In-Furnace Thermal Imaging for Process Optimisation for Energy Reduction and Asset Protection.

AIGMF 2023 – MUMBAI

LAND
AMETEK®
PROCESS & ANALYTICAL INSTRUMENTS

Philippe Kerbois
Global Industry Manager - Glass

QUALITY CUSTOMER SOLUTIONS

SHORT INTRODUCTION

Philippe Kerbois

Global Industry Manager - Glass

- Philippe has extensive sales and project management experience from working in the steel, glass and automotive industries including Rockwell Automation and ABB where he was specifically involved in major robot-based factory automation projects.
- Having worked at AMETEK Land since 2012, Philippe initially managed the sales of infrared temperature measurement solutions into line builders and glass and steel furnace OEMs within France, however now he works very closely with the global glass market and is actively promoting the award-winning Near Infrared Borescope (NIR-B) Glass thermal imaging solution for glass furnaces.

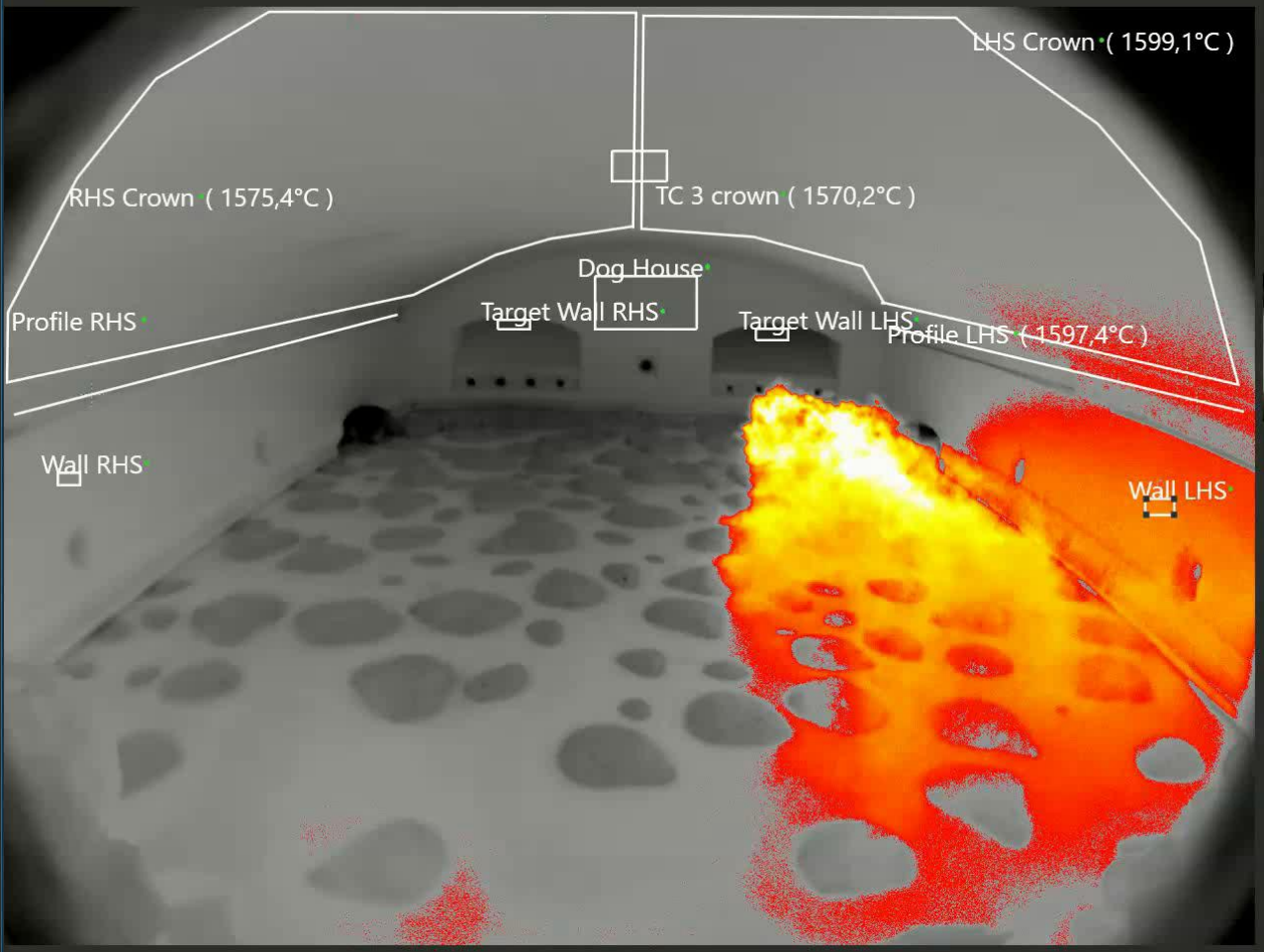
- **philippe.kerbois@ametek.com**
- +33 (0) 6.75.38.39.87

NIRB Images in Glass Furnace

AMETEK Land IMAGEPro (Administrator)

Configuration Data Views Help

SIM Live Image



ROI Editor

Zoom 100 % Reset

Palette 1700 1585 1400

0:00:00 , 0000 MB 0:01:00 , 0332 MB

SIM (NIR 2K) 127.0.0.1 ε: 1.00

X: Y: T:

Noir1Blanc V1

SIM (NIR 2K) 127.

SIM (NIR 2K) 1

Glass batch SIM

Live Analysis

Batch Display

Batch Overlay Visible

Matrix Settings

Batch Matrix Visible

Batch Percent Visible

Max Temperature Visible

Mean Temperature Hidden

Min Temperature Hidden

Text Color A

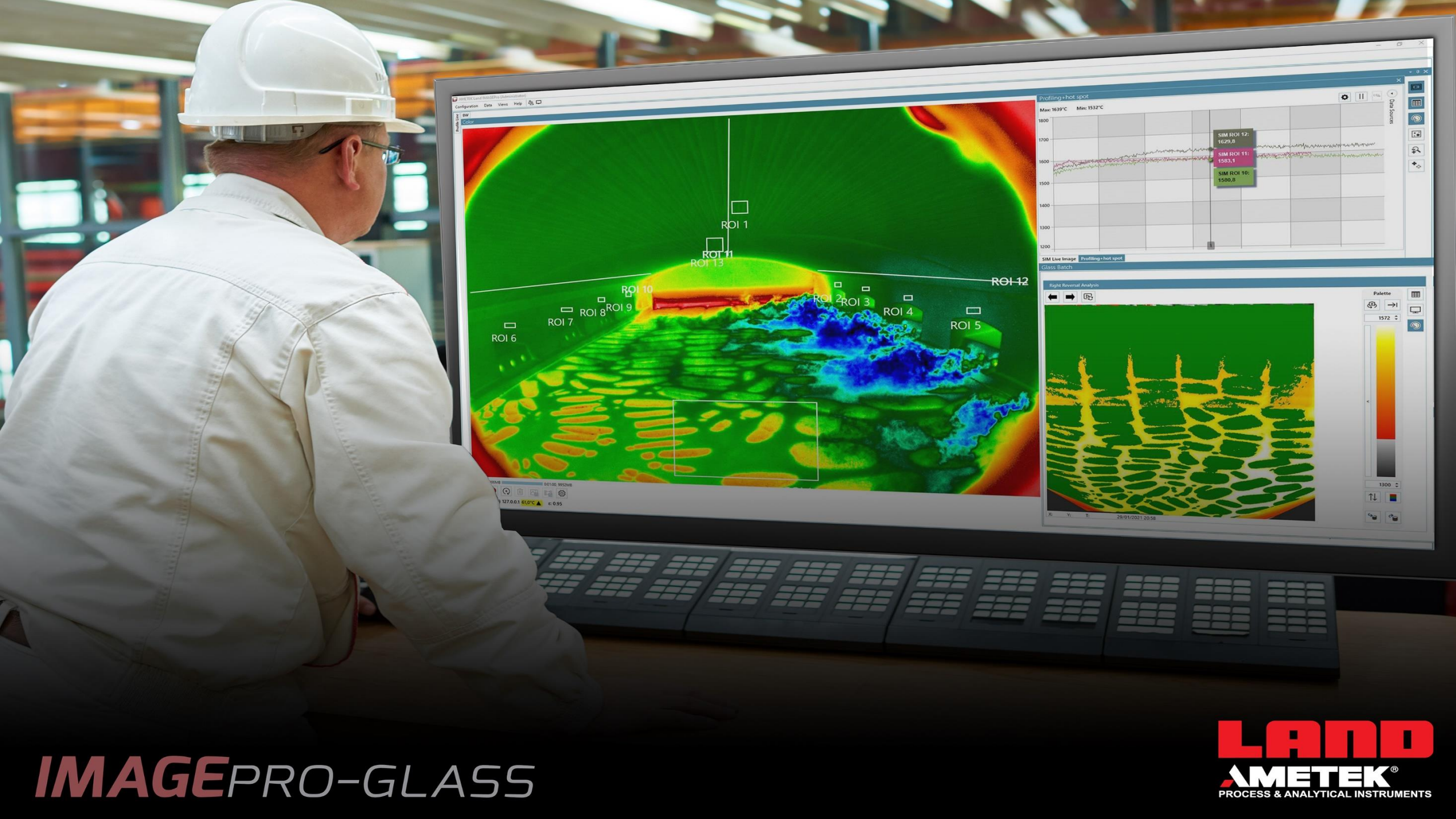
Left Reversal Analysis

14/09/2022 13:58

Right Reversal Analysis

14/09/2022 14:09

12:00:00:0 14:00:00:0



IMAGEPRO-GLASS

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LAND PORTFOLIO IN GLASS APPLICATIONS

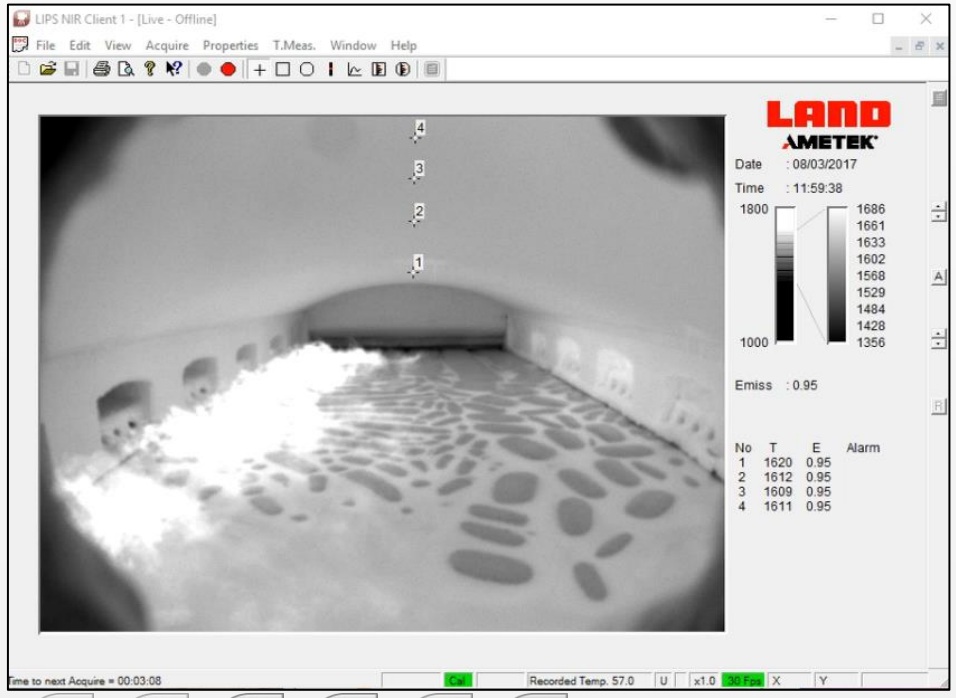
Complete temperature offering

- Leverage demand for the NIRB borescope to promote a wider portfolio packages including :
  - The Fiber Optics “Legend FG”
  - Lancom 4 Gas analyser
  - FLTs and LSPHDs for thin bath and Lehrs
- As installation becomes more critical – possible to integrate and provide AMEcare Advanced Services into the offering
- Thermal Surveys with NIRB 2K demonstrating benefits of NIRB
- More than 150 NIRBs implemented Worldwide in major producers in the Glass industry

LAND AMETEK Advanced Services

Previous DGG/HVG Conference Papers:

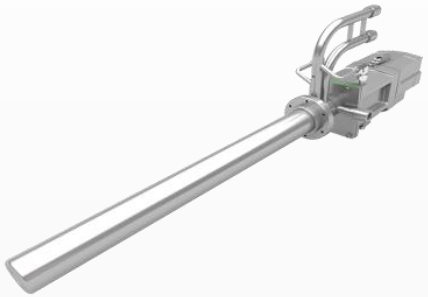
- **2016** – Infrared temperature Measurement in Glass Melt Tanks
- **2017** – Controlling a Glass Furnace Using Thermal Imager
- **2018** – Infrared Temperature Measurement in Glass Melt Tank to optimize furnace operation & Nox
- **2019** – Criticality of Accuracy and Traceability of Temperature Calibration
- **2022** - Specific Energy Reduction through infra red furnace monitoring and optimisation



Equipment bundle Used:

NIR-B-2K-GLASS - Near Infrared Borescope Glass Solution

- 3,000,000 pixels each measuring temperature ≡ 3M Cyclops
- (Output of 100 x continuous measurement points via TCP/IP)
- Max, min and average temperatures with user defined emissivity.
- Patent Pending



Cyclops C100L

- Portable Infrared Thermometer
- Industry Standard
- Verify spot temperatures
- 550 to 3000° C
- 1022 to 5432° F

Lancom 4 – Portable Gas Analyser

- 9 Gas Analyser for NOx
- CO low • CO high • O2
- NO • NO2 • NOx
- CO2 • H2S • SO2 • CxHy

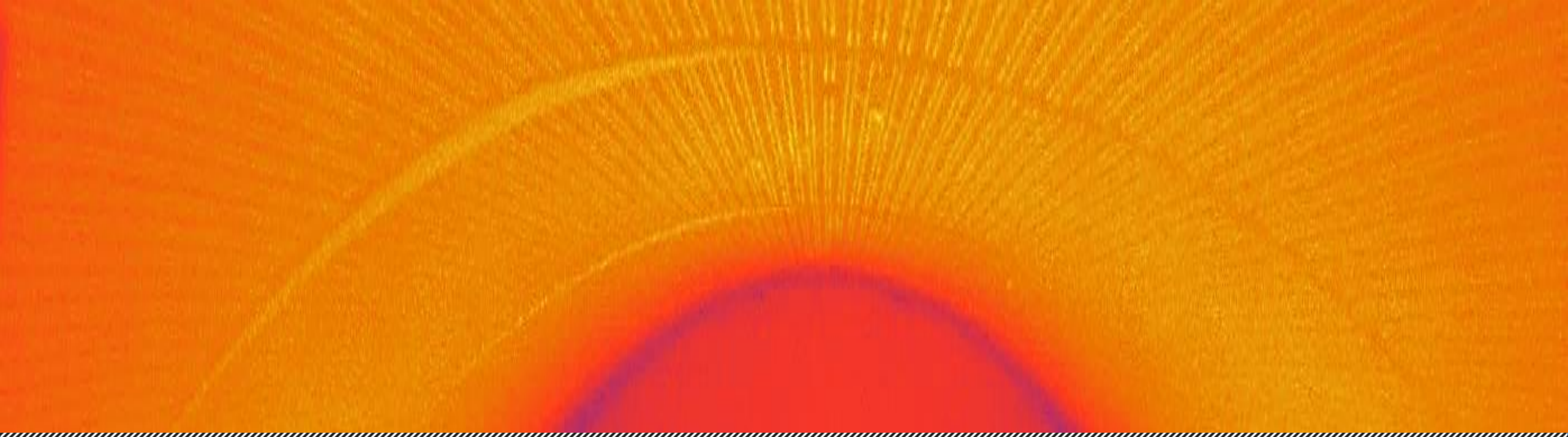
The survey kit comprises of the following equipment

Full survey kit in Storm case

NIR-B 2k camera, 2ft probe, range 1000-1800C.

2ft Water Cooled Jacket

25m Power and Ethernet cables.

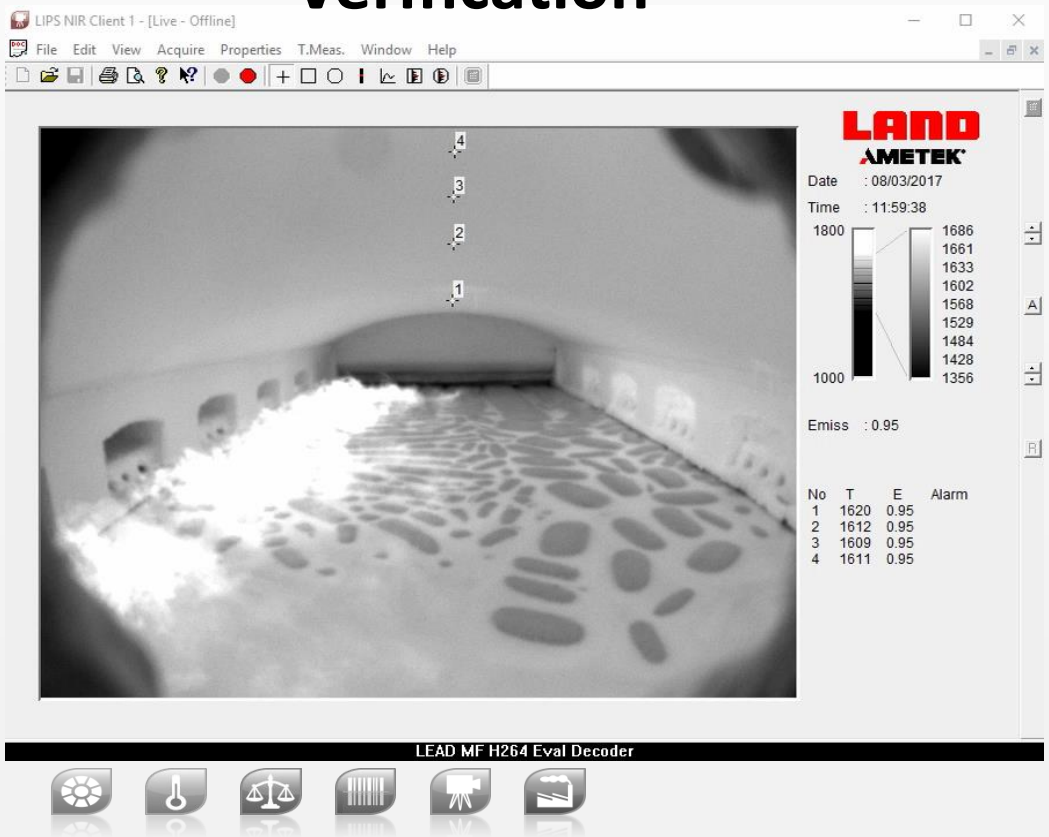


THE BENEFITS IN FURNACE OPERATIONS
“NOT JUST A PRETTY IMAGE”

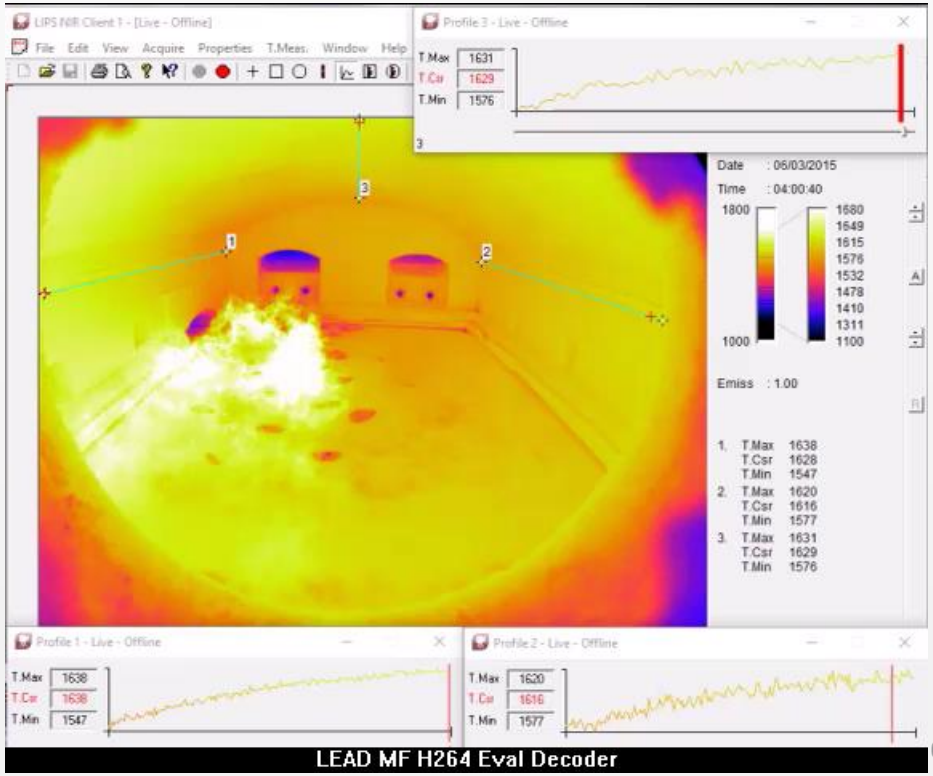
QUALITY CUSTOMER SOLUTIONS

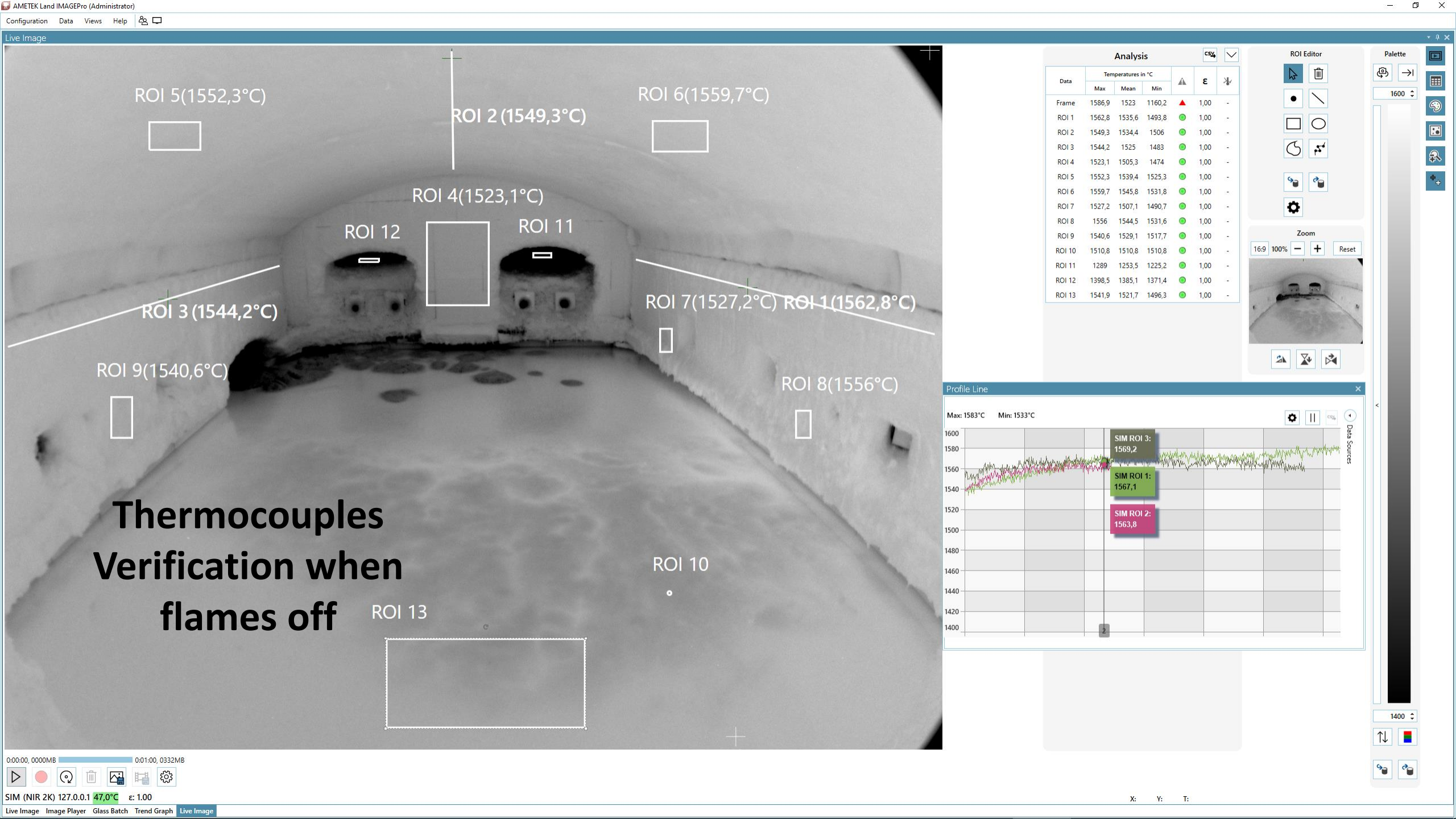
Remember the four Pillars of Benefits with Thermal Imaging NIR-B!
This is not only a pretty image!

Thermocouple Verification



Optical-Thermal profiles with hot spots

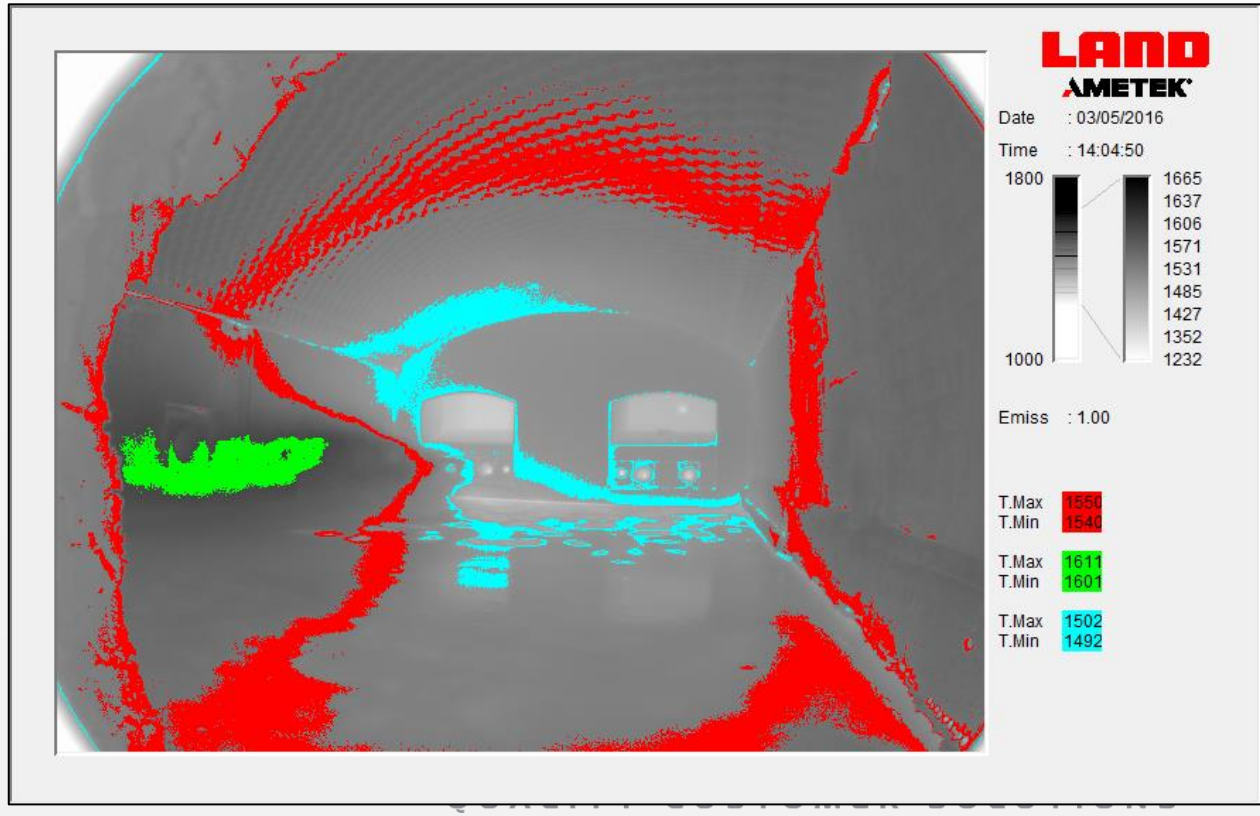



AMETEK Land IMAGEPro (Administrator)
Configuration
Data
Views
Help
Live Image
ROI 5(1552,3°C)
ROI 2 (1549,3°C)
ROI 6(1559,7°C)
ROI 4(1523,1°C)
ROI 12
ROI 11
ROI 3 (1544,2°C)
ROI 7(1527,2°C)
ROI 1(1562,8°C)
ROI 9(1540,6°C)
ROI 8(1556°C)
ROI 10
ROI 13
Thermocouples
Verification when
flames off
Analysis
Data
Temperatures in °C
Max
Mean
Min
ε
Frame 1586,9 1523 1160,2 1,00
ROI 1 1562,8 1535,6 1493,8 1,00
ROI 2 1549,3 1534,4 1506 1,00
ROI 3 1544,2 1525 1483 1,00
ROI 4 1523,1 1505,3 1474 1,00
ROI 5 1552,3 1539,4 1525,3 1,00
ROI 6 1559,7 1545,8 1531,8 1,00
ROI 7 1527,2 1507,1 1490,7 1,00
ROI 8 1556 1544,5 1531,6 1,00
ROI 9 1540,6 1529,1 1517,7 1,00
ROI 10 1510,8 1510,8 1510,8 1,00
ROI 11 1289 1253,5 1225,2 1,00
ROI 12 1398,5 1385,1 1371,4 1,00
ROI 13 1541,9 1521,7 1496,3 1,00
ROI Editor
Zoom
16:9
100%
Reset
Palette
1600
1400
Profile Line
Max: 1583°C
Min: 1533°C
SIM ROI 3: 1569,2
SIM ROI 1: 1567,1
SIM ROI 2: 1563,8
Data Sources
0:00:00, 0000MB
0:01:00, 0332MB
SIM (NIR 2K) 127.0.0.1 47,0°C ε: 1.00
X:
Y:
T:
Live Image
Image Player
Glass Batch
Trend Graph
Live Image

Remember the four Pillars of Benefits of NIR-B

BW Palette for Air ingress and Batch pattern

Isotherms with 3 bands for hot and cold spot locations



FLAME SHAPE AND INTENSITY – MONO / RAINBOW / INTEGRATOR

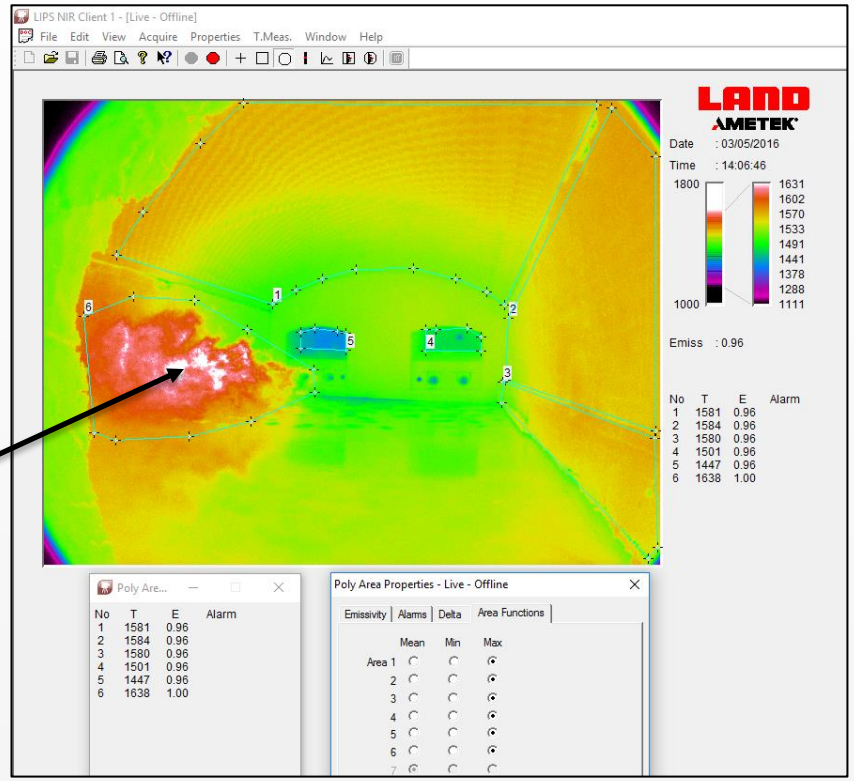
- Highlights flame shape and areas of high intensity for combustion and emissions optimisation.
- Continuous real time Temperature data.
- Areas used to monitor Highest or Average or Lowest Temperature.
- Crown, Regenerator and Side Wall temperature monitoring.

Nitrogen Oxide NOx formation

There are typically 4 modes of NOx formation:

- Fuel NOx – from Nitrogen elements in fuel
- Prompt NOx – relatively low temperature reaction
- Feed NOx – from raw ingredients such as Niter in the past
- Thermal NOx - at temperatures in excess of 1600°C

The upper limit of the NIR B is 1800°C areas above the upper limit are shown in white colour, by adjusting the range limits to increase contrast it is possible to determine what parts of the flame are the hottest and thereby assess generation of thermal NOx.



In glass manufacture as a result of modern batch materials typically the greatest source of NOx is believed to be thermal according is by Thermal NOx. At temperatures in excess of 1600°C (2900°F) the Oxygen molecules in air start to dissociate into elemental atoms. The higher the process or flame temperature, the higher the dissociation and therefore the greater formation of NOx. In the hottest zone of the flame a super equilibrium level of Oxygen atoms exists.

IMAGEPro GLASS

2.1

BATCH COVERAGE AND CROWN TEMPERATURES WITH NIR-B 2K GLASS AND IPV2

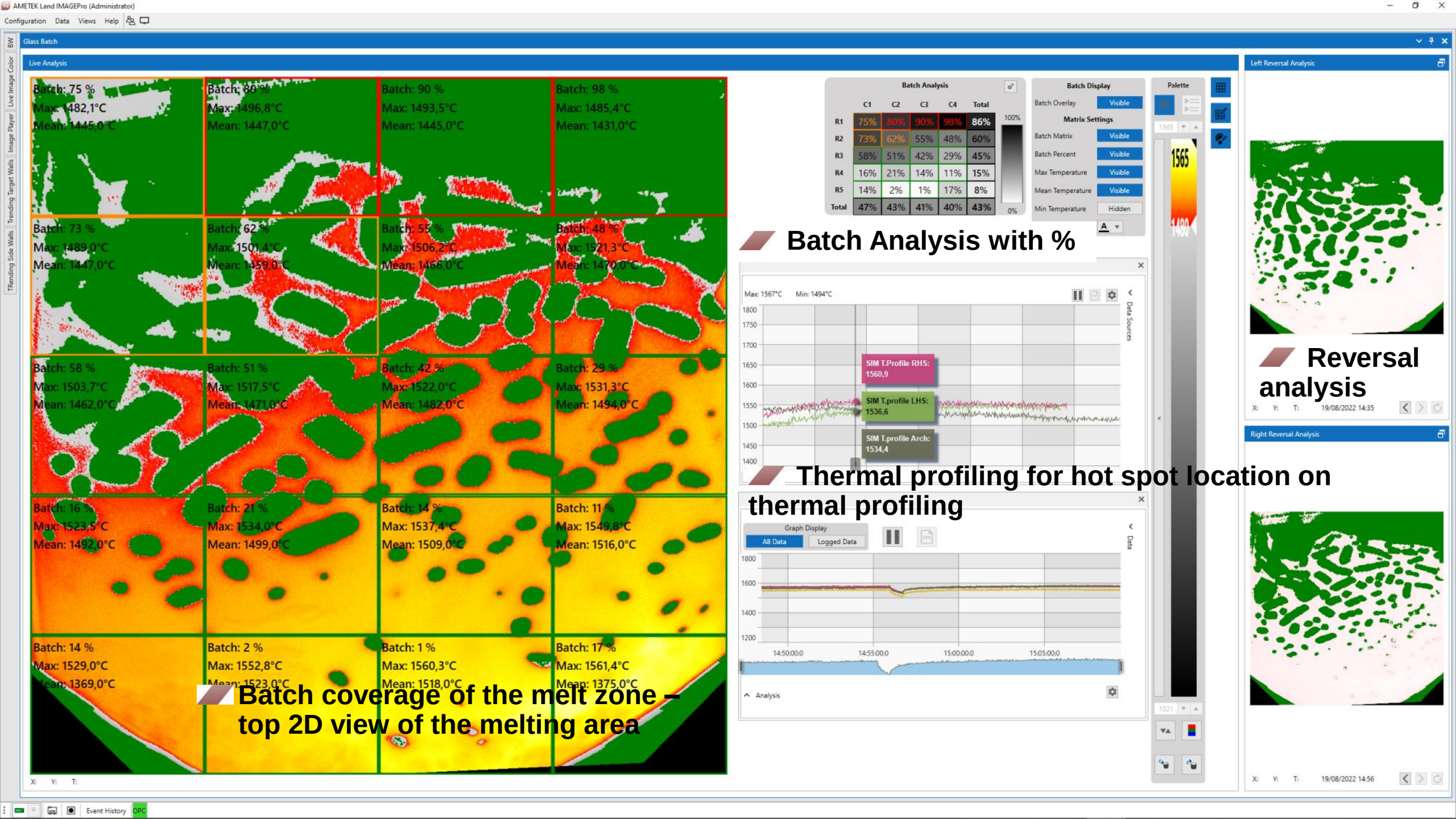
CONTAINER GLASS FURNACES

Image Pro– Gateway to Infrared Control

- Connection with all Land Instrument solutions including LWIR
- Digital and analogue Inputs/outputs
- TCPIP, OPC UA server, Modbus server and SDK
- Modbus server for data exchange with DCS (100 zones of interest possible to be monitored)+RTMP for video streaming
- Built-in Communication for Celsian rMPC (EU Reference)
- Built-in Communication for GS – ESIII (EU Reference)
- Any DCS communication for SCADA data analysis (Zenon Platform) with existing Drivers (TCPIP Modbus or OPC)

Batch Coverage and Crown Temperatures

- Variation in Batch coverage has a direct impact on furnace temperatures . The temperature clearly drops when the batch moves to the front of the furnace. These ROIs can be used to set some alarms to the Furnace DCS and get a better efficient control of the batch coverage by adjustment of the batch charging direction:
  - Setting to have top 2D view of the melter with the Image Pro furnace configuration feature.
  - Setting of a ROI in front of the Throat.
  - Configuration of a Batch ROI in the coverage melting grid near the throat (ROIs in C4R2 for example).
  - Batch length can be adjusted.
- The Batch coverage in this critical ROI near the throat could be monitored to:
  - Avoid large amount (below 15%) of batch in this area even for large pull rates.
  - Prevent Glass Defects.


AMETEK Land IMAGEPro (Administrator)
Configuration Data Views Help
Glass Batch
Live Analysis
Batch: 75 %
Max: 1482,1°C
Mean: 1445,0°C
Batch: 80 %
Max: 1496,8°C
Mean: 1447,0°C
Batch: 90 %
Max: 1493,5°C
Mean: 1445,0°C
Batch: 98 %
Max: 1485,4°C
Mean: 1431,0°C
Batch: 73 %
Max: 1489,0°C
Mean: 1447,0°C
Batch: 62 %
Max: 1501,4°C
Mean: 1459,0°C
Batch: 55 %
Max: 1506,2°C
Mean: 1466,0°C
Batch: 48 %
Max: 1521,3°C
Mean: 1470,0°C
Batch: 58 %
Max: 1503,7°C
Mean: 1462,0°C
Batch: 51 %
Max: 1517,5°C
Mean: 1471,0°C
Batch: 42 %
Max: 1522,0°C
Mean: 1482,0°C
Batch: 29 %
Max: 1531,3°C
Mean: 1494,0°C
Batch: 16 %
Max: 1523,5°C
Mean: 1492,0°C
Batch: 21 %
Max: 1534,0°C
Mean: 1499,0°C
Batch: 14 %
Max: 1537,4°C
Mean: 1509,0°C
Batch: 11 %
Max: 1549,8°C
Mean: 1516,0°C
Batch: 14 %
Max: 1529,0°C
Mean: 1369,0°C
Batch: 2 %
Max: 1552,8°C
Batch: 1 %
Max: 1560,3°C
Mean: 1518,0°C
Batch: 17 %
Max: 1561,4°C
Mean: 1375,0°C
Batch Analysis
C1 C2 C3 C4 Total
R1 75% 80% 90% 98% 86%
R2 73% 62% 55% 48% 60%
R3 58% 51% 42% 29% 45%
R4 16% 21% 14% 11% 15%
R5 14% 2% 1% 17% 8%
Total 47% 43% 41% 40% 43%
100%
0%
Batch Display
Batch Overlay Visible
Matrix Settings
Batch Matrix Visible
Batch Percent Visible
Max Temperature Visible
Mean Temperature Visible
Min Temperature Hidden
Palette
1565
1490
Batch Analysis with %
Max: 1567°C Min: 1494°C
Data Sources
SIM T.Profile RHS: 1560,9
SIM T.profile LHS: 1536,6
SIM T.profile Arch: 1534,4
Thermal profiling for hot spot location on thermal profiling
Graph Display
All Data
Logged Data
Data
14:50:00:0
14:55:00:0
15:00:00:0
15:05:00:0
Analysis
Batch coverage of the melt zone – top 2D view of the melting area
Left Reversal Analysis
Reversal analysis
19/08/2022 14:35
Right Reversal Analysis
19/08/2022 14:56
Event History
OPC

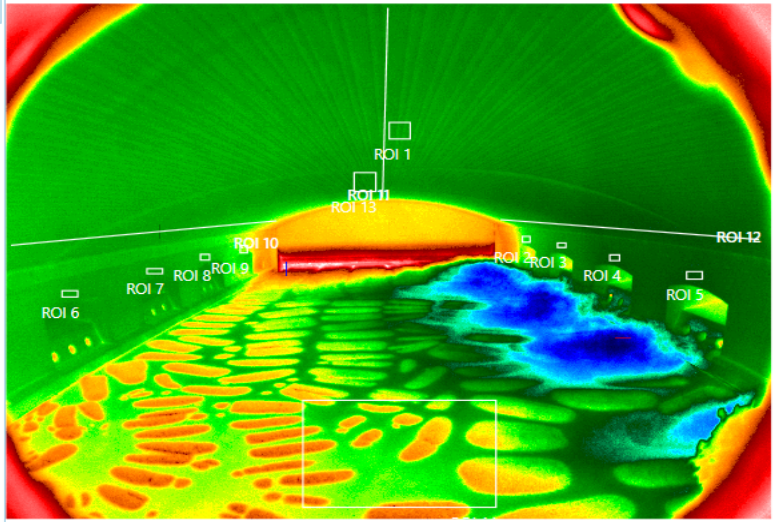
AMETEK Land IMAGEPro (Administrator)

Configuration Data Views Help

Profile Line

Color

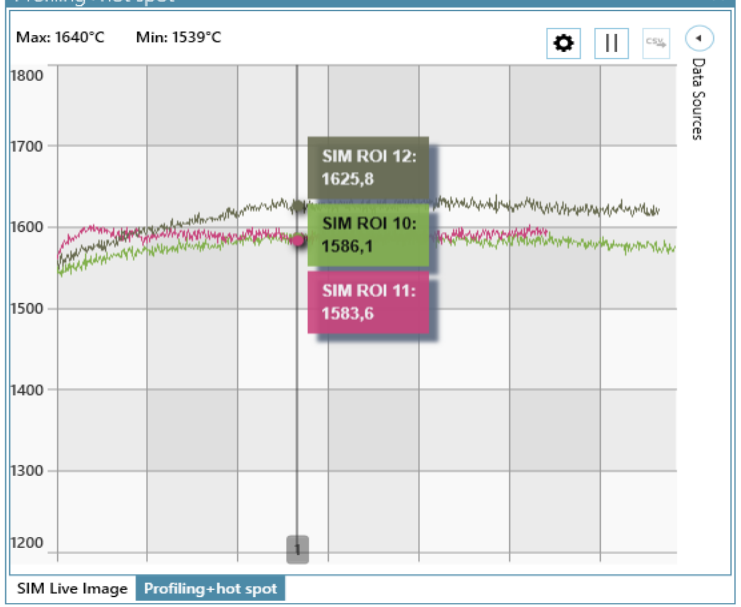
BW



0:00:00, 0000MB 0:01:00, 0331MB

SIM (NIR 2K) 127.0.0.1 62,0°C ▲ 32 ε: 0.95

Profiling+hot spot



SIM Live Image | Profiling+hot spot

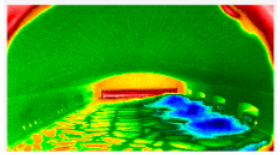
Analysis

Data	Temperatures in °C			▲	ε	
	Max	Mean	Min			
Frame	1796,3	1572,5	1274,7	▲	0,95	-
ROI 2	1584	1564,5	1547,6		-	-
ROI 3	1611,7	1599,4	1586,6		-	-
ROI 4	1635,7	1623,9	1607,6		-	-
ROI 5	1643,1	1628,8	1615,3		-	-
ROI 6	1599,9	1585,2	1566,7		-	-
ROI 7	1598,6	1588,2	1575,1		-	-
ROI 8	1588,7	1578	1566,4		-	-
ROI 9	1569,1	1550,7	1535,3		-	-
ROI 10	1596	1578,9	1539,3		-	-
ROI 11	1602,3	1589,3	1559,8		-	-
ROI 12	1640,1	1615,5	1554,1		-	-

ROI Editor

Zoom

16:9 100% Reset



Palette

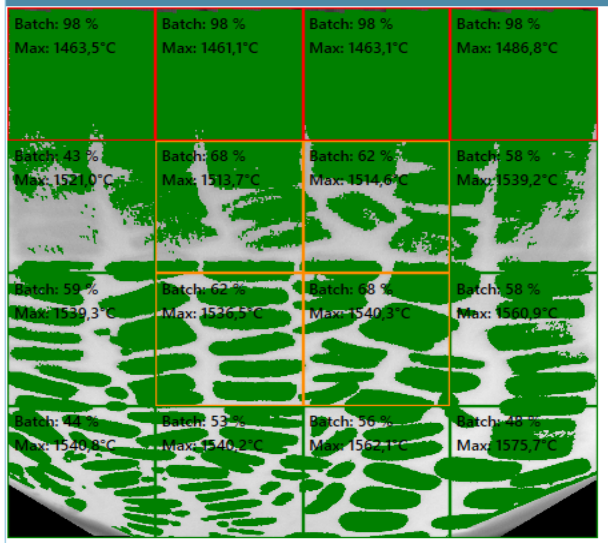
1789

1335

X: Y: T:

Glass Batch

Live Analysis



Batch Analysis

	C1	C2	C3	C4	Total
R1	98%	98%	98%	98%	98%
R2	43%	68%	62%	58%	58%
R3	59%	62%	68%	58%	62%
R4	44%	53%	56%	48%	50%
Total	61%	70%	71%	65%	67%

100% 0%

Batch Display

Batch Overlay Visible

Matrix Settings

Batch Matrix Visible

Batch Percent Visible

Max Temperature Visible

Mean Temperature Hidden

Min Temperature Hidden

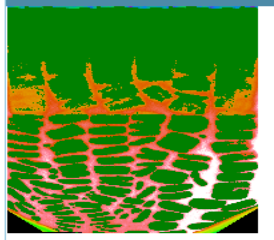
Text Color

Palette

1583

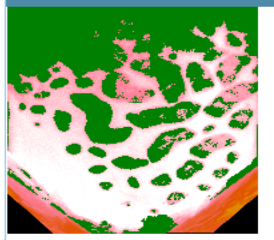
1190

Left Reversal Analysis



X: Y: T: 11/10/2020 23:14

Right Reversal Analysis



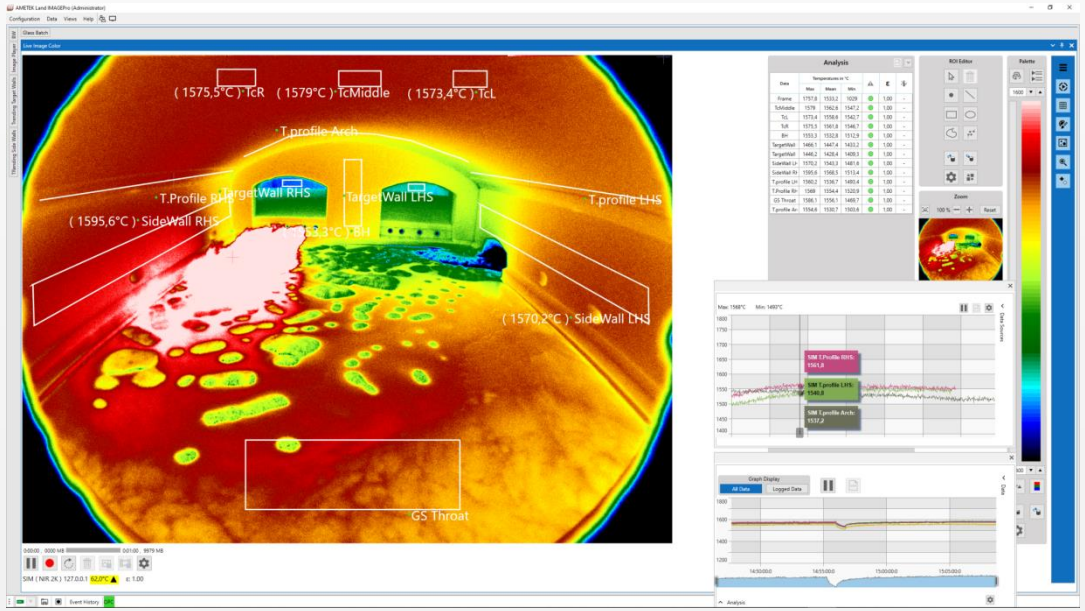
X: Y: T: 30/09/2020 15:41

Batch coverage and Reversal analysis

FRA 23:24

ImagePro Glass 2

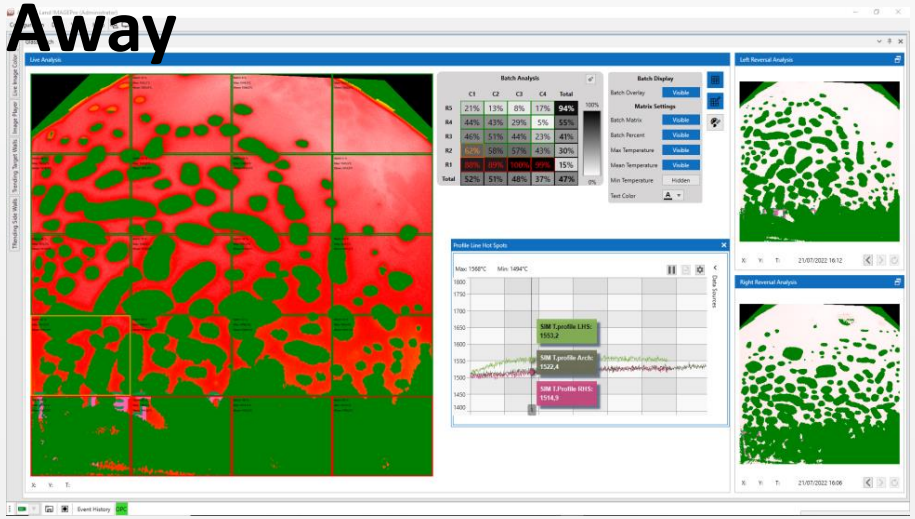
- More Stable interface with possible multiple displays , Interface External Flame Detection
- Essentially the same as IPV1 Glass based on more reliable , quick and efficient IPV2 engine
- Batch analyser based on trapezoid geometry with flame detection



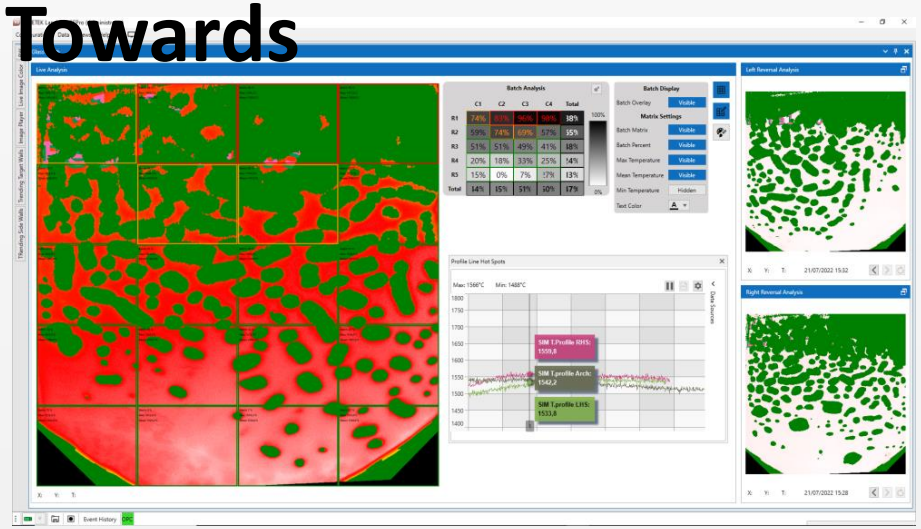
ImagePro2 Glass – new features

- **Flow Direction for multi locations**
  - Glass flow direction can be configured in furnace settings
  - **Towards :** Glass flow towards camera (existing)
  - **Away:** Glass flow away from camera
- If flow direction away from camera is selected then Batch display will be flipped

Away

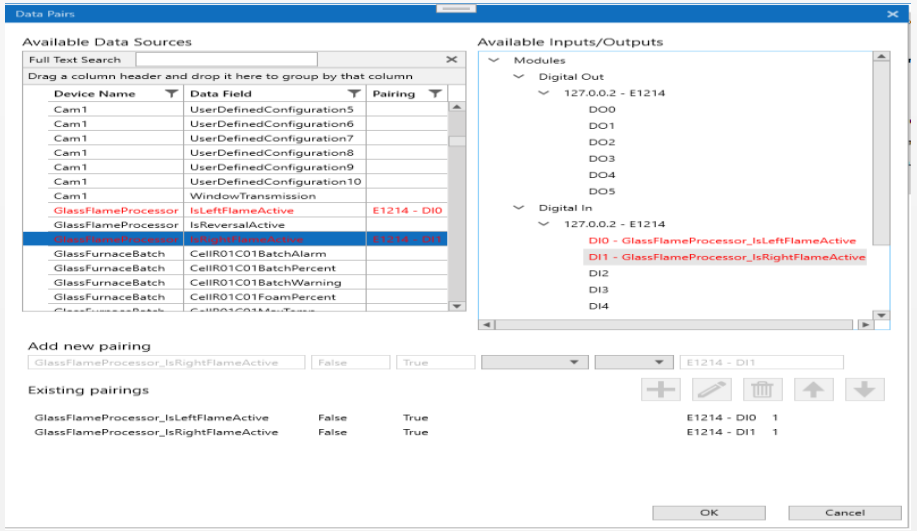


Towards

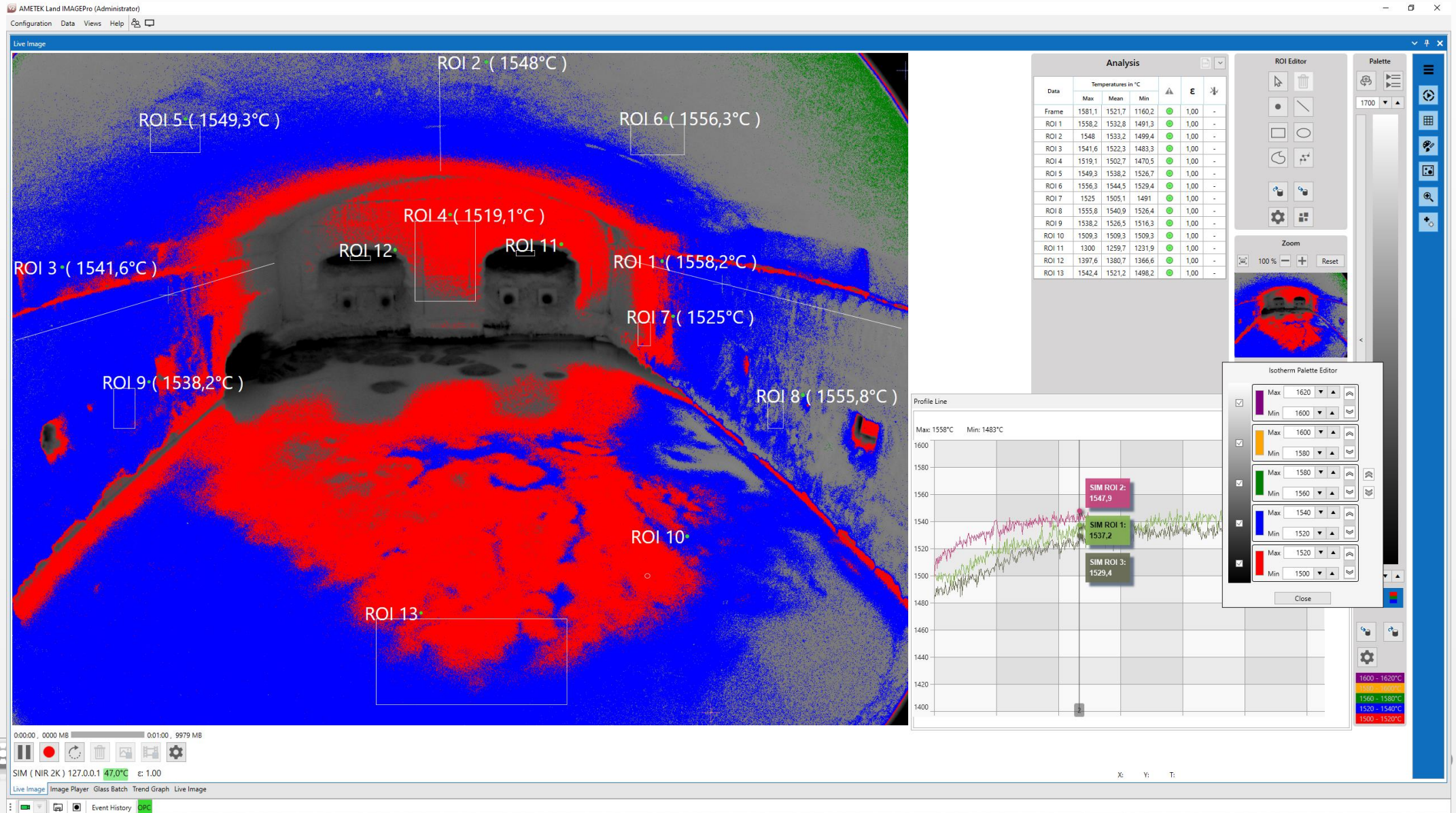


ImagePro2 Glass – new features

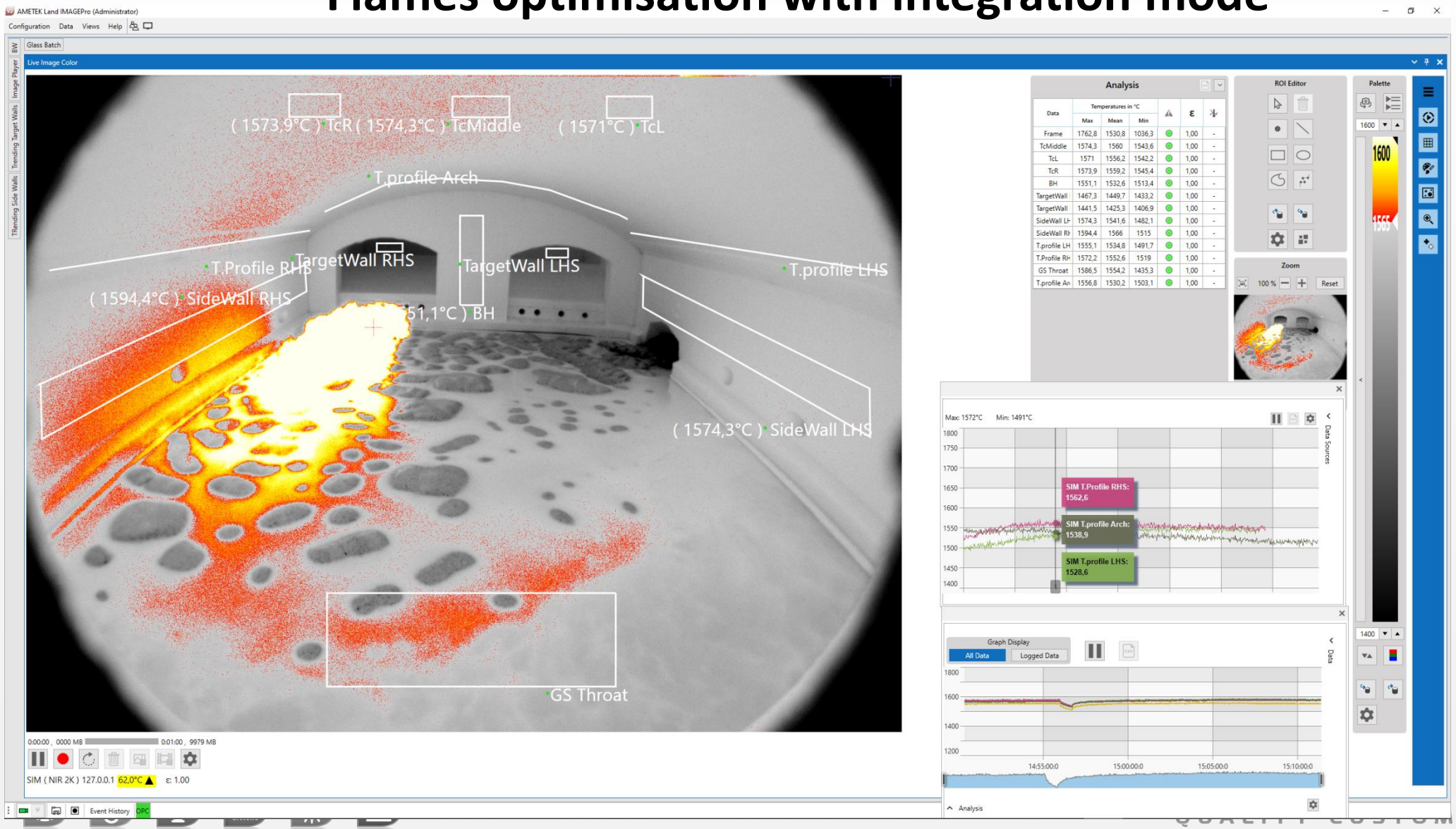
- **External Flame Detection**
  - There are now 2 types of flame detection (select in furnace settings)
    - Automatic
    - I/O
- Left and Right flame's status can be controlled from IO by data pairing the following tags
  - **IsLeftFlameActive**
  - **IsRightFlameActive**

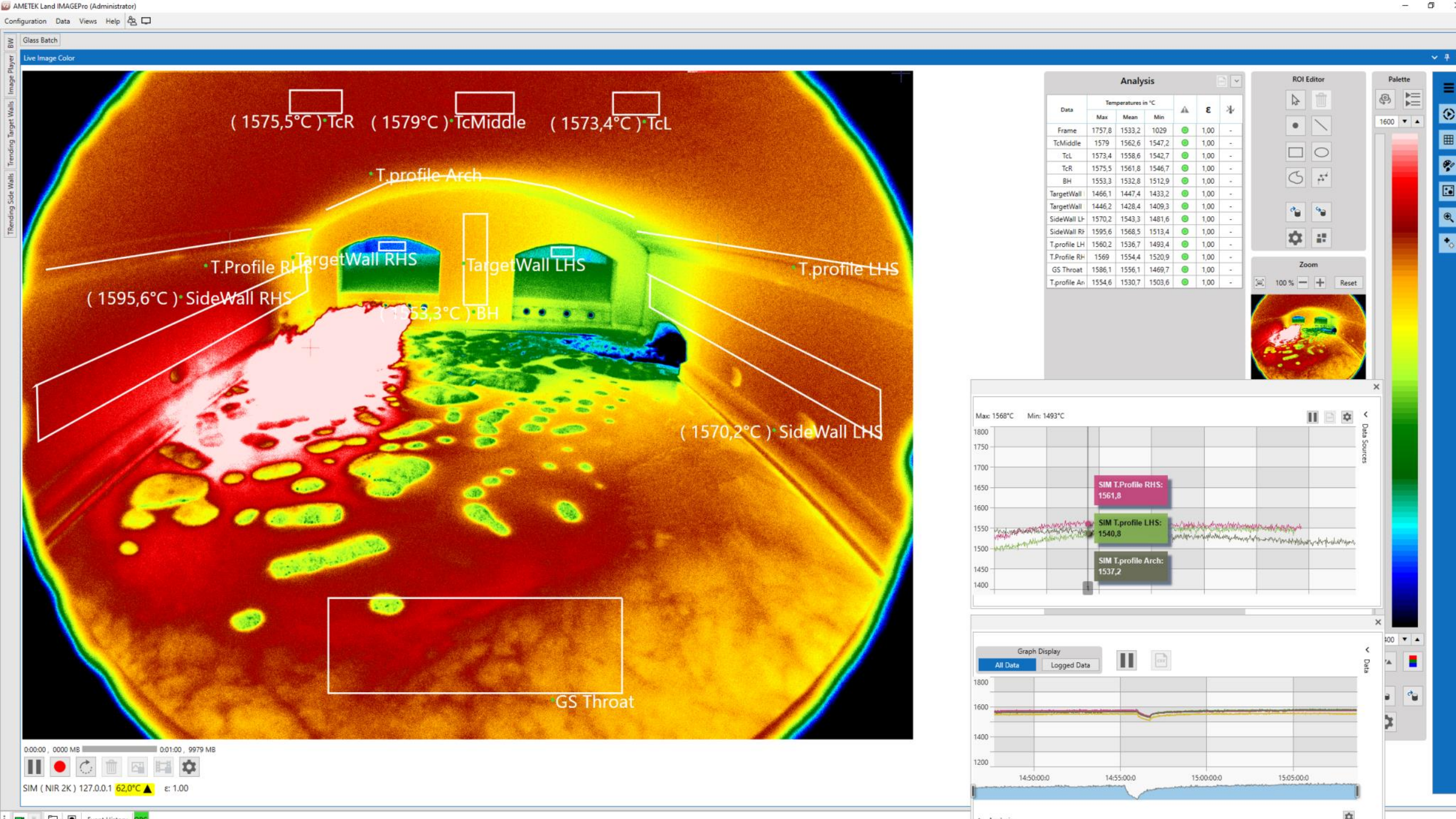


Isotherms


AMETEK Land IMAGEPro (Administrator)
Configuration Data Views Help
Live Image
ROI 2 (1548°C)
ROI 5 (1549,3°C)
ROI 6 (1556,3°C)
ROI 4 (1519,1°C)
ROI 12
ROI 11
ROI 3 (1541,6°C)
ROI 1 (1558,2°C)
ROI 7 (1525°C)
ROI 9 (1538,2°C)
ROI 8 (1555,8°C)
ROI 10
ROI 13
Analysis
ROI Editor
Palette
Zoom
Isotherm Palette Editor
Profile Line
SIM ROI 2: 1547,9
SIM ROI 1: 1537,2
SIM ROI 3: 1529,4
SIM (NIR 2K) 127.0.0.1 47,0°C ε: 1.00
Live Image Image Player Glass Batch Trend Graph Live Image
Event History OPC

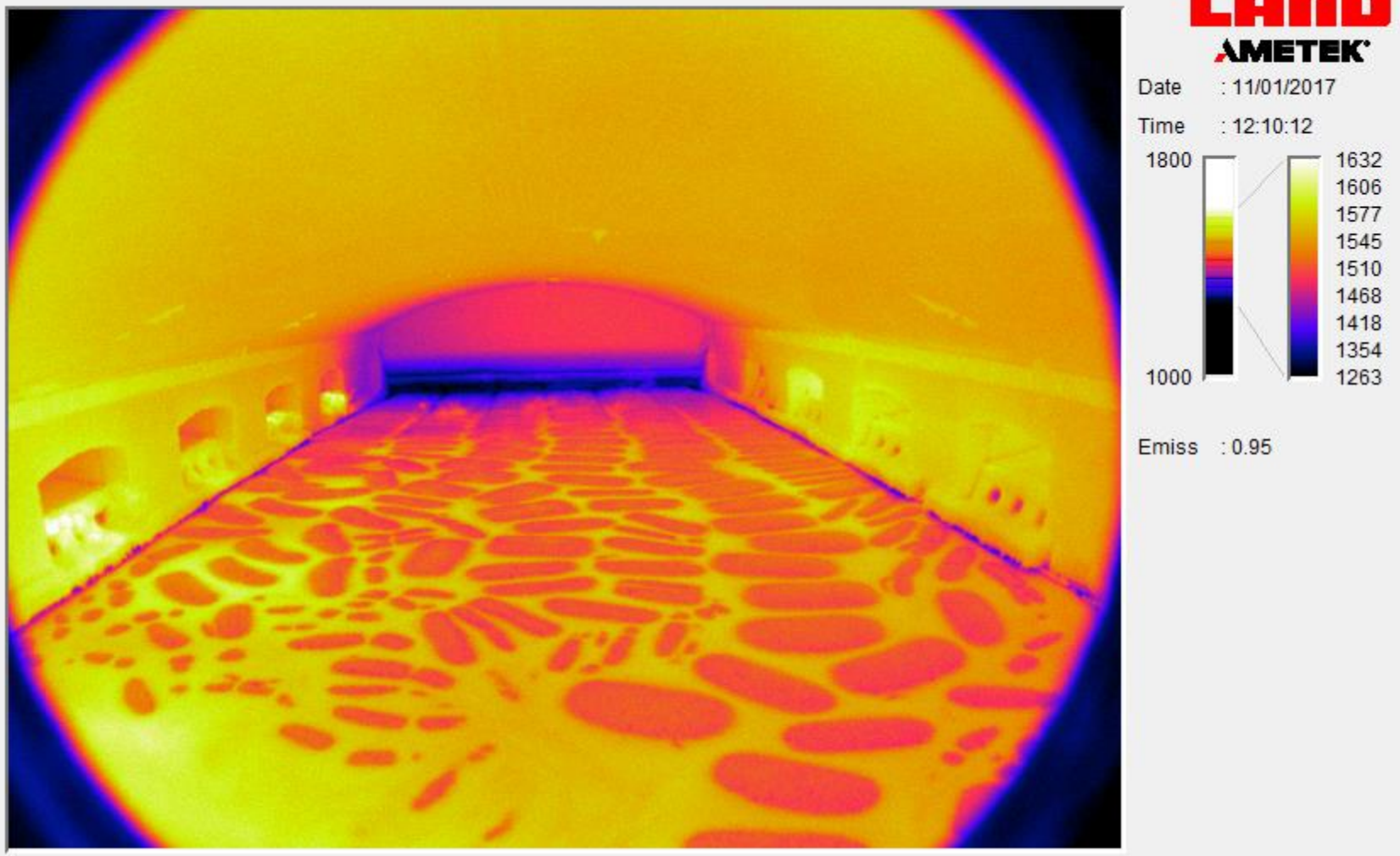
Flames optimisation with integration mode




AMETEK Land IMAGEPro (Administrator)
Configuration
Data
Views
Help
Glass Batch
Live Image Color
(1575,5°C) TcR
(1579°C) TcMiddle
(1573,4°C) TcL
T.profile Arch
T.Profile RHS
TargetWall RHS
TargetWall LHS
T.profile LHS
(1595,6°C) SideWall RHS
(1553,3°C) BH
(1570,2°C) SideWall LHS
GS Throat
Analysis
Data
Temperatures in °C
Max
Mean
Min
ε
Frame 1757,8 1533,2 1029 1,00
TcMiddle 1579 1562,6 1547,2 1,00
TcL 1573,4 1558,6 1542,7 1,00
TcR 1575,5 1561,8 1546,7 1,00
BH 1553,3 1532,8 1512,9 1,00
TargetWall 1466,1 1447,4 1433,2 1,00
TargetWall 1446,2 1428,4 1409,3 1,00
SideWall LH 1570,2 1543,3 1481,6 1,00
SideWall RH 1595,6 1568,5 1513,4 1,00
T.profile LH 1560,2 1536,7 1493,4 1,00
T.Profile RH 1569 1554,4 1520,9 1,00
GS Throat 1586,1 1556,1 1469,7 1,00
T.profile An 1554,6 1530,7 1503,6 1,00
ROI Editor
Palette
Zoom
100 %
Reset
Max: 1568°C
Min: 1493°C
SIM T.Profile RHS: 1561,8
SIM T.profile LHS: 1540,8
SIM T.profile Arch: 1537,2
Data Sources
Graph Display
All Data
Logged Data
14:50:00:0
14:55:00:0
15:00:00:0
15:05:00:0
0:00:00 , 0000 MB
0:01:00 , 9979 MB
SIM (NIR 2K) 127.0.0.1 62,0°C
ε: 1.00

Why to use NIR-B 2K on glass furnaces? Extended Benefits

- Possible Thermal Surveys with transportable NIR-B combining bundles Lancom 4 and Cyclops C100
  - Potential energy reduction with combustion optimization on every furnaces
  - Heat-up features at starting point with thermal references
  - Demonstration of recovery post repair with temporary oxy burners during repairs
  - Preventive maintenance
  - Needs to include this tool to best practices part of training sessions for optimisation
- Digitalisation with thermal distribution and bird eyes pictures
  - Potential to have data analysis for Expert System or SCADA through the furnace of the DCS (Zenon platform , Crowley Carbon or any data analysis solutions)
  - Existing communication with Expert system
  - Simple Batch control with Image pro Glass for basic analysis
  - Combustion and flames optimization for improved heat balance
- Traceability and Data for quality management
  - All furnaces images saved for future enquiries and reference points for quality controls
- Extended life of assets and improved daily furnace operations



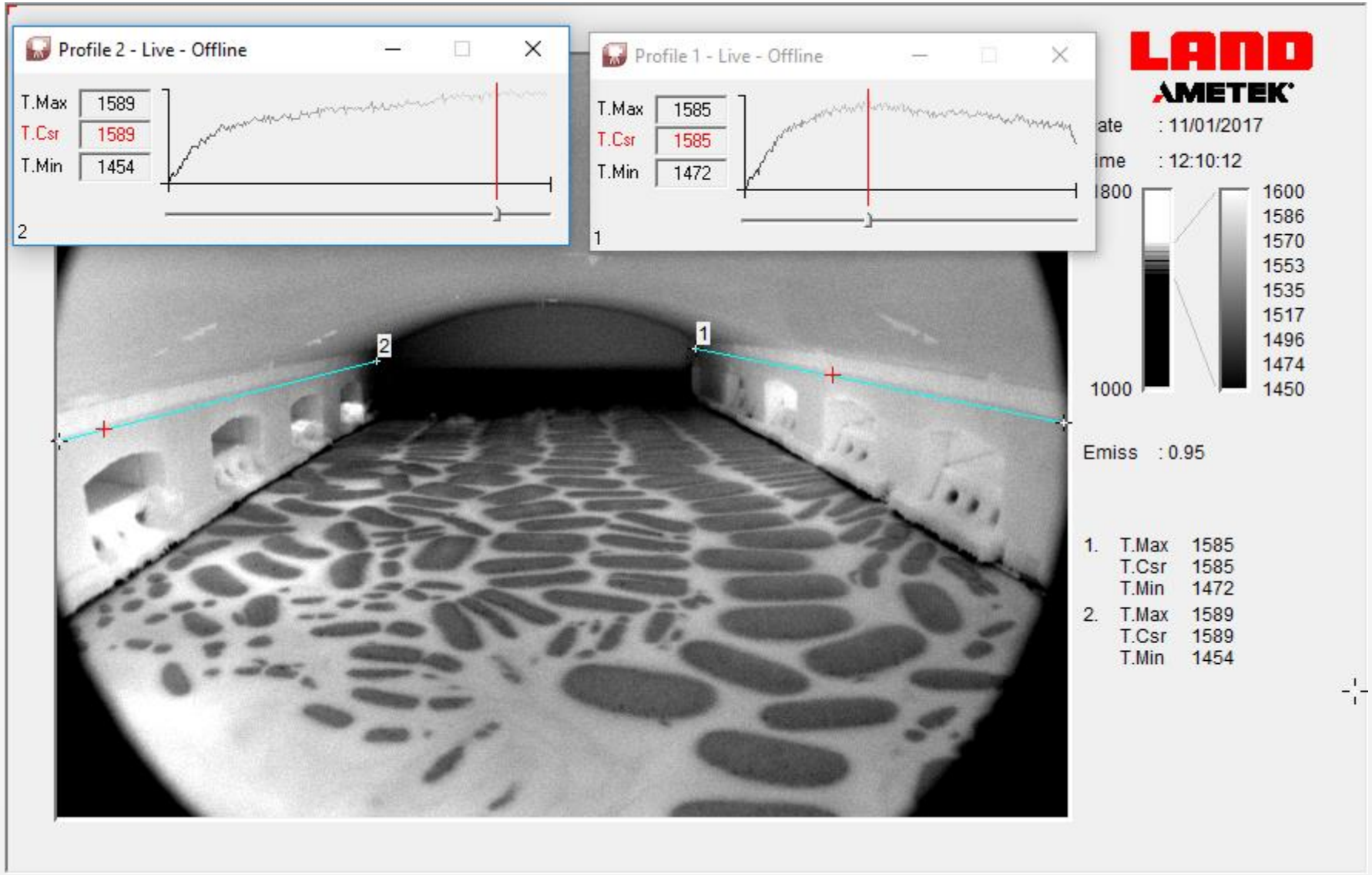
End Firing from Right to Left

4 Ports Clearly visible on firing side

3 Ports Clearly visible on exhaust side. Port 2 looks hot.

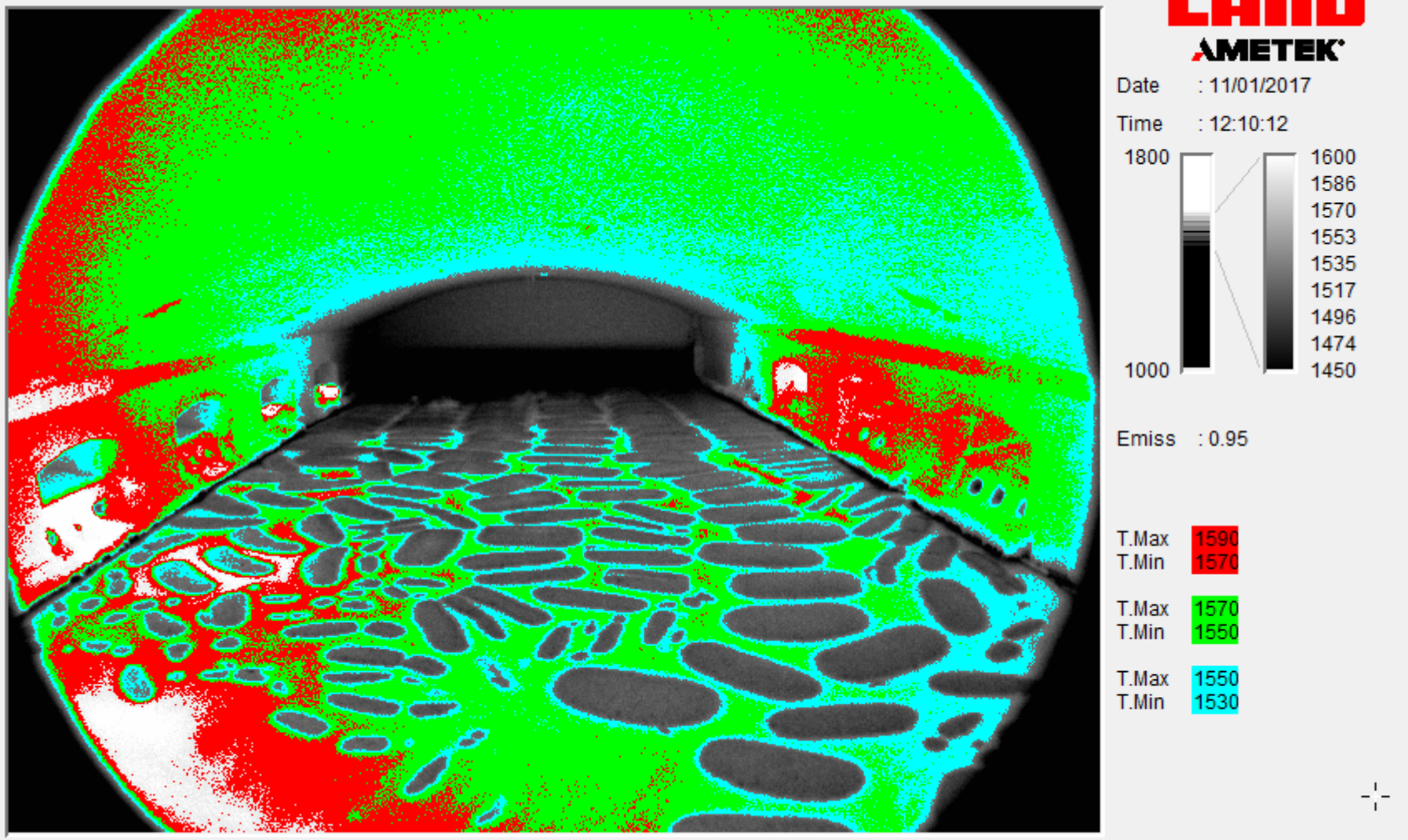
End Firing Right to Left

Temperature range band reduced to improve contrast and clarity of image.



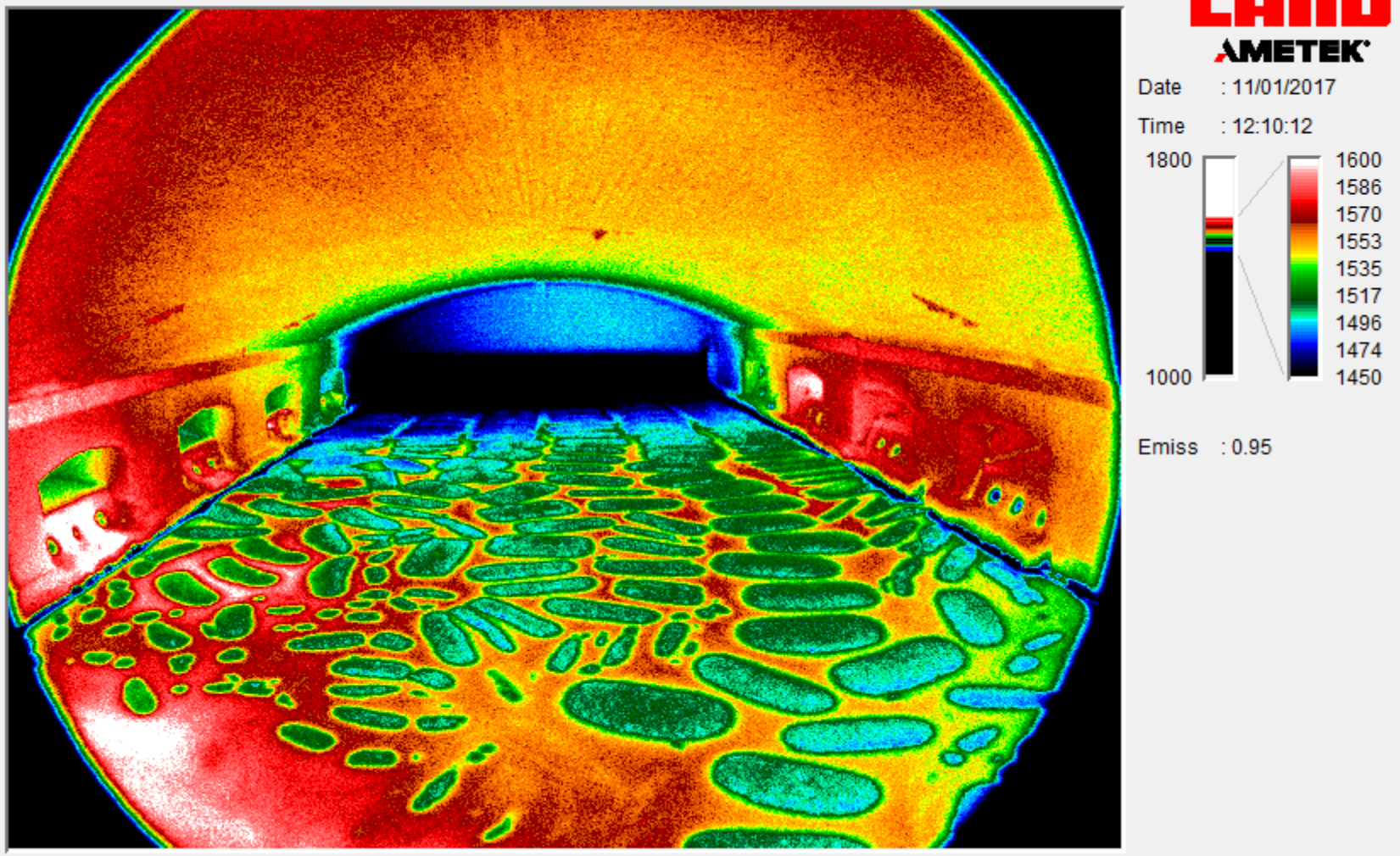
End Firing Right to Left

Profile is clearly skewed on the exhaust side.



End Firing Right to Left

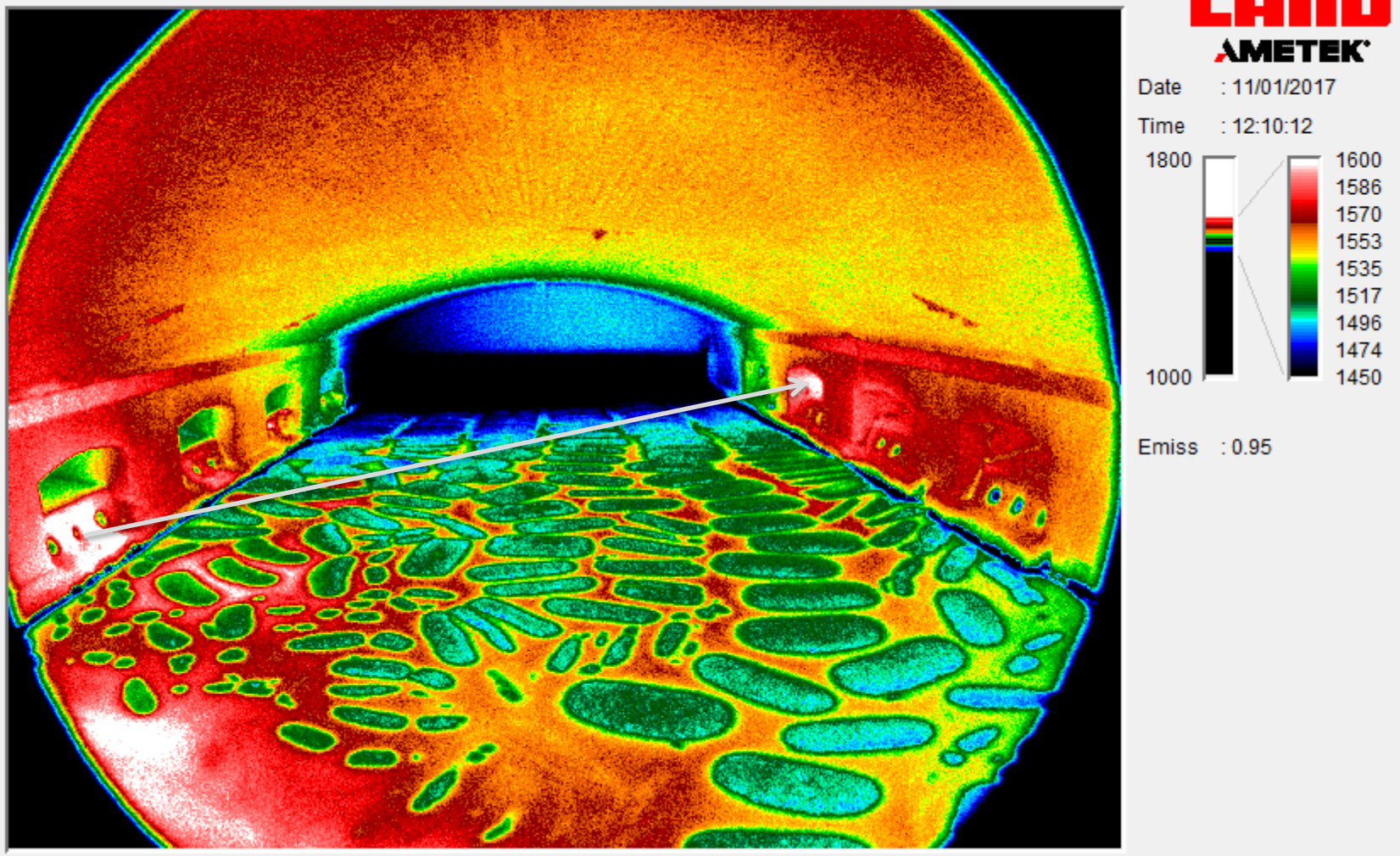
20 Degree Isotherms show the skewed profile



End Firing Right to Left

Palette 5 indicates the maximum contrast

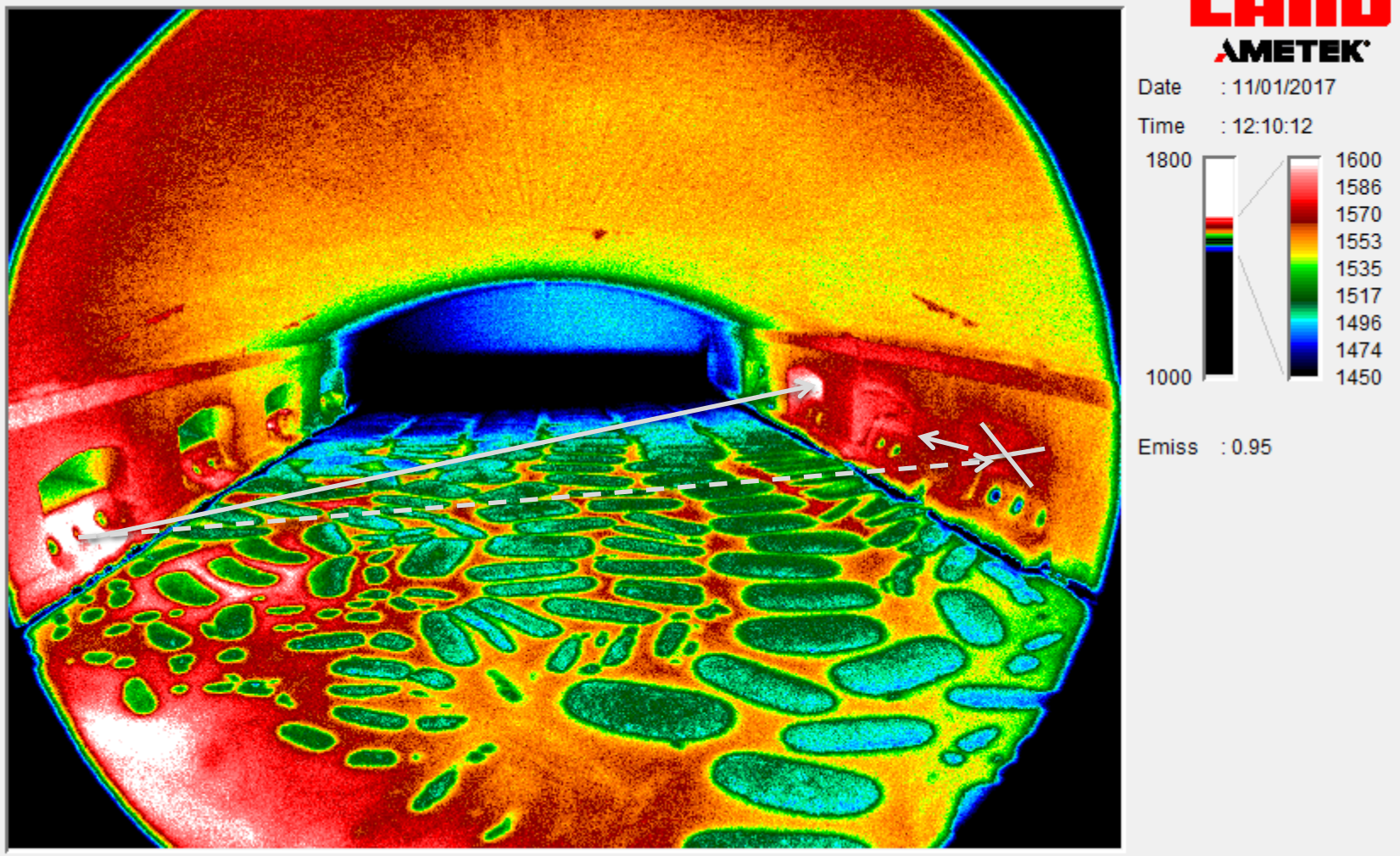
Port 4 on Firing side is hottest but Port 2 on the exhaust side is the hottest.



End Firing Right to Left

Palette 5 indicates the maximum contrast

Port 4 on Firing side is hottest but Port 2 on the exhaust side is the hottest.

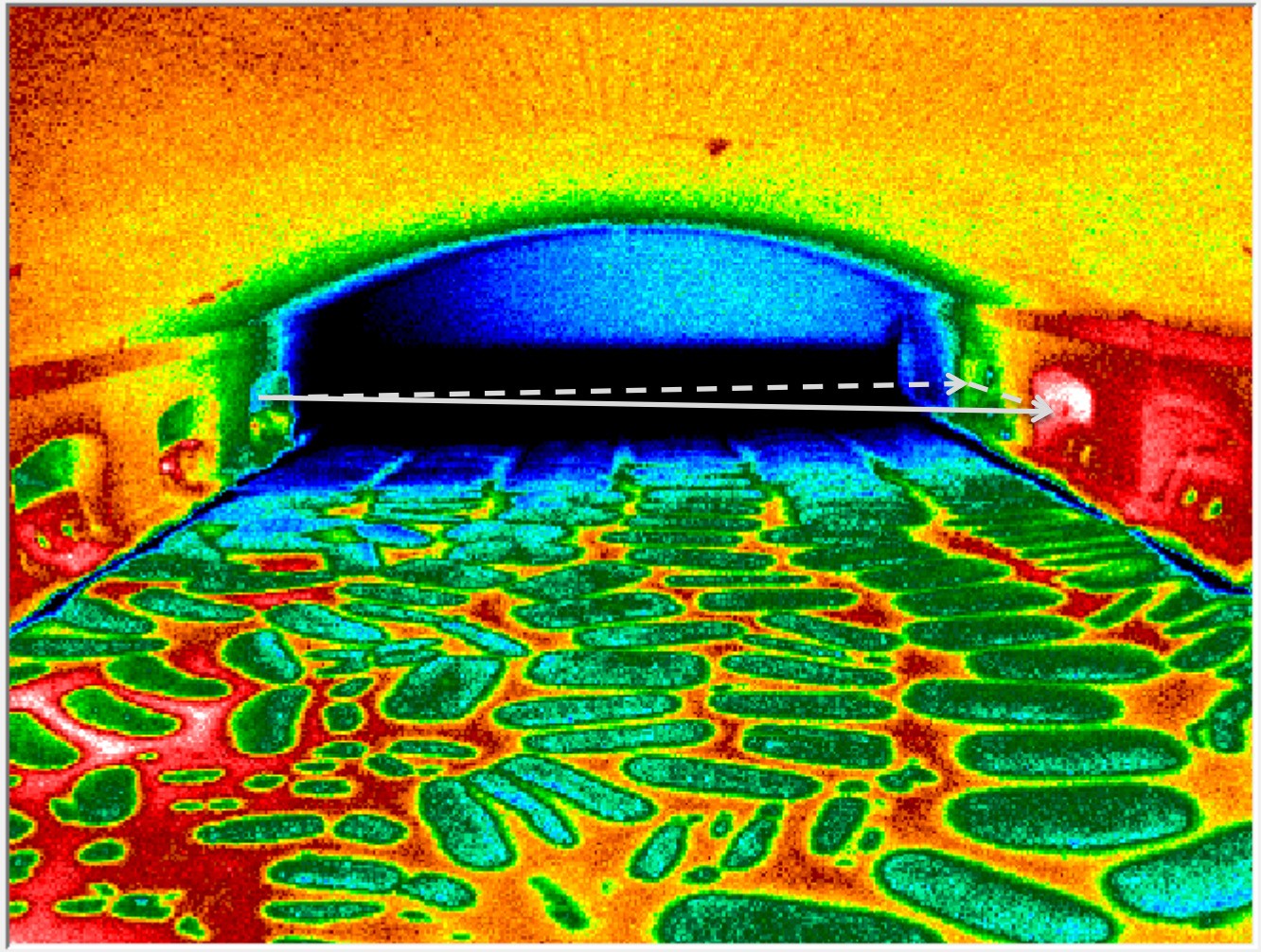


End Firing Right to Left

Palette 5 indicates the maximum contrast

Port 4 on Firing side is hottest but Port 2 on the exhaust side is the hottest.

The reality is that Port 4 on the LHS is partially blocked and flue gases are heading to Port 3.



End Firing Right to Left

Palette 5 indicates the maximum contrast

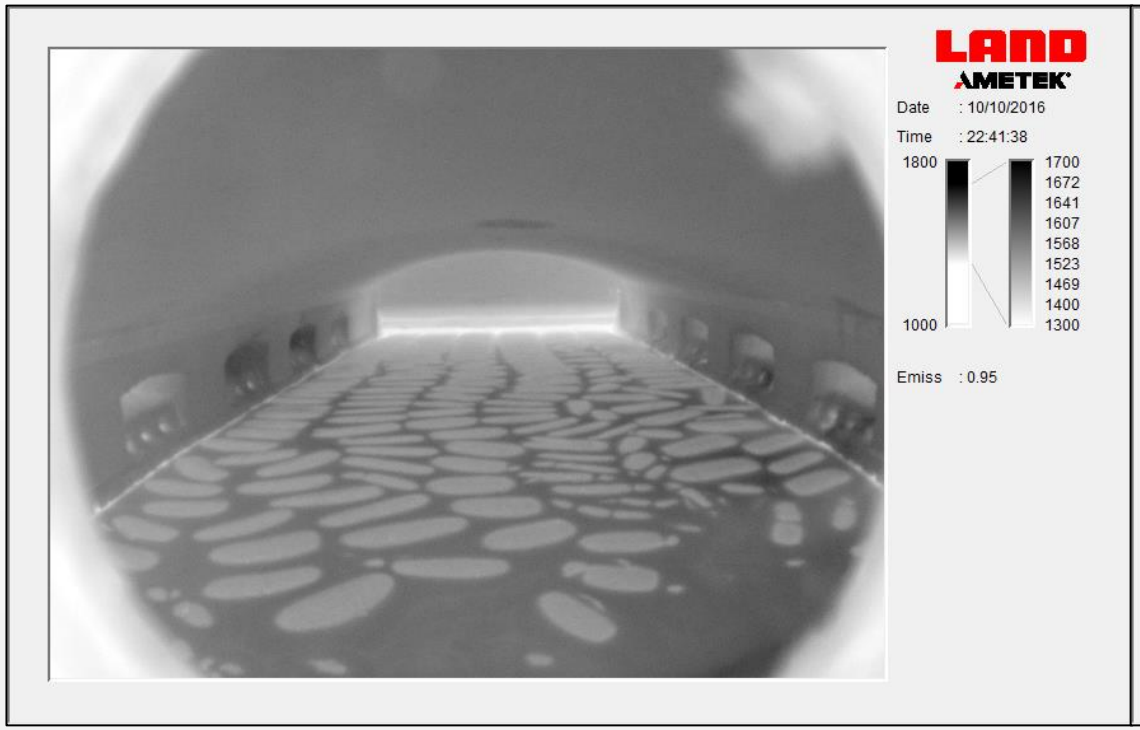
Port 4 on Firing side is hottest but Port 2 on the exhaust side is the hottest.

The reality is that Port 4 on the LHS is partially blocked and flue gases are heading to Port 3.

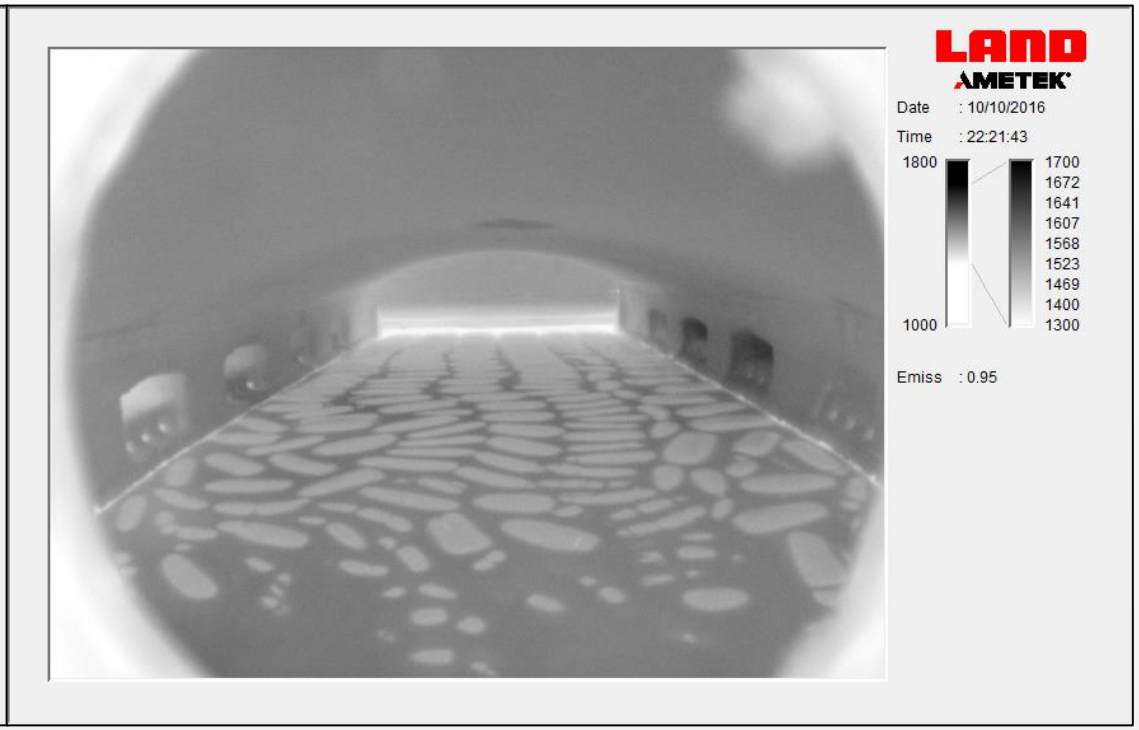
The reason port 2 is the hottest s because Port 1 is also partially blocked!

Negative Image Showing Cooling (10/10/2016)

End of Firing Left to Right

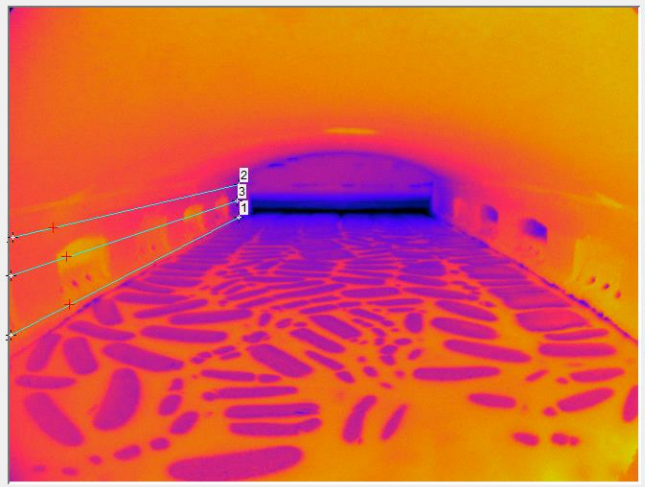


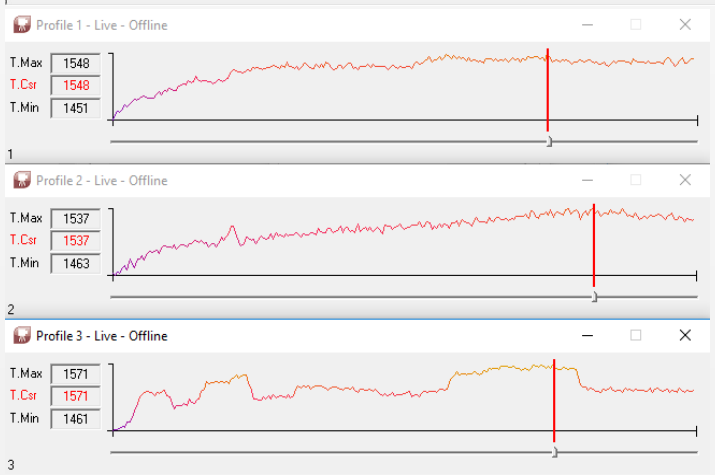
End of Firing Right to Left



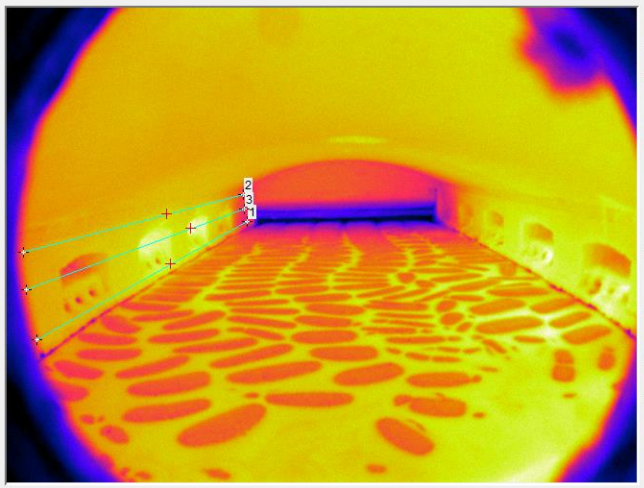
End of Firing L-R

01/09/14

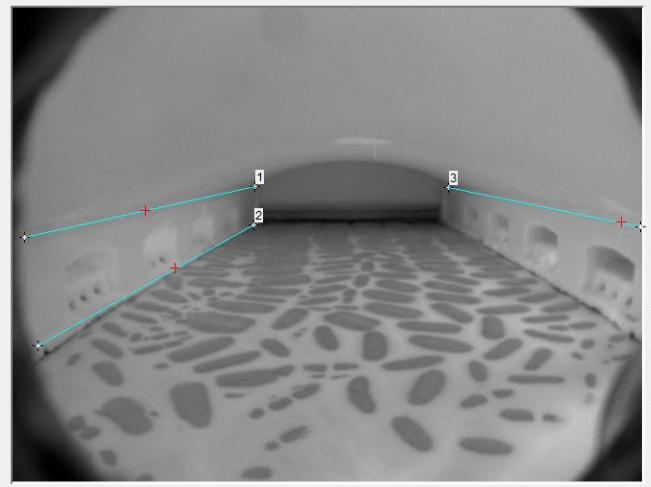


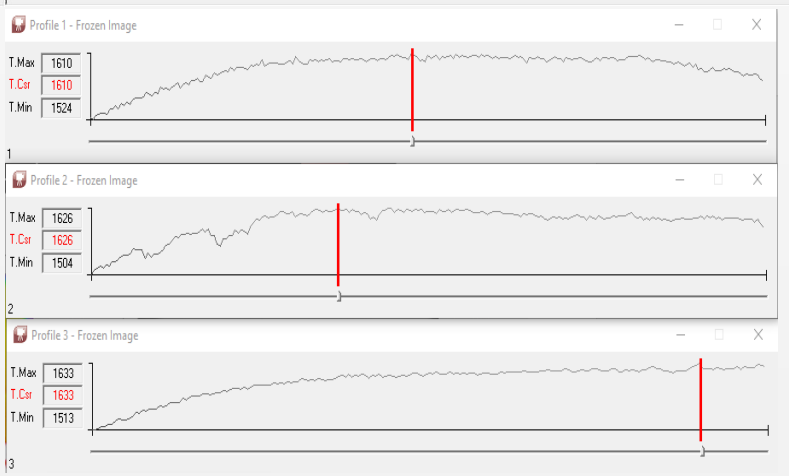


10/10/16



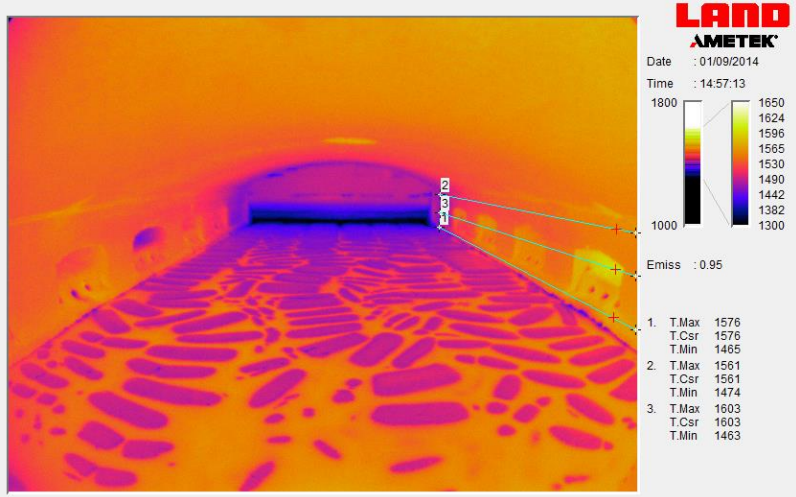
15/03/17

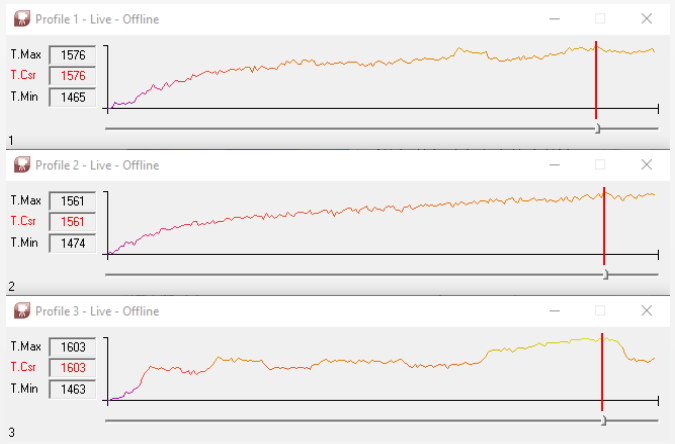




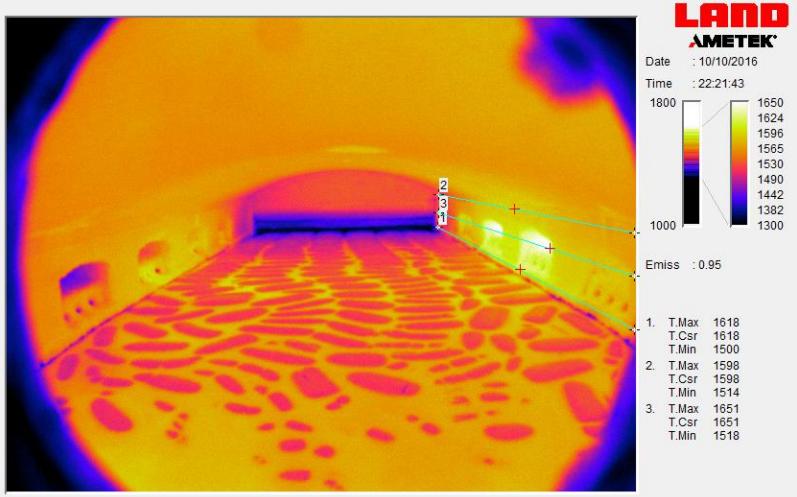
End of Firing R-L

01/09/14

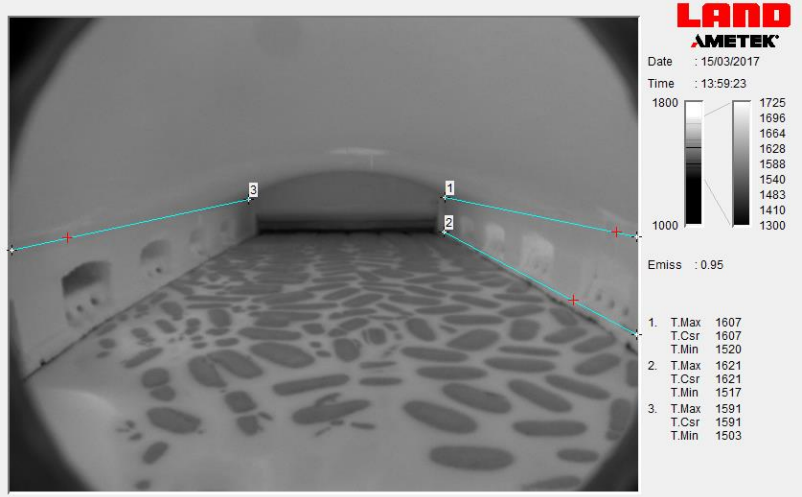


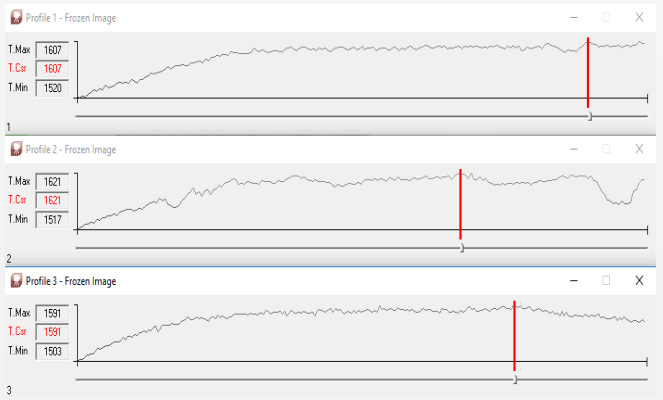


10/10/16



15/03/17

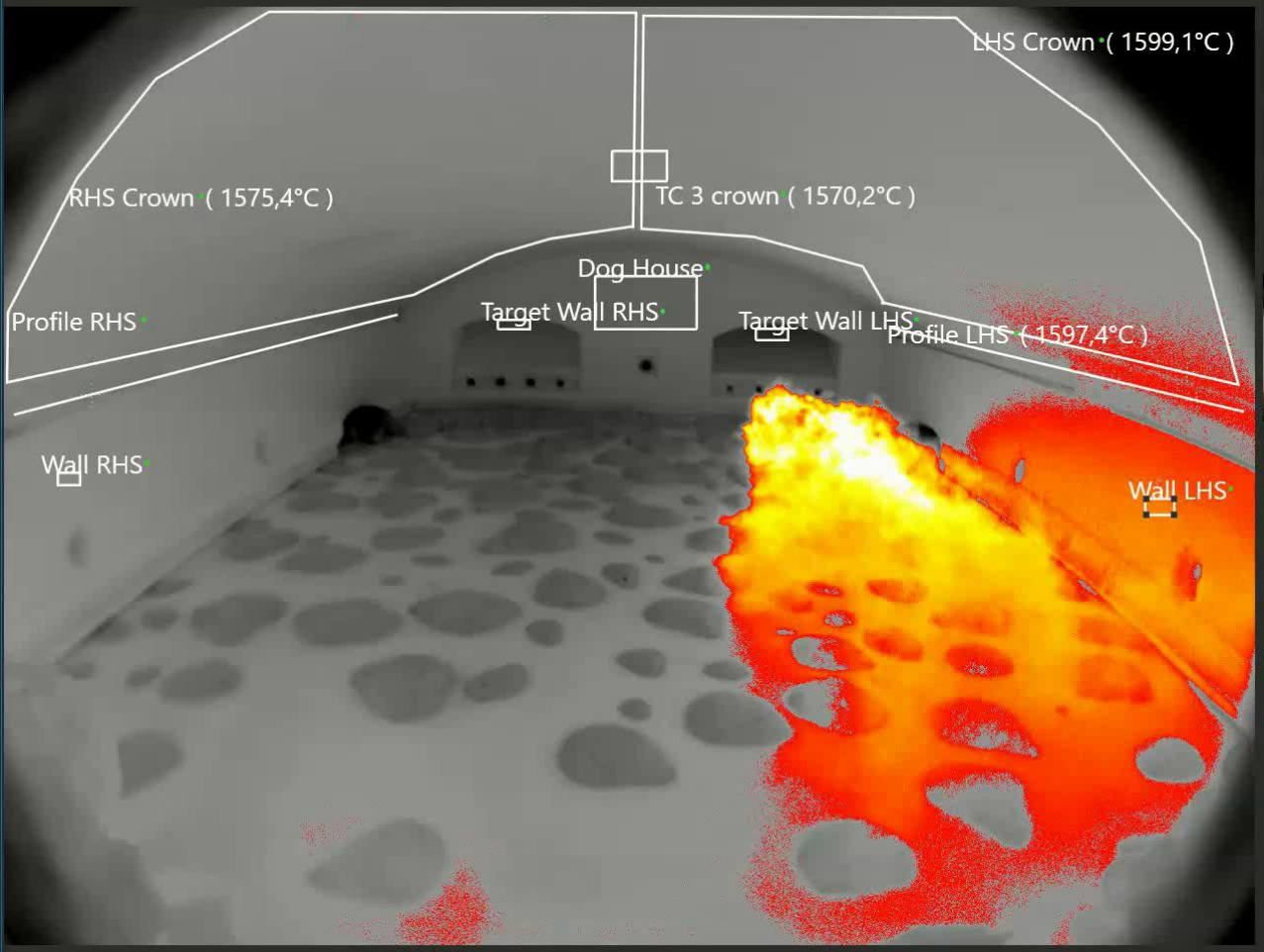




AMETEK Land IMAGEPro (Administrator)

Configuration Data Views Help

SIM Live Image



ROI Editor

Zoom 100 % Reset

Palette 1700 1585 1400

0:00:00 , 0000 MB 0:01:00 , 0332 MB

SIM (NIR 2K) 127.0.0.1 ε: 1.00

X: Y: T:

Noir1Blanc V1

SIM (NIR 2K) 127.

SIM (NIR 2K) 1

Glass batch SIM

Live Analysis

Batch Display

Batch Overlay Visible

Matrix Settings

Batch Matrix Visible

Batch Percent Visible

Max Temperature Visible

Mean Temperature Hidden

Min Temperature Hidden

Text Color A

Left Reversal Analysis

14/09/2022 13:58

Right Reversal Analysis

14/09/2022 14:09

12:00:00:0 14:00:00:0

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