are selective to xylene even in the presence of a mixture of methane and butane.

The Figaro 823 sensor cross sensitivity to butane is larger in a mixture than would be expected. At the background level (500 ppm methane, 500 ppm butane, 100 ppm xylene), the Figaro 823 sensor reads over 300 ppm xylene. This error can be attributed mainly to the presence of 500 ppm butane. The Figaro 823 sensor is insensitive to methane by the slight increase in the xylene level as the methane is increased to 5000 ppm. When the butane level is raised to 5000 ppm, the xylene reading increases to over 1000 ppm, and when the xylene level is raise to 1000 ppm, the xylene reading is increased to 1700 ppm.

Conclusion

Both the Adsistor and Figaro sensors have properties that are useful for UST leak detection. The two sensors respond well to xylene and are relatively insensitive to methane, which is the primary interfering compound to sensor systems in subsurface detection of leaking underground storage tanks. The Figaro sensor is more sensitive to lower levels of solvents than the Adsistor. The Adsistor sensors as a group had better reproducibility and had a much smaller humidity interference in comparison to the Figaro sensors. These facts make the Adsistor easier to deal with from an instrumentation and calibration point of view. However, the Adsistor sensors were observed to have longer xylene recovery times than the Figaro sensor, which is a factor one must take into consideration when choosing a sensor technology.

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The complete report, entitled "Measurement and Analysis of Adsistor and Figaro Gas Sensors Used for Underground Storage Tank Leak Detection," (Order No. PB93-126589; Cost: $19.50; subject to change) will be available only from
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