OPTICAL METHANE DETECTOR (OMD™): LEAK SURVEY'S ROAD TO THE NEW MILLENNIUM

DÉTECTEUR OPTIQUE DE MÉTHANE (OMD™): ROUTE D'ÉTUDE D'ÉTANCHÉITÉ QUI MÈNE VERS LE NOUVEAU MILLÉNAIRE

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ABSTRACT

Public Service Electric and Gas (PSE&G), the Gas Research Institute (GRI) and Heath Consultants have worked closely together for several years in the design, evaluation and development of an improved leak survey approach based on the use of an infrared sensing system with novel electro-optics. The absorption of infrared light by methane is used as a means to detect the presence of leaking gas and has replaced conventional leak sampling techniques. Specialized technology was developed to selectively detect methane as a survey vehicle moves down the street. The main features of the equipment will be presented along with a detailed analysis of its effectiveness and advantages for over-the-surface leak detection. PSE&G's extensive evaluation and deployment of the equipment will be used for gaining a better understanding of the field benefits of this leak detection approach from a user perspective.

RÉSUMÉ

Public Service Electric and Gas (PSE&G), le Gas Research Institute (GRI) et Heath Consultants ont travaillé étroitement pendant plusieurs années sur la conception, évaluation et développement d'une méthode améliorée d'essai d'étanchéité basée sur l'utilisation d'un système de détection à infrarouges comportant de nouveaux éléments d'optique électronique. L'absorption de la lumière infrarouge par le gaz naturel est utilisée comme moyen de détection de la présence de fuite de gaz et remplace les techniques conventionnelles d'échantillonnage des fuites. Une technologie spécialisée a été développée afin de détecter spécifiquement le méthane alors que le véhicule d'étude parcourt la rue. Les caractéristiques principales de l'équipement seront présentées avec une analyse détaillée de son efficacité et de ses avantages pour la détection de fuites sur la surface. L'évaluation étendue et le déploiement de l'équipement de PSE&G seront utilisés pour acquérir une meilleure compréhension des avantages pratiques de cette méthode de détection de fuites du point de vue de l'utilisateur.

1. INTRODUCTION

In the United States, natural gas leak detection survey requirements fall under the jurisdiction of the Department of Transportation (DOT) under Title 49 Code of Federal Regulations Part 192. These are regulations that all U.S. gas companies must comply with as a minimum. The specific reference to leak surveys for distribution systems reads as follows:

§192.723 Distribution systems: leakage surveys procedures

- (a) Each operator of a distribution system shall provide for periodic leakage surveys in its operating and maintenance plan.
- (b) The type and scope of the leakage control program must be determined by the nature of the operations and local conditions, but it must meet the following minimum requirements:
  - (1) A gas detector survey must be conducted in business districts, including test of the atmosphere in gas, electric, telephone, sewer and water system manholes, at cracks in pavement and sidewalks, and at other locations providing an opportunity for finding gas leaks, at intervals not exceeding 1 year.
  - (2) Leakage surveys of the distribution system outside the principal business areas must be made as frequently as necessary, but at intervals not exceeding 5 years.

Because of the age of PSE&G's system, diversity of piping materials, population, congestive environment, and operating experience, PSE&G has always conducted an annual leakage survey of the distribution system outside the principal business areas, in lieu of the 5 year minimum requirement cited above.

Early leak survey methods were primitive, consisting of vegetation and/or combustible gas indicator (CGI) surveys. These were slow surveys and relied considerably on the expertise of the survey technician. Many times leaks were missed; leaks that could become potentially hazardous and possibly result in an explosion.

The introduction of Flame Ionization (FI) equipment in the 1960's resulted in significant improvement, quickly becoming the state-of-the-art leak survey process. While this equipment significantly improved the survey process, it was still hampered by its slow speed, frequent calibration, need for hydrogen fuel gas, and occasional false readings. Leak survey productivity was ultimately limited by the equipment speed.

In the late 1980's, a GRI project was formally initiated to provide the necessary research, design and development support for an improved leak survey vehicle approach utilizing infrared technology. The focus of this technology is based on the fact that methane absorbs a specific wavelength of light occurring in the region of 3.3 microns. PSE&G was actively involved in the development and testing of this equipment since the inception of the concept.

The balance of this paper will review the equipment development, technology status at PSE&G, equipment benefits, and operating experience of PSE&G in using this equipment.

2. EQUIPMENT DEVELOPMENT

2.1 Prototype

In early 1994, the favorable demonstration of a breadboard system in a laboratory led to the development of a first generation prototype system. Preliminary evaluation of this prototype was very positive. Sensitivity to gas leaks met all expectations. The laptop computer worked as designed but the software still required some debugging. A simple leak rate display with adjustable alarm needed to be added to make the unit more user friendly.

With these equipment modifications a complete prototype unit was evaluated over a known leak in January 1995, at PSE&G's Clifton District. The design of this prototype was such that it could be installed on a vehicle equipped with existing FI equipment allowing both leak detectors to operate in parallel. The weather consisted of a light mist with rain drizzle, temperatures around 4 ^{o}C with the winds to 40 km/h. Table 1 lists the results of operating the two leak detection units in parallel.

Vehicle Speed (km/h)	FI Response	Infrared Prototype Response
24	Yes	Yes
32	No	Yes
40	No	Yes
40	No	Yes
48	No	Yes
48	No	Yes

Table 1. January 12, 1995 Test Results
FI vs. Infrared Prototype

Aside from the productivity benefits associated with the increased vehicle speed during the testing, an immediate response of the infrared equipment directly over the leak was observed as opposed to the lag time normally associated with the conventional FI equipment.

A compilation of side-by-side field evaluation results is summarized in Table 2 over a variety of known leaks tested during this testing period.

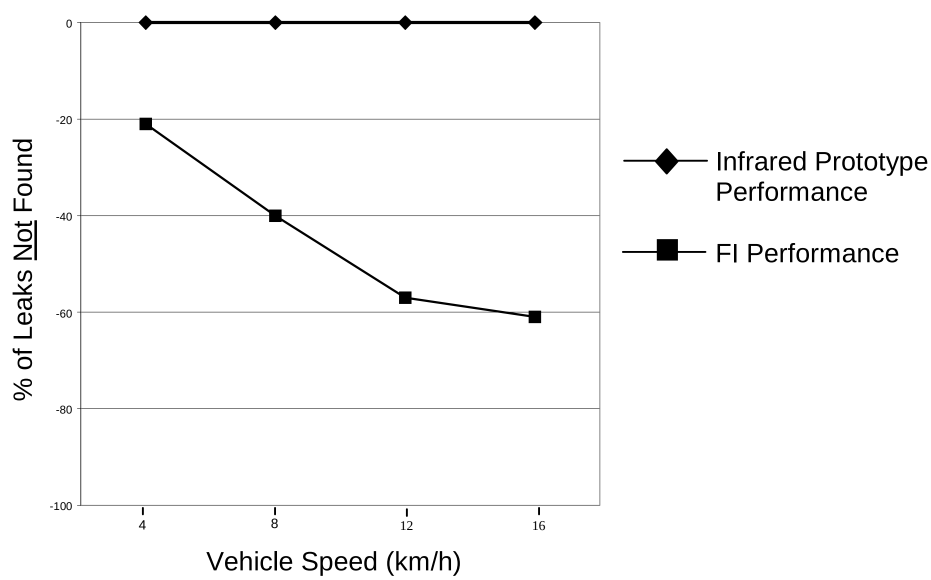

Table 2. Field Evaluation
FI vs. Infrared Prototype

It became clear that the concept was successful and needed to be pursued for commercialization. This primarily entailed field hardening the components and equipment repackaging.

A final pre-production prototype was again evaluated by PSE&G in 1998, because of our early involvement in the developmental process. We were very anxious to retrofit our existing mobile leak survey units with this new technology.

2.2 Optical Methane Detector (OMD) Equipment Description

The equipment essentially consists of three major components. The first major component is a light bar (Figure 1. A) that mounts on the survey vehicle front, usually 30 – 40 cm above the roadway. A light source is mounted on one end facing an optical detector located on the opposite end. The light source produces a wide range of light wavelengths, including the infrared wavelengths absorbed by methane. The optical detector contains a glass filter with a coating that prevents light with wavelengths other than those primarily absorbed by methane from reaching the electronic detector. The detector translates the intensity of the light into a digital signal displayed in real time on the screen of a display unit (Figure 1. B), the second major component. If a cloud of methane passes through the beam of light, some light will be absorbed by the methane and less will reach the detector. This drop in light intensity is indicated by a peak on the display screen while also triggering an audible alarm. Since the wavelength of light absorbed is preferential to methane, gas detection by the OMD is selective primarily to methane gas. The third component is simply a power pack (Figure 1. C) that is used to supply power to the equipment from the vehicle battery.

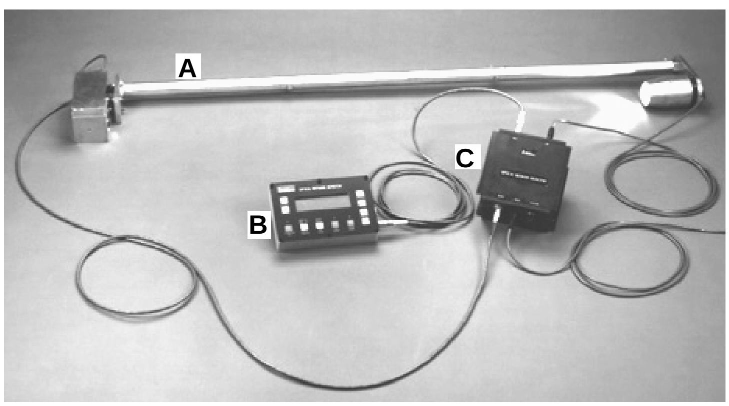

Figure 1. The Three Components

3. TECHNOLOGY STATUS AT PSE&G

PSE&G's annual leak mobile survey cycle involves the survey of over 15,600 miles of main in a very diverse operating environment. The northern end of the territory is very congested, heavily populated, and has many older pipeline systems. The southern end, in contrast, has some isolated areas with older pipeline systems, but is primarily a load growth area.

In mid 1998, 7 OMD's were purchased of which 6 were mounted on vehicles, as shown below in Figure 2, with the seventh unit being a complete spare. If the equipment malfunctioned, this allowed one of the 3 major components to be replaced with a spare component and sent out for repair without impacting the survey.

Figure 1. The Three Components

Figure 2. OMD Vehicle Mount

The operating results were so favorable, that by June 1999, we completed the transition to this equipment on a statewide basis with the addition of 5 more units. We currently operate 11 OMD's, one for each of our field operating districts, still maintaining a twelfth unit as a spare.

A typical installation in a district, including hands-on training for our leak survey technicians, was completed within one day. We scheduled the local survey technicians to observe the installation of the equipment and described the individual equipment components along with their operation. In that way, they were part of the installation process and were generally eager to test the equipment. After installation (about one half day), the remainder of the day would be spent receiving training by the manufacturer, Heath Consultants.

A statewide dedicated PSE&G support person was assigned to be focal point for any operating questions or concerns. He quickly became our resident expert for this equipment and became very adept in supporting this technology. His responsibilities entailed equipment troubleshooting, minor repair, periodic calibration, retraining, and overall equipment support. In implementing any new technology it is important to minimize adverse impact to the field in the form of downtime, retraining, etc. Any new technology has its bumps and a dedicated support person goes a long way in smoothing out the process and making it easier for the field when minor problems do occur.

After 6 months of use, a formal refresher training session was held with the survey technicians. This provided an opportunity to listen to issues/concerns, answer questions, and obtain overall feedback from the day-to-day users.

PSE&G leak survey standards have been revised to reflect a 48 km/h maximum leak survey vehicle speed, given traffic, weather and roadway conditions.

4. EQUIPMENT BENEFITS

Since the equipment is fully electronic, there are no moving parts, plumbing, or sampling system typical of conventional FI equipment. In addition, it requires no support gases.

Surveys can be completed in significantly less time (20% to 50% productivity improvement) depending on the roadway conditions. When travelling at high speeds the sensitivity is not lost because the electronics enable the OMD to take 14,000 readings per second. Since the equipment responds instantaneously, survey accuracy has also been improved. The equipment is selective primarily for methane down to levels of 1 ppm but can see propane and ethane at 1/3 the sensitivity; because of this selectivity there are overall less false positives. Lastly, the equipment operated favorably in a wide variety of environmental conditions.

5. PSE&G OPERATING EXPERIENCE

On the average, actual productivity on an overall basis has increased by 25% at PSE&G. In specific open road or off road applications, productivity increases to 50% have been realized.

PSE&G feels safety has been greatly enhanced through the use of this equipment, for both the survey technician and the customer. The survey technician no longer needs to contend with a potentially explosive situation, should a cylinder leak or vehicle accident occur, because the use of hydrogen fuel gas has been eliminated. The customer is also safer since the survey is completed significantly faster with no loss of accuracy.

Safety is particularly important when PSE&G performs the Winter Patrol during periods of frost. This survey is repeated over certain portions of our distribution system being supplied with high pressure (1 bar to 4 bar) gas through cast iron mains. Because we can survey at higher speeds we cover more of our system territory in a shorter period of time which is of prime importance in a continuous type survey. The need for overtime has also been reduced when performing this survey because of increased speeds.

There has also been a corresponding reduction in false positives primarily attributed to vehicle exhaust.

6. ENHANCEMENTS IDENTIFIED

As can be expected with any new technology, several enhancements have been identified through the long term use of the equipment at PSE&G. These enhancements include:

- Relocating/Modifying the electric connectors to make them more rugged, weather-resistant, and less susceptible to external damage.

- Installing an in-line fuse in the wiring from the vehicle battery to the power pack to protect the wiring.

- Modifying the externally supplied calibration cell to simplify filling with methane, and installing a relief valve mechanism to prevent over-pressurization.

- The need for periodic calibration of the unit to compensate for crystal drift.

- The need for a protective cage to minimize damage to the equipment in the event of a vehicle accident.

The manufacturer has been very responsive in working with PSE&G to incorporate the above modifications into future equipment. In fact, many of the changes have already been made.

7. CONCLUSIONS

The OMD has performed accurately and reliably throughout our use of the equipment under normal leak survey conditions. It is capable of operating in moderate rain, snow, cool or hot weather.

The equipment is capable of surveying at higher speeds than conventional equipment, very easily up to 48 km/h, with corresponding reduced maintenance costs making for dramatic increases in productivity. The unit has consistently provided effective and reliable readings up to these speeds without being influenced by weather conditions or road type. Response to a leak is instantaneous.

From the daily user perspective, it is easy to check the calibration of the equipment. The equipment is user-friendly making users feel comfortable operating the equipment by virtue of the push button commands, data display functions and prompts provided on the LCD display screen.

Interpretation by the user is also simple. The output generated is easy to understand because the graphical display combined with an audio alarm notifies the operator of a leak indication.

Lastly, the installation of the OMD is much easier, faster and more simple when compared with FI equipment which requires the installation of vacuum lines, sampling pumps and gas cylinders with respective piping.

8. FUTURE ACTIVITIES

PSE&G plans to continue actively working with Heath Consultants and GRI to enhance the technology where appropriate. Through our continuing long term use of the equipment, we hope to be able to contribute our operating insights in an effort to continue improving and expanding on the use of this exciting new technology.