

Application of Digital Thermal Imaging Cameras for Environmental Analysis

Mark Landress P.G.

Project Navigator, Ltd.

10497 Town & Country Way Suite 830

Houston, TX 77024

www.projectnavigator.com

TAEP - ECIC 2009



Project Basis

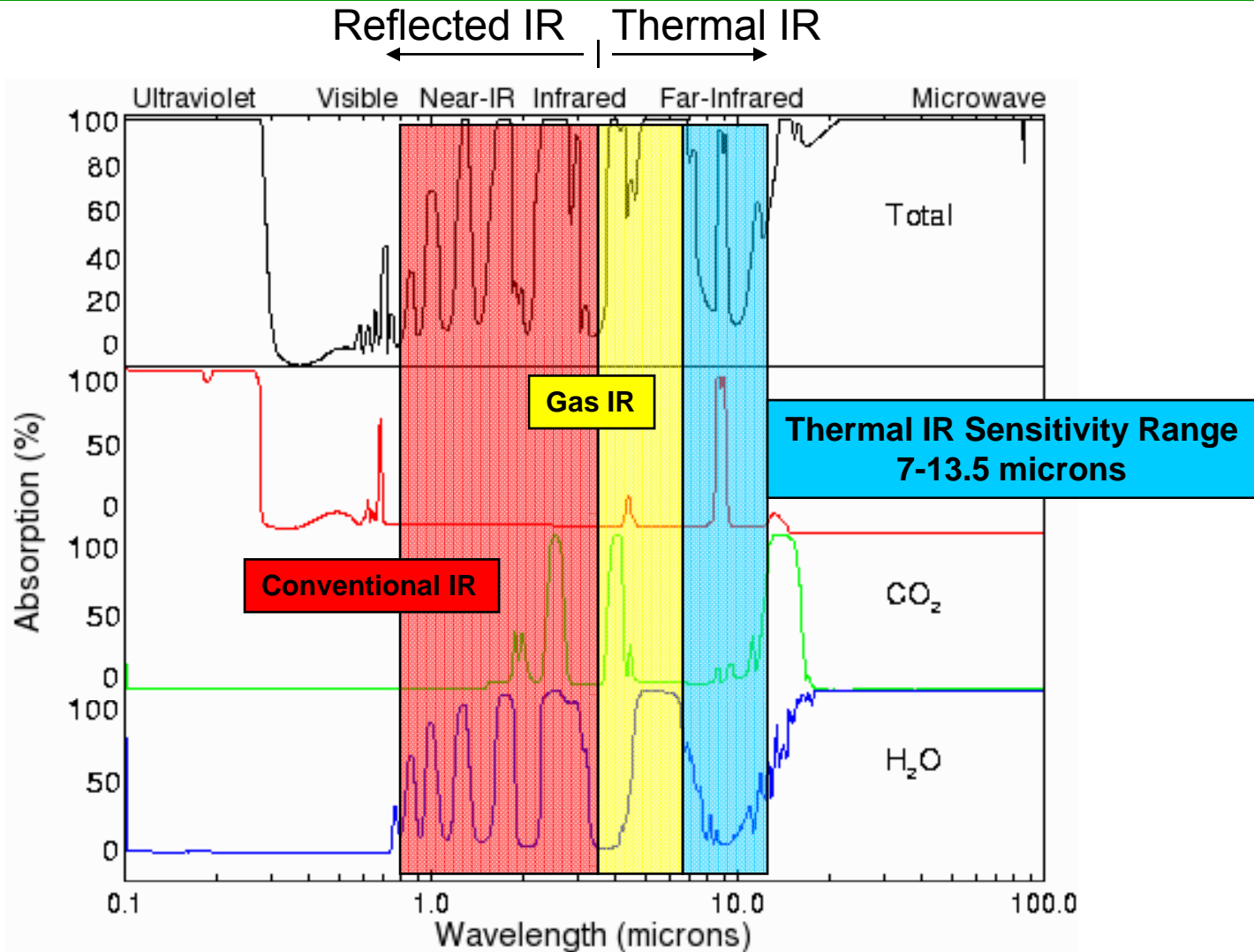
- Thermal imaging cameras were tested to assess their use for environmental measurements.
 - Measurement of product levels in above ground hazardous waste, petroleum and water storage tanks.
 - Temperature of piping and equipment at landfills and industrial facilities.
 - Surface temperature of soils in landfills associated with enhanced subsurface oxidation.
 - Measurement of product levels in drums, boxes and small containers.
 - Gas detection from gas recovery wells.

Thermal Imaging Equipment

- Fluke /TiR 50 Flexcam
- Range set from 0-350F
- Fluke Smartview 1.8 imaging software
- Data records to proprietary format file on compact flash card
- Thermal and plain light image overlay and registration possible
- overlay and image registration possible
- Practical battery life ~ 4 hours
- Image resolution is fair. Large display visible in direct sunlight
- Camera is high quality, sturdy, easy to operate under field conditions
- Daily rental ~\$500. Purchase price ~ \$8,000



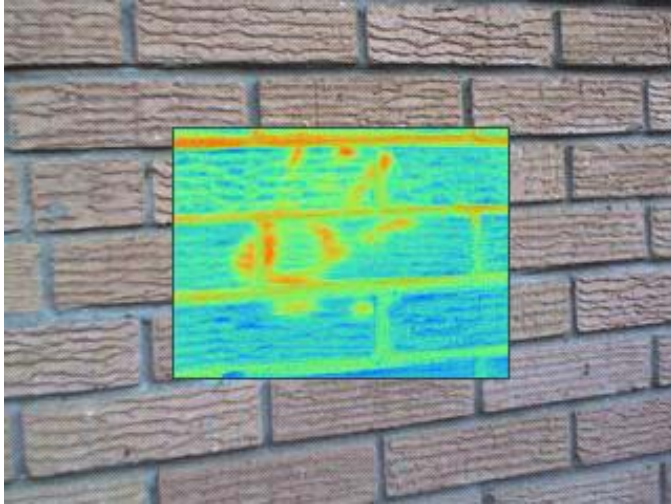
Infrared Camera Spectral Range



Thermal Image Analysis General

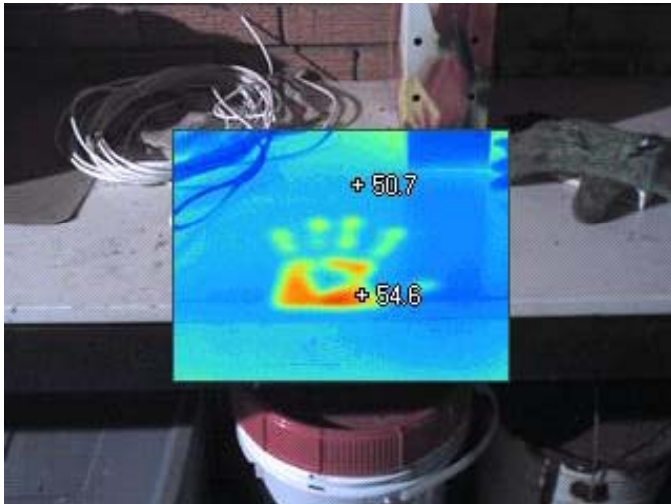
- Instruments sensitive - read to tenths of a degree.
- Readings influenced by color, texture, lighting and distance.
- Best when object is uniform in color, texture and thermal emissivity.
- Optimal conditions are early morning or evening when temperature contrasts between contents and shell is maximum.
- Objects should have at least 1 degree temperature differential.
- Imaging software has features to enhance images, pinpoint temperature, and alter the color palette.
- Benefits: Non-invasive, fast, permanent photographic record.

Camera Sensitivity



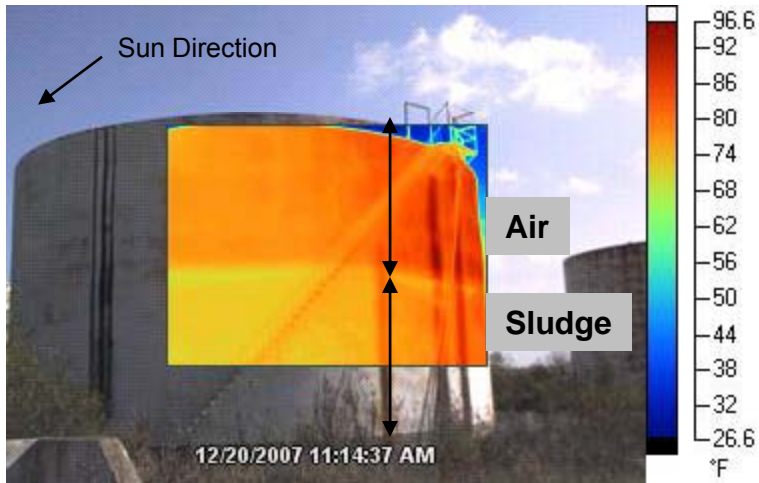
- With fraction of a degree sensitivity, a handprint serves to illustrate the sensitivity of the method.

- 20 second hand contact with structural brick. Latency time approximately 3 minutes.

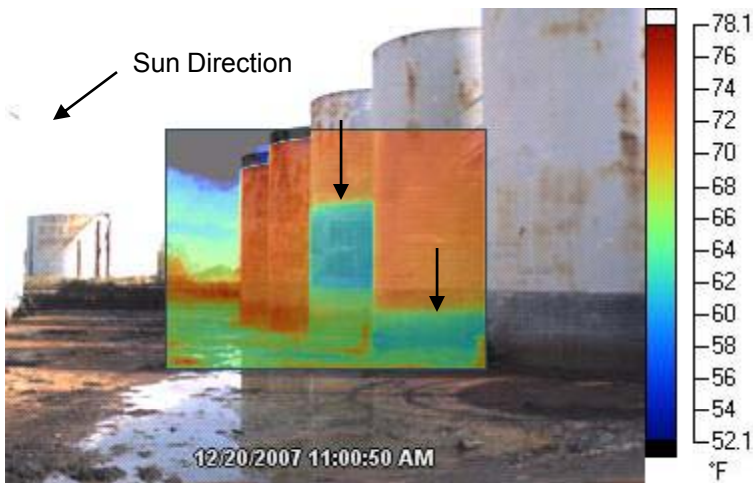


- 10 second hand contact with structural with artificial counter top material. Latency time approximately 5 minutes.

Tank Gauging Image Analysis

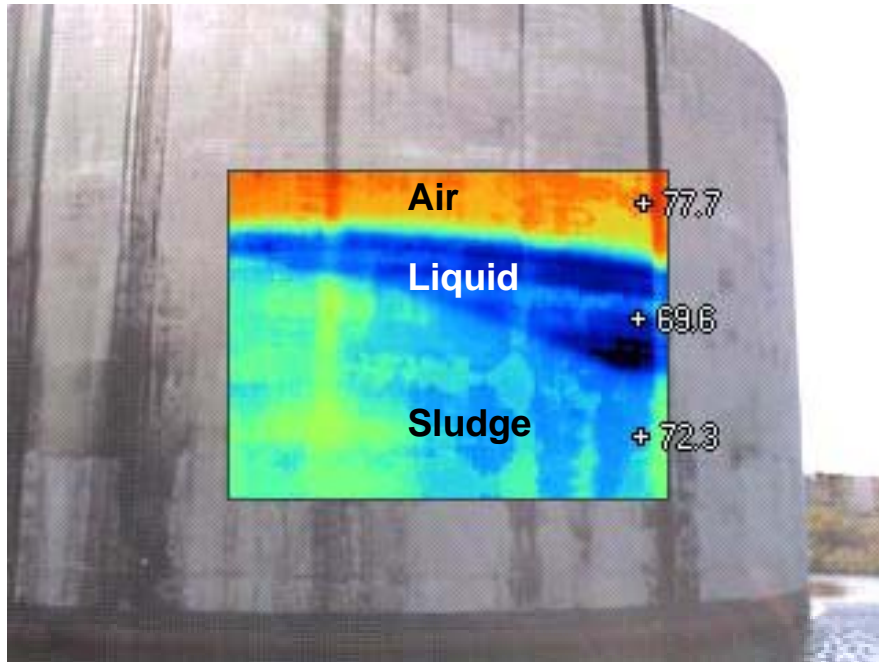


- Measurement for large AST
- Tank Volume: 40,000 bbl (75 x 50')
- Visible light with IR overlay
- Tank bottom contents clearly visible. Sludge cooler than tank shell. Default temperature span.



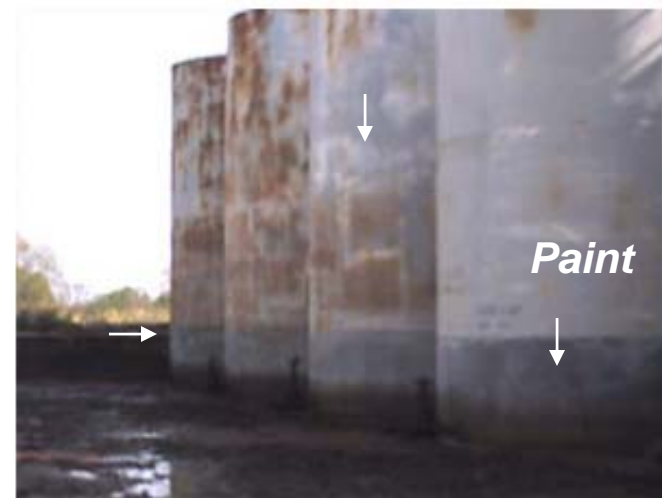
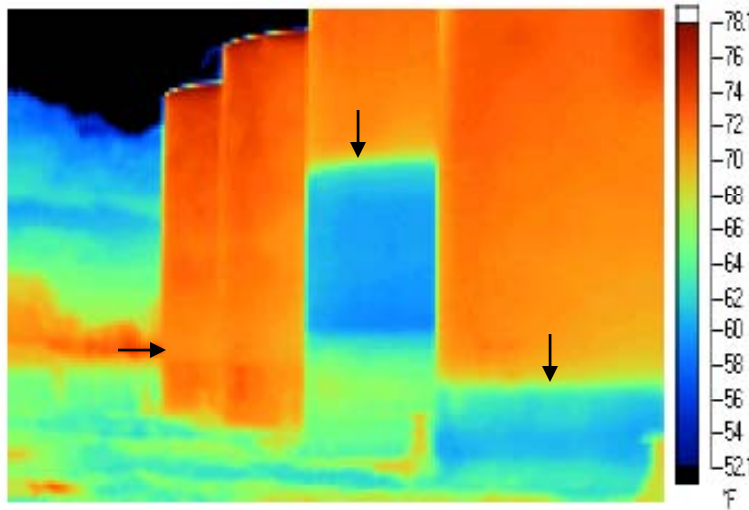
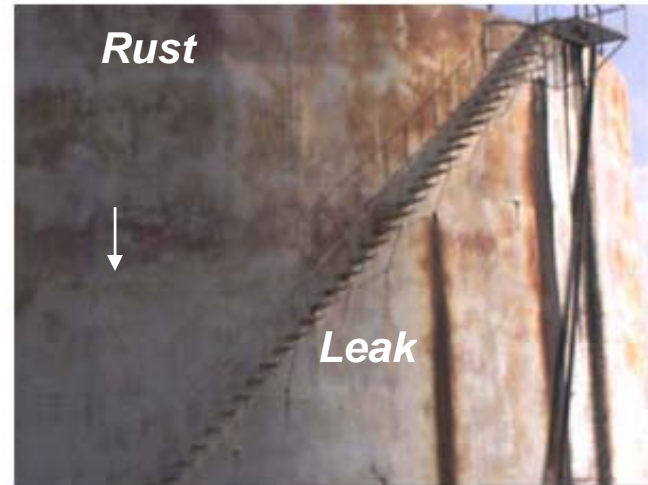
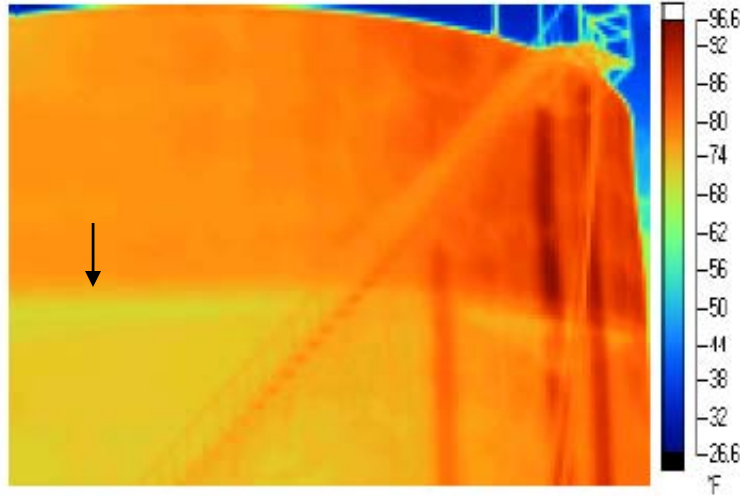
- Measurement for small AST
- Tank Volume: 400 bbl (12 x 20')
- Visible light with IR overlay.
- Tank bottom contents clearly visible. Cooler than tank shell. Temperature span reduced to enhance levels.

Tank Gauging Image Analysis – Heels



- Evaluation of tanks sludge heel.
- Irregular sludge heel not detected in conventional gauging because only a single access point was available.
- Mid-morning shot after direct sun.
- Tank: 40,000 bbl (75 x 50') painted steel.

Close-up Image Details



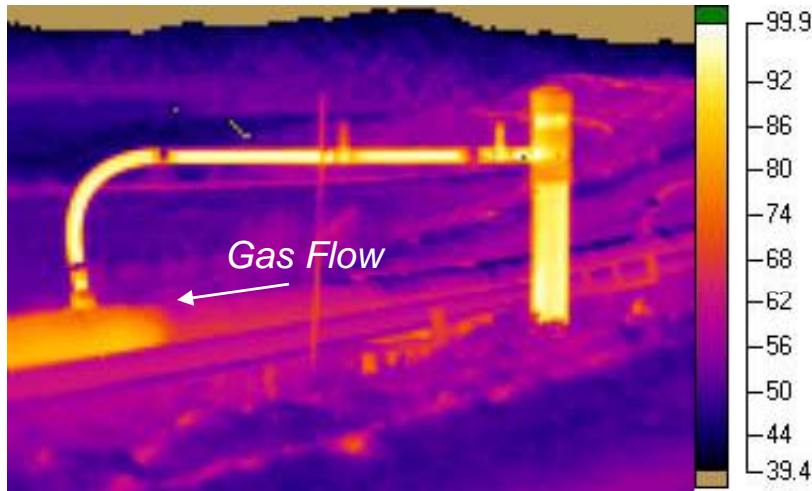
Wellhead Temperature Analysis Results

- An assessment was made for remote temperature monitoring for landfill gas extraction wells as a method to speed evaluation and identify defects.

Results

- Gas wells exhibiting elevated temperature are clearly visible in thermal images.
- Temperature contrast is usually sufficient so that different wellhead conditions, (material & paint) only marginally affect the images.
- Camera measured temperatures read lower than wellhead temperature due to air and emissivity effects.

Landfill Gas Wellhead Temperature Analysis



Thermal Image



Plain Light Image

- Landfill gas extraction well and header line.
- Thermal contrast clearly evident between wellhead and surrounding area.
- Gas flow revealed by temperature contrasts.
- Material – unpainted PVC

Landfill Gas Wellhead Temperature Analysis



Thermal Image



Plain Light Image

- Landfill gas extraction well and header line.
- Elevated temperature at well flange with high of 90.5 deg at flange.
- Material – painted PVC.

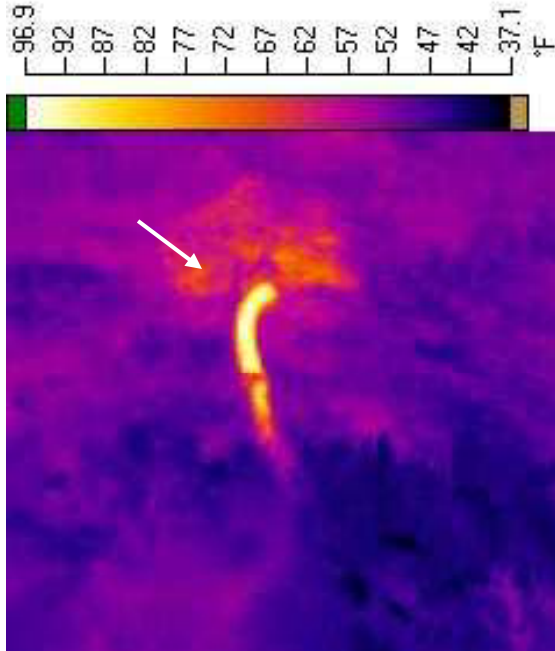
Detecting Subsurface Oxidation

- An analysis to determine if subsurface thermal anomalies associated with enhanced oxidation zones, (i.e. fires) could be detected with thermal cameras.

Results

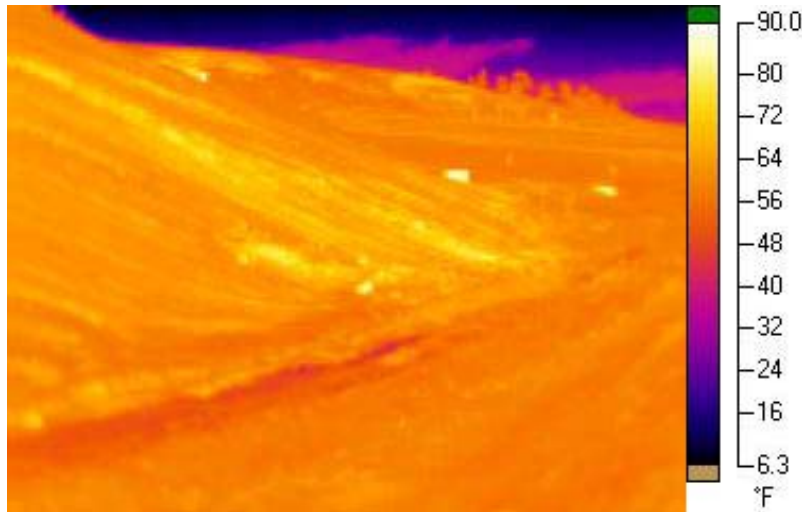
- Under a variety of conditions surface effects of subsurface enhanced oxidation zones could not be reliably detected under the measurement conditions at the time of imaging.
- Both day and evening images were collected with air temperature contrasts of +/- 50 degrees F being evaluated.
- Detection of EOZ under test conditions is not conclusive. Vegetation clearly masks thermal effects. Sun angle and solar heating effects mask thermal effects under the test conditions.

Detecting Subsurface Oxidation in Landfills



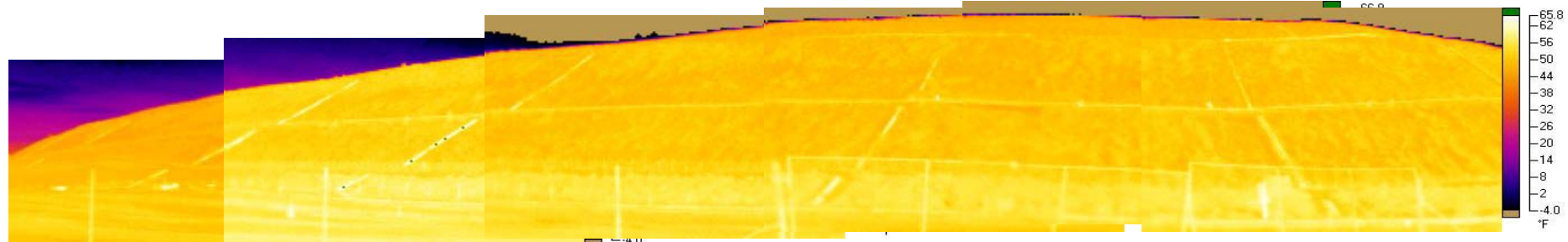
- Looking for hot-spot anomalies in landfill soils. Near-surface hot line evaluated to see if it was detectable under shallow soil.
- **Results:** The line could not be reliably detected under the soil under the conditions of the test image. Apparent elevated temperature on lighter colored soil is an artifact. (arrow)

Detecting Subsurface Oxidation in Landfills



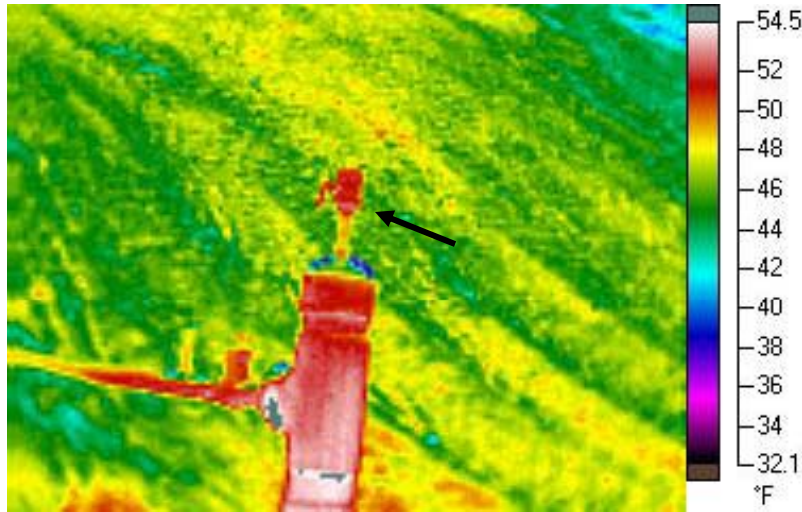
- Looking for thermal anomalies in landfill areas with known subsurface temperature anomalies.
- **Results:** Variation in soil moisture and effects from solar heating mask any obvious anomalies at the surface. Apparent temperature variations due to moisture and soil types.

Detecting Subsurface Oxidation in Landfills



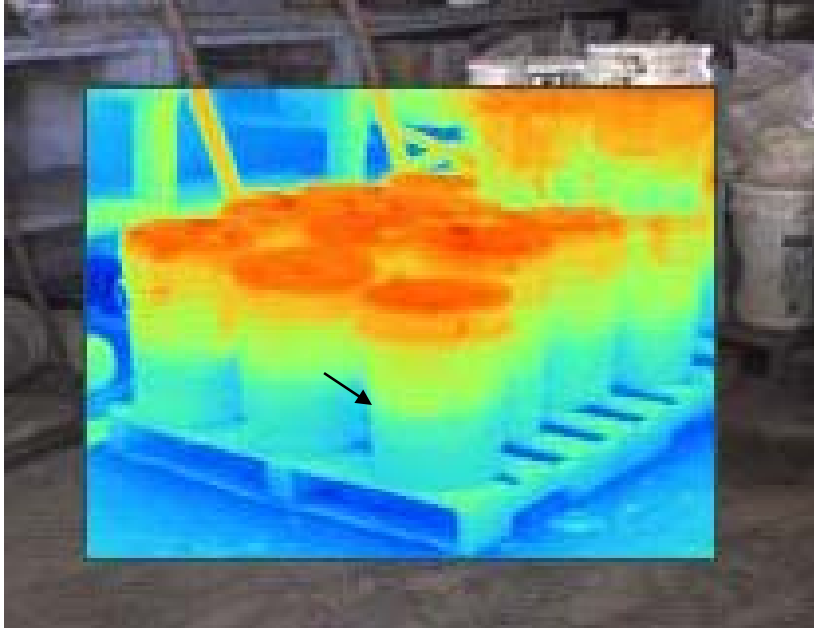
- Thermal and visible light image large landfill in California. Roads and drain lines with gas headers visible due to color and emissivity contrast. Area known for subsurface thermal anomalies which affect landfill stability.
- **Results:** Heavy vegetation on surface masks any obvious thermal effects from enhanced oxidation that might be present under the cap.

Detecting Landfill Gas Releases

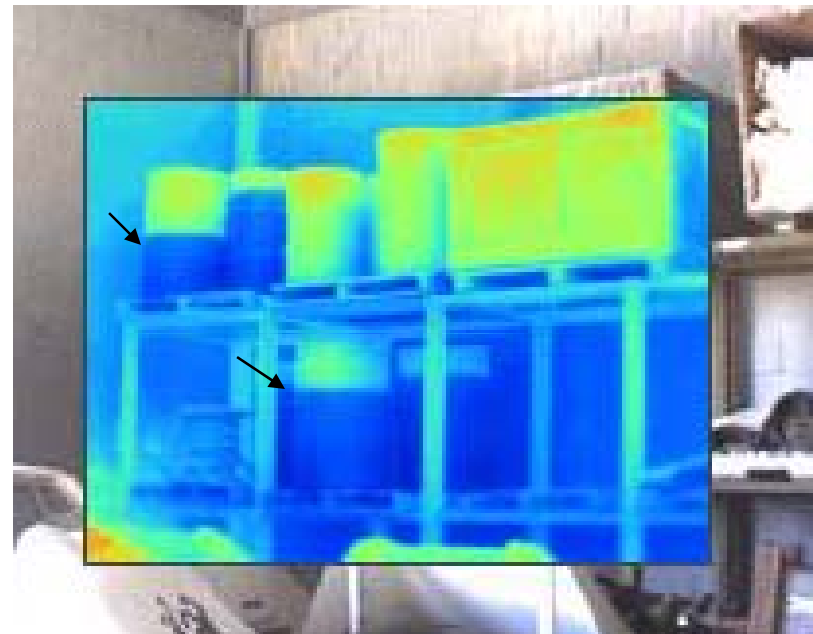


- Wellhead valve was opened slightly to release landfill gas (arrows). Image processed for maximum color variation by temperature.
- **Results:** Flow of landfill gas could not be detected from the wellhead since there not sufficient temperature contrast. Infrared absorption of gas by camera is not in the thermal spectral range.

Measuring Levels in Containers



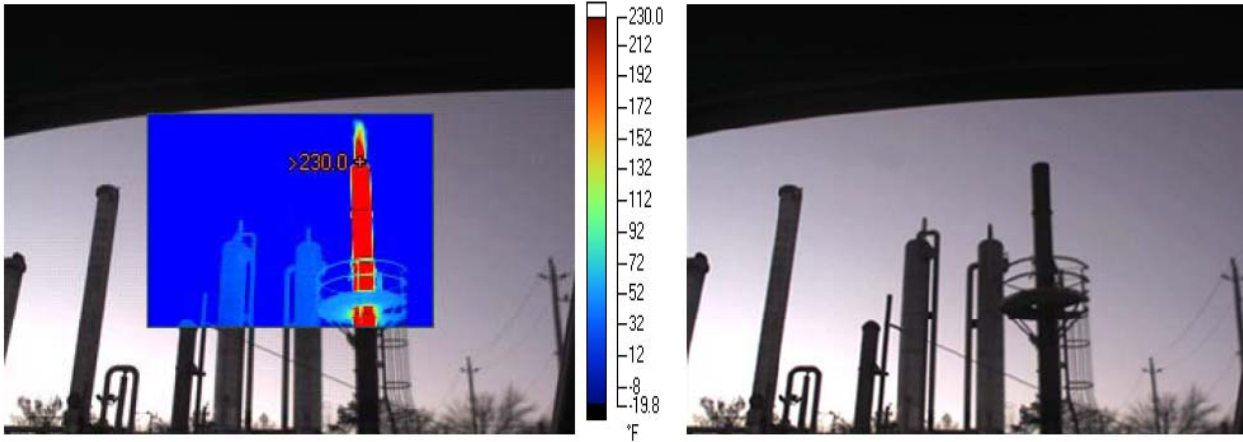
Product levels measured in plastic buckets.



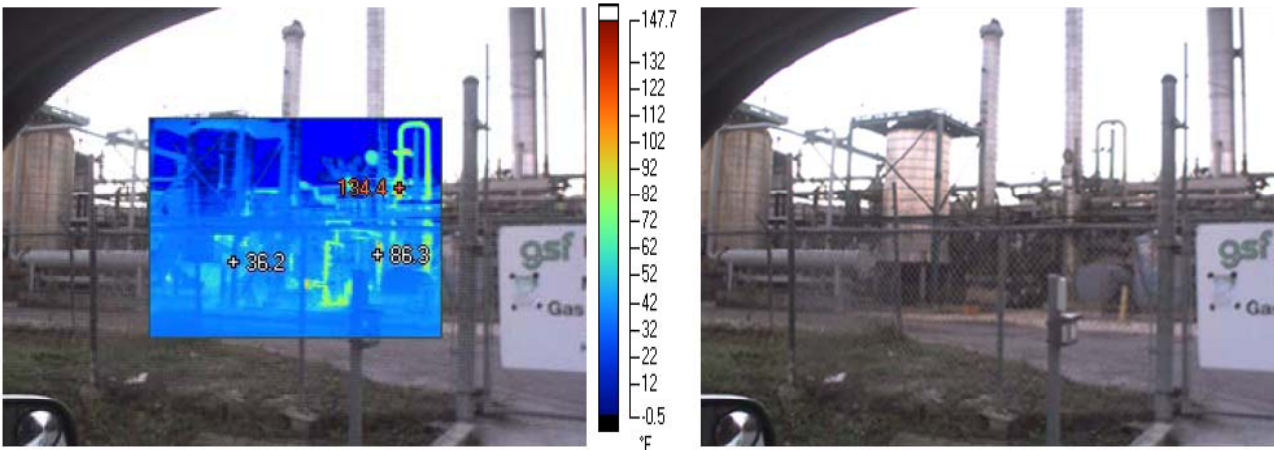
Product levels measured in drums.

- Thermal images of materials in drums and buckets.
- Depending on the material and conditions, liquids and solids can be distinguished.

Mechanical Applications

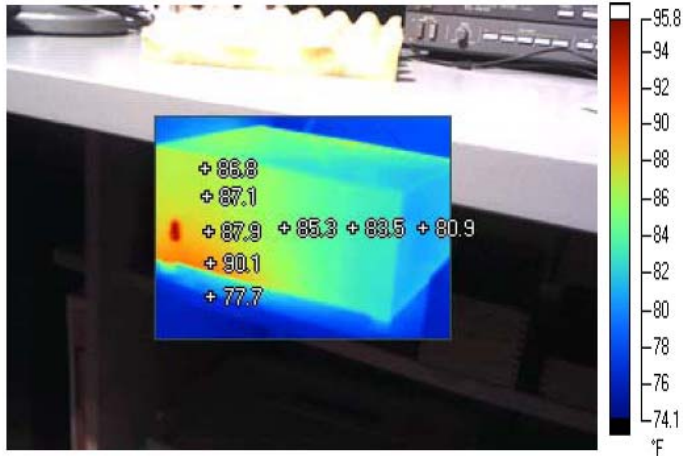


Flare Stack Monitoring

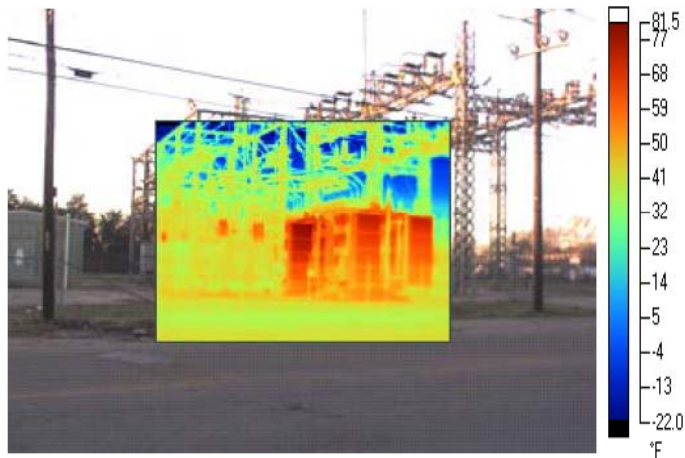


Plant Piping

Electrical Applications



Power Supplies



Transformers and Substations

Summary

- Thermal cameras are applicable to a variety of environmental measurements.
- Offers a quick method to assess liquids and solids in drums and tanks.
- Useful where thermal contrast is strong.
- Provides photographic record of conditions not possible from direct measurement.
- Relatively inexpensive compared with other tools for direct measurement.