Tracking Down the Greenhouse Gas SF6 with Infrared Thermography

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Review of the GasFindIR

- Light weight
- Portable
- One-Hand Operation
- 5-Hour Li-Ion batteries
- High Sensitivity Mode to find small leaks
- MDLR - 10 ppm of SF6 or the equivalent of less than one (1) pound (0.45 kg) per year

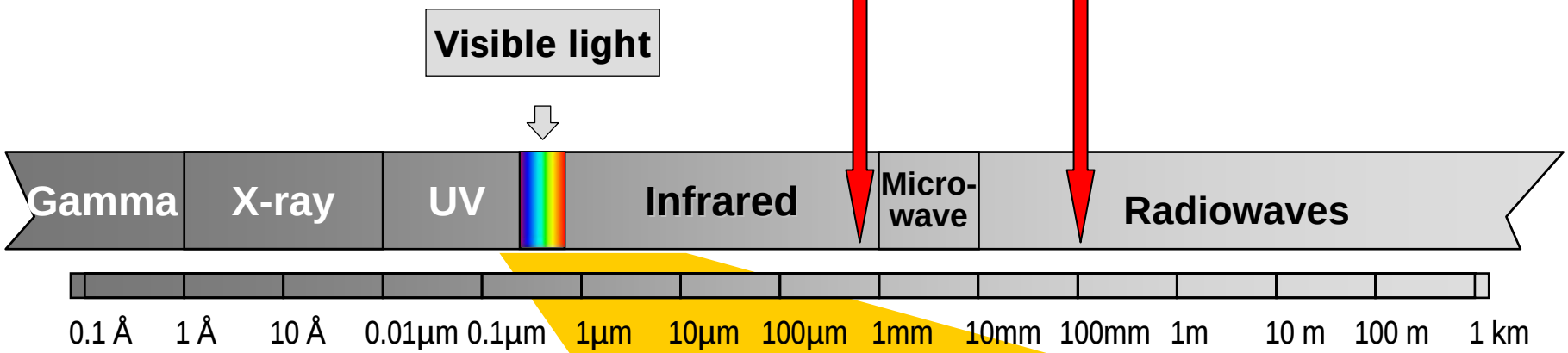
What is GasFindIR LW?

- **F-Number** 2.3
- **Thermal Sensitivity** <35mK @ 30C
- **FPA** QWIP 320x240 format 30um pitch
- **Spectral Range** 10-11um
- **Integration Time** 16.6ms and selectable
- **Power** <6W
- **Weight & Size** 4.6lbs, 10”x5.2”x5.7”
- **FOV** 25mm(22°), 50mm(11°), 100mm(5.5°)
- **Controls** Push Buttons on Camera and RS232
- **Outputs** NTSC/RS-170, C-Video, PAL
- **Inputs** RS232

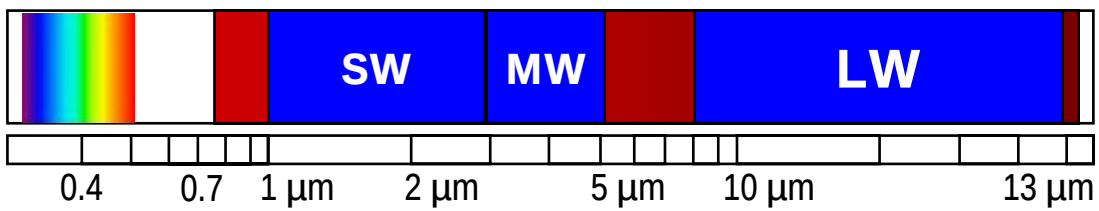
PATENT PENDING

The Electromagnetic Spectrum

Infrared energy is part of the electromagnetic spectrum and behaves similarly to visible light. It travels through space at the speed of light and can be reflected, refracted, absorbed, and emitted. The wavelength of IR energy is about an order of magnitude longer than visible light, between 0.7 and 1000 µm (millionths of a meter).



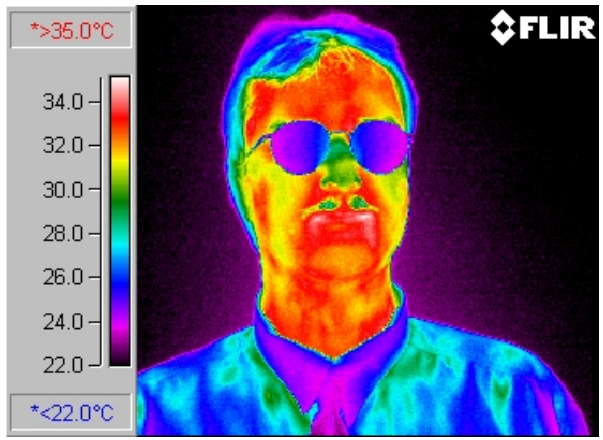
Visible: 0.4-0.7 µm
Near IR: 0.7-~1 µm
IR Short wave: 1-3 µm
IR Mid wave: 3-5 µm
IR Long wave: 8-14 µm



Different Types of Imaging

VISIBLE

NIGHT VISION

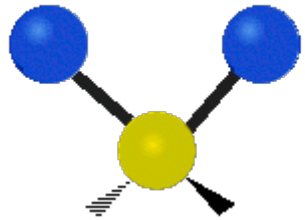


THERMAL

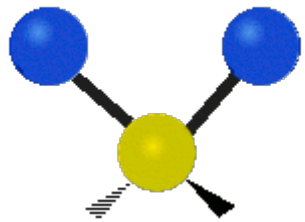
How Does an Infrared System "See" Gas

- The camera employs a spectral filter designed to transmit in a region of the IR spectrum that is coincident in wavelength with vibrational/rotational energy transitions of VOC molecular bonds.
- These transitions are typically strongly coupled to the field via dipole moment changes in the molecule, and are common to many types of gases and vapors.
- With this in mind, the camera's detection sensitivity to a wide variety of gases and vapors is extremely small.
- Thermally, the camera's sensitivity is <35mK when FLIR's adaptive temporal filter is engaged.

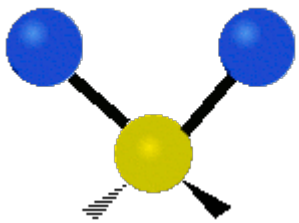
Scissoring



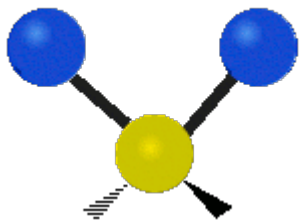
Twisting



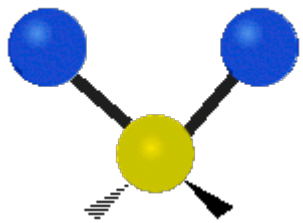
Symmetric stretch



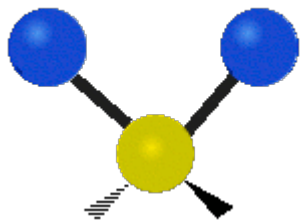
Asymmetric stretch



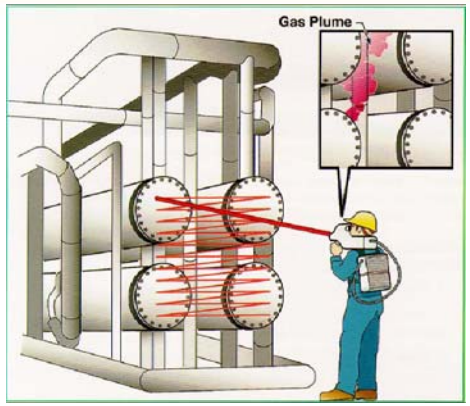
Rocking



Wagging

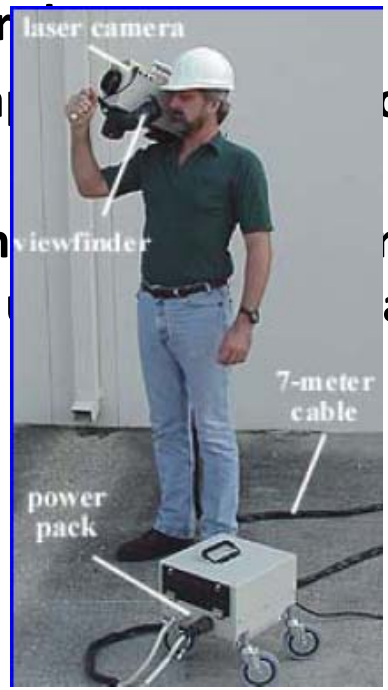


Development of SF6 Leak Detection



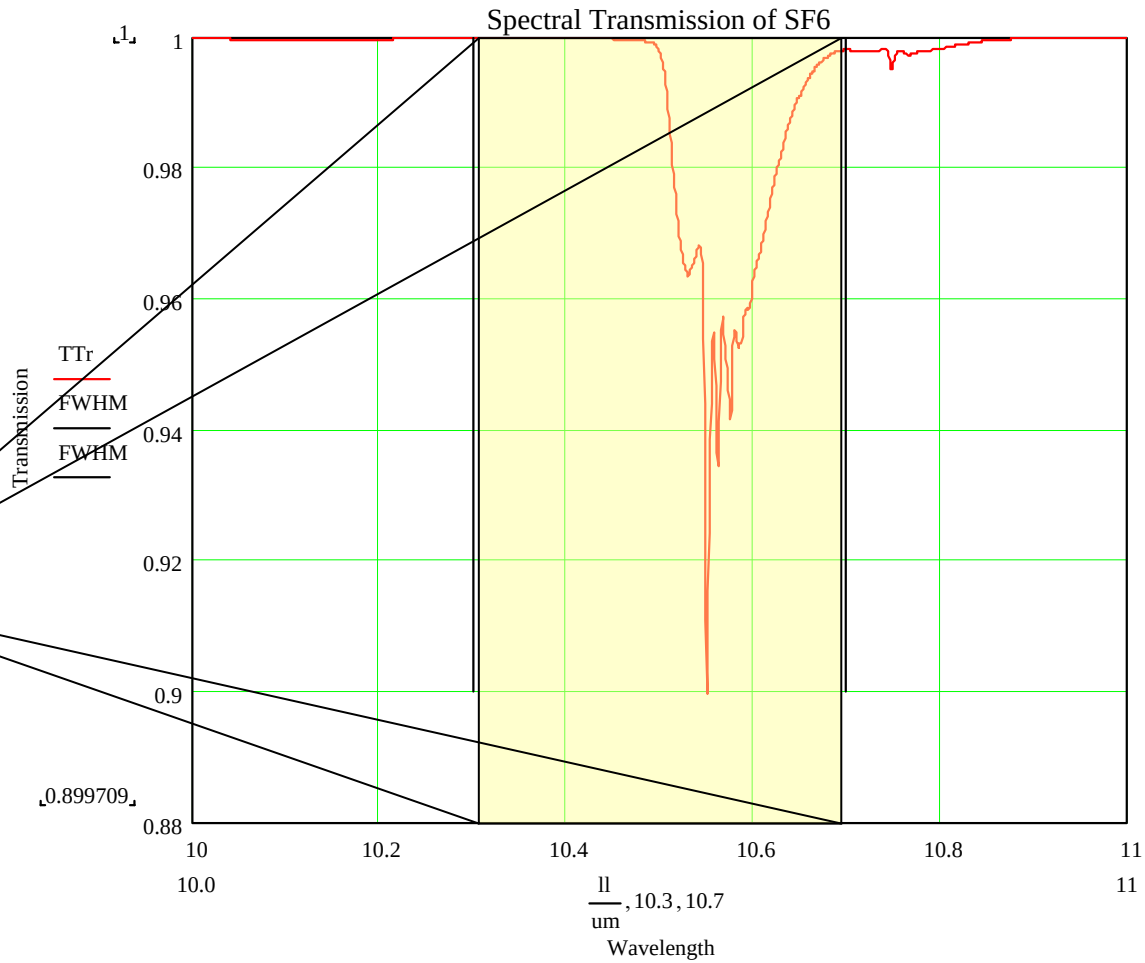
- Early systems for detecting SF6 gas emissions relied on a combination of infrared imaging and active CO2 laser illumination.

- Called Backscatter Absorption Gas Imaging (BAGI)
  - A CO2 laser is scanned over
  - Reflected laser energy is ca camera forming an image
  - If gas was present between rget and the camera, it would show age.



How Does a Passive IR Camera "See" Gas

- **As an example, we can "match" the spectral response of the camera to the "peak" spectral absorption of SF6.**



Field Demos

Customer supplied video.

Field Demos

Video of Bushing leak on a 138KV Westinghouse breaker.

Field Demos

Video of 500KV breaker. In this video we are looking inside the cabinet at the governor switch.

Field Demos

Video of leaking bushing on Westinghouse 220KV breaker.

Field Demos

This video was taken at a maintenance yard, where there were a rack of empty SF6 bottles. We viewed the rack and found that one of the valves was loose.

Field Demos

Video of 500KV breaker. The leak is an upper rupture disk on the C Phase bus side. The leak is viewed from approximately 40 feet.

Field Demos

This is a brand new circuit breaker that was on the delivery truck.

Field Demos

Very small leaks can difficult to detect with soap and water approach.

Other Gases that Passive IR Cameras will See

- Sulfur Hexafluoride (SF6)
- Acetyl Chloride
- Acetic Acid
- Allyl Bromide
- Allyl Chloride
- Allyl Fluoride
- ***Anhydrous Ammonia***
- Bromomethane
- Chlorine Dioxide
- Ethyl Cyanoacrylate
- Ethylene
- Freon® 11
- Freon® 12
- Furan
- Hydrazine
- Methylsilane
- Methyl Ethyl Ketone
- Methyl Vinyl Ketone
- Propenal
- Propene
- Tetrahydrofuran
- Trichloroethylene
- Uranyl Fluoride
- Vinyl Chloride
- Vinyl Cyanide
- Vinyl Ether

Benefits of an SF6 Reduction Program

- Better Substation Maintenance & Inventory
- Real-Time Visualization of Leaks
- The ability to trace leaks to their source
- Improved inspection times and safety
- Prioritization of larger leaks and leaks that have the highest potential for environmental, safety, or production losses
- Helps ensure continuous service to customers
- Protects the environment for everyone

Summary

- Optical gas finding technologies evolve and draw from current state of the art technologies in Infrared imaging
- IR imaging technology hold great promise for the development of new gas/vapor detection applications.
- Significant resources are invested in the continued R&D of equipment, 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.

Thank You!

Questions?

www.goinfrared.com