WELL INTEGRITY ANALYSIS USING INFRARED IMAGING

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OUTLINE

- Introduction
- Infrared imaging
- New regulations
- Field applications
- Conclusions

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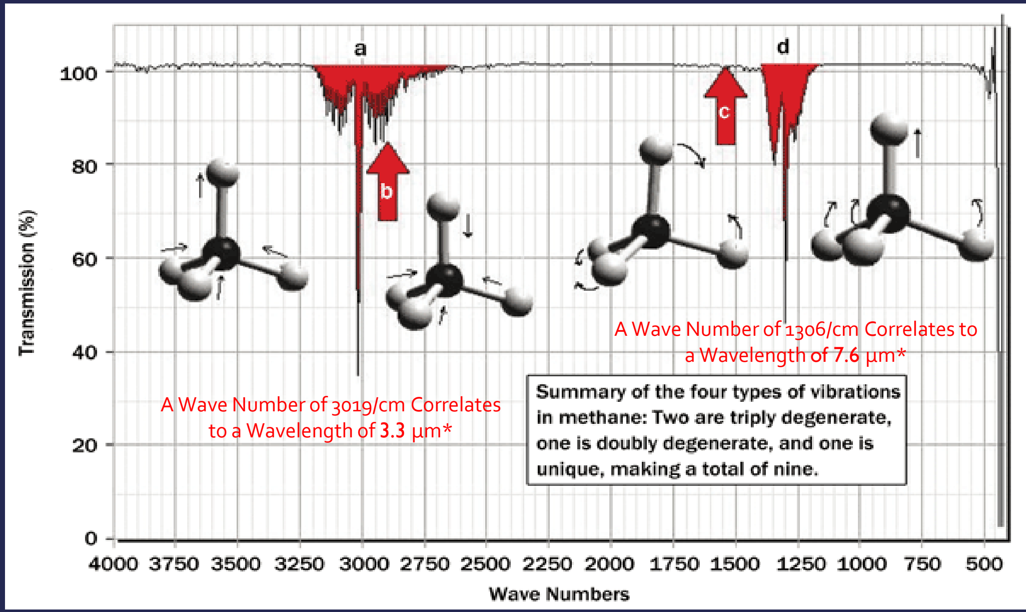
INTRODUCTION

- Most well integrity test methods have been around for decades
- Infrared (IR) camera oil & gas use is relatively recent
- Use of IR camera has been expanding
- Accepted by regulators and industry for use to assess integrity of surface equipment
- IR camera is a reliable qualitative screening tool to identify fugitive hydrocarbon emissions at the surface
- Applications for IR camera use are emerging

Aliso Canyon Gas Leak
Source: EDF

METHANE IMAGING IN INFRARED

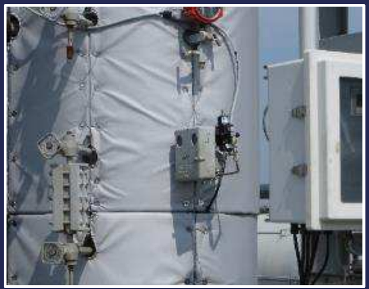
- Clouds or smoke appear in IR camera images where absorption differences in specific IR wavelengths are detected. These IR wavelengths correspond to the absorption wavelengths of chemicals present in the atmosphere. IR cameras do not distinguish which chemicals are present or allow quantitation of the chemicals in the images.
- The absorption of infrared light by methane is stronger at 3.3 µm, making this frequency the most useful for the detection of methane



Source: Raf Vandersmissen

OIL & GAS USES OF INFRARED

- Air permit compliance monitoring for fugitive emissions
- Leak detection



NEW REGULATIONS

- June 3, 2016 - US EPA published changes to New Source Performance Standards (40 CFR 60 Subpart OOOOa), effective August 2, 2016 (81 FR 35824)
  - New requirements for operators of new or modified oil & gas well sites to monitor and repair fugitive emission components with an optical gas imaging camera initially and then twice/year
    - Method 21 "sniffer" is an alternative method under the rule

ESTIMATED LEAK RATES

- Ohio RBDMS data for 2015 indicates inspectors responded to wellhead leaks at 908 wells, 6.4% of Ohio's wells
- Well fugitives rank #6 in projected oil & gas industry methane emissions for 2018 (see table)

Source	2018 Emissions (Bcf)	Percent of Total
Reciprocating Compressor Fugitives	53.8	13%
High Bleed Pneumatic Devices	28.7	7%
LDC Meters and Regulators	28.7	7%
Centrifugal Compressors (wet seals)	24.0	6%
Gas Engine Exhaust	22.2	5%
Well Fugitives	**20.8**	**5%**
Reciprocating Compressor Rod Packing	17.6	4%
Liquids Unloading - Wells w/ Plunger Lifts	13.2	3%
Intermittent Bleed Pneumatic Devices	13.0	3%
Kimray Pumps	11.5	3%
Oil Tanks	11.5	3%
Flares	9.0	2%
Stranded Gas Venting from Oil Wells	8.4	2%
Intermittent Bleed Pneumatic Devices - Dump Valves	7.7	2%
Oil Well Completions - with Fracturing	6.9	2%
Pipeline Leaks (All)	6.7	2%
Pipeline Venting (Transmission)	6.6	2%
Centrifugal Compressors	6.4	2%
Mains – Plastic	6.3	2%
Mains - Cast Iron	6.3	2%
Transmission Station Venting	6.2	2%
Chemical Injection Pumps	5.9	1%
Residential	5.6	1%
Gathering and Boosting Stations	5.6	1%
Miscellaneous (assorted 105 sources)		

Source: ICF 2014

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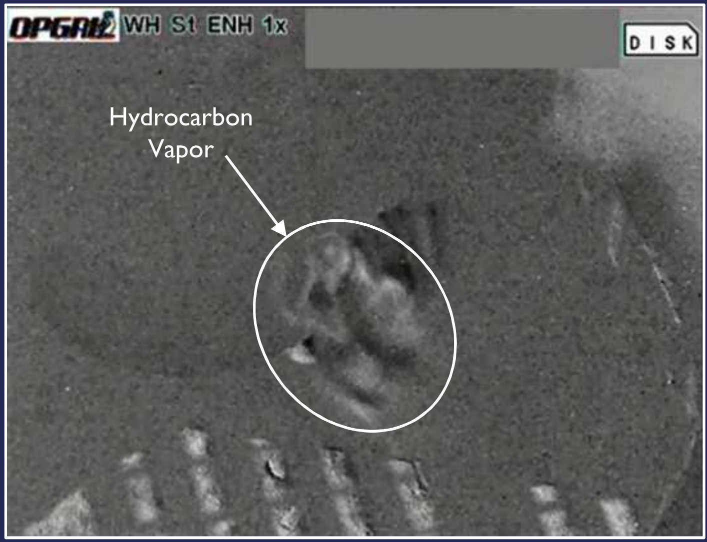
INFRARED SCREENING BENEFITS

- Surface well mechanical integrity testing
  - Enhanced ability to identify leaks at the wellhead
  - Guide to rapid repair/maintenance
- Potential subsurface integrity problems
  - May identify gas migration outside of wellbore
  - Informed decision-making for repair/remediation



EXAMPLE FIELD EXPERIENCE

- In a limited study of orphan wells, half of the orphan wells exhibited fugitive gas emissions, one-third of which exceeded the lower explosive limit (LEL)
- In a limited study of producing wells:
  - 20% were reported as having bubbling cellars:
  - 64% of these bubbling cellars were eliminated through equipment servicing, including:
    - Tightening nuts on flanges
    - Tightening threaded connections
    - Greasing valve stems
    - Closing valves
- IR Screening reduced time spent finding leaks but does not estimate venting flow rate

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WELL INTEGRITY EVALUATION

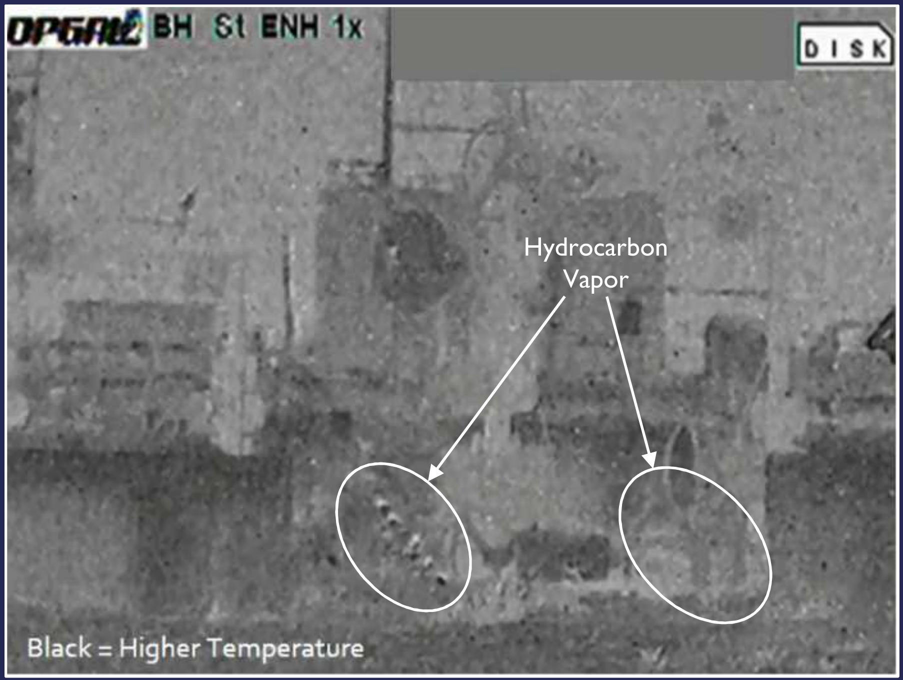
- Integrity issues observed at the surface
  - Ports lacking plugs
  - Lack of well caps
  - Corroded well casings
  - Valves left open
  - Leaking flanges
  - Leaking glands
  - Loose threaded fittings
  - Valves requiring grease
  - Uncontrolled instrument gas venting

APPLICATION TO WELL TYPES

- Production
- Historic production
- Orphan wells
- Plugged & abandoned
- Gas storage wells

PRODUCTION WELL EXAMPLE #1

- Wellhead inspected in visible light and in infrared
- Hydrocarbon vapors are visible in infrared



PRODUCTION WELL EXAMPLE #2

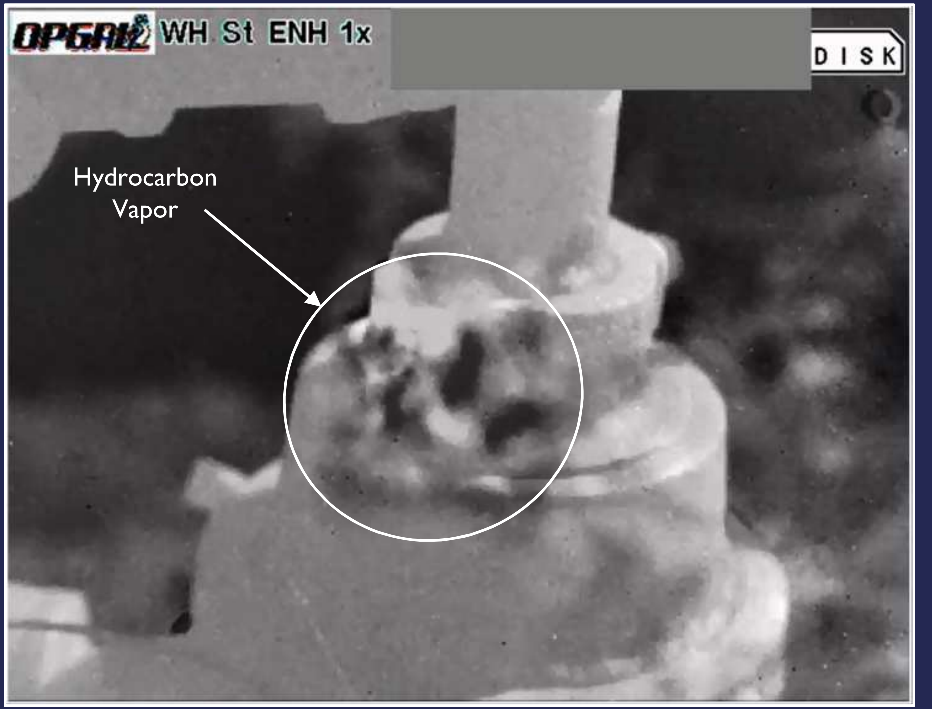
- Wellhead inspected in visible light and in infrared
- Hydrocarbon vapors are visible in infrared

GAS STORAGE WELL EXAMPLE

- Wellhead inspected in visible light and in infrared
- Hydrocarbon vapors are visible in infrared

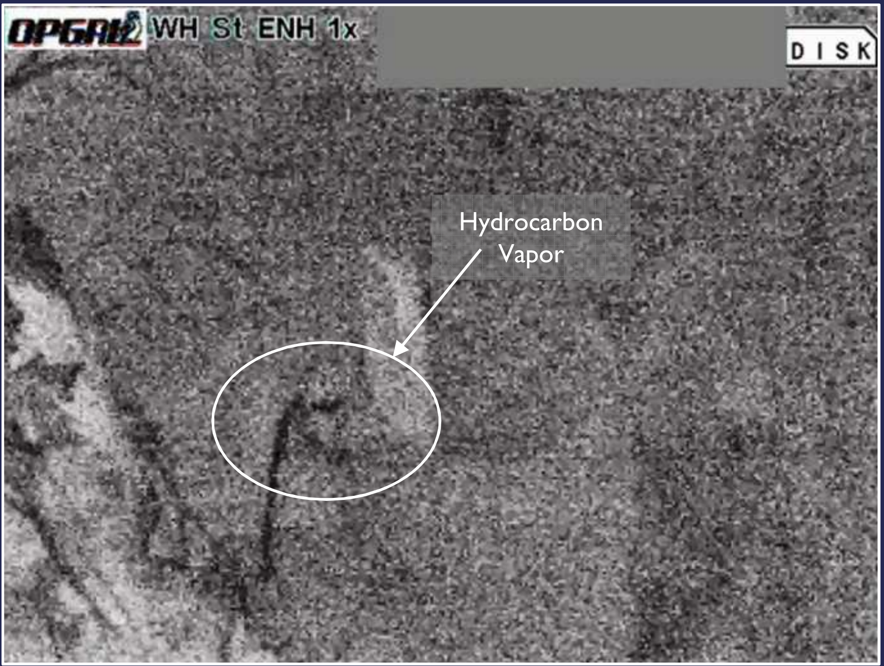
HISTORIC PRODUCTION WELL

- Wellhead (age undetermined) inspected in visible light and in infrared
- Hydrocarbon vapors exceed the LEL and are visible in infrared



ORPHAN WELL EXAMPLE #1

- Wellhead (age 112 yrs) inspected in visible light and in infrared
- Hydrocarbon vapors are visible in infrared



ORPHAN WELL EXAMPLE #2

- Wellhead (age uncertain) inspected in visible light and in infrared
- No hydrocarbon vapors are visible in infrared

ORPHAN WELL EXAMPLE #3

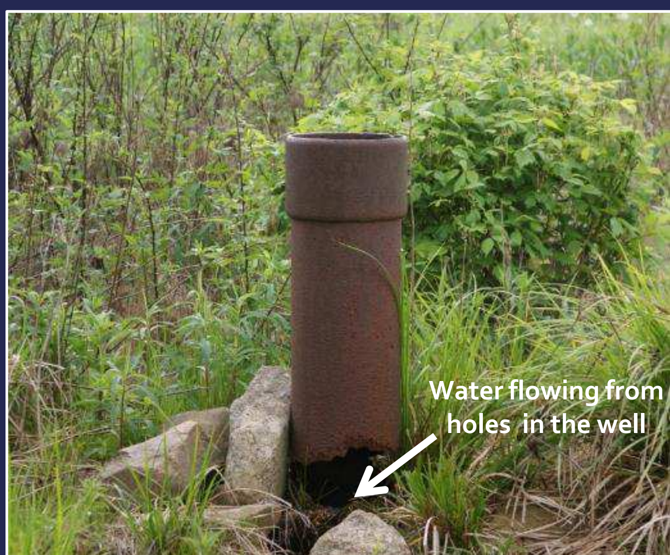
- Wellhead (age unknown) inspected in visible light and in infrared
- Hydrocarbon vapors are visible in infrared

PLUGGED & ABANDONED WELL

- Well inspected in visible light and in infrared. Well age is unknown
- No apparent hydrocarbon emissions were identified

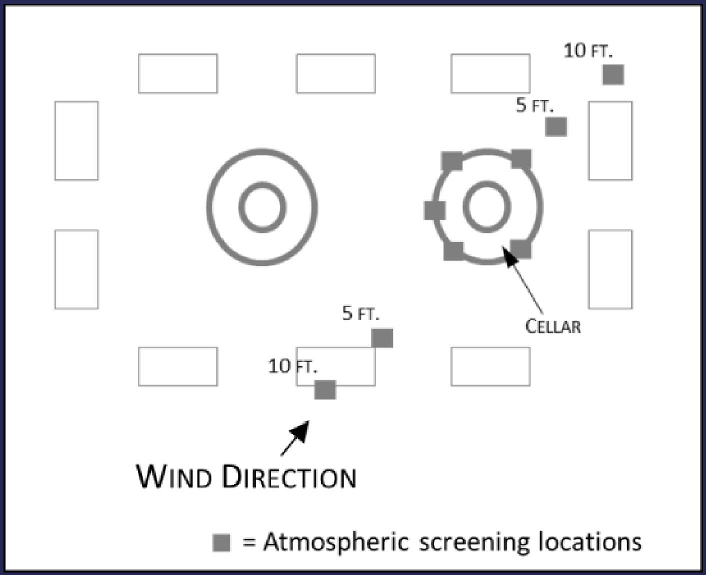
FIELD TECHNIQUES

- Wellhead Evaluation includes:
  - Screening for hazardous atmosphere (e.g., 4-Gas Meter)
    - characterize any emissions and entry safety
  - Evaluate well with IR camera
  - Document identified integrity issues
  - Communicate identified issues to operator



SCREENING FOR HAZARDS

- Wellhead area screened to establish entry safety, e.g., with a 4-Gas Meter:
  - Percent of the lower explosive limit (LEL)
  - Hydrogen sulfide
  - Carbon monoxide
  - Oxygen



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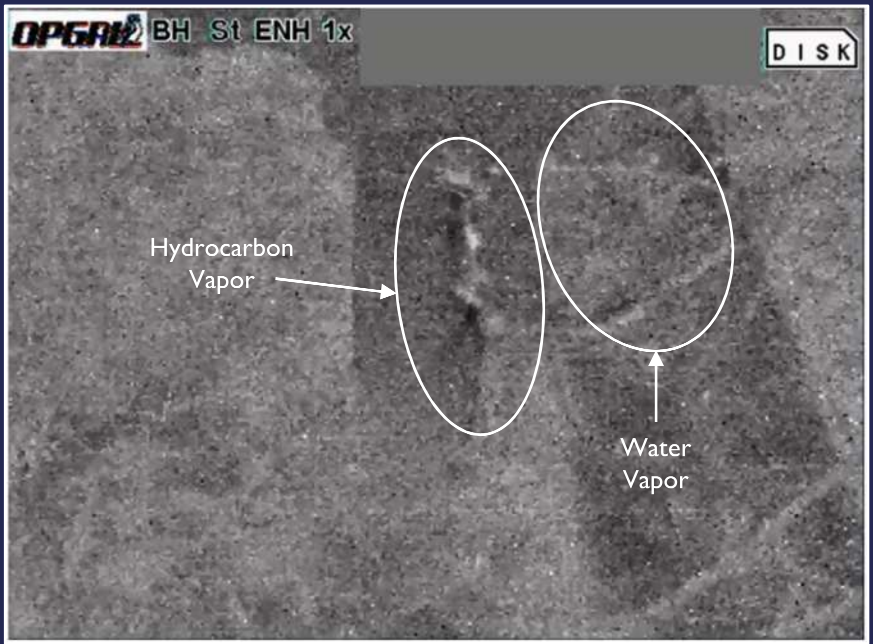
ADD SCALE TO ESTIMATE AREA

- Add scale to give context to emissions descriptions
  - Place scale at water surface (bubbles)
  - Half inch grate for IR work
- Can't quantify emissions with IR camera

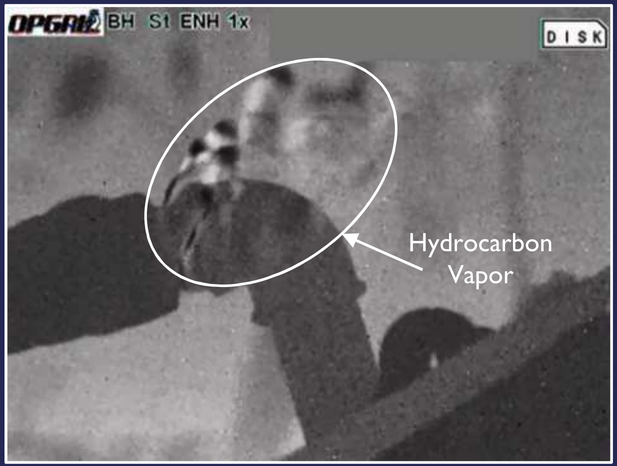
DIFFERENTIATING WATER VAPOR

- Water vapor tends to appear "2-dimensional," across a surface; whereas hydrocarbons tend to rise or fall from their sources



CONCLUSIONS

- IR camera use has seen widespread acceptance as a reliable screening tool
- US EPA is promoting IR camera use to identify fugitive emissions
- Applications for IR camera use are emerging
- Infrared imaging can speed remedial action and guide decision making
- Prompt action and informed decision making can reduce emissions and product losses



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CITATION INFORMATION:

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