TELEDYNE FLIR

THERMAL IMAGING TO VISUALISE FUGITIVE EMISSIONS

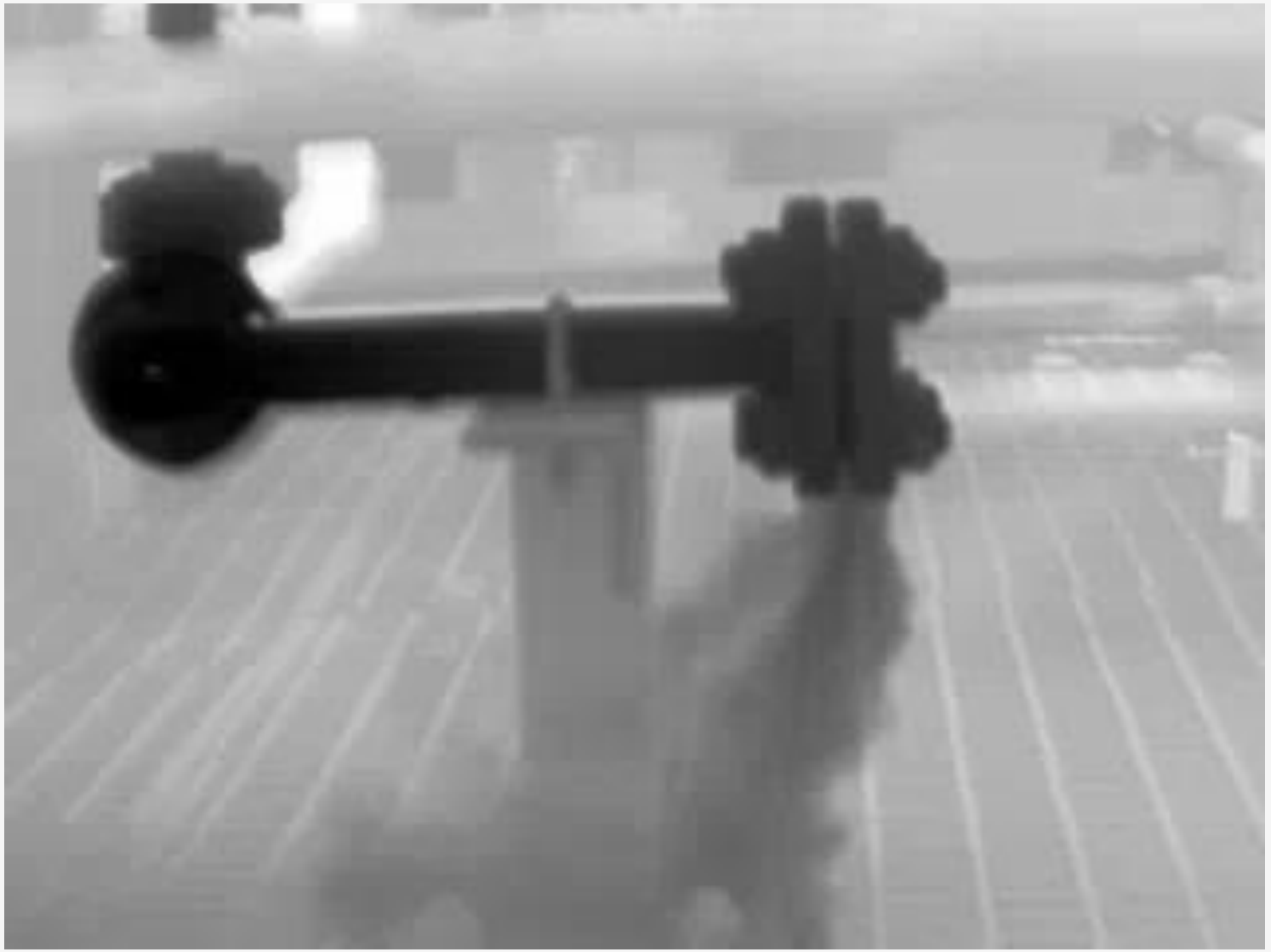
OPTICAL GAS IMAGING

WORLD BIOGAS EXPO JUNE 15 2022

AGENDA

- What is Optical Gas Imaging (OGI)
- How does it work?
- Biogas Examples
- Evolution of OGI
- Training

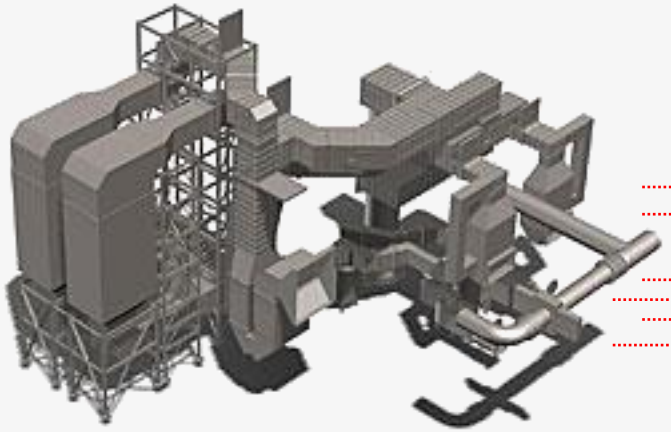
WHAT IS OPTICAL GAS IMAGING?



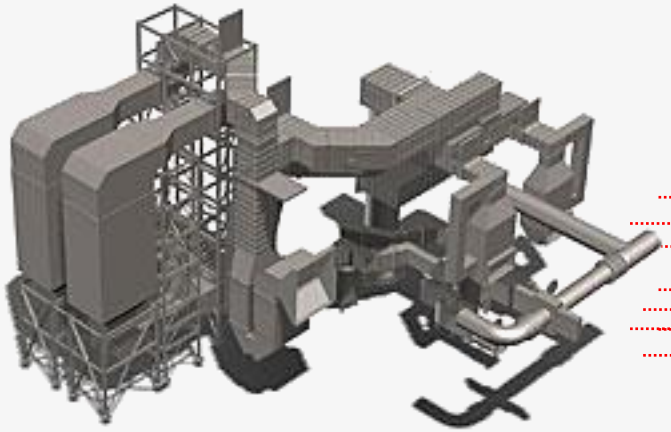
ROI – THE $1M FIND

- How does Optical Gas Imaging Work?

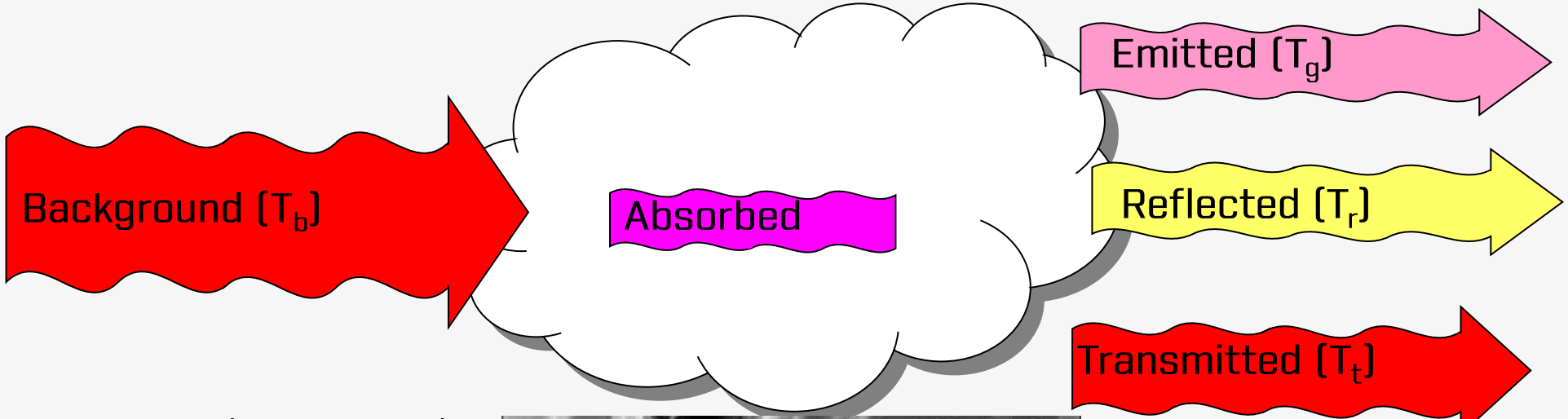
HOW DOES OPTICAL GAS IMAGING WORK?



HOW DOES OPTICAL GAS IMAGING WORK?



HOW DOES IT ‘SEE’?

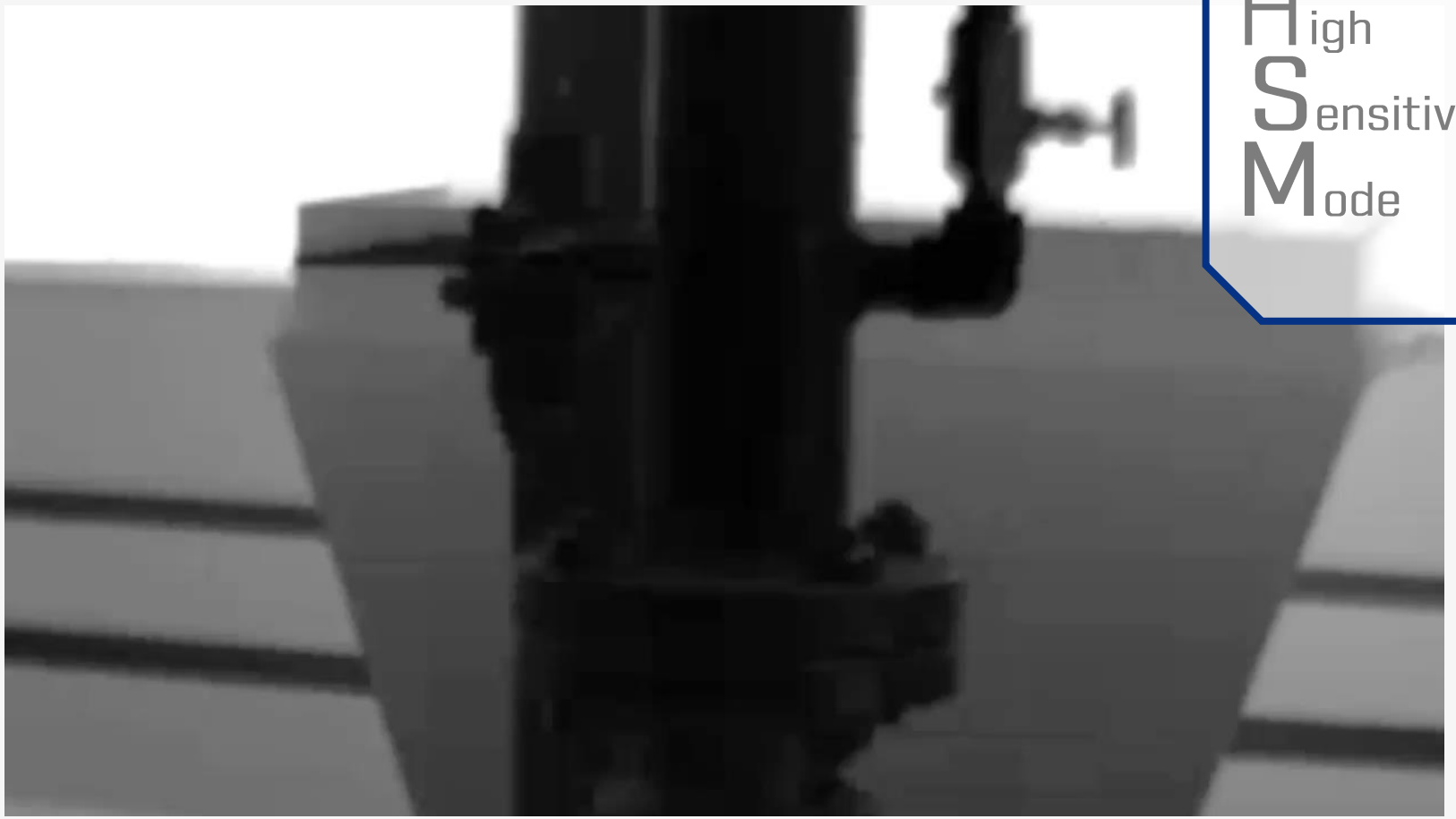


Ground, truck and person are the background

Gas “Cloud”

GAS MOVEMENT

- Greatly enhances gas visibility
- Real Time ‘Frame Subtraction’ technique
- Able to see leaks from a safer distance
- Proprietary to Teledyne FLIR GF Series



High Sensitivity Mode

WHAT CAN INFLUENCE OGI?

- Gas Concentration Path Length
- Gas Flow Rate
- Gas Response Factor
- Ambient Temperature
- Gas/Background Delta Temperature
- Wind Speed
- Distance

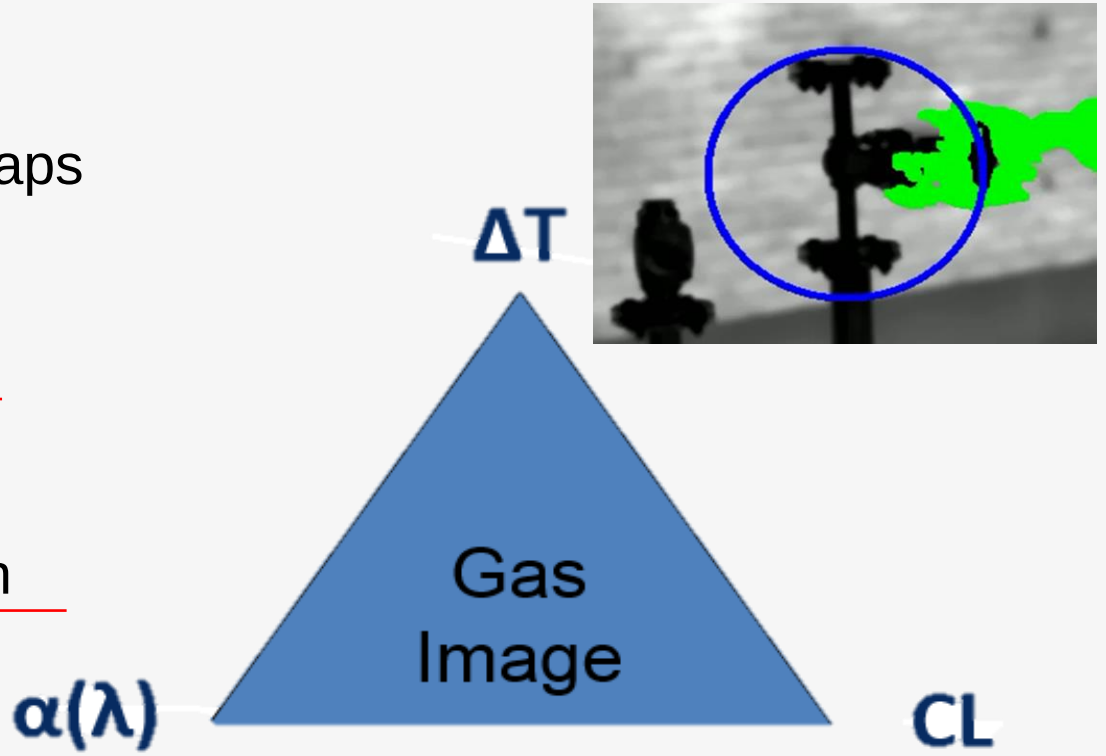
THE OGI TRIANGLE

You need three things to image a gas with an infrared camera:

1) α(λ): The gas has IR absorption peak that overlaps with the spectral window of the OGI camera

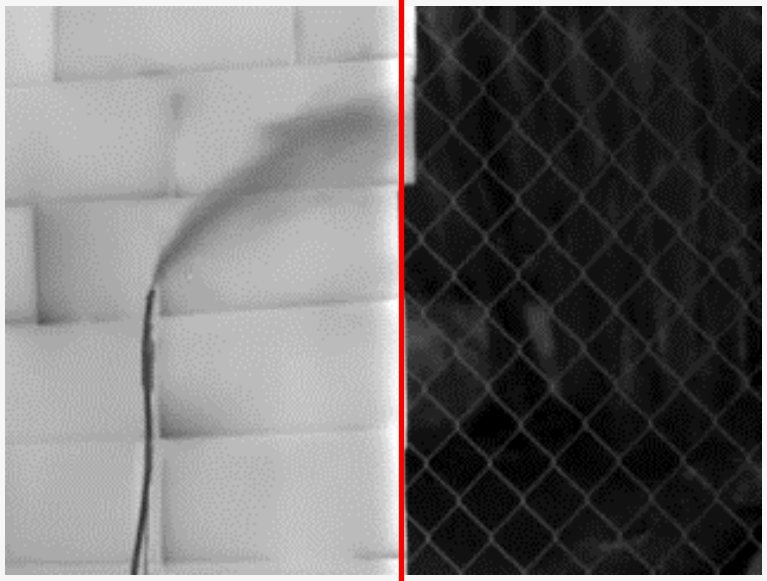
2) ΔT: There is sufficient temperature differential between the gas plume and the background

3) CL: There is sufficient concentration path-length



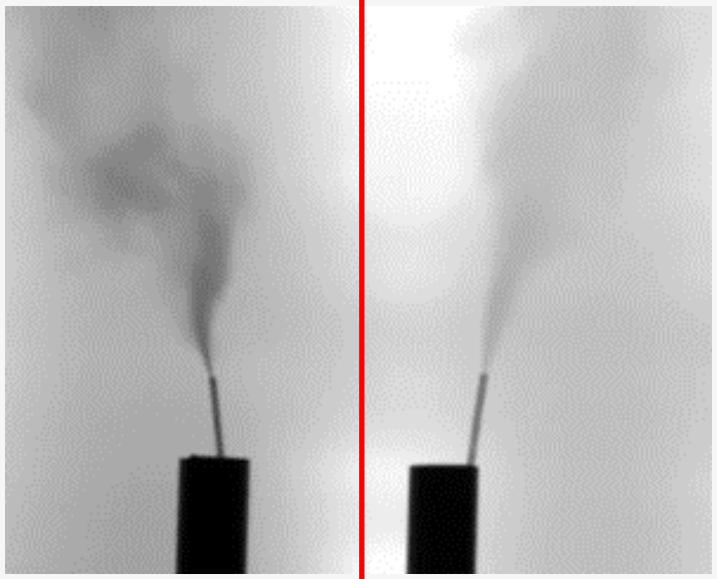
OGI FACTORS

Good ΔT | Poor ΔT



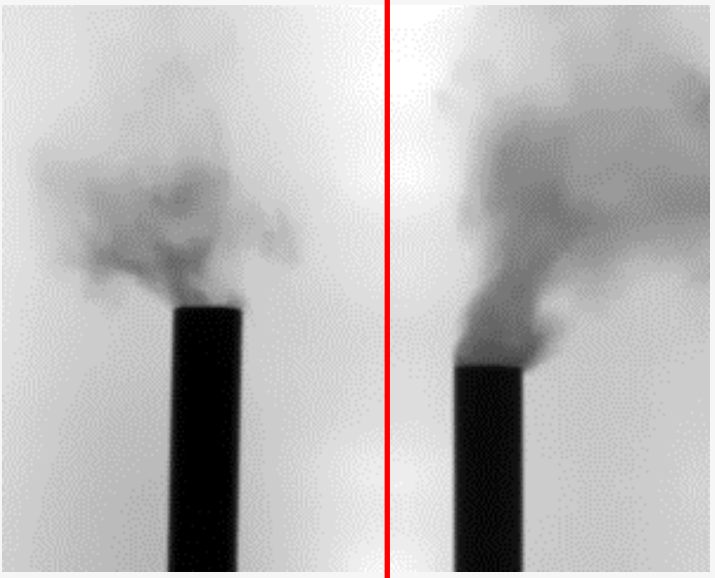
ΔT between gas and background

Propane (RF = 1.00) | Methane (RF = 0.297)



RF between different compounds

Propane (2 l/min) | Methane (16 l/min)



Concentration path-length

(this is what we want to measure)

WHAT IS THE SMALLEST LEAK I CAN SEE OVER A GIVEN DISTANCE?

- Testing was performed by the National Physical Laboratory (NPL), which confirmed the FLIR GFx320, GF320, GF300, and G300a optical gas imaging cameras are capable of imaging a gas that is half methane/half propane at a Concentration of 10,000 ppm at a flow rate of ≤60g/hr from a quarter inch diameter orifice.
- With the potential to detect gases leaking at just 0.4 g/hr, the GFx320 is verified to meet sensitivity standards defined in the US EPA's 0000a methane rule.

In Conclusion: Two FLIR GF320 optical gas imaging cameras (with the f=23mm and f=38mm lenses) were independently tested and have been demonstrated to be able to detect emissions according to the conditions set out in EPA's *NSPS 40 CFR part 60, subpart 0000a sensitivity standard for optical gas imaging equipment*. The tests showed that operators were able to detect the emission at ranges of 65.6 ft (at gas/background temperature differences greater than 13.5 °F and wind speeds up to 10 mph).

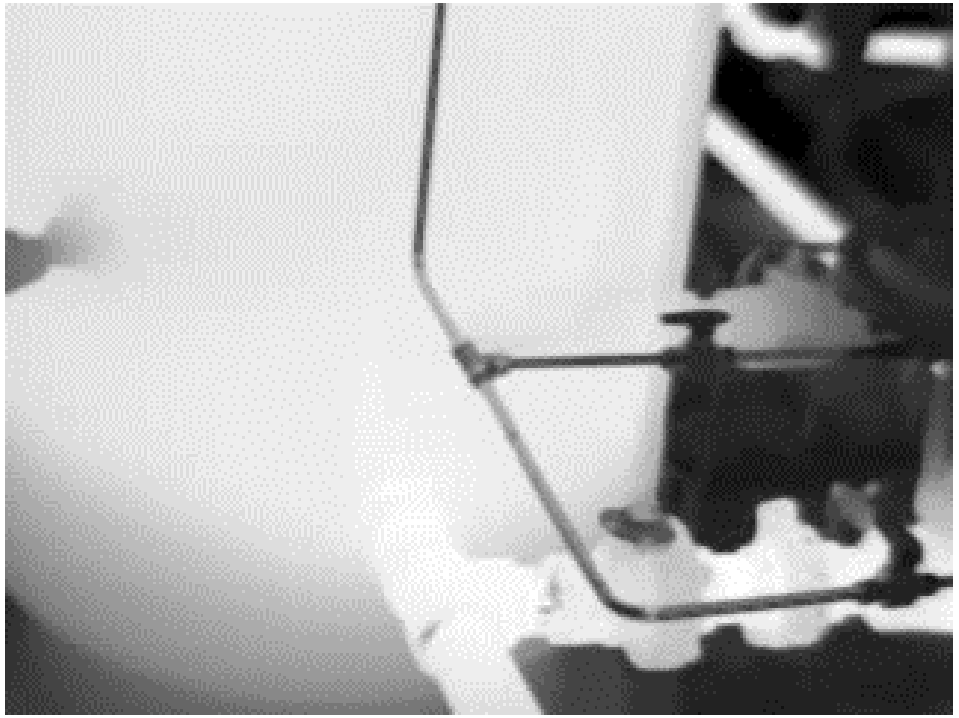
**Note: In these conditions 65.6 ft was the longest range at which the cameras were tested. However, some initial testing at 98.4 ft was done for lower temperature differences ($\Delta T < 4.5$ °F, low wind), which confirmed that gas detection at distances greater than 65.6 ft was possible.*

Uncooled vs Cooled OGI Comparison

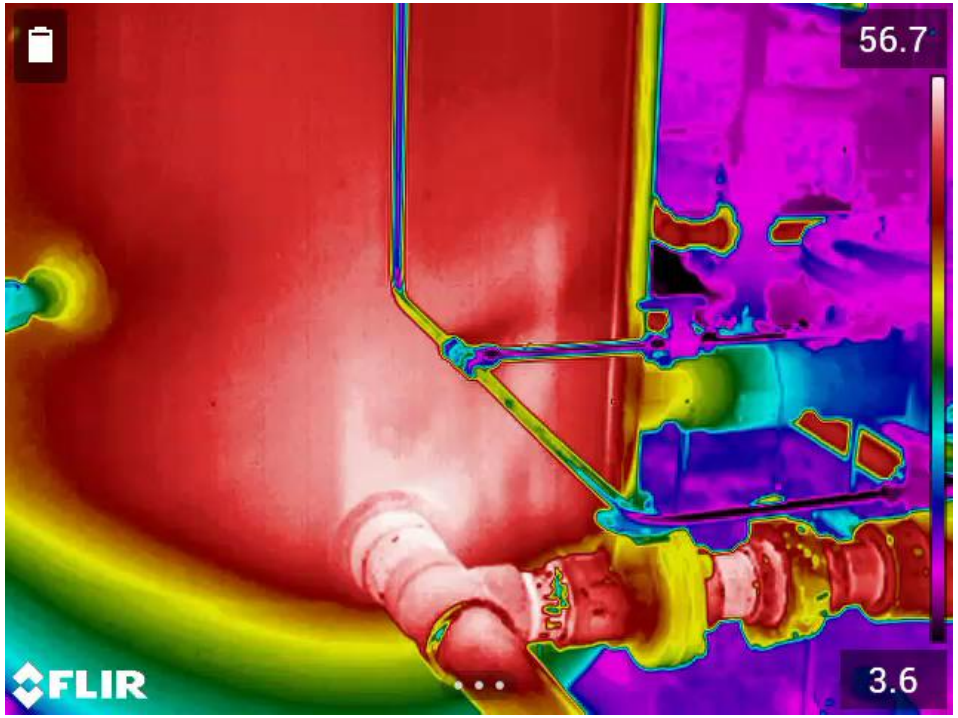
GF77 EXAMPLES (COMPARED TO GF3XX)

Fitting Leak in Natural Gas Industry

GFX320



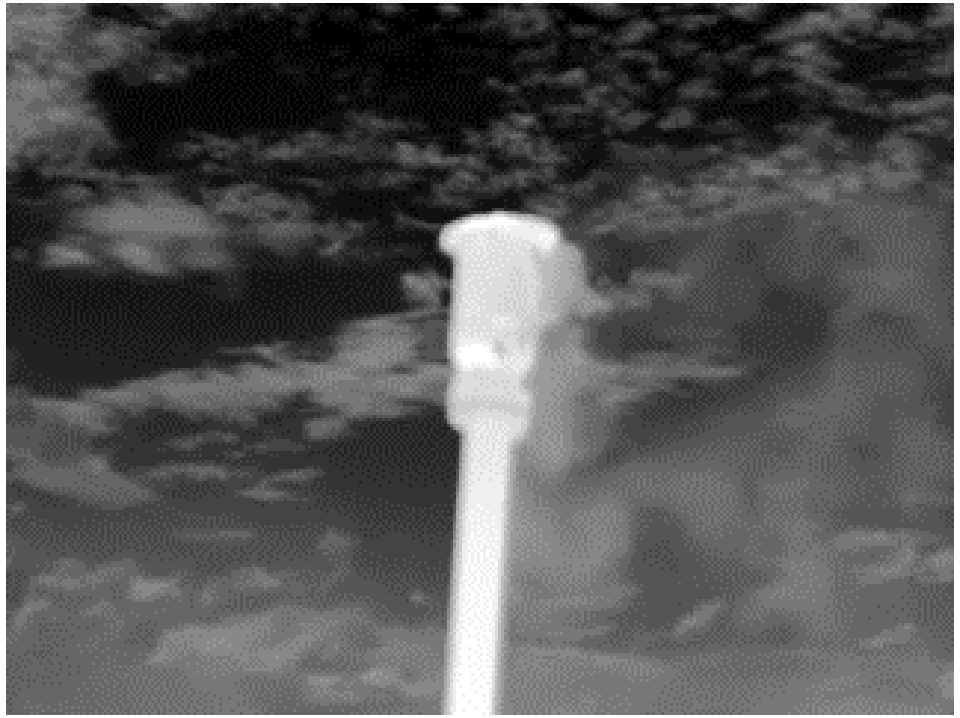
GF77



GF77 EXAMPLES (COMPARED TO GF3XX)

Enardo Valve (~350 liters/minute)

GFX320

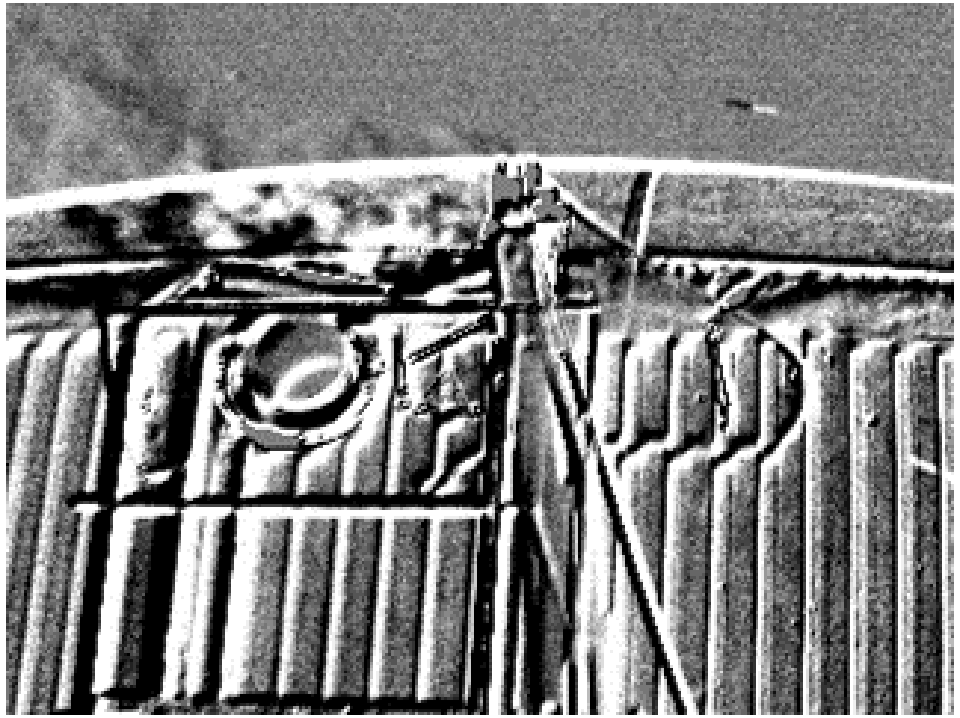


GF77

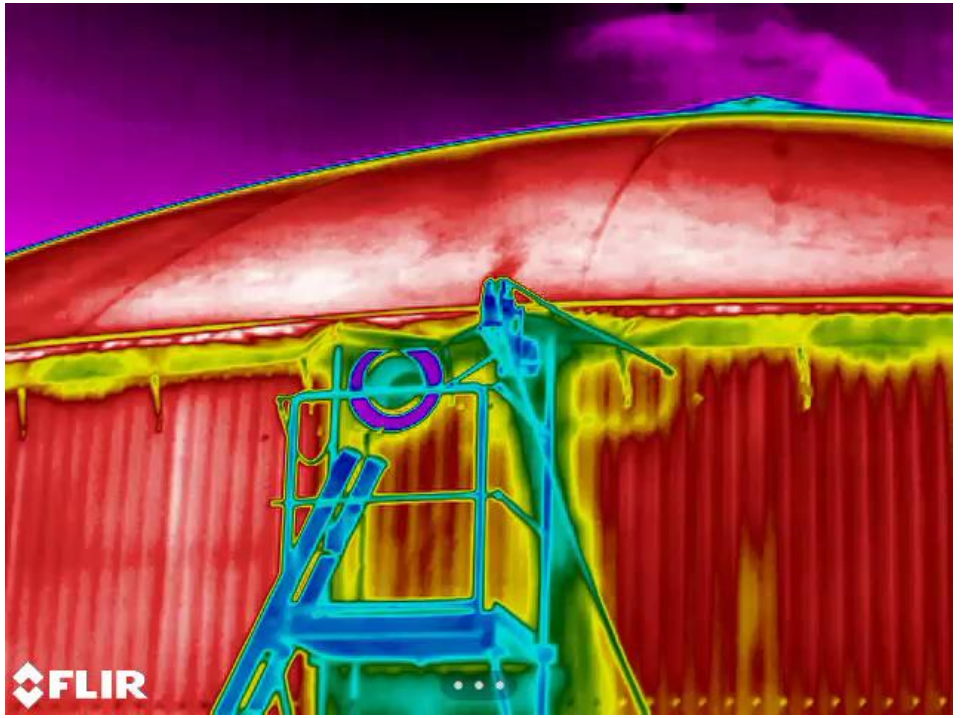
GF77 EXAMPLES (COMPARED TO GF3XX)

Leak on Digester (~33 liters/minute)

GFX320 IN HSM



GF77-25 IN NORMAL



PERFORMANCE – A CLEAR DIFFERENTIATION

Camera	Cooled (320 x 240)	Cooled (640 x 480)	Uncooled
Hazardous Classification	ATEX Zone 2, Hazloc Class 1 Div 2	None	None
NETD (thermal sensitivity)	<15 mK	<20 mK	<100 mK
NECL (gas sensitivity)	10 ppm x m	25 ppm x m	100 ppm x m
MLLR (Methane)	0.6 g/h	0.6 g/h	2.7 g/h
Visualized gases	Over 400 gases	Over 400 gases	CH_4, N_2O, SO_2
Quantification mode	Yes	Yes	No
Camera Cost	£95,773	£85,773	£24,995

visualized gases and hazardous locations classification.

WHAT GASES ARE YOU LOOKING FOR?

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NOTE: This data is for reference only and should be confirmed by in-field testing or other means

NOTE: Cameras gas detection sensitivity levels vary dependent on camera model

Can the FLIR GF Camera Model Visualize the Listed Gas and the theoretical sensitivity level (high/medium/low)?

Note: All uncooled GF Cameras have a maximum sensitivity of "medium"

YES

MAYBE (requires field testing)

NO (or Assumed No)

			Cooled Cameras					Uncooled Cameras	
Gas	**Chemical Name**	**Chemical Formula**	**GF320/GFx320**	**GF343**	**GF346**	**GF304**	**GF306**	**GF77-LR**	**GF77-HR**
Ammonia	Ammonia	NH_3					high		medium
Butane	Butane	C_4H_{10}	high						
Carbon Dioxide	Carbon Dioxide	CO_2		high					
Carbon Monoxide	Carbon Monoxide	CO			high				
Ethyl Alcohol	Ethanol	C_2H_6O	high			low		low	medium
Ethylene	Ethylene	C_2H_4	medium				high		medium
Hydrocarbons	Multiple	C_xH_x	high			low			
Methane	Methane	CH_4	high					medium	
Propane	Propane	C_3H_8	high						
R22	Chlorodifluoromethane	$CHClF_2$	medium					low	
R134A	1,1,1,2-Tetrafluoroethane	$C_2H_2F_4$				high	medium	high	low
R410A	R-32 / 125 (50% / 50%)	50% CH_2F_2 • 50% C_2HF_5				high		high	low
Sulfur Dioxide	Sulfur Dioxide	SO_2						high	
Sulfur Hexafluoride	Sulfur Hexafluoride	SF_6					high		medium

- Evolution of OGI Technology

QUANTITATIVE OPTICAL GAS IMAGING (QOGI)

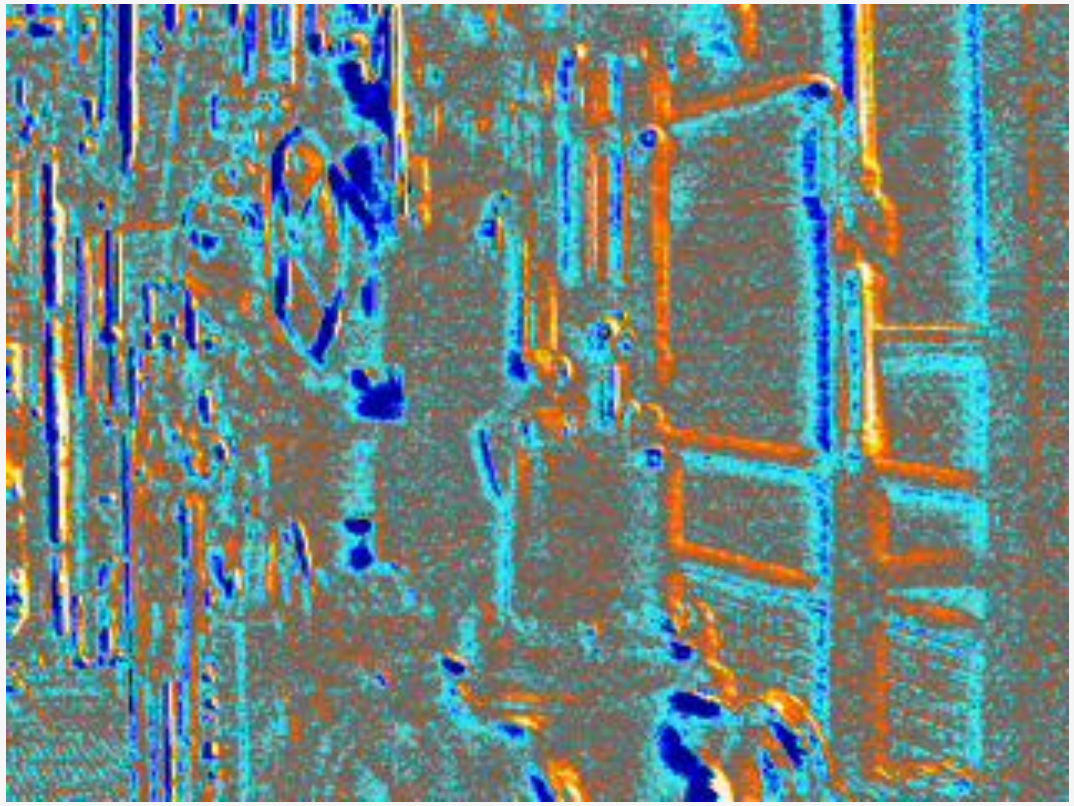
- By using QL320 in conjunction with a FLIR GF cooled camera, users can measure mass leak rates (lb./h or g/h) or volumetric leak rates (cc/min or L/min) for most hydrocarbons. The QL320 can be used at a variety of distances, so operators can monitor hard to reach areas and storage tanks as well as survey massive leaks from a safe location.

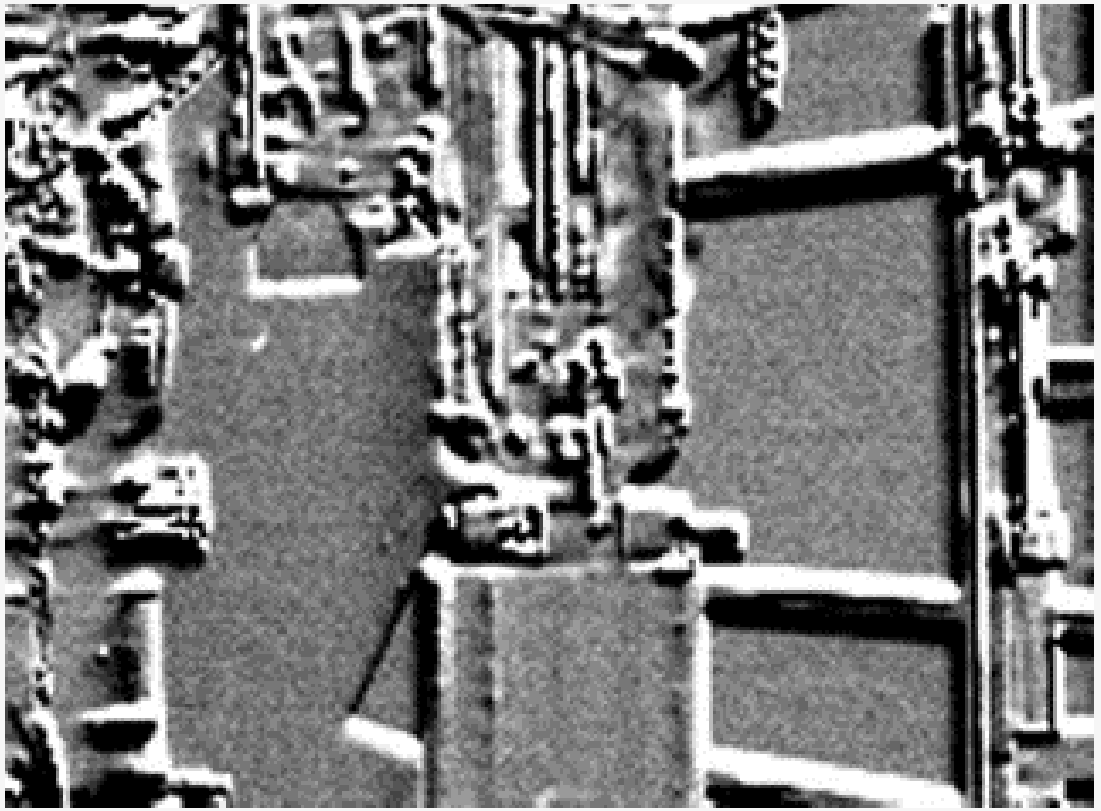
SUCCESSFUL DEPLOYMENT OF OGI

- OGI Camera Operation/support
  - Training (including offshore)
  - Consultancy
  - Application Support

- .....all offered locally through dedicated partners.

UNTRAINED V'S TRAINED





REFERENCE MATERIAL

- Application Stories
- Technical Working notes
- Videos

www.teledyneflir.com/ogi

Thank you!

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