Going Green: Tracking Down the "Greenhouse Gas" SF_6 with Infrared Thermography

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Abstract

Sulfur Hexafluoride (SF6), used as an insulator in high-voltage utility equipment, has been targeted for emissions reduction by the EPA. Together, the EPA and many major utility companies are working to better control SF_6 emissions because it contributes more to the greenhouse effect than any other gas and has a projected atmospheric life of 3,200 years.

This presentation will explore how a recent technological advancement in infrared thermography allows us to detect SF_6 in real time. Some of the benefits of using this technology will be highlighted, including decreasing SF_6 emissions, helping to preserve the environment, and detecting more than twenty other fugitive gases.

Discussion

Cooperative Emission Reduction Programs

"Through Power Partners, the power sector, and the Department of Energy (DOE) are working together to develop and implement voluntary climate actions to sustain economic growth. Of particular interest to the electric power sector is SF_6. Sulfur hexafluoride is used as an insulator for circuit breakers, switchgear, and other electrical equipment. The electric power industry uses roughly 80% of all SF_6 produced worldwide. SF_6 has a very high GWP - 23,900 times the warming effect of carbon dioxide per ton emitted. Therefore, even small amounts of SF_6 emissions can constitute a significant carbon-equivalent emission tonnage," according to a report by Power Partners - a joint government-industry initiative to reduce greenhouse gas emissions.

"Under ideal operating conditions, SF_6 would remain contained within transmission and distribution equipment. In reality, however, SF_6 is inadvertently emitted into the atmosphere during various stages of the equipment's life cycle. Leaks generally increase as equipment ages. Fugitive emissions can escape through valve fittings and at joints between flanges and porcelain bushings. SF_6 can be accidentally released at the time of equipment installation as well as during servicing."

Industry Commitment to Reduce SF_6 Emissions

To proactively address the challenge, members of the electric power industry and the EPA have come together in a collaborative effort to reduce SF_6 emissions. In 1999, the EPA created the SF_6 Emissions Reduction Partnership for Electric Power Systems to help the electric power industry reduce its emissions of SF_6.

Each year, the program's participants have exceeded their goals for reducing SF_6 emissions. According to the EPA's 2005 Annual Report, "SF_6 Partners in 2005 have collectively achieved a 32-percent decrease in emissions from the 1999 baseline year. Approximately 190,644 pounds of SF_6, or the equivalent of 2.07 $MMTCO_2$ emissions have been avoided. Cumulatively (1999-2005), emissions avoided total 635,182 pounds or 6.88 $MMTCO_2$."

The EPA and 81 partner utility companies are now working together voluntarily in a program called SF_6 Emission Reduction Partnership for Electric Power Systems. More information about this initiative can be found at www.epa.gov/electricpower-sf6.

In addition to basic information about the partnership, the website contains proceedings from past conferences, details about upcoming conferences and workshops, case studies, a directory of service providers, a list of the 81 partners, and other documents that can help utilities develop strategies for reducing SF_6 emissions. In addition to maintaining the website, the EPA sponsors research, conducts technical conferences, and helps partners implement voluntary programs.

Industry Success in Emission Reduction

There are several examples of successful SF_6 reduction programs in industry. Each are noteworthy and show the need for further similar programs.

One major utility reduced SF_6 emissions by 50% according to an EPA website case study called "Reducing SF_6 Emissions Means Better Business for Utilities". The emissions savings program has been yielding net savings of $300,000 annually. In addition, the firm estimates it can save an additional $50,000 to $100,000 annually as a result of improved SF_6 handling. Overall, utility industry partners are achieving the goal to cut emissions below acceptable levels.

The EPA website highlights another study titled "SF_6 Leaks from High Voltage Circuit Breakers – US EPA Investigates Potential Greenhouse Gas Emissions". More than 2,300 high voltage circuit breakers were analyzed. The study found that leaks occurred in 23% of SF_6-filled circuit breakers that were five years old.

Development of SF_6 Leak Detection

Early IR cameras used a combination of active illumination with scanning technology to detect leaking SF_6.

The active scanning combination of IR camera and illuminator was designed to emit an infrared beam, which, when scattered off an object, would return to the camera. If an absorbing gas was located between the scattering object and the camera, then part of the beam would be attenuated. It was this slight difference in the amount of return beam that allowed an IR image to be displayed showing the presence of the gas. These types of active camera systems can only detect a SF_6 cloud when the beam has a background object to bounce back from.

This requirement for background beam returns is a liability with active scanning systems. They are completely dependant on the amount of the beam that is returned. Since different objects scatter the beam in varying amounts and in varying directions, the return beam is never consistent. When surveying outdoor substations for instance, the camera operator is typically on the ground. When he points the camera upwards towards tall gear with only the sky as a background, the active system fails, as there is nothing to bounce the beam back.

GasFindIR LW Scans Large Areas

FLIR's GasFindIR LW (longwave) IR camera, with its High Sensitivity Mode™ feature, helps utilities detect the smallest SF_6 gas leaks. GasFindIR is a 100% "Passive" IR system, which means the system does not require an active illuminator. This key difference from previous IR technology enables safer, more productive, and more complete inspections.

"For years, electric utility transmission thermographers have wanted a camera that could spot leaking sulfur hexafluoride, SF_6…. Now there is an IR camera that can spot SF_6 in very small amounts and is a completely passive system, requiring no infrared laser but for the smallest leaks," according to a report delivered by Robert Madding and Robert Benson at the October 15, 2007 InfraMation Conference in Las Vegas.

"U.S. electric utilities used over 1.5 million pounds of SF_6 as refill for leaks. At the current price of about $10/lb., this amounts to a $15M annual cost to our electric utilities just to replace leaking SF_6, not to mention the reliability costs associated with potential downtime, outages, and expensive repairs."

Safeguard SF_6 Losses and Minimize Environmental Impact

Inspecting SF_6-pressurized equipment at tens of thousands of substations in the U.S. is a daunting task. IR optical imaging offers a smart solution - it's a better way.

The GasFindIR camera can be used to find leaks over significant distances. One can often find small leaks at a 30 foot range with standard 50mm EFL optics. The GasFindIR infrared camera is able to survey tremendously large areas quickly. It detects as fast as the operator can see.

A well-planned gas emissions detection program can help to reduce health and safety hazards, save money, and improve production by eliminating or recovering lost product.

Benefits of an SF_6 Reduction Program

- Better substation maintenance and inventory control
- Real-time visualization of gas leaks
- The ability to trace leaks to their source
- Improved inspection times and safety
- Prioritization of larger leaks and leaks that have the most potential for environmental, safety, or production losses
- Ensure continuous service to customers
- Protect the environment for everyone

Thermal Imaging and Volatile Organic Compounds (VOCs)

The GasFindIR MW (midwave) camera also is capable of detecting volatile organic compound (VOC) gas emissions from petrochemical facilities, gasoline refinery installations, natural gas pipelines, transfer stations, supertankers, moving railway tank cars, and even landfills emitting methane gas and other chemicals into the environment.

The camera can also be equipped with a longer focal range lens for distance surveillance such as conducting pipeline surveys from a helicopter. A number of US gas transmission companies, including El Paso Natural Gas and Western Gas Resources, already have acquired the camera. The Texas Commission on Environmental Quality (TEQC), the Louisiana Department of Environmental Quality (LDEQ), ExxonMobil, Dow Chemical, Texas Petrochemical, and other companies and agencies use gas finding cameras to help reduce the risk of explosions, fines, and greenhouse gas emissions.

GasFindIR MW has been certified for the detection of a wide range of gases, including benzene, ethanol, ethylbenzene, ethylene, heptane, hexane, isoprene, MEK, methane, methanol, MIBK, octane, pentane, 1-Pentane, propylene, toluene, and xylene, as well as butane, ethane, and propane.

Some of the first discoveries with the early cameras included gas plumes escaping from valves, gasoline vapors escaping a non-vapor recovery hose at a gas station, as well as methane, propane, naphthalene, and butane.

Improving Natural Gas Transmission

"The natural gas system in the U.S. is vast, being comprised of hundreds of thousands of wells, hundreds of gas processing facilities, over one million miles of pipeline, and millions of consumers," according to the Power Partners Resource Guide, which was published by an initiative of government and industry representatives established to help reduce greenhouse gases.

The EPA and the natural gas industry, through the Natural Gas STAR Program, have identified several Best Management Practices (BMPs) for reducing methane emissions.

The EPA describes the "Natural Gas STAR Program" at its website:
http://www.epa.gov/gasstar/index.htm

Summary

Optical gas finding technologies evolve and draw from the current state of the art in IR imaging. Infrared imaging technology holds great promise for the development of new vapor detecting applications. Significant resources are invested in continued research and development, development of guidelines, and training for the next generation of IR imagers. The benefit of this commitment to industry and the public will be improved safety, cost-savings, and protection of the environment.