Setting the Standard for Automation

Process Measurement & Control Division

December 2009 Newsletter

Director's Message

Rick Williams

Greetings division members. This is the final message from your current director since my term will conclude at the end of this month. It has been a rewarding experience to serve as your director. We have made a lot of progress toward our goals to improve division activities and will continue to do so in the future.

There are some exciting things going on within the division. This message is inclusive within our newsletter which has been absent for some time. The division will strive to publish and electronic newsletter twice per year. All division members will receive an e-mail notification of the newsletter when it becomes available. So, rather than bog down your mail with a hefty file you can simply click on a link to access the newsletter. This is part of our objective to improve communications within the division. We are also creating a PMCD forum on LinkedIn. This will create opportunities for members to communicate with each other and share knowledge. We now have a webmaster who will be working to update and improve the quality of the division website. We want to explore other communication options and welcome your input. Please opt in for LinkedIn and let us know how we can best communicate with you.

In this newsletter we will share with you the experience of the 55th International Instrumentation Symposium held this past June in League City, TX and the ISA Expo held in Houston this past October. There is also information about the upcoming 56th IIS to be held this coming May in Rochester, NY. We hope to see you there.

See the call for papers in the newsletter or submit your abstract for presentation and publication consideration today.
You may submit to www.isa.org/abstracts to aubri.buchanan@radiancetech.com
For more details on the 55th IIS Symposium,
visit www.isa.org/iis

Finally, I would like to introduce our incoming board of directors. This is the largest board that has been involved with PMCD in the six years that I have served so far. I am excited about the opportunity to see the division prosper under the leadership of the new division director, Ken Belteau. Please welcome Ken and his board members as we explore new horizons in 2010.

Again, it has been a pleasure to serve as your division director. I look forward to serving as an active board member in the future and will continue my efforts to support the program content with the International Instrumentation Symposium.

Rick Williams

55th International Instrumentation Symposium

The 55th IIS was held in League City, Texas from June 1-5, 2009. This is ISA's longest running symposium and is sponsored by the Aerospace Industries, Test and Measurement, and Process Measurement and Controls Divisions of ISA. The symposium was attended by 75 persons from around the globe including Canada, Saudi Arabia, Germany, Great Britain, Columbia and nineteen states in America.

The symposium featured keynote speakers from ISA society leadership including past president Kim Miller Dunn and Secretary Elect/nominee Leo Staples. Other keynote speakers featured prominent industry leaders such as Dr. Louis Iselin "Your New Method may be Quite Valuable, but is it Patentable", Dr. James Hall "Instrumentation Challenges for Deepwater Subsea Oil & Gas Production" and Dr. Angela Summers who spoke at the awards banquet on safety.

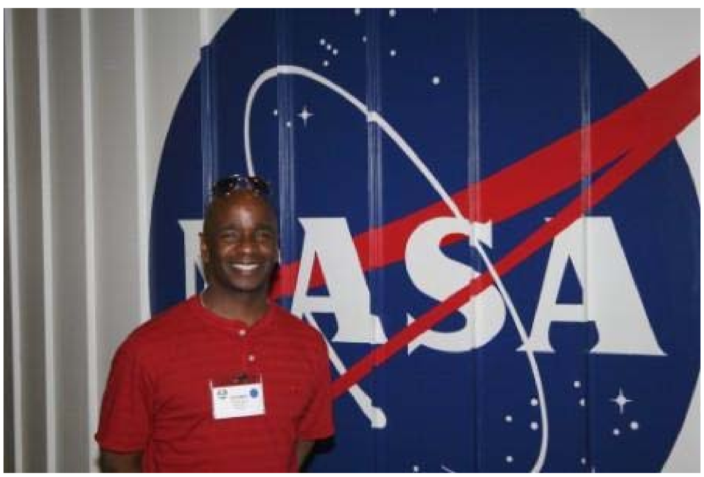
A total of forty-eight papers were presented at the symposium within a variety of topics including Fire and Gas Detection, Surface Temperature and TBC Health Monitoring for Turbine Engines, Distributed Control Systems, Wireless Applications, Data System Applications, Process Measurement and Control Systems, Instrumentation and Measurement Systems and Student Paper session. A highlight for the 55th IIS was a record number of undergraduate and graduate paper presentations. Students presented on a broad array of topics that were well attended and appreciated by all conference attendees.

The symposium was highlighted with a tour to NASA followed by dinner at a popular restaurant in Kemah on Galveston Bay. In addition, the guests and spouses were treated to a trip to Galveston for a tour of historical areas

2009
55TH INTERNATIONAL INSTRUMENTATION SYMPOSIUM
LEAGUE CITY, TEXAS

Opening remarks at the hospitality event

Student Paper Awards



Field Trip to NASA

Group Night Out at the Kemah Boardwalk

Awards Banquet

Registration Form

ISA IIS Symposium2010

International Society of Automation
67 Alexander Drive
P.O. Box 12277
Research Triangle Park, NC 27709
PHONE (919) 549-8411
FAX (919) 549-8288
E-MAIL info@isa.org
www.isa.org

56th International Instrumentation Symposium

10–14 May 2010 • Rochester Marriott Airport • 1890 Ridge Road West • Rochester, NY 14614

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❑ Speaker ❑ Developer ❑ Chairman ❑ Vendor ❑ Staff ❑ Attendee

2. All PARTICIPANTS ARE REQUIRED TO PAY REGISTRATION FEES

Symposium Registration
- ❑ ISA Member ....$495 (On or before 31 March 2010)
- ❑ Non–member ....$595 (On or before 31 March 2010)
- ❑ ISA Member $545
- ❑ Non–member $645
- ❑ Student ....$100 (Excluding Banquet)
- ❑ Non–Working Retiree...................$250 (Excluding Banquet)
- ❑ Single Day $250
- ❑ Thursday PIWG Sessions $250
- ❑ Extra Exhibitor $250
- ❑ Tuesday Exhibits Only $50
- ❑ Wednesday Tour and Dinner..........$70
- ❑ Banquet $25
- ❑ Guest $75
- ❑ Guest Tuesday Tour $25
- ❑ Guest Banquet $35
- ❑ Guest Registration, Tuesday Tour, and Banquet.....$100
- ❑ Guest Wednesday Tour and Dinner........................ $60

Your Full Symposium registration includes admission to all paper sessions, tutorials and scheduled meals.

Training Course
- ❑ Overview of Wireless Technology ....$445 ISA Member/$545 Non–member

Registration and Short Course Total: $__________

3. Payment Summary

Charge: ❑ Visa ❑ MC ❑ Amex ❑ Discover

Charge Account Number: ______________________

Exp. Date: ______________________

Signature: ______________________

Make Checks Payable to: ISA

Military vouchers or company purchase orders not accepted.

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Rochester, NY 14615
www.marriott.com
Rates start at $118

Hotel Reservation cut off date: **19 April 2010**

55-3393-129

ISA EXPO 2009
Attracts Thousands & Features Dozens of Special Events

Research Triangle Park, NC (22 October 2009) –ISA EXPO 2009, held at the Reliant Center in Houston, Texas, USA, attracted 8,500 attendees and included a 61,500 Sq. Ft. exhibition showcasing 364 companies. The ISA Fall Training Institute ran 13 courses and trained 113 students at the event.

ISA EXPO 2009 featured seven co-locating organizations, including ARC Advisory Group, Industry2Grid (I2G), MCAA, OpenO&M, Microsoft and the Microsoft Manufacturing User Group (MSMUG), Houston SmartPlant Instrumentation (LTUF), and WBF.

The co-location of these organizations' events with the ISA Fall Training Institute, Industry Standards Forum, six technical conferences, and the exhibition brought an abundance of technical content, professional development, and networking opportunities to attendees. New technologies were a focus of both conference sessions and presentations on the exhibit floor, with attendees anxious to see the latest trends in the field. "I'm always looking for new technology. That's what I'm here to see. I'm a control systems engineer, and anything that can make our processes work better, whether that's software, wireless, or fieldbus, I want to have a look," said James Pitts of Goodyear Tire and Rubber in Beaumont, Texas.

The ISA EXPO 2009 technical conference featured six Exchange Conference Tracks centered on key issues facing instrumentation, automation, and control professionals, including safety, security, process automation and control, energy and environment, wireless and networking, and enterprise integration. The conference program also included several events open to all attendees, including keynote addresses from key leaders. John Hofmeister, CEO and Founder of Citizens for Affordable Energy, and retired President of Shell Oil Company presented the opening keynote address on Tuesday, 6 October. Hofmeister's presentation, entitled "Energy Security and Affordability in the 21st Century," tackled these two critical concerns for industrial operations.

Wednesday's keynote address, "Securing the Nation's Industrial Control Systems Infrastructure," was delivered by Marty Edwards, U.S. Department of Homeland Security Program Manager of the Control Systems Security Program (CSSP). Edward's address discussed the current threat landscape, common vulnerabilities and security issues facing critical infrastructure control systems, and mitigation strategies being developed to address these challenges.

Lisa Long, Safety Engineer with the U.S. Department of Labor-OSHA (U.S. DOL-OSHA), presented the final keynote address on 8 October, titled, "Overview and Findings from OSHA's Refinery and Chemical National Emphasis Programs." Long's address described the Petroleum Refinery National Emphasis Program's inspection protocol and procedures, and reviewed preliminary findings from the program, including data on the most frequently cited paragraphs of the process safety management standards and example citation language.

The event also featured activities for young automation professionals and students. YAPFEST, in its fourth year, attracted 200 automation professionals in the under-30 category to interact with sponsoring companies, learn more about careers in automation, and discuss how they might make a difference in the automation world. Students from several local colleges attended the event to learn about real-world applications of the automation and engineering concepts they're learning about in school, and young professionals already working in the field attended to network and build their knowledge of the industry. Tamara Freasier, a graduate of LIT, works as a commissioning admin for Chicago Bridge and Iron. "We're building a liquid natural gas plant in Sabine Pass, Texas," she said. "I came to EXPO to get exposed to instruments and what they do."

The second annual iAU2M8 event, designed for middle and high school students, attracted over 600 students from the Houston area. Students had a chance to walk through the ISA EXPO exhibit, see automation technology in action through an interactive demonstration area, and learn about career opportunities from real-world automation professionals. Sponsored by Shell, the event attracted several participating organizations and schools, including Citizens for Affordable Energy, FIRST Robotics, Houston Community College, the Houston Museum of Natural Science, Lee College, the Offshore Energy Center, Texas State Technical College, and the University of Houston.

The students attended a keynote address entitled "Deadliest Innovation," given by Greg Crouch, Embedded Systems Business Development Director at National Instruments. Crouch is active in National Instrument's academic STEM (Science Technology Engineering and Math) program efforts, helping to expand excitement of engineering among youth.

During ISA EXPO 2009, ISA announced its plans for a new event in 2010. ISA Automation Week 2010 will be held 4-7 October 2010 at the Westin Galleria Complex in Houston, Texas, USA. ISA Automation Week is a new, knowledge-focused event that will feature educational and applications-based technical conference sessions delivered by subject matter experts. Discrete and process automation professionals will have a chance to learn techniques and solutions for creating more efficient, productive, and economical manufacturing processes. ISA training courses and standards meetings will also be held concurrently, making ISA Automation Week a one-stop shop for automation and control knowledge and networking opportunities.

ISA Automation Week will attract management, engineering, production, IT, and R&D professionals responsible for automation, control systems, plant-wide communications/ networks, plant operations and maintenance, and systems integration in continuous and batch manufacturing environments.

Selection and Use of Ultrasonic Gas Leak Detectors

By Edward Naranjo

Keywords: Leak rate, sound pressure level, ultrasonic gas leak detection

Abstract: Combustible gas detectors often constitute the first line of defense toward mitigating the risk of fire. Gas detected at the source can be contained to prevent its further spread and avoid explosions. Gas from high-pressure pipes and other pressurized systems pose a particular challenge, since leaks produce highly localized accumulations that quickly dissipate from the core of the jetting gas. Detection methods that rely on the transport of gas to the sensor may fail to respond to leaks if the gas does not reach the sensor in sufficient quantities. Unlike these conventional technologies, ultrasonic gas leak detection does not depend on gas concentration. The operating principle of this type of detection is that the escaping gas from a pressurized vessel generates ultrasound, which can be identified by an acoustic sensor and measured as a leak rate. In this paper, we provide an overview of ultrasonic gas leak detection and its application to industrial safety. A final section provides the reader guidelines for the allocation, commissioning, and maintenance of these instruments.

Introduction

The late 1990's has seen the emergence of ultrasonic gas leak detection as a powerful method for detecting gas. Unlike traditional gas detection devices, fixed ultrasonic gas leak detectors do not depend on the gas making contact with a sensor element, but rather, respond to the ultrasound emitted by escaping gas. Such simplicity is one of its advantages and has contributed to its widespread use. To date there are over 2,500 installations of ultrasonic gas leak detectors worldwide.

In spite of its rapid adoption, much of the operation of ultrasonic gas leak detectors is still poorly understood. To many managers I have interviewed, the detectors do not fit a common mold of plant safety they have come to expect with catalytic, solid state, and optical gas detectors. The very use of ultrasound as a proxy for a hazard raises questions about the proper placement of detectors at a plant, especially if sources of ultrasound are known to be present throughout the facility. Equally important, many are confused about the selection and upkeep of such instruments.

This article presents a brief discussion on the principles of ultrasound gas leak detection and the strengths and weaknesses of the technology. It also provides advice on the selection and use of fixed ultrasonic gas leak detectors, so that armed with these insights, process engineers and managers may be able to make more informed decisions about the application of these instruments to plant safety.

Physical Principles of Ultrasound Gas Leak Detection

The operating principle of ultrasonic gas leak detectors is that jetting gas from a high pressure vessel or other pressurized system generates ultrasound, which when detected by an acoustic sensor, provides a measure of leak rate. Ultrasound is the term for the range of sound frequencies above those audible to humans. The frequency range of human hearing extends over three orders of magnitude, from about 20 Hz to 20 kHz. A spectrum of sound spanning several frequencies is illustrated in Figure 1.

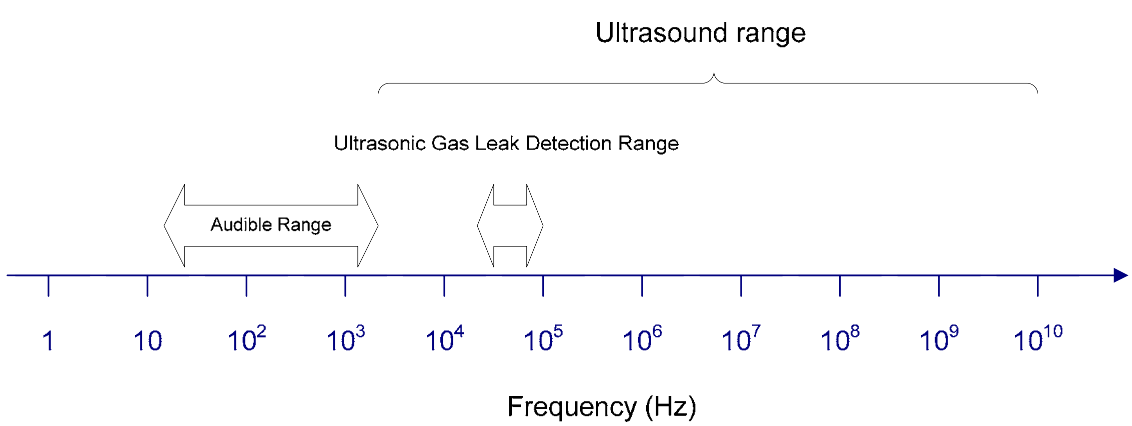

Figure 1. Noise spectrum showing audible and ultrasonic ranges. At a span of 25 to 75 kHz, the ultrasonic gas leak detection range is a small portion of the range of ultrasound.

The pressure amplitudes of sound waves are commonly measured on a logarithmic scale, called the decibel (dB) scale. Using such scale, one can define sound pressure level (SPL) as

$$SPL = 20\log\left(\frac{p}{p_0}\right)$$

where p_0 is the pressure amplitude of a reference sound, taken to be 20 kPa. Thus, at $p = p_0$, the scale is assigned a sound pressure level of 0 dB.

One important characteristic of sound is that the speed of propagation depends on density and pressure. As a result, the velocity of sound varies with the medium. Such phenomenon has important implications for ultrasound as a means for detecting leaks. As shown in the expression below, the wavelength l of a wave propagating in an isotropic medium is directly proportional to the velocity of the wave (v) and inversely proportional to its frequency (f).

$$\lambda = \frac{v}{f}$$

Thus, the wavelength of sound decreases as frequency increases into the ultrasound region. For example, assuming a velocity of sound in dry air of 331 m/s, a wavelength in a mid ultrasound, say between 25 kHz and 70 kHz, can range between 5 and 13 mm. Ultrasound generates high energy, short wave signals that are directional and localized. Because of their short wavelengths, ultrasound is less susceptible to diffraction than audible sound and ultrasonic gas leak detectors are able to detect leaks. As Figure 2 shows below, a gas leak generates sound through a wide range of the frequency spectrum.

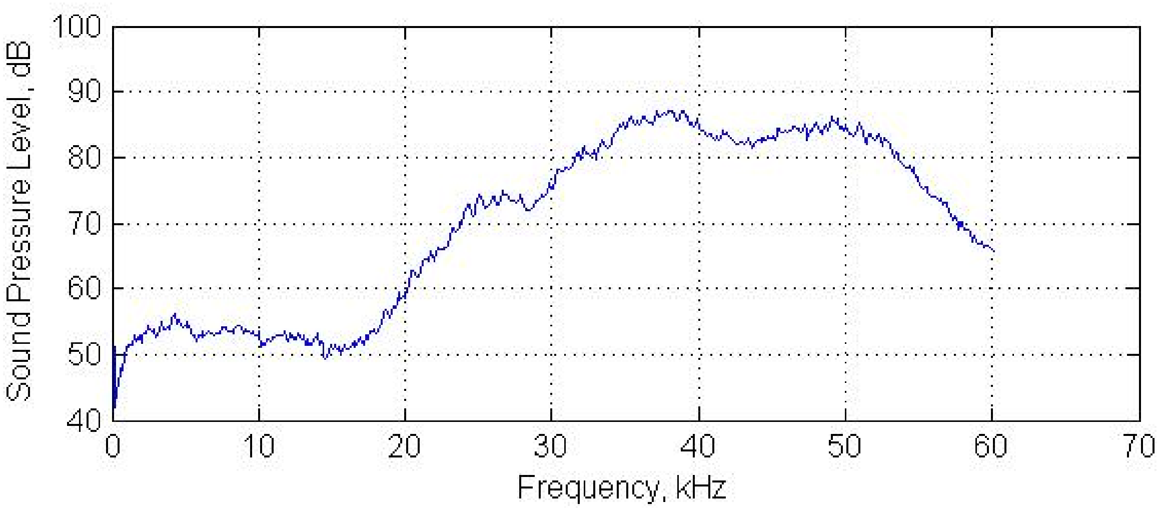

Figure 2. Noise spectrum of nitrogen gas leak in the 20 kHz to 60 kHz frequency band (Leak size = 1 mm; p = 2,758 kPa).

Further, the ultrasonic sound level is proportional to the log of the mass flow rate (leak rate) at a given distance:

$$SPL \propto \log \dot{m}$$

It is this property that airborne ultrasound detectors employ in order to detect leaks. The turbulent flow of the gas in air produces heat and sound energy as the gas molecules collide. And although heat dissipates quickly, the sound energy is transmitted at considerable distances, allowing the detectors to respond to changes in the sound pressure level.

The leak rate is a function of the leak size, the differential pressure across the orifice, and thermodynamic properties of the gases, as expressed in the following equation:

$$\dot{m} = Ap\sqrt{\left(\frac{\gamma M}{RT}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}\right)}$$

where *A* is the area cross section of the orifice, *p* the internal pressure, *M* the molecular weight, *T* the absolute temperature, and *R* the gas constant. The specific heat ratio *g* is the ratio of the specific heat of constant pressure to that of constant volume ($\gamma = c_p / c_v$). Figure 3 shows the variation in the noise levels generated by four gases of varying molecular weights, for the given leak rates.

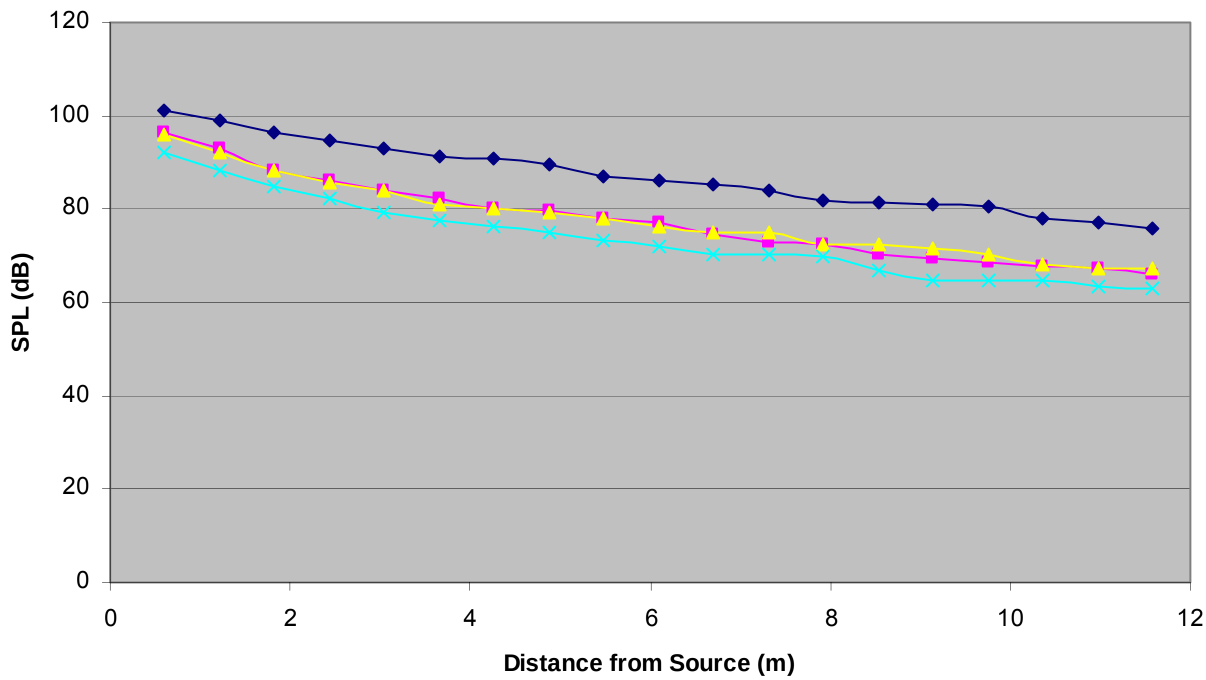

Figure 3. Sound pressure level as a function of distance. Legend: ¨ He 0.004 kg/s, ■ CH_4 0.007 kg/s, ▲ N_2, 0.01 kg/s, ´ CO_2 0.011 kg/s. Ambient SPL = 36 – 40 dB.

ADVANTAGES AND DISADVANTAGES

As with any technology, ultrasonic gas leak detection is not suitable for all applications and its effectiveness may be diminished if its advantages and disadvantages are not weighed carefully. Recently the United Kingdom's Health Safety Executive (HSE) reported on the strengths and limitations of ultrasound gas leak detection.

Advantages of the sensing technology follow from the properties of ultrasound described above. To begin, ultrasonic gas leak detectors have short response times, governed by the speed of airborne sound. A detector 20 m away from a leak source, for instance, will respond to a gas leak in about 60 ms. Responses are thus much faster than those of catalytic or optical detectors, typically in the order of 10 seconds.

Ultrasonic gas leak detectors are not influenced by the dilution of the gas cloud. Since the devices respond to the source of the gas release, the evolution of the gas cloud over time and its concomitant changes in concentration have no effect on the instruments. Such strength sets ultrasonic monitoring apart from most traditional forms of gas detection, which rely on the gas making contact with a sensor element.

Gas leak detectors are able to detect a variety of combustible, toxic, or inert gases. As evidenced by the mass flow equation, the leak, and hence detection, are dependent on thermodynamic properties that are shared by all gases.

Another advantage of ultrasonic gas leak detectors is that their performance can be verified with live gas leaks during commissioning. Using an inert gas, operators can carry out simulations of gas releases of a known leak rate and test the response of the detectors in potential locations.

Despite these advantages, acoustic sensing technology faces several limitations for fire and gas protection. Probably the most significant one is the restriction to pressurized systems. Pressure leaks below 10 bar or 145 psi do not produce acoustic emissions at levels substantially higher than the background noise (~ 50 – 80 dB). Additionally, ultrasonic gas leak monitors can only detect leaks produced by turbulent flow. At a minimum, the pressure behind the leak must be at least twice that on the other side in order for turbulent flow to occur. Vapors created from leaking liquids will also not be detected by acoustic sensing technology though they might reach flammable or toxic levels.

The detectors are also affected by ultrasonic noise interference. In a plant, such interferences can arise from electrical generators, pneumatic actuators, fans, and other man-made or natural sources. In order to prevent false signals, the detection threshold must be increased. The detectors will then respond only to noise whose SPL is greater than the background level. If a source of ultrasound issues noise for a few seconds, the detector response can be adjusted by means of a time delay function. The effect is that the detectors will be less susceptible to short timescale background noise, but at the cost of increased detector response time.

A summary of the advantages and disadvantages of ultrasonic gas leak detection is presented in Figure 4.

Advantages

- ❑ Near instant detection of pressurized gas leaks
- ❑ Versatile – detects pressurized leaks regardless of type of gas
- ❑ Not sensitive to changing wind direction and gas dilution
- ❑ Minimal maintenance and no consumable parts
- ❑ Robust, fail safe operation

Disadvantages

- ❑ Not suitable for low pressure leaks
- ❑ Under certain conditions affected by man-made or natural ultrasonic sources
- ❑ Background noise levels need to be estimated prior to installation
- ❑ Unable to determine concentration of gas

Figure 4. Advantages and disadvantages of ultrasonic gas leak detection.

PLACEMENT OF ULTRASONIC GAS LEAK DETECTORS

The placement of ultrasonic gas leak detectors is a function of the location of the potential gas leaks, an acceptable level of risk, and extraneous sources of ultrasound. All three factors materially influence the allocation of the monitors around the plant. In order to determine placement, users must first assess plant and equipment to identify the most likely sources of gas plumes' . Process gases can be released from a variety of sources like valves, weld joints, flanges, and gaskets. Other high risk areas are high pressure vessels and well bays.

Once potential hazards and release points are identified, the next step is determining the minimum leak rate to be detected by the ultrasonic gas leak detector. Although the concept of mass per unit time is well known, a sense of an acceptable leak rate is rather new among fire and gas safety professionals. Depending on the gas, a leak rate of 0.01 kg/s may represent a hazardous leak and thus grounds for issuing an alarm. Under other circumstances, larger leak rates that are two orders of magnitude larger may not constitute a hazardous event.

To date, the HSE has been the only governmental body to issue a categorization of gas leaks according to dispersion models employed in the oil and gas industry:

Minor leak	< 0.1 kg/s and duration < 2 min
Significant leak	leak rate between 0.1 and 1 kg/s, duration between 2 and 5 min
Major leak	> 1.0 kg/s and duration > 5 min

These categories have been defined based on the speed of a gas cloud to accumulate into an explosive gas concentration. According to the above categorization, the performance standard of ultrasonic gas leak detectors for typical applications is based on gas leaks of 0.1 kg/s. For reference, a methane leak of this flow rate can be generated with gas pressurized to 650 psi (45 bar) and expelled through a hole measuring 4 mm in diameter. At 0.1 kg/s in average background noise conditions an ultrasonic gas leak detector can detect hydrocarbon leaks in a radius of 8 – 12 m.

For special applications, the performance standard of ultrasonic gas leak detectors may be changed in order to detect even smaller leaks. This is possible without increasing the risk of false alarms. For example, an ultrasonic gas leak detector can respond to a leak rate of 0.03 kg/s if the detection coverage is decreased to 4 – 8 m. To be sure, standards for gas leaks will continue to evolve as industries adopt ultrasonic gas leak detection to their own use.

Having defined the target leak rate one can now determine the maximum detection range of the ultrasonic monitor *for a given level of background noise*. Since the detectors can only respond to changes in sound pressure level above a background, the level of the baseline can severely restrict the detection range. In areas where there is very little noise (< 58 dB), ultrasonic gas leak detectors can cover approximately 9 – 12 meters in radius. This could include salt dome storage areas or onshore wellheads, for example. In contrast, the devices may see their detection ranges curtailed to 5 – 8 m in high noise areas with background noise around 68 to 78 dB. Figure 5 shows the maximum detection range attained.

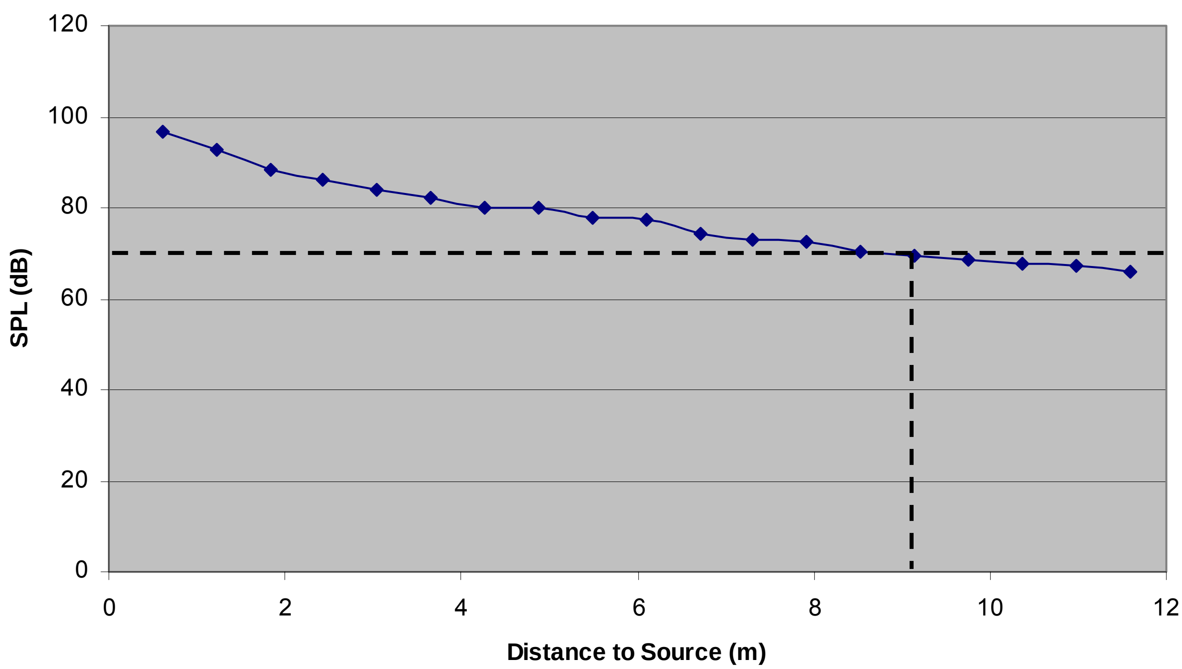

Figure 5. Sound pressure level as a function of distance for a methane leak ($\dot{m}$ = 0.007 kg/s; leak size = 1 mm; *p*= 5,516 kPa). At an alarm threshold of 70 dB, the maximum detection distances is approximately 9 m.

Taken together, the three factors – location of potential hazards, leak rate, and background noise – help define the placement of detectors so as to maximize coverage per device.

SELECTION

Several manufacturers of fixed ultrasonic gas leak detectors provide recommendations for product selection. In general, the devices should be sufficiently sensitive to detect gas leaks at pre-defined levels. Such products should also have a dynamic range that accommodates the sound pressure levels emitted by gas leaks in most plant environments. This is particularly important because as environmental conditions change threshold values may need to be adjusted to allow for these changes. Equally important, the detectors should be equipped with an electronic high-pass filter to filter the audible spectrum of broadband sound below approximately 24 kHz. Removing the audible frequencies eliminates background noise interference, rendering detectors more immune to false signals. The gas leak spectrum shown in Figure 2 is obtained using an ultrasonic detector that eliminates noise between 0 and 20 kHz.

Additional considerations are instrument fail to safe features such as an acoustic self check. Like the continuous optical path monitoring of flame detectors, the self check regularly probes the integrity of the sensor circuitry and the microphone to ensure detection is not compromised. If foreign material on the surface of the microphone were to block it, the detector issues a fault. Coupled with the acoustic self check are ancillary devices that provide an independent means of verifying the operation of the instruments. These include calibration and testing units.

Last, the capacity of ultrasonic gas leak detectors to communicate with programmable logic controllers (PLCs) is an essential requirement. Detectors that support analog output or two-way digital communication integrate easily with fire and gas safety systems, further enhancing the benefits of fail to safe features and routine maintenance.

CONCLUSION

Ultrasonic gas detection represents an innovative approach to plant safety, proven effective in the field for monitoring gas leaks. In pressurized systems, the detectors respond rapidly to jetting gas by triggering an alarm if a specified sound pressure level is exceeded. The operating principle of ultrasonic gas leak detection is the generation of ultrasound by turbulent gas flow, which, when detected by an acoustic sensor, provides a measure of the leak rate.

The advantages of the system include near instant detection of pressurized gas leaks. Ultrasonic gas leak detection can detect ultrasonic noise in open, well ventilated areas, where traditional gas detection may not be effective or independent of ventilation. Ultrasonic detection applies to all types of gas, whether combustible, toxic, or inert, and it is thus, quite versatile on many applications.

Despite these advantages, the technology will not respond to low pressure sources of gas (ex. unpressurized gas storage tanks) and incipient leaks on process equipment. Attempts to detect small scale leaks can be accomplished but it requires that the detector be placed close to potential sources. Ultrasonic gas leak detection is also affected by interference from natural and artificial ultrasonic noise. Because of these considerations, users must carefully choose alarm thresholds and delay settings for their instruments.

Proper planning and placement of the ultrasonic gas leak detectors is the first step in protecting workers and plant assets from potential hazards. Placement is defined by the location of potential sources of high-pressure gas leaks, the target leak rate to be detected, and the maximum detection range that provides a margin above a background noise level. When configuring the detectors, it is not only essential that the alarm threshold is set above this noise floor, but that the time delay is also set to ensure only continuous noises will cause an alarm.

Several models of ultrasonic gas leak detectors are commercially available today. These rely on very similar principles of operation, employing a microphone, filtering circuitry, and signal processing to measure sound pressure level for a specific area. When choosing a detector, users are advised to consider features that improve reliability, provide communication with alarm and emergency shutdown systems, and allow operators to configure the detectors to a wide range of ultrasonic background levels and intermittent ultrasonic sources.

ACKNOWLEDGEMENTS

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2010-2011

BOARD OF DIRECTORS

DIRECTOR
Ken Belteau
Spectra Energy Transmission
713-627-4427
713-515-3758 (Cell)
krbelteau@spectraenergy.com

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713-354-6522
tajani@uei-houston.com

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Siemens
281-300-7731
rwill74018@aol.com

WEBMASTER
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edwardn@generalmonitors.com

ASSISTANT WEBMASTER
Joseph Cate
jcate@logicalsysinc.com

ASSISTANT NEWSLETTER EDITOR
Mary Carmichael
KROHNE Oil & Gas
281-598-0050
m.carmichael@krohne-oilandgas.com

NEWSLETTER EDITOR
Rick Williams
Siemens
281-300-7731
rwill74018@aol.com

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