



Context

- Infrared imaging technologies have gradually emerged for air quality monitoring
- Numerous tests and projects enable the team to determine the capabilities and limits of the camera
- Misconceptions and misunderstanding of the real capabilities of the technology from clients and air quality community

Objectives

1. Demonstrate some applications for the technology
2. Share the experience and lessons learned
3. Expose the advantages and limitations

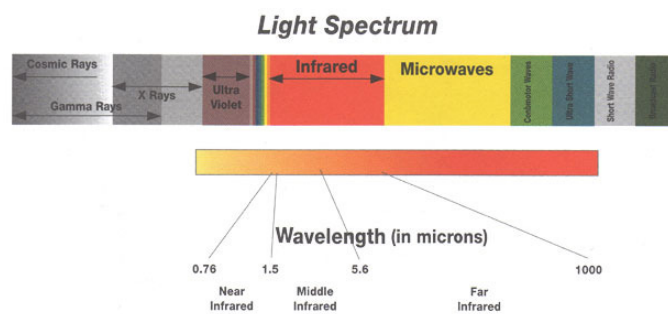
Outline

1. Technology Overview
2. Applications
3. Advantages/limitations
4. Field results



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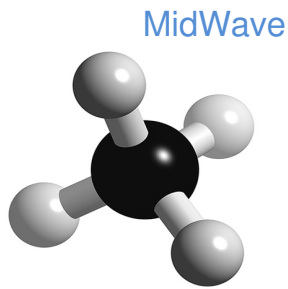
TECHNOLOGY OVERVIEW



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TECHNOLOGY OVERVIEW

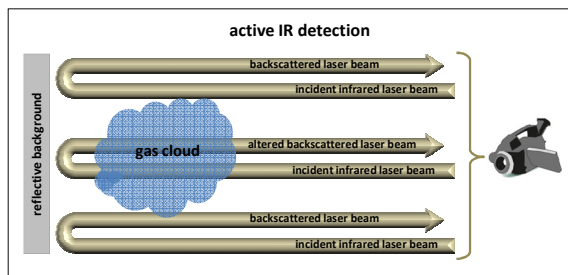
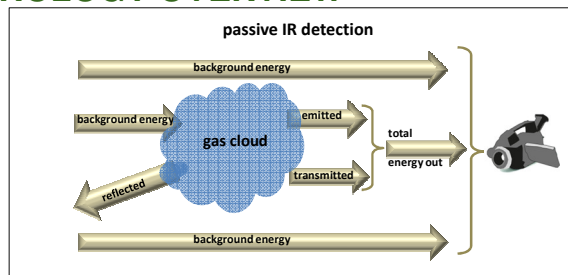
“A travelling electromagnetic wave incident on an atomic structure induces oscillation in the atoms of that structure, thereby causing them to emit their own electromagnetic waves.”



Bond	$\lambda/\mu\text{m}$	Bond	$\lambda/\mu\text{m}$
—C—H	3.4–3.5	—C—C—	6.6–16.7
=C—H	3.2–3.3	>C=C<	5.9–6.2
≡C—H	3.0	—C≡C—	4.4–4.8
—O—H	2.5–2.8	—C—O—	7.7–10.0
—O—H^*	2.9–3.1	>C=O	5.7–5.9
—N—H	2.8–3.0	—C≡N	4.3–5.0

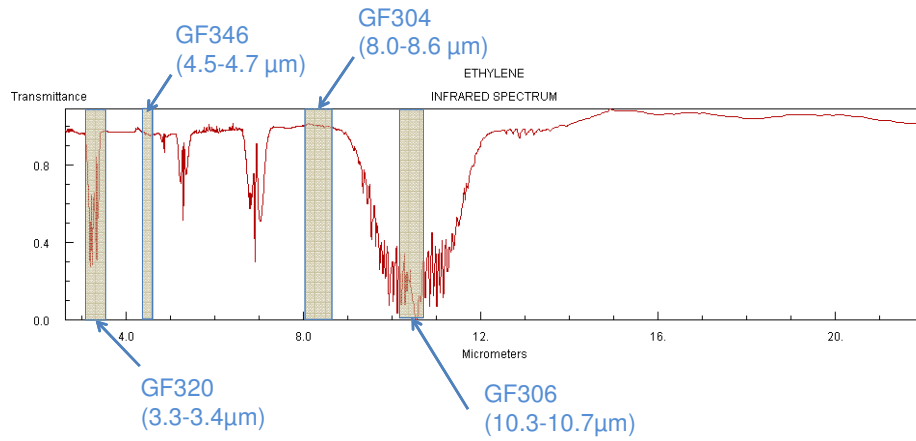
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TECHNOLOGY OVERVIEW



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TECHNOLOGY OVERVIEW

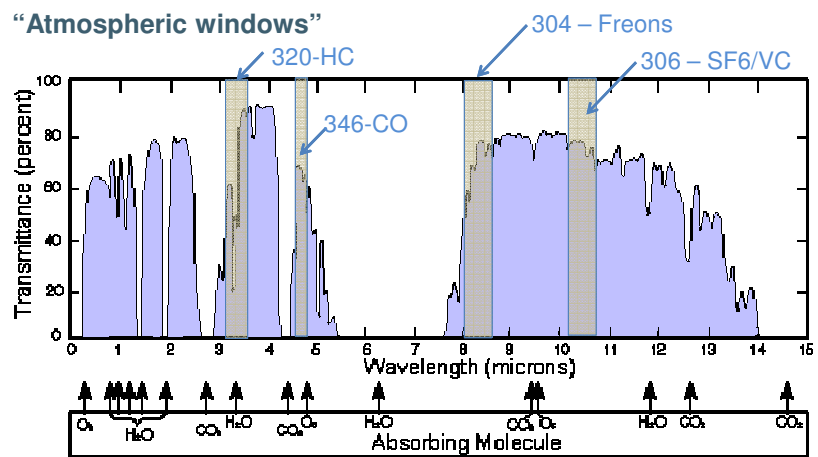


<http://webbook.nist.gov/chemistry/>

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TECHNOLOGY OVERVIEW

"Atmospheric windows"



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TECHNOLOGY OVERVIEW

Camera GasFindIR Specs

- NOT intrinsically safe (Hot Work Permit)
- Detector : 320 x 240 pixels (76 800 pixels) (cooled to -196°C)
- Waterproof and shock resistant
- No internal memory
- Li-ion batteries (last 6-8 hrs)
- 2.4 kg
- Interchangeable lens available



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TECHNOLOGY OVERVIEW

Camera GF

- NOT intrinsically safe
- Built-in memory
- Built-in GPS
- LCD screen
- Visual camera
- Not waterproof
- Li-ion batteries (last 3-4 hrs)
- Interchangeable lens



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IR Camera GF 320

List of detectable gases

- | | | |
|-------------------|-------------|-------------|
| ♦ Benzene | ♦ Toluene | |
| ♦ Butane | ♦ Xylene | |
| ♦ Dimethylformate | ♦ MEK | ♦ Isoprene |
| ♦ Ethane | ♦ MIBK | ♦ Methane |
| ♦ Ethanol | ♦ Octane | ♦ Propylene |
| ♦ Ethyl Benzene | ♦ Pentane | ♦ Methanol |
| ♦ Heptane | ♦ 1-Pentene | |
| ♦ Hexane | ♦ Propane | |



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IR Camera GF 306

List of detectable gases

- | | | |
|-------------------|-----------------------|---------------------|
| ♦ SF ₆ | ♦ Chlorine dioxide | ♦ Propenal |
| ♦ Acetyl Chloride | ♦ Ethyl Cyanoacrylate | ♦ Propene |
| ♦ Acetic Acid | ♦ Ethylene | ♦ Tetrahydrofuran |
| ♦ Allyl Bromide | ♦ Furan | ♦ Trichloroethylene |
| ♦ Allyl Chloride | ♦ Hydrazine | ♦ Uranyl Fluoride |
| ♦ Allyl Fluoride | ♦ Methylsilane | ♦ Vinyl Chloride |
| ♦ Ammonia | ♦ MEK | ♦ Vinyl Cyanide |
| ♦ Bromomethane | ♦ MVK | ♦ Vinyl Ether |



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IR Camera GF 304

List of detectable gases

- R404A
- R407C
- R410A
- R134A
- R417A
- R422A
- R125
- R245fa
- R507A
- R143A



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IR Camera GF 346

List of detectable gases

- Carbon Monoxide (CO)
- Nitrous Oxide (N₂O)
- Ketene
- Ethenone (C₂H₂O)
- Butyl Isocyanide
- Hexyl Isocyanide
- Cyanogen Bromide(CNBr)
- Acetonitrile (C₂H₃N)
- Acetyl Cyanide
- Chlorine Isocyanate (CCINO)
- Bromine Isocyanate (CBrNO)
- Methyl Thiocyanate (C₂H₃NS)
- Ethyl Thiocyanate
- Chlorodimethylsilane
- Dichloromethylsilane
- Silane
- Germane
- Arsine



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APPLICATIONS - LDAR

LDAR Overview

- **Fugitive emissions detection**
- **US EPA Method 21** (Portable vapour analyzer)
 - Flame Ionisation Detection / Photo Ionisation Detection
 - 100 000 ppm “methane equivalent” detection limit (FID)
 - 2,000 ppm “isobutylene equivalent” detection Limit (PID)
 - Minimum 10 seconds per monitoring
 - Firmware for easy multiple recording
 - Exclusions : +2m/out of reach, dangerous to monitor, insulated



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APPLICATIONS - LDAR

Smart LDAR

- **Use of optical instrument for leak detection**
- **EPA Alternative way of practice (IR Camera)⁽¹⁾**
- **50% of total hydrocarbon emissions come from fugitive emissions⁽²⁾**
- **90% of fugitive emissions comes from 0.13% of the equipment⁽³⁾**



(1) U.S. Environmental Protection Agency, Alternative Work Practice to Detect Leaks from Equipment, Federal Register Vol. 73, No 246, Dec 2008

(2) Robinson et al. Refinery Evaluation of Optical Imaging to Locate Fugitive Emissions, Journal of AWMA, July 2007.

(3) API analysis of refinery screening data. Pub 310, Nov 1997

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APPLICATIONS - LDAR

Smart LDAR – Advantages

- Rapid scan of a large number of equipment
- Allows:
+2m/inaccessible/dangerous to monitor/ insulated
- No maximum screening value
- Visual impact (identification of exact source)



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APPLICATIONS - LDAR

Smart LDAR – Limitations

- Field condition dependant
- Operator dependant
- Compound dependant
- No quantification
- Not as sensitive as FID/PID (500/1,000 ppmv???)
- Large memory requirements for record keeping



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APPLICATIONS - LDAR

Smart LDAR – Field Work Experience: Refinery

Complete refinery done using both methods (more than 100 000 equipment components)

- XX times faster with IR
- %% of the leaks found by the portable analyzer were visualized with the camera (the bigger leakers)
- Several significant leaks found with IR not found with traditional methods (out of reach, unexpected places)
- Overall economy (XX times less expensive)

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APPLICATIONS - LDAR

Smart LDAR – Field Work Experience: VC Plant

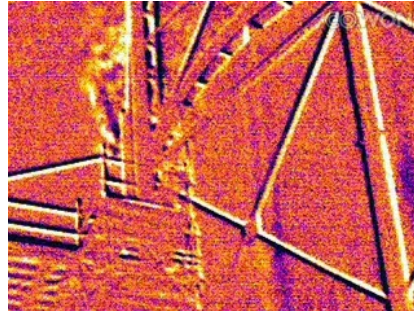
Leak detection performance tests on Vinyl Chloride, alongside a portable analyzer

- Very sensitive (leaks found with IR measured at 200 ppmv with analyzer)
- Emissions found from unexpected sources (holes in tanks, electrical wires guides,...)

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APPLICATIONS - LDAR

VCM Leak from a welded joint



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APPLICATIONS - LDAR

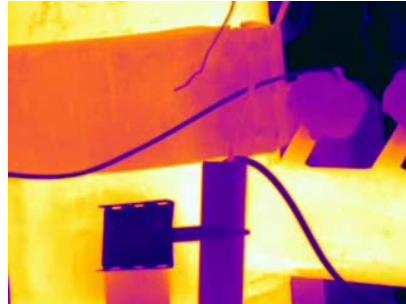
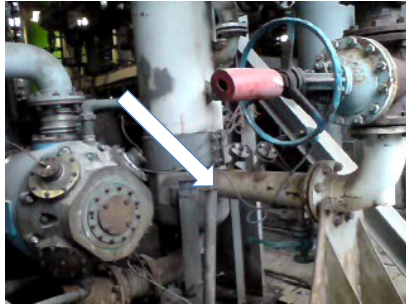
- Detected at 15-20 meters
- Leaky welded joint
- Inaccessible for conventional leak detection method
- Not covered by conventional campaign of inspection



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APPLICATIONS - LDAR

Guide for electric wires near compressor



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APPLICATIONS – TANKS

Inspection of tank roofs, vents and equipments

Tanks are the more significant contributors of VOC emissions on a petroleum facility (refinery, petrochemical plants)



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APPLICATIONS – TANKS

Advantages

- Safety
- Accessibility
- Time

Limitations

- Field condition /Operator dependant
- Compound dependant
- No quantification
- Large memory requirements for record keeping



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APPLICATIONS – TANKS

Tanks– Field Work Experience

- Leaks on welding threads (fixed roofs)
- Leaks on level gages and sampling hatches
- Vacuum breakers (floating roofs)
- Unexpected sources
 - Cracks in concrete near the tank: Tank leaking from floor
 - Emissions from foam lines: damaged rupture disc

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APPLICATIONS – TANKS

Tanks– Field Work Experience

- Levels in tanks (liquid and sludge)
- Floating roof location
- Can be done at great distance
- Good results

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APPLICATIONS – PROCESS VENTS

- Vapor recovery units efficiency
- Degassing to atmosphere from loading activities
- Venting activities

Field Work Experience

- Yield very good results
- Can be done at great distance



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APPLICATIONS – SF₆

SF₆ Detection on high voltage equipment

- One of the easiest gas to detect



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