Optimizing Fired Heaters Using Infrared Sensors from LAND

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Why Measure Reformer Tubes?

Knowing the true temperature of Reformer tubes in operation, is critical to good operational performance.

- If temperatures are **lower** than optimal, the operators will not get as higher yield as possible, therefore less profit.
- If temperatures are **higher** than optimal, tube life can be seriously reduced with an increased risk of costly and dangerous tube failures.
- Optimal = Maximum profit / Maximum tube life.
- The tubes are extremely high cost Nickel alloy types
- For the best performance they are operated at very high temperatures, however, operating the tubes just 20 C above the optimum temperature will shorten tube life by 50%. A typical rebuild of a reformer can easily exceed $10M US

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Syngas

Furnace Tubeskin Temperature Measurement

36° F can result in a dramatic change in tube life. [i]

Deg F	Deg C	Mean Tube Life
1580	860	10 Years
1616	880	5 Years
1652	900	2.5 Years
1697	925	11 Months
1742	950	4.5 months
1787	975	2 months
1832	1000	4 weeks
1922	1050	5.5 days
2012	1100	1 day

[ii]

How to Measure Reformer Tubes?

- The industry understands that tube skin temperatures have to be constantly and accurately measured to prevent early failures and extend lifespan. Tube skin temperatures also indicate other phenomena like coking which can severely reduce the efficiency of the reformer.
- There are many methods of measuring reformer tubes:
- Welded thermocouples
- Reference Tube

V/S

- Cyclops 390
- Borescope Cameras
- Gold Cup

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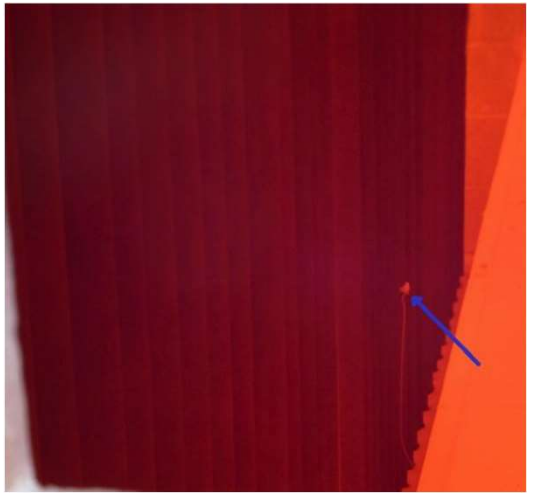

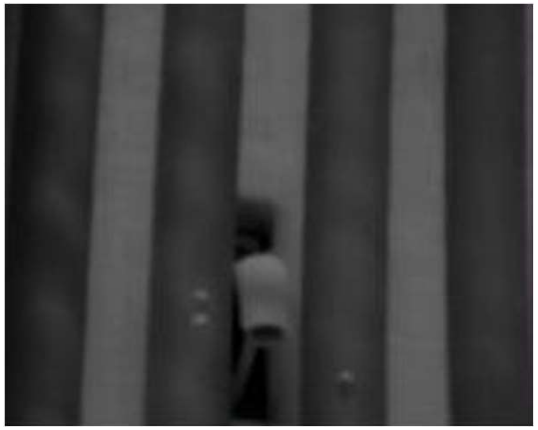

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Cyclops 390L

3.9-micron Spectral Response.

Temp range 450 to 1400°C / 842 to 2552°F

Why 3.9 microns?

- If present in sufficient quantities, hot water vapor & CO_2 vapor can make a 1 µm thermometer read falsely high.
- 3.9 µm is an atmospheric “window” through hot products of combustion (water vapor & CO_2 found in many furnace environments) – at 3.9 µm these hot gases and many flames are transparent.
- 3.9 microns is also much less sensitive to hotter reflective furnace backgrounds.

Applications: SMR’s and Ethylene crackers

- Industry standard for shooting tube temperatures
- Multiple wavelengths, temperature measurement ranges and operating modes
- Bluetooth connectivity
- Unique route planning software

A PEEPHOLE IN A STEAM REFORMER FURNACE

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Cyclops 390L Specification

Temperature Range	450 to 1400°C / 842 to 2552°F
Spectral Response	Nominally 3.9µm; advanced spectral filter
Emissivity Adjustment	0.10 to 1.20 in 0.01 steps
Display	Internal in viewfinder and external on LCD graphics panel.
Measurement Types	Average, Instantaneous, Peak, and Valley
Trigger Modes	Classic, Burst, Latched and Route
Alignment	Through the lens sighting with target defining square reticle
Optical	Variable Focus 1m to infinity - 180:1 FOV
Power Source	Battery (MN1604 6LR61). Typical life >100hours operating or External power via USB connector
Ambient Temperature	0 to 50°C / 32 to 122°F (noncondensing).
Sealing	IP40
Data Logging	10,000 reading internal memory. Live or saved data transfer to mobile device or Windows laptop running optional Cyclops Logger software via USB or Bluetooth connection

- Plants with reformer tube furnaces
- Chemical/ Petrochemical and Refinery Plants
- Reformer tube life and efficiency are very dependent at the temperature at which they are operated at!
- Higher tube temperatures may increase process efficiency but will substantially reduce tube life.

Cyclops 390L Specification

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NIR and MWIR BORESCOPES

Applications: SMR’s, Ethylene crackers, Incinerators, Carbon black.

- 1um [NIR-B-2K] and 3.9um [MWIR-B-640] options for flame filtering
- Temperature ranges from 300 to 2000C.
- Fixed and portable options
- Air cooled and water cooled
- Haz-loc certified variant

NIR and MWIR Light Portable Thermal Imaging System

- Camera Options: NIR-B-2K-800 /1400 -95/2
  MWIR-B-640-300/1200C-90/2 – LF
- Accuracy : 1% of reading (K)
- Repeatability : 1 K
- Max. Camera Probe Tip Temperature: 85 °C / 185 °F - NIR-B
  60 °C / 140 °F - MWIR-B
- Max. Camera Operating Temperature: 1200 °C
- Battery capacity: One 97 Wh power bank to power the instrument
- Max. 11 hours (Imager power only)

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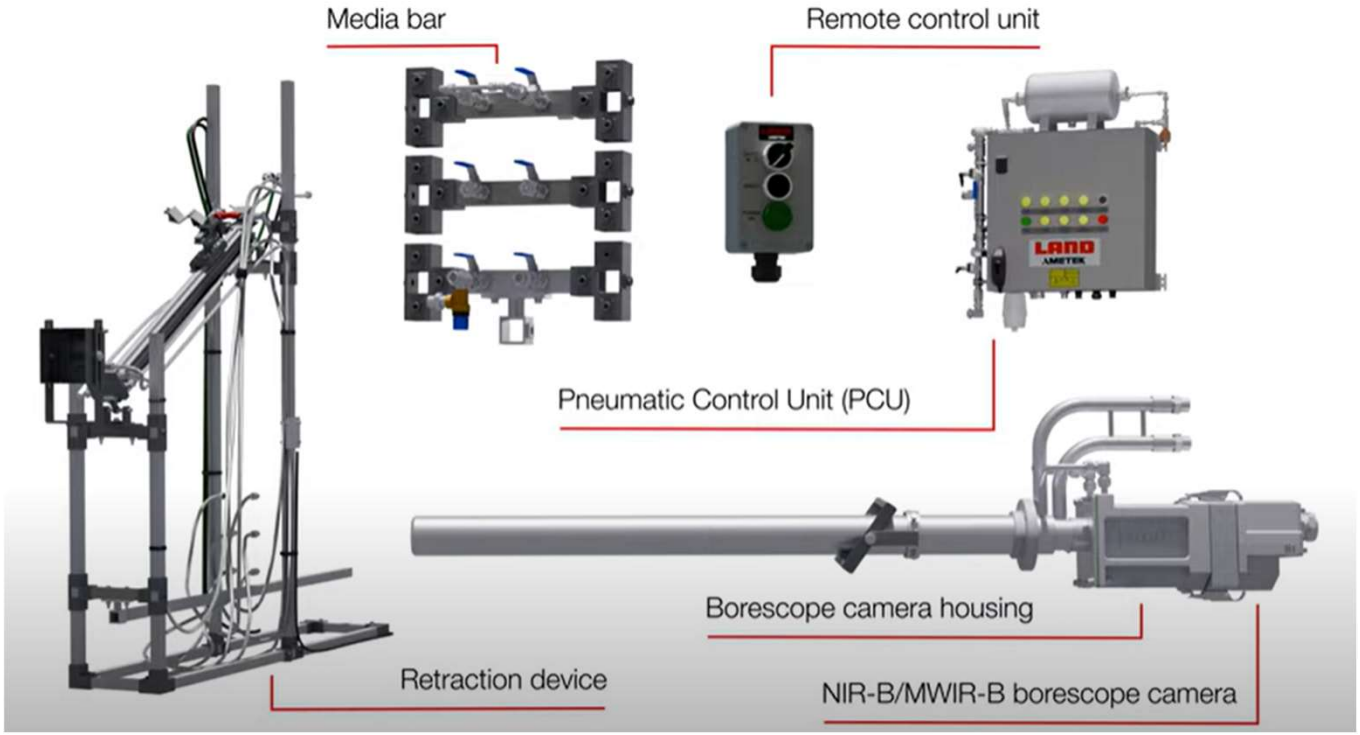
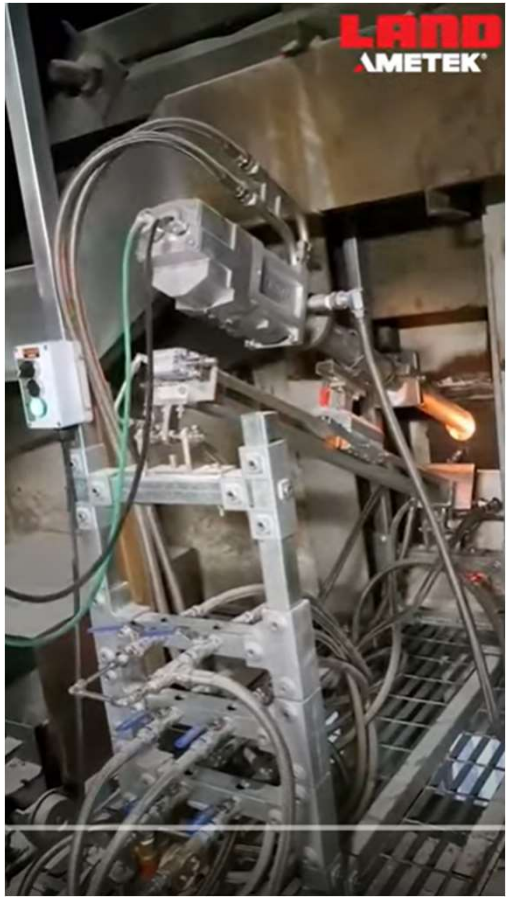
Thermal Imaging Cameras with Retract Mechanism



- Borescope Housing, Camera & Cables (25/50 m)
- Cylinder Assembly (Incl. Port & Borescope Seal)
- Media Bars (Water, Air Purge, Pneumatic Air)
- Pneumatic Control Unit (PCU) & Remote Box & Cable



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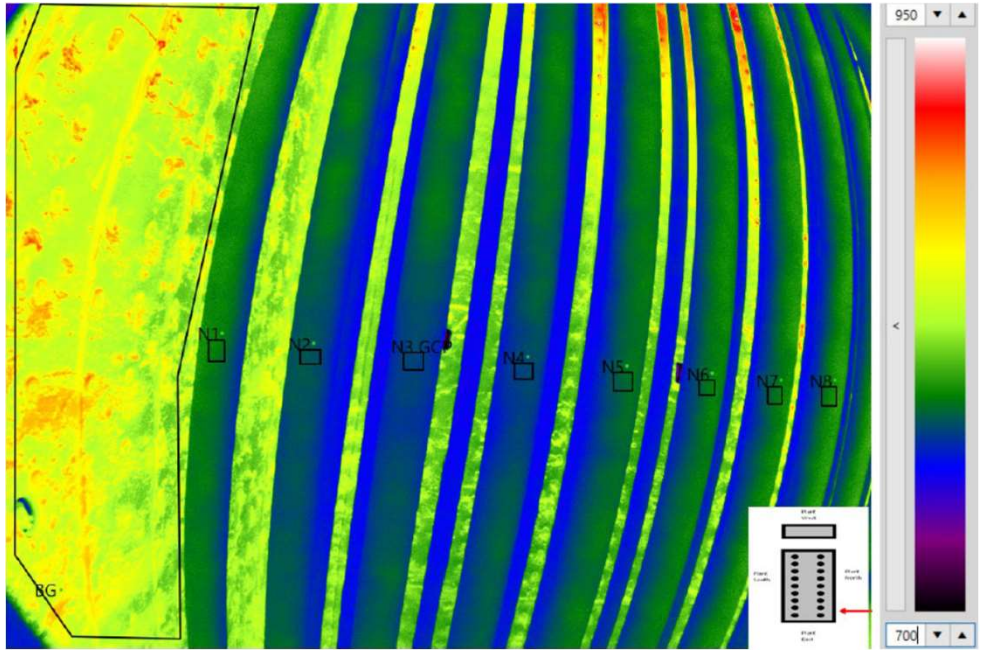
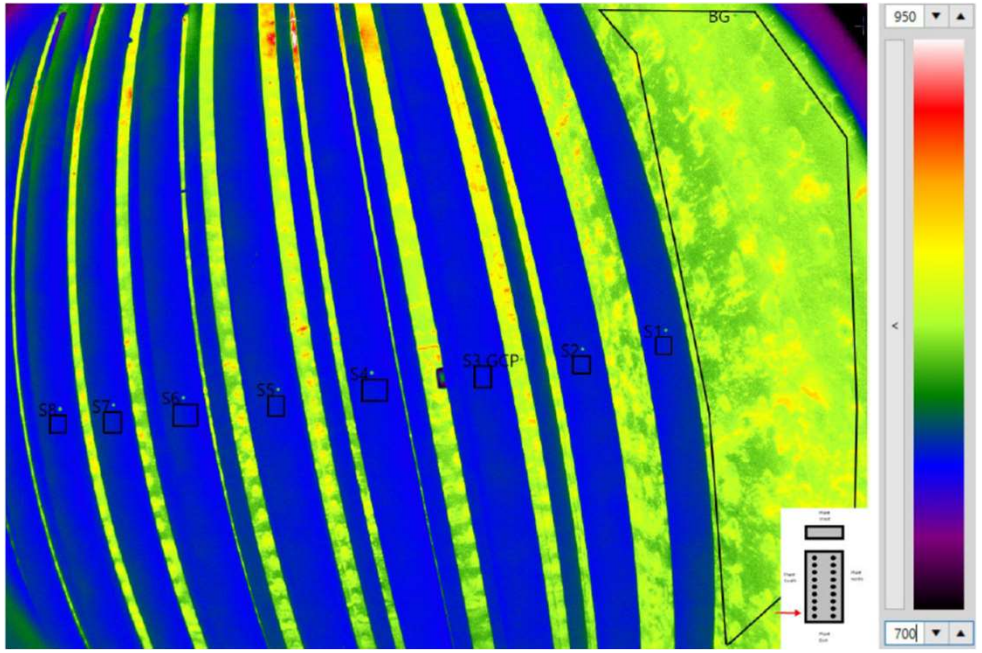
Fixed Imaging Cameras / ATEX, IECEx and CSA compliance

- NIR-B-640-EX - 1um
- Temperature range : 600 to 1800 °C
- Fixed camera system
- Air cooled and water cooled
- Haz-loc certified variant

NIR-B-2K Cameras



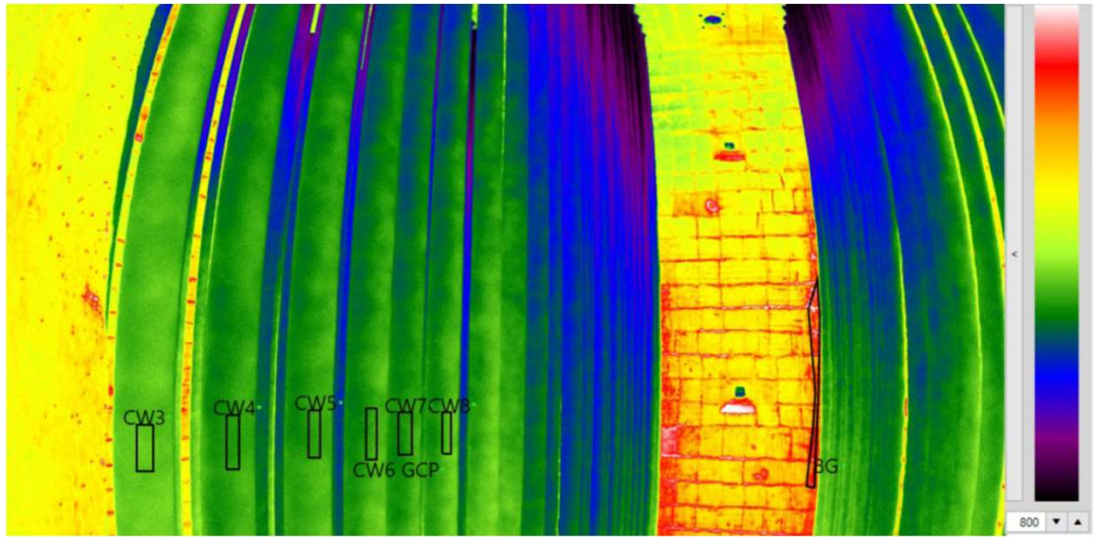
NIR-B-2K IMAGE FROM NORTH ROW EAST SIDE



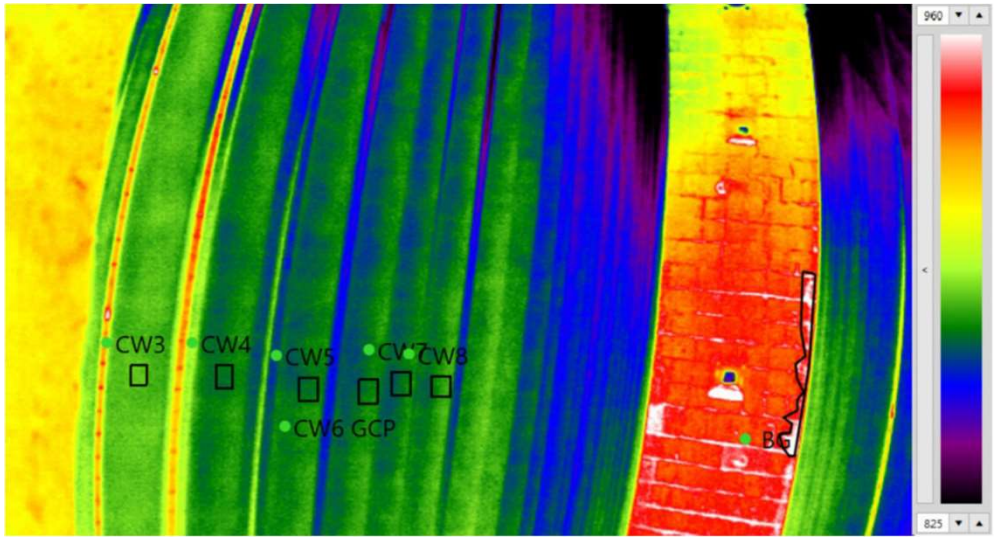
NIR-B-2K IMAGE FROM SOUTH ROW EAST SIDE

- 1 µm wavelength.
- 4 x resolution of a 640 x 480 camera.

NIR-B-2K V/S MWIR-B Cameras



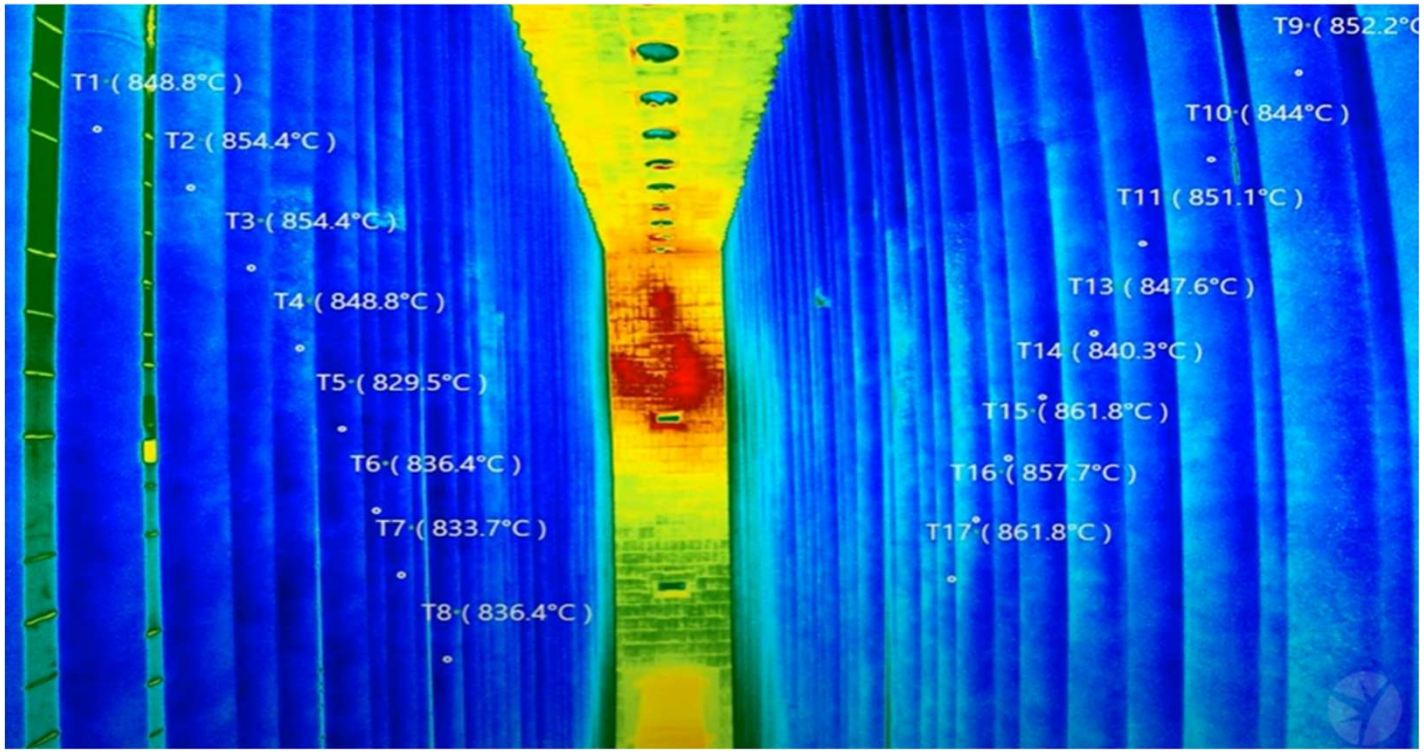
NIR-B-2K IMAGE FOF THE CENTRE WEST ROW NORTH SIDE LOWER LEVEL



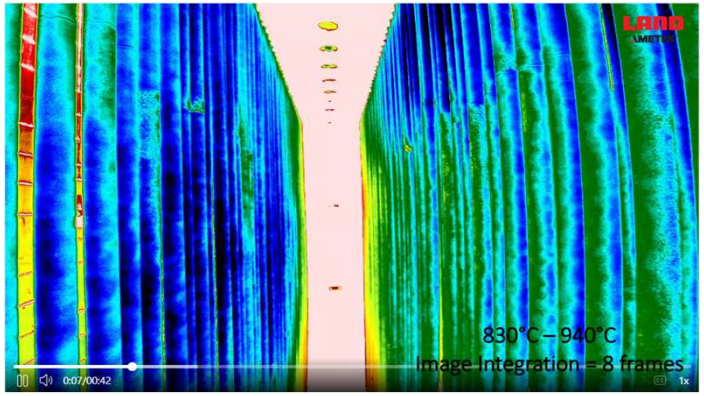
MWIR-B IMAGE FOF THE CENTRE WEST ROW NORTH SIDE LOWER LEVEL

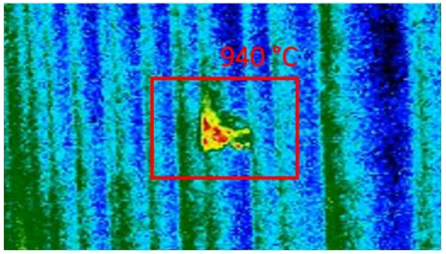
- The NIR-B-2K offers better resolution but may require more extensive Gold Cup validation to ensure data accuracy.
- The MWIR-B-640, while not needing as much in-furnace validation, has lower image resolution, which can affect image quality compared to the NIR-B-2K.

NIR-B 2K Cameras



- Large no of tubes can be visualized
- Flame impingement in the wall clearly visible
- Hotspot on the tube clearly visible.





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NIR-B 2K Cameras

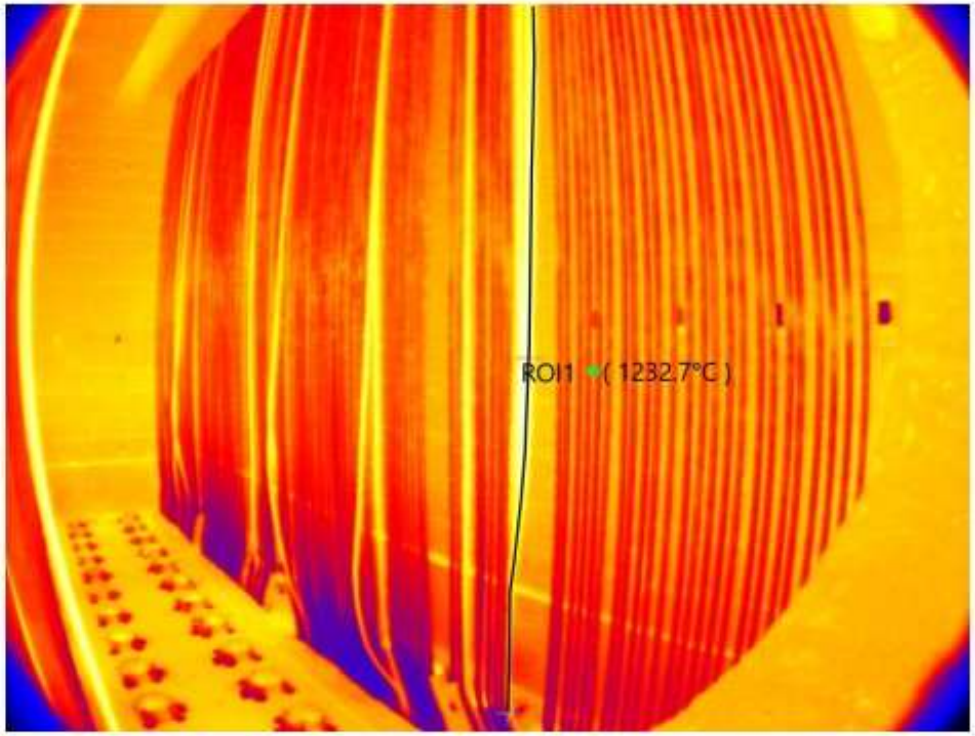
Camera 1

Serial Number: H11003C1P7P5T36T1

Image 1: 26/10/2022
After initial commissioning

The selected tube shows a maximum temperature of 992.1°C which is comparable to other surrounding tubes.

Image 2: 13/12/2023
Several tubes are operating outside normal conditions



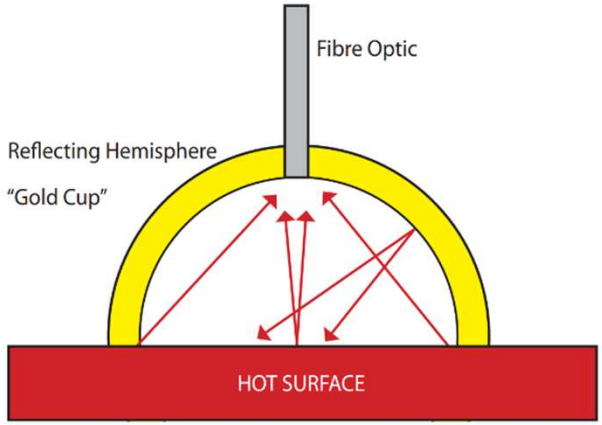
This cameras FOV alone does not allow a detailed analysis of all 144 tubes in this row, but this image alone suggests at least 9 tubes have deformed since the previous image was taken and are now operating at elevated temperatures (~1150°C).

The selected tube has a measured temperature of 1232.7°C. This is not only the highest tube temperature measured in this frame but also the maximum temperature of the entire frame. The maximum cursor can be seen just above the ROI label.

This is significantly higher than the other tubes which measure approximately 1020°C.

Gold Cup Pyrometer

- Gold Cup Pyrometer is a Contact Infrared Spot Thermometer/Pyrometer
- Measures surface temperatures of reformer tubes by simulating a blackbody condition.
- Eliminate errors from erroneous reflected temperature sources [E+R+T=1]
- Designed to contact the furnace tube and block out the reflected infrared radiation
- Eliminates reflection which is the major error source in temperature measurement via infrared thermometry



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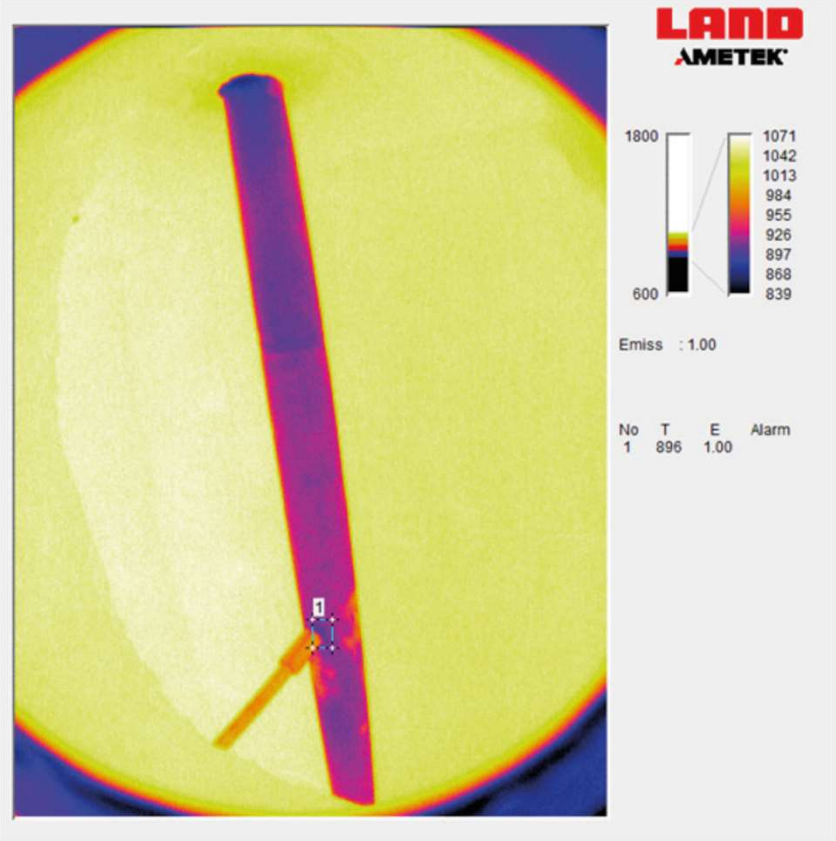
Gold Cup Pyrometer

Pro

- Fast
- Most Accurate Physical Method of Measuring Tube Wall temperature
- Simple to Use, Repeatable Results
- Cost Effective
- Temperature Trending & Onboard data storage

Con

- Length of Probe Limits the Distance that It can be Inserted Into the Furnace (typically 3m max)
- Long and Cumbersome to Manoeuvre
- Requires Several People to Support
- Only Spot Temperature
- Training is Required to Prevent Improper Use which Will Lead to Inaccuracies



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