Beyond the Visible: Industry 3.91 AFGM 2019 - Cebu (In-Furnace Near IR Borescope)

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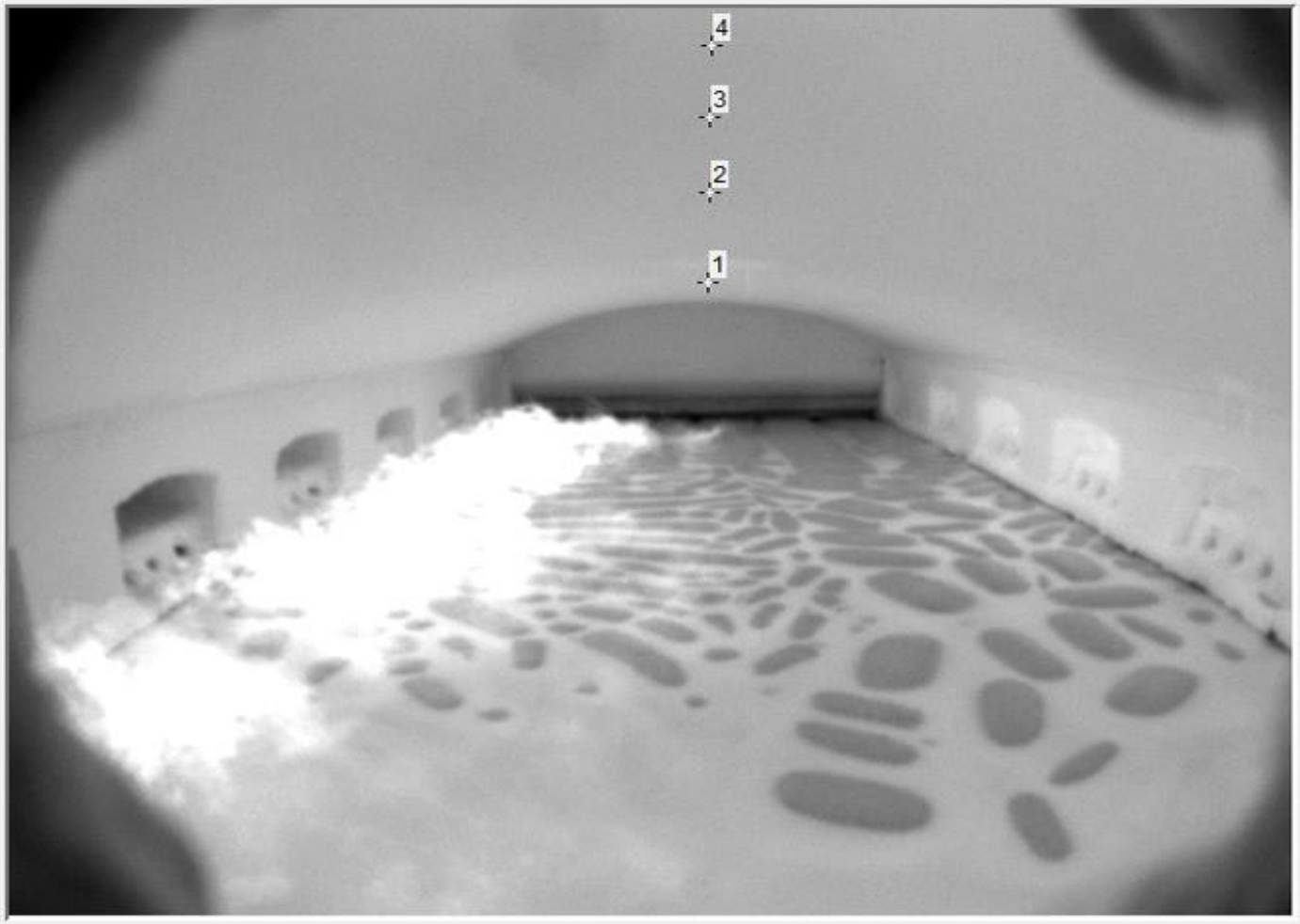
QUALITY CUSTOMER SOLUTIONS

Contents

- Background 2017 GPC summary Cross-Fired Furnace Thermal profile and NOx
- Overview of Equipment Used
  - Need for true temperature measurement at all points
- Original background to end fired project
- Phase 1 Initial 3hr survey
- Equipment rental for extended use
- Thermal and NOx optimisation by customer alone
- Lessons learned and potential for
  - automatic reversal control – reduce energy & emissions
  - Alarm on hot spot deviation and correction
  - Alarm on <1388 NaOH condensation

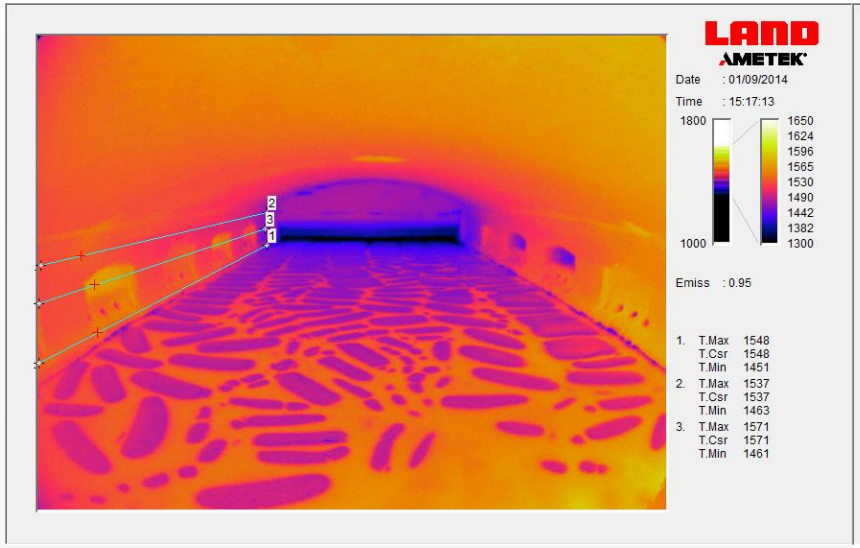
Mark Bennett – AMETEK Land + Neil Simpson – Simpson Combustion and Energy

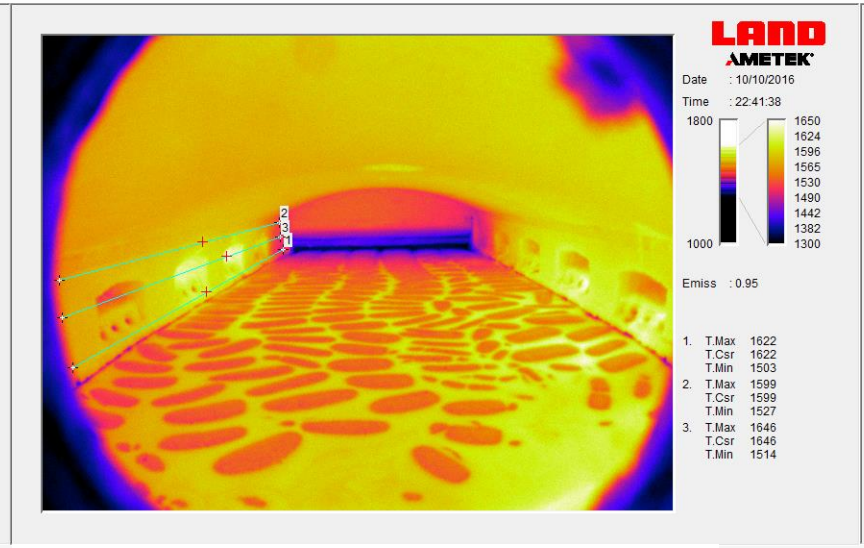
VIDEO of Continuous Temperature Measurement – Thermocouple Verification

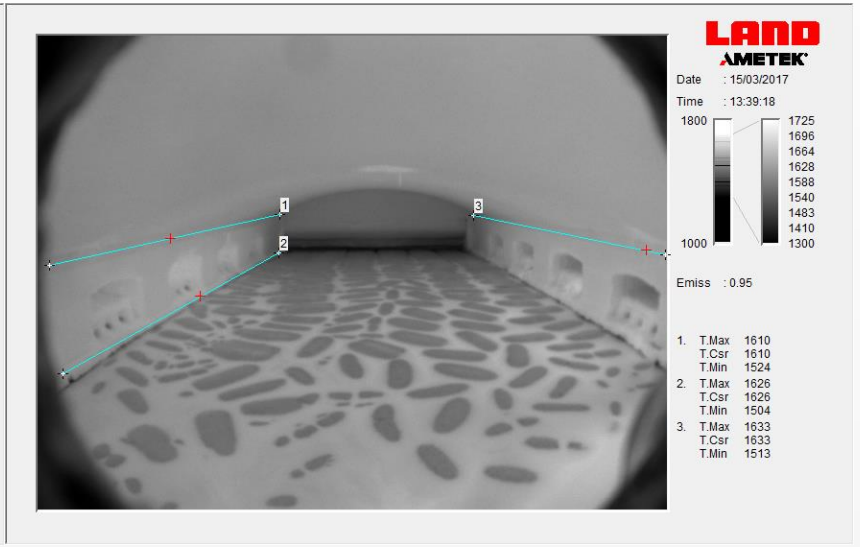


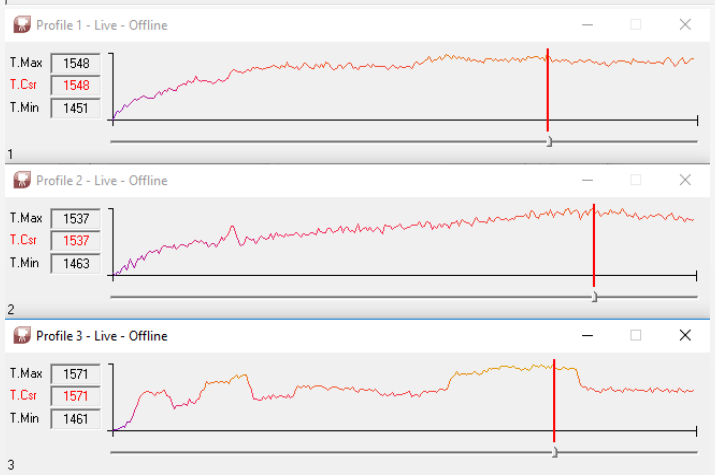
End of Firing L-R

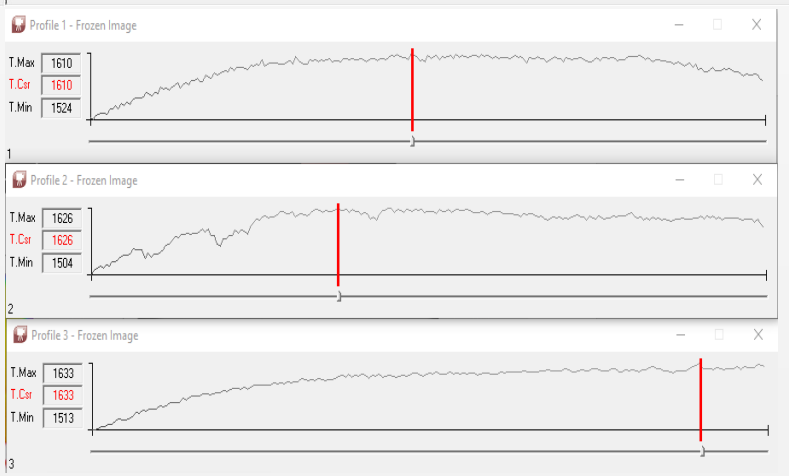
01/09/14	10/10/16	15/03/17





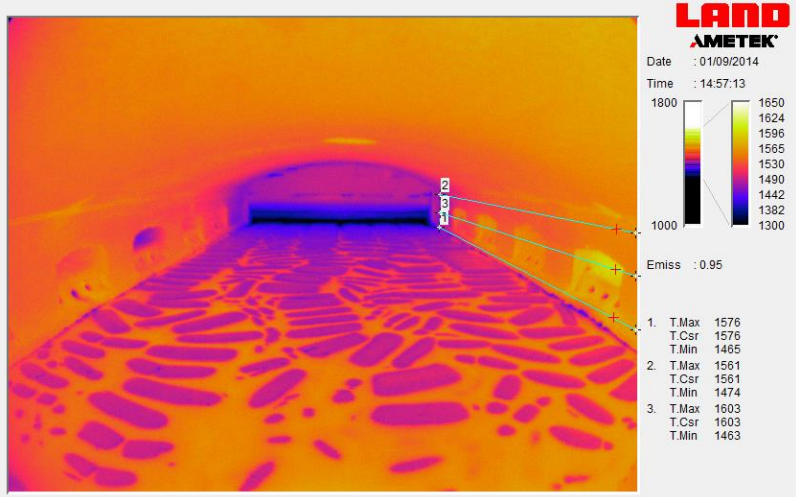


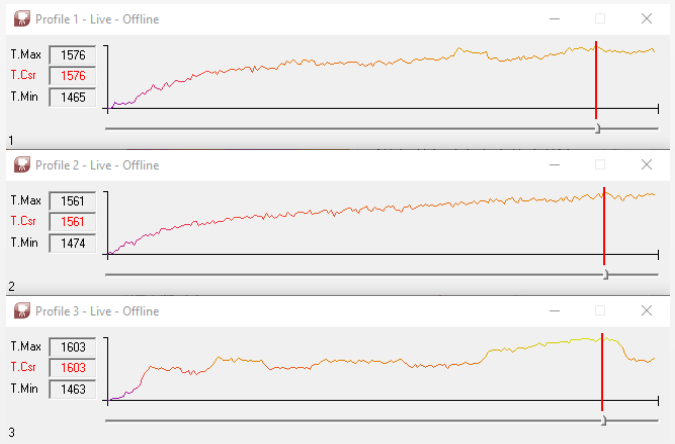




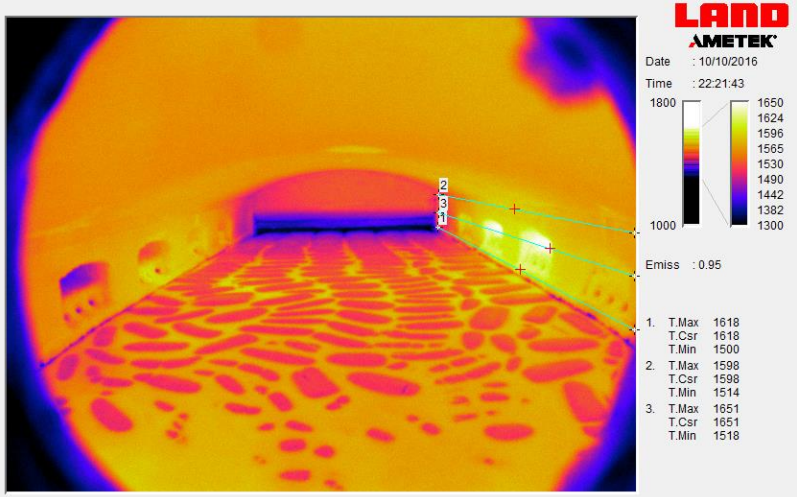
End of Firing R-L

01/09/14

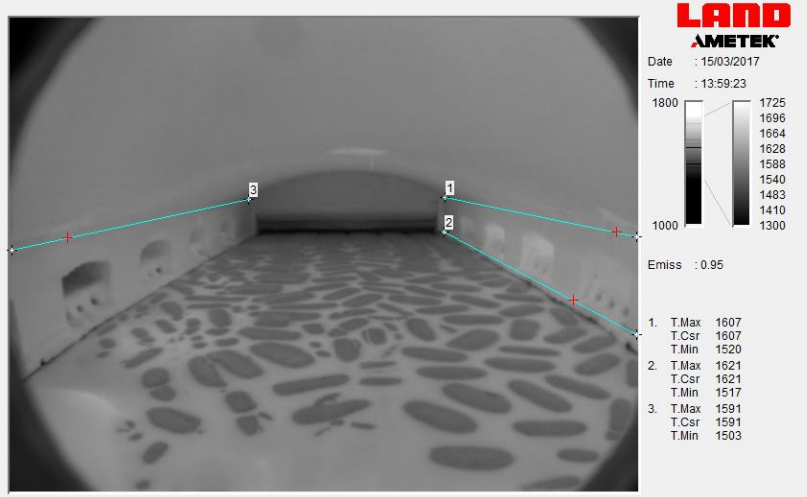


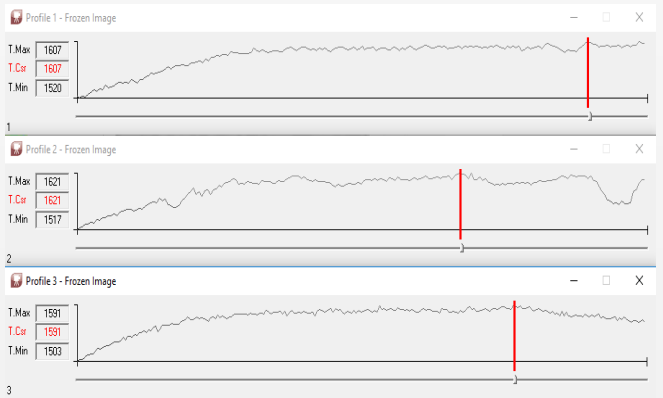


10/10/16



15/03/17





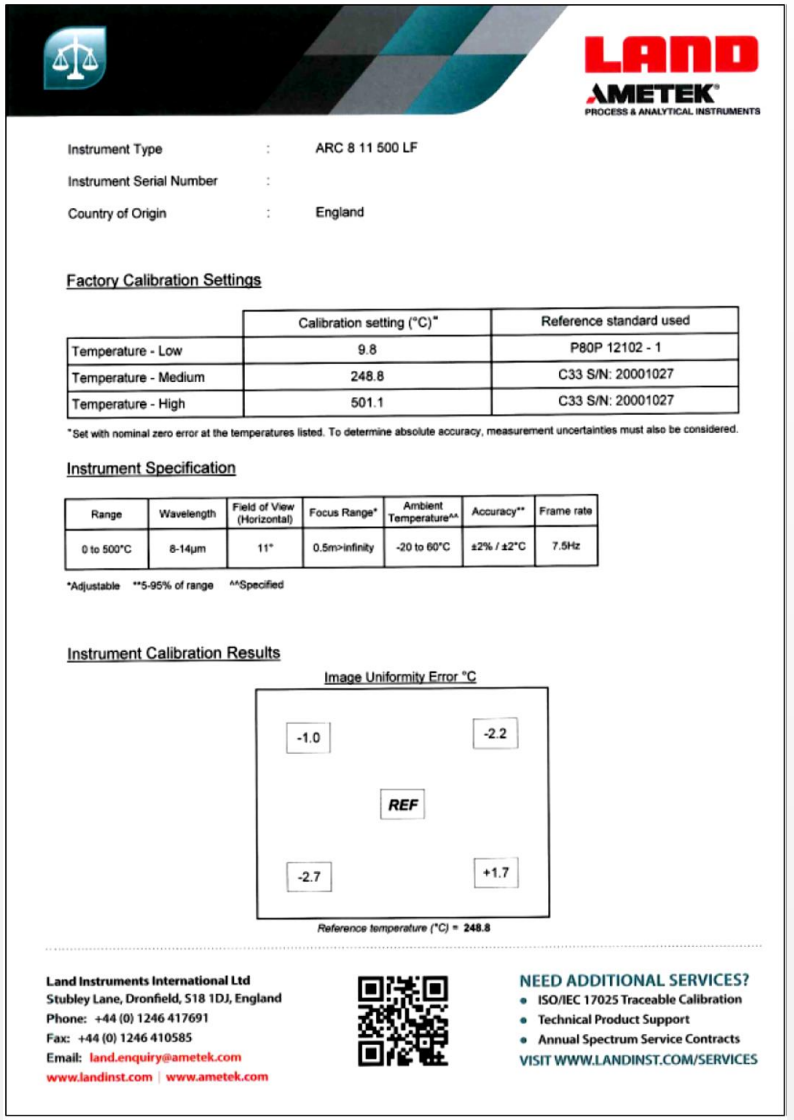
Conclusions from GPC 78th paper

- Operations -Temperature thermal profile
  - Potential energy reduction, pull or yield increase on unrestricted furnace
  - Demonstration of recovery post repair
- Emissions - Flame Intensity and NOx correlation
  - Potential to use as part of NOx/NH3 reduction
- Maintenance – Furnace Sealing
  - Energy and emission reduction with asset protection
- Asset Protection
  - Over and under temperature alarms
  - Identify regenerator restrictions before blockage/deterioration
  - NaOH condensation
  - Preventative maintenance on weak/thin refractory

Thermal Imagers That Accurately Measure Temperatures

- There are two common types of thermal imagers:
  1. Those which produce a thermal image of a scene as a picture or video – known as Non-Radiometric Thermal Imagers. These are commonly used to detect the presence of something hot or cold in a scene like a deer at the side of a road, an intruder or the presence of a hot area somewhere on an object.
  2. Those which produce a thermal image of a scene as a picture or video and accurately measure temperatures anywhere within that thermal scene – known as Radiometric Thermal Imagers. These are commonly used for automation, process control or quality verification.
- Many imagers which are described as Radiometric are only calibrated at one central point in the thermal image and make assumptions about temperature measurement accuracy elsewhere in the scene. It might be argued that one accurate point in the scene makes a thermal imager Radiometric, that isn't what most customers expect.
- When using for control accuracy is required so there is a need test Radiometric Thermal Imagers to verify and document that they accurately measure temperatures across the entire scene.

- NIR-B GLASS thermal imagers are calibrated against blackbody standards over the whole image, not just the central area.
- The Certificate of Conformity shows centre accuracy plus the four corners of the scene.
- Calibration in accordance with ISO 9001:2008 and calibrated against national and international standards.
- Calibration to ISO / IEC 17025:2005 standard.



LAND AMETEK PROCESS & ANALYTICAL INSTRUMENTS

Instrument Type : ARC 8 11 500 LF
Instrument Serial Number :
Country of Origin : England

Factory Calibration Settings

	Calibration setting (°C)*	Reference standard used
Temperature - Low	9.8	P80P 12102 - 1
Temperature - Medium	248.8	C33 S/N: 20001027
Temperature - High	501.1	C33 S/N: 20001027

*Set with nominal zero error at the temperatures listed. To determine absolute accuracy, measurement uncertainties must also be considered.

Instrument Specification

Range	Wavelength	Field of View (Horizontal)	Focus Range*	Ambient Temperature^^	Accuracy**	Frame rate
0 to 500°C	8-14µm	11°	0.5m>infinity	-20 to 60°C	±2% / ±2°C	7.5Hz

*Adjustable **5-95% of range ^^Specified

Instrument Calibration Results

Image Uniformity Error °C

-1.0 -2.2 REF -2.7 +1.7

Reference temperature (°C) = 248.8

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NEED ADDITIONAL SERVICES?
- ISO/IEC 17025 Traceable Calibration
- Technical Product Support
- Annual Spectrum Service Contracts

VISIT WWW.LANDINST.COM/SERVICES

Certification Service Coverage

National Accreditation			AMETEK Land Instrumentation		Other Manufacturer's Instrumentation
			Infrared Pyrometers, Thermometers, Thermal Imagers and Scanners	Blackbody Sources	
	United Kingdom	UKAS (United Kingdom Accreditation Service)**	✔ -10 °C to 2500 °C 14 °F to 4532 °F	✔ -10 °C to 1600 °C 14 °F to 2912 °F	✔
	United States	ANAB (ANSI-ASQ National Accreditation Board)	✔ 0 °C to 2300 °C 32 °F to 4172 °F	✔ -10 °C to 1600 °C 32 °F to 2912 °F	✔
Certificate No. CC-2041	India	NABL (National Accreditation Board for Testing and Calibration Laboratories	✔ 0 °C to 1600 °C 32 °F to 2912 °F	✘	✔

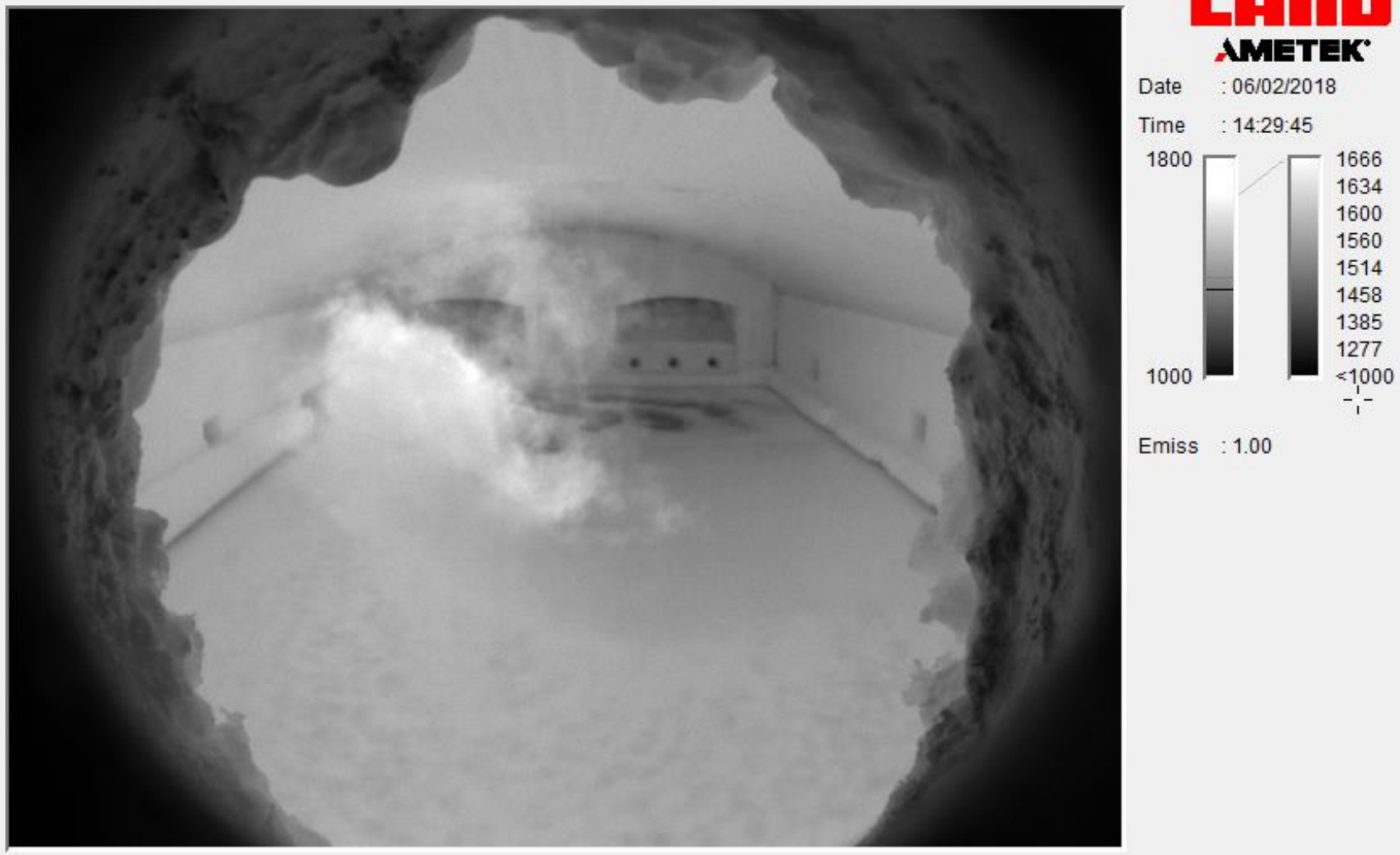
***Note: With agreements through the European Cooperation for Accreditation (EA), International Laboratory Accreditation Cooperation (ILCA) and International Accreditation Forum (IAF) - UKAS has recognition in over 90 countries worldwide.*

Background to Project

- In early 2018 EU customer with a medium through-put and traditional furnace design had a recent NOx issue and approached Neil Simpson to investigate options to reduce.
- Several staging options were discussed with decision to focus on baseline and optimisation of existing equipment.
- Part of suggested solution was to use the Ametek Land NIR b to establish possible sources.
- On 6th Feb a 3 hour demonstration was performed.
- The following data was obtained for NOx and thermal conditions.

Using as a CCTV Standard Batch Line/Movement

B & W Mode 1 Auto Range



Good initial image

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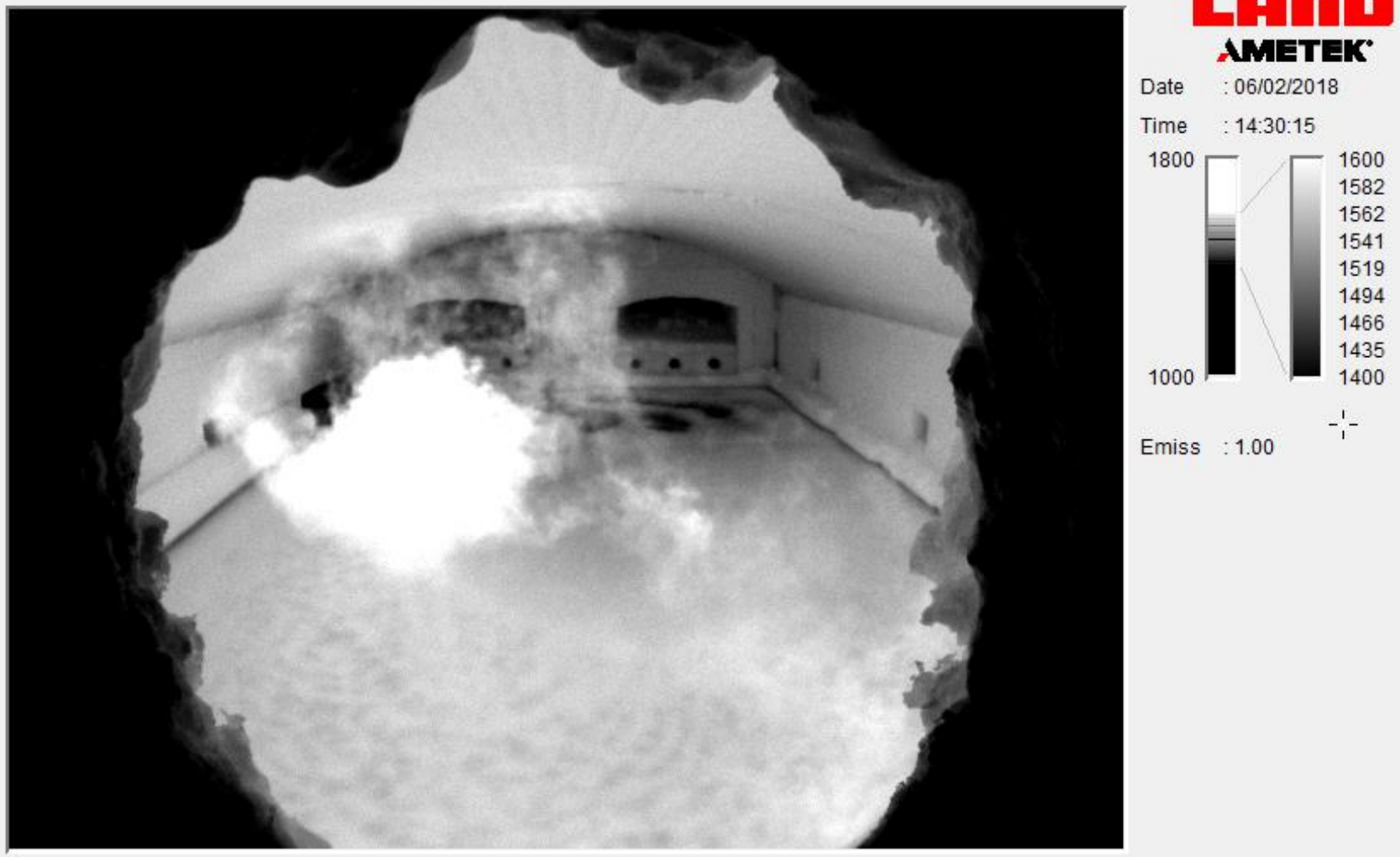
B & W Mode 1 Man 1400-1600 Range



Lowering the temperature range increase contrast for batch monitoring

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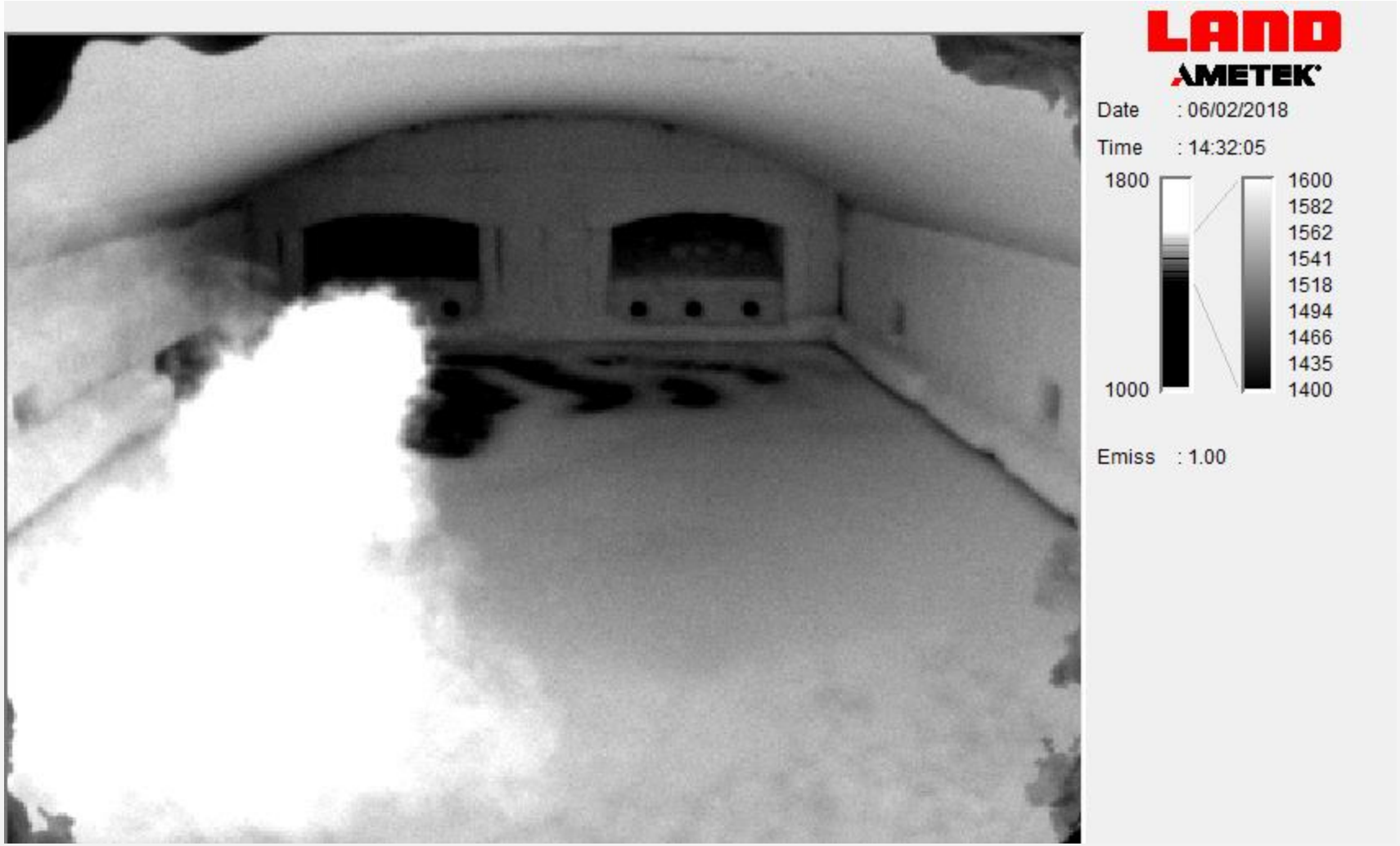

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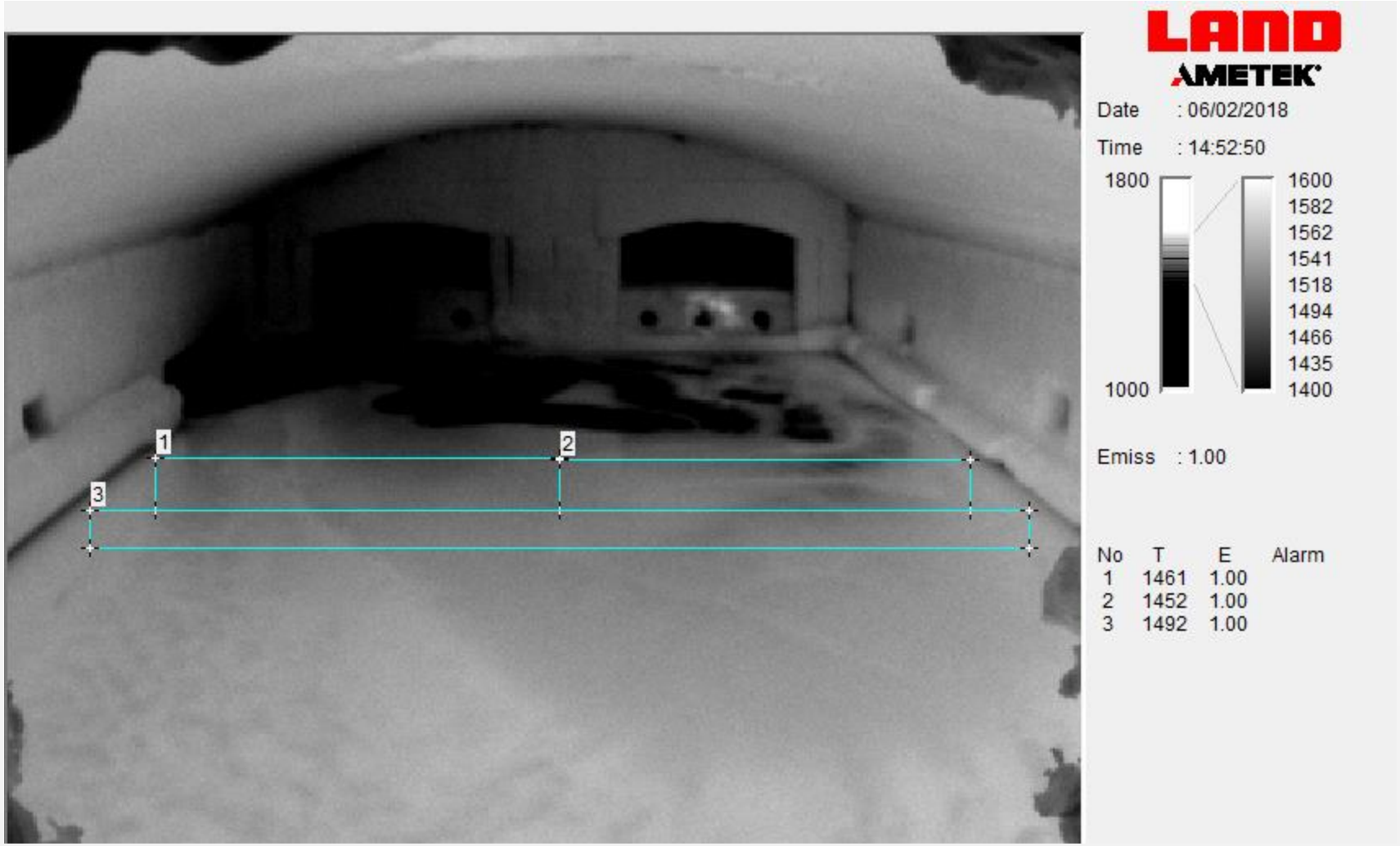

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Reversal – End Firing R-L

Normal view batch line, foam line and front surface

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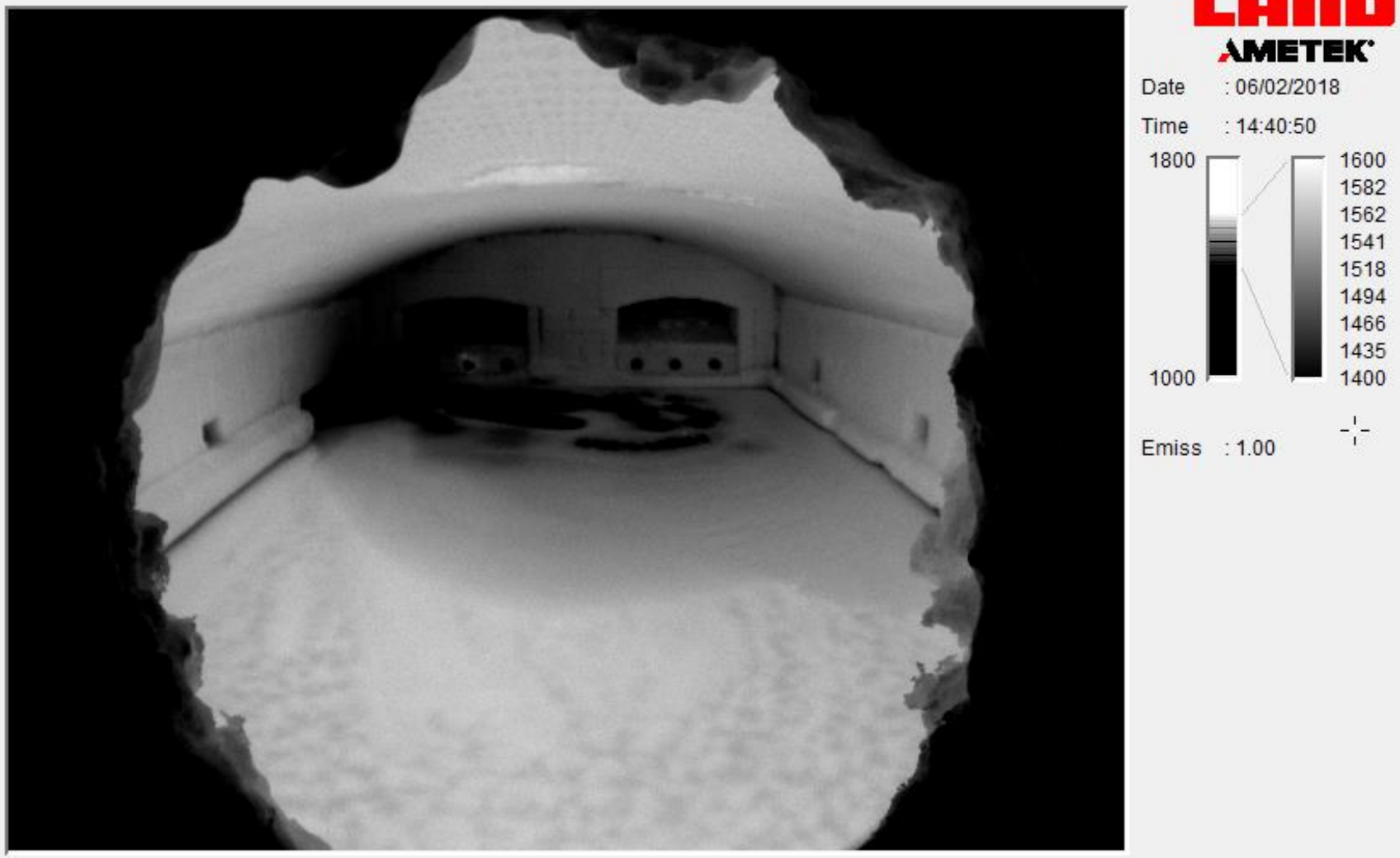
B & W Mode 1 Man 1400-1600 Range



Increase contrast to highlight phase transition lines.

Mark Bennett – AMETEK Land + Neil Simpson – Simpson Combustion and Energy

1.5* B&W1 Man 1400-1600 Range

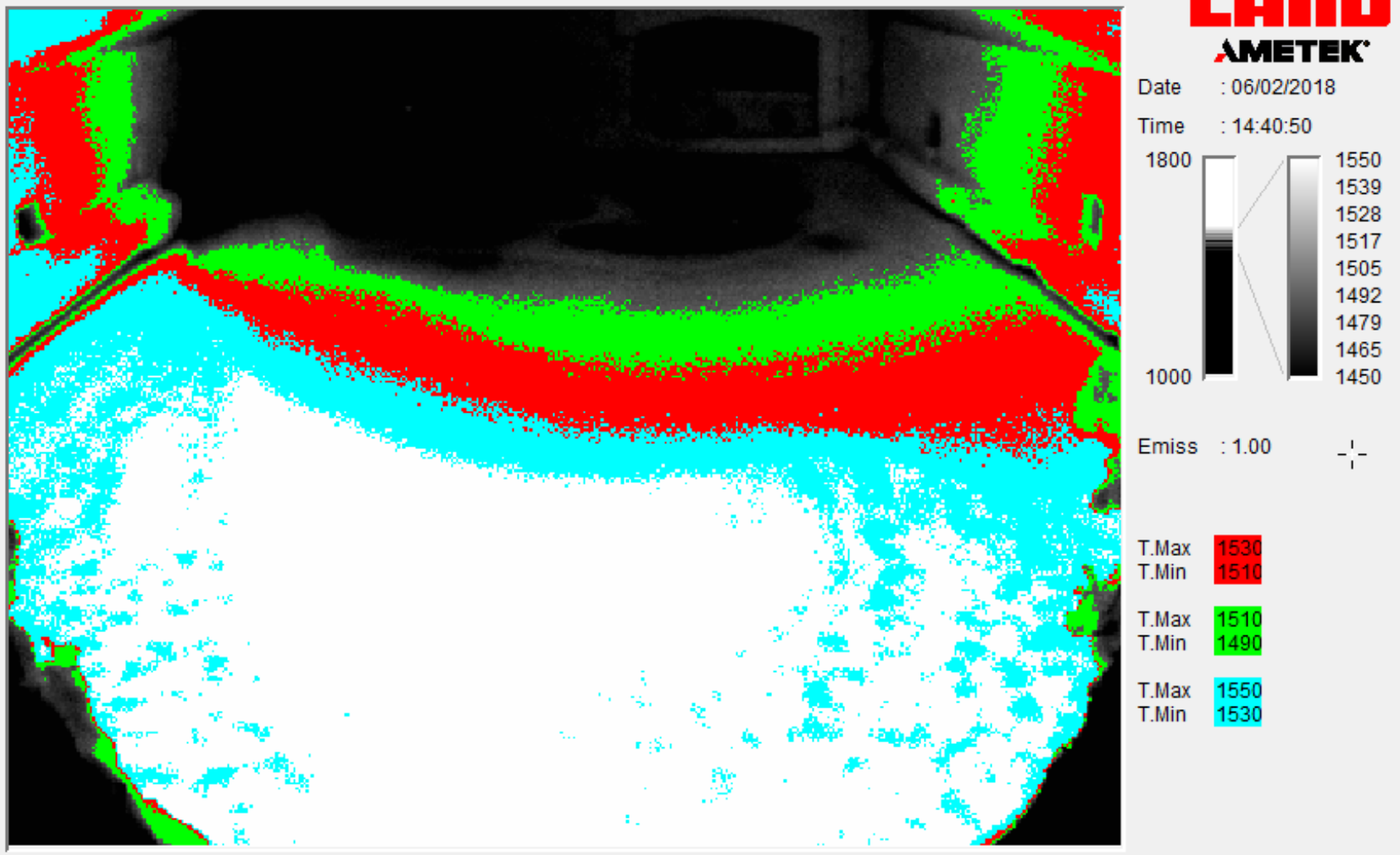
Zoom in to see ripple lines.

Mark Bennett – AMETEK Land + Neil Simpson – Simpson Combustion and Energy

1.5* B&W1 Man 1450-1550 Range

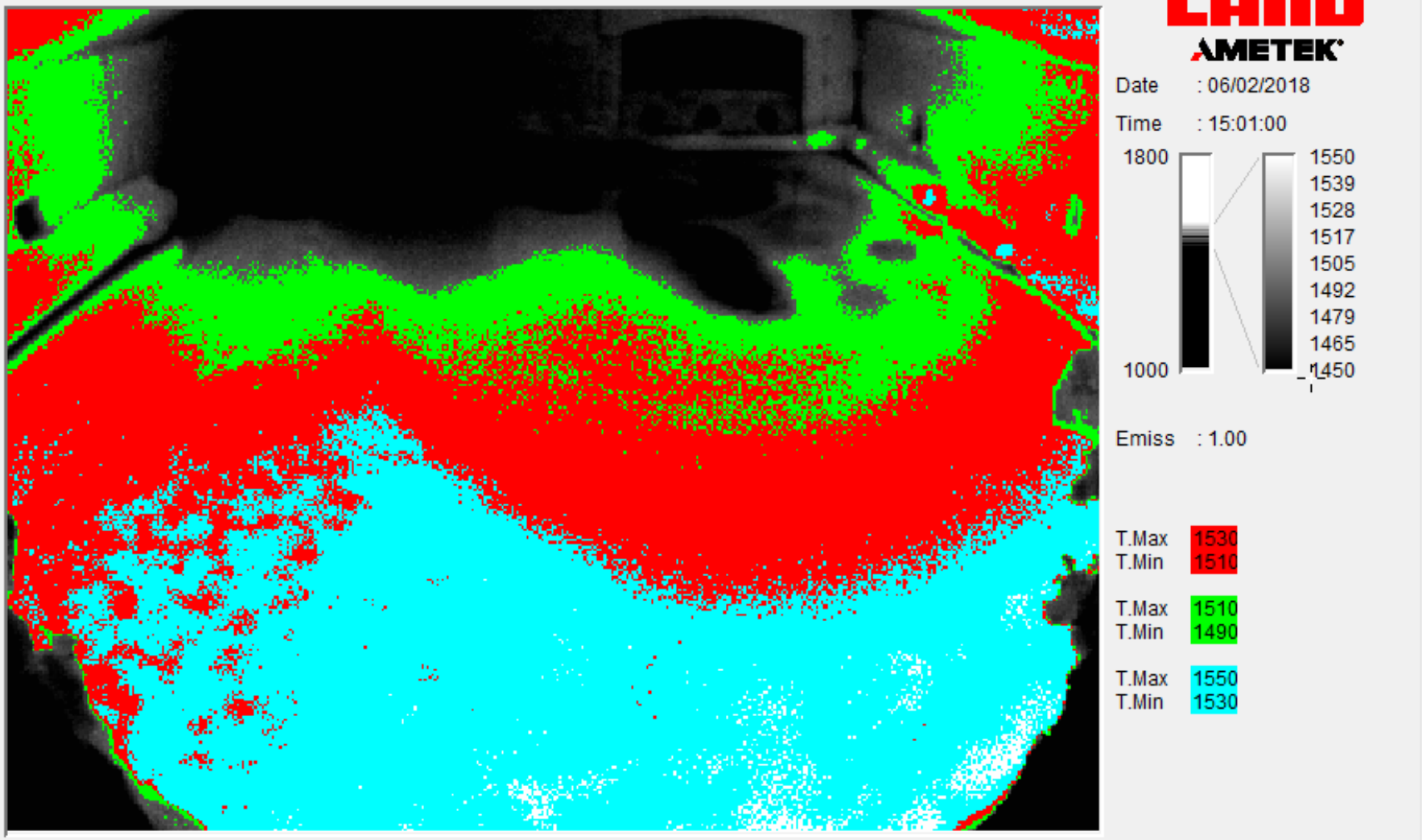
Increase contrast on front melt.

With 20 Degree Isotherms



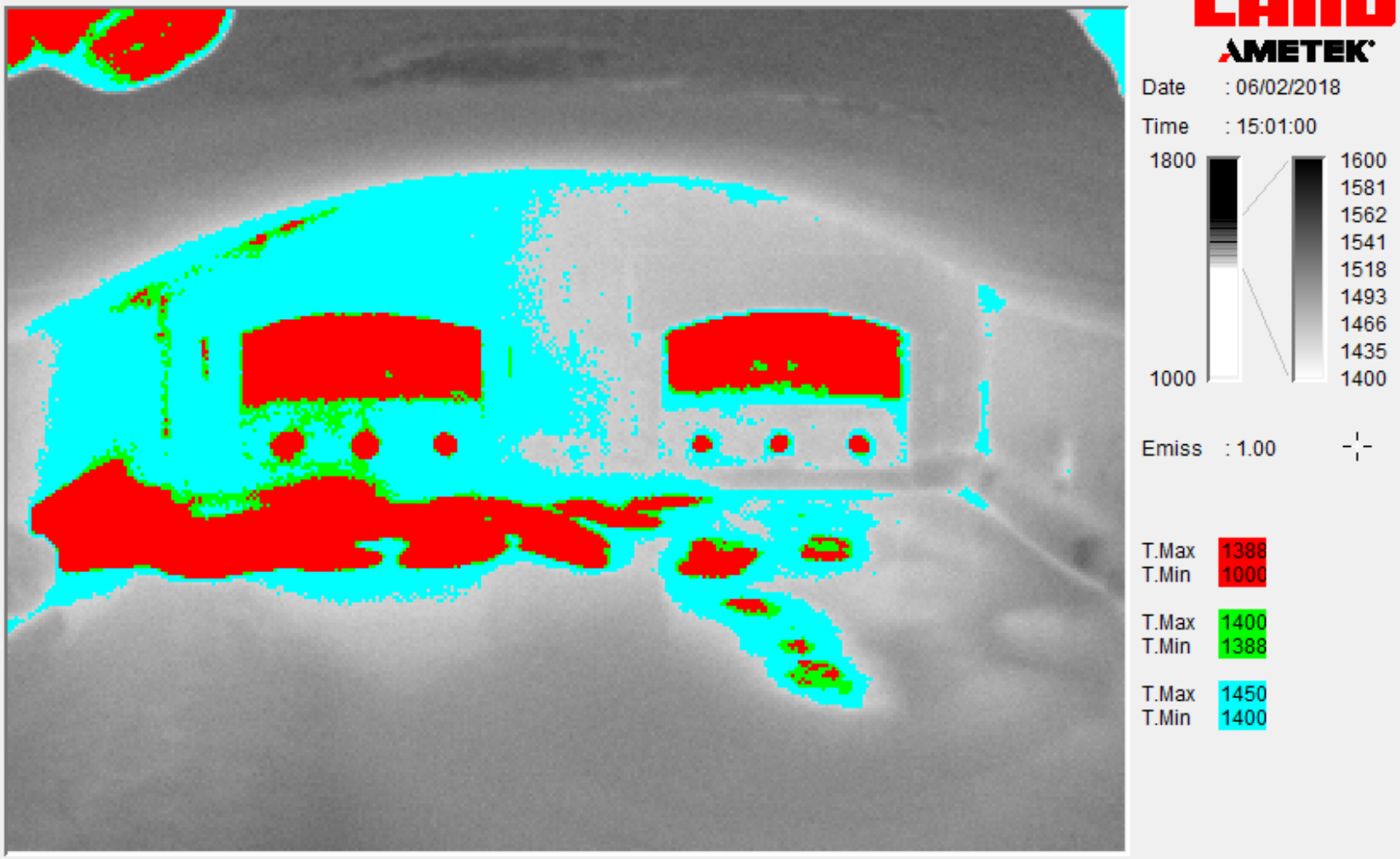
Add isotherms to enhance thermal difference on melt

End Firing
L-R



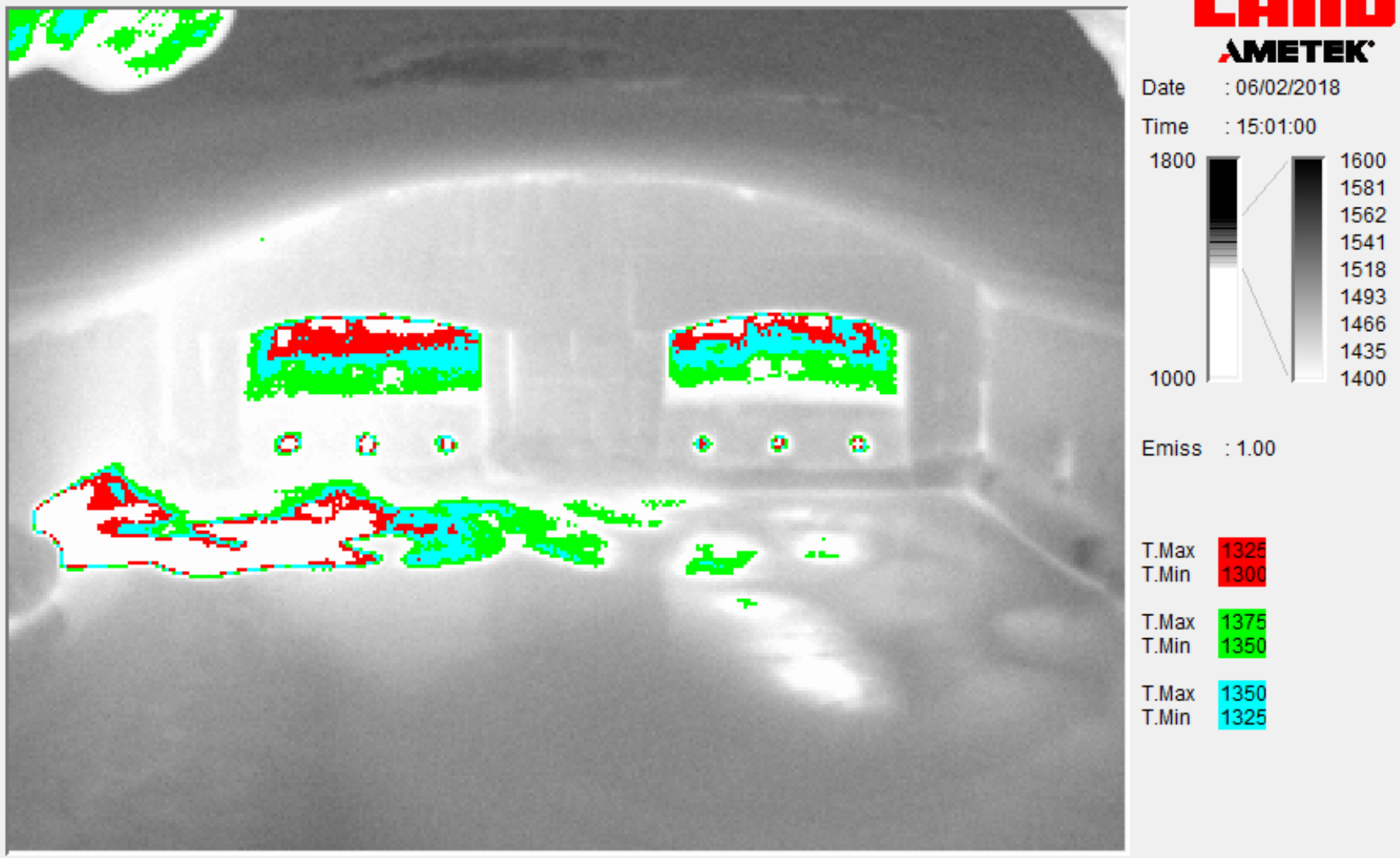
Difference in firing end L-R

NaOH Condensation Zones



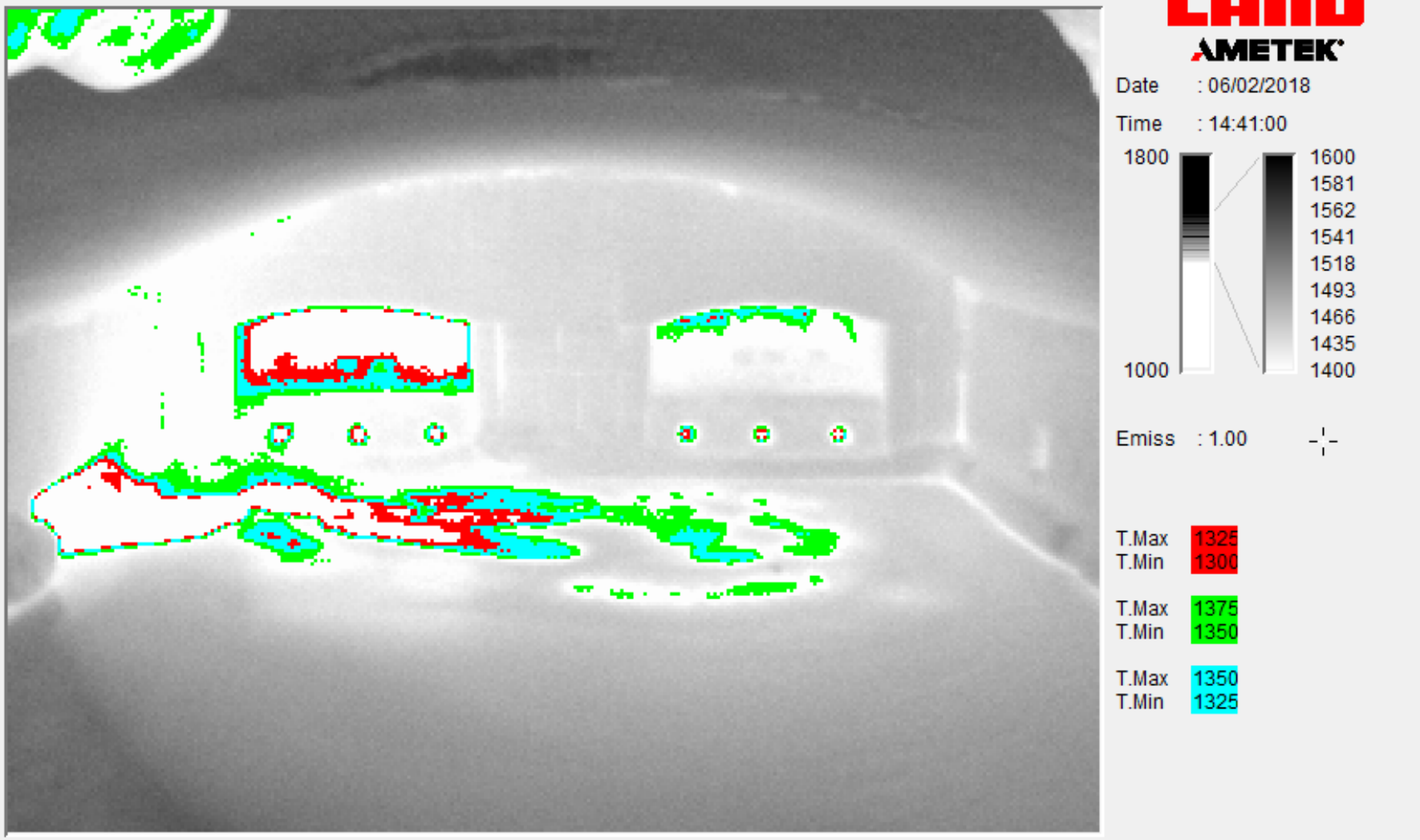
NaOH condenses at 1388

End L-R 25C Isotherms on Target Wall



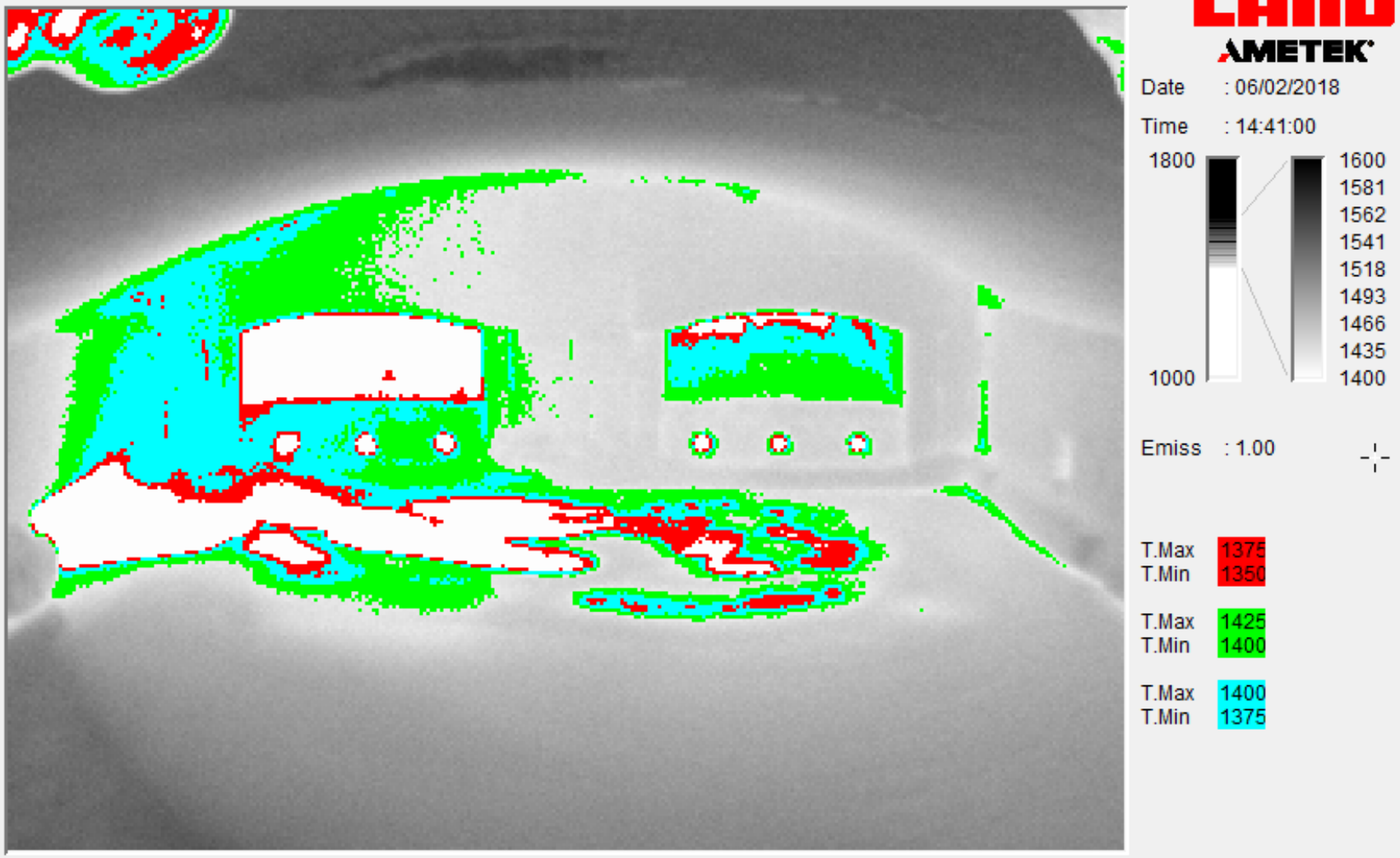
Temperatures seem unusual since almost similar.

End R-L 25C Isotherms Same Scale



End R-L target wall temps way higher

End R-L 25C Isotherms +50C



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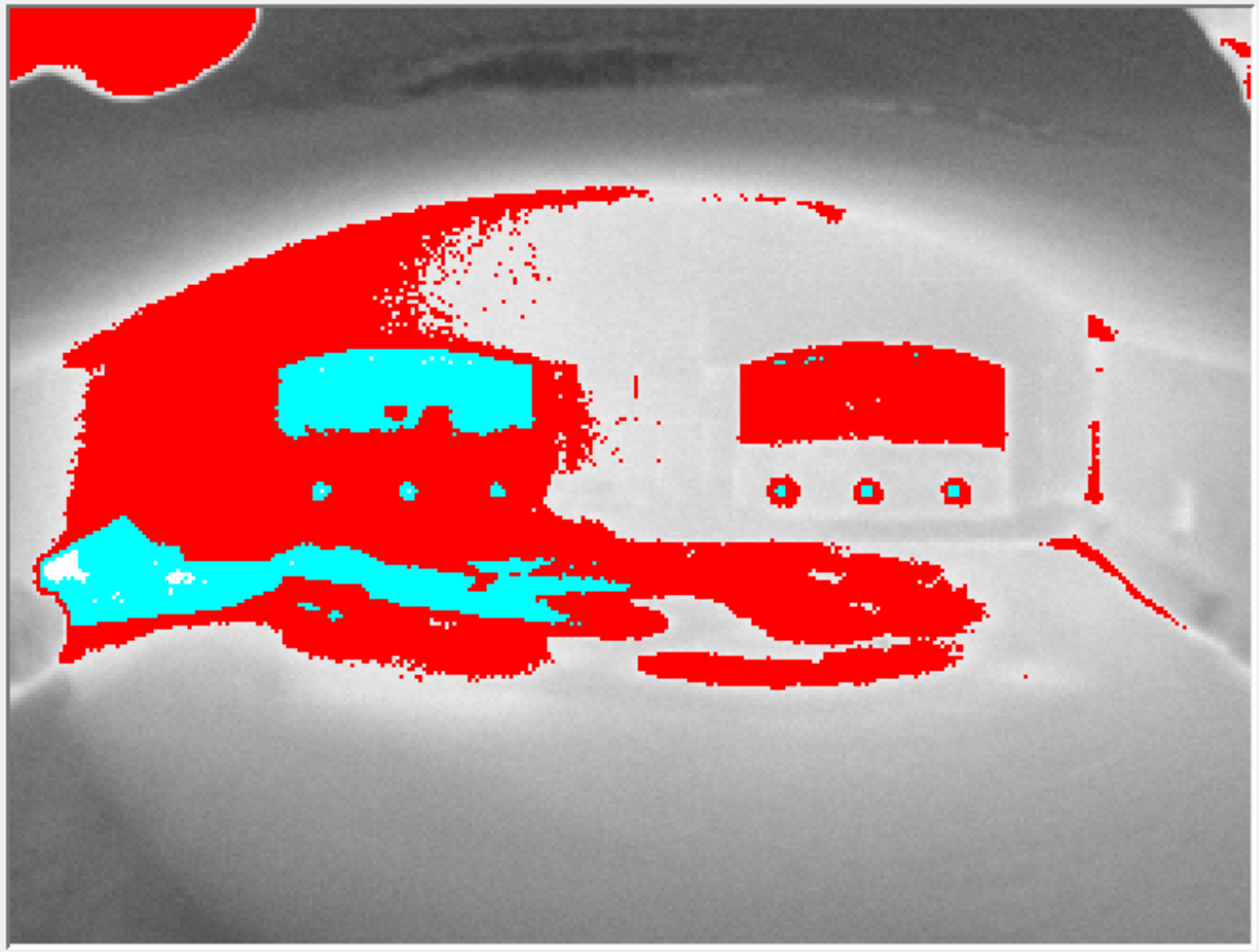
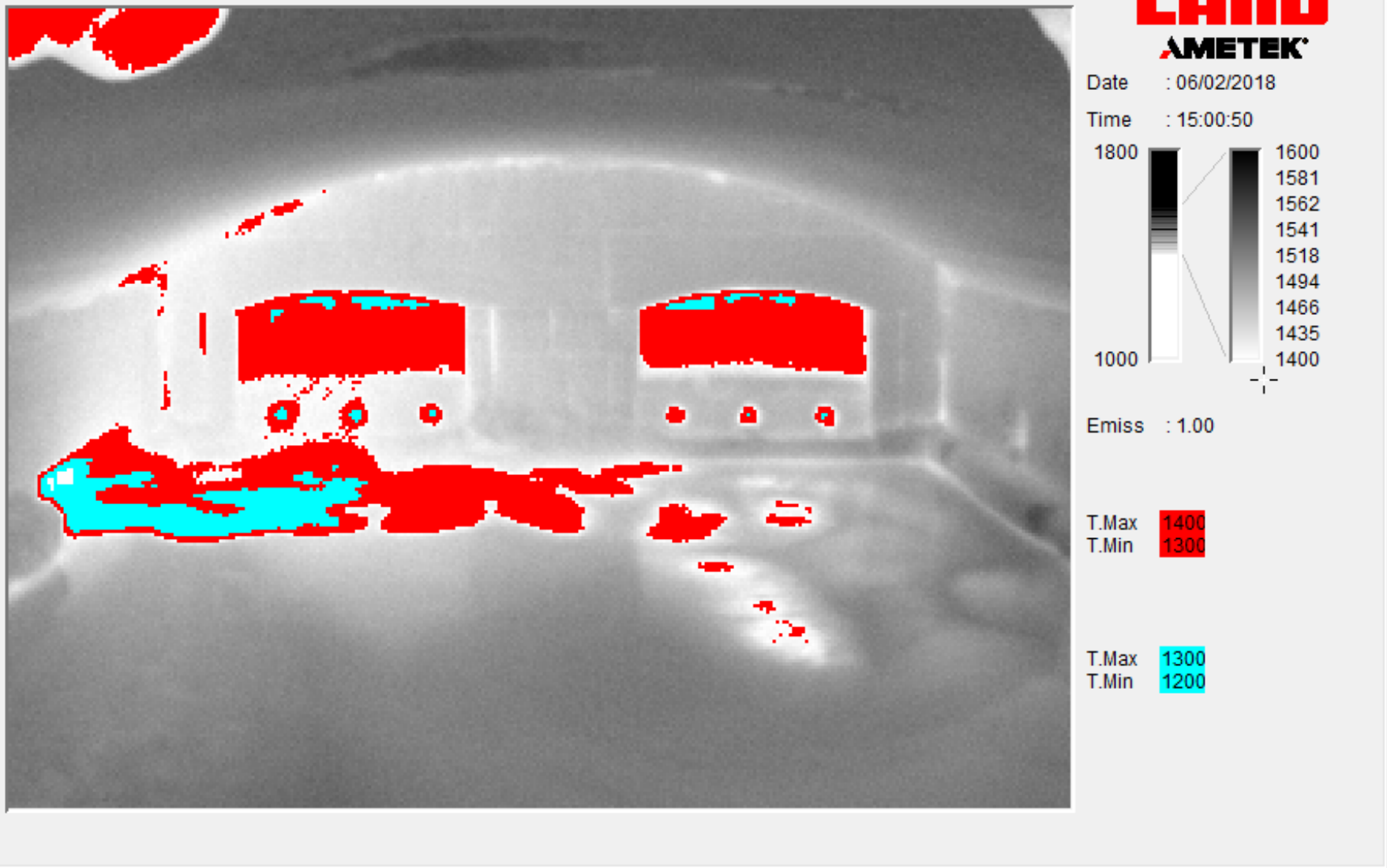
End R-L 2*
100C Isotherms



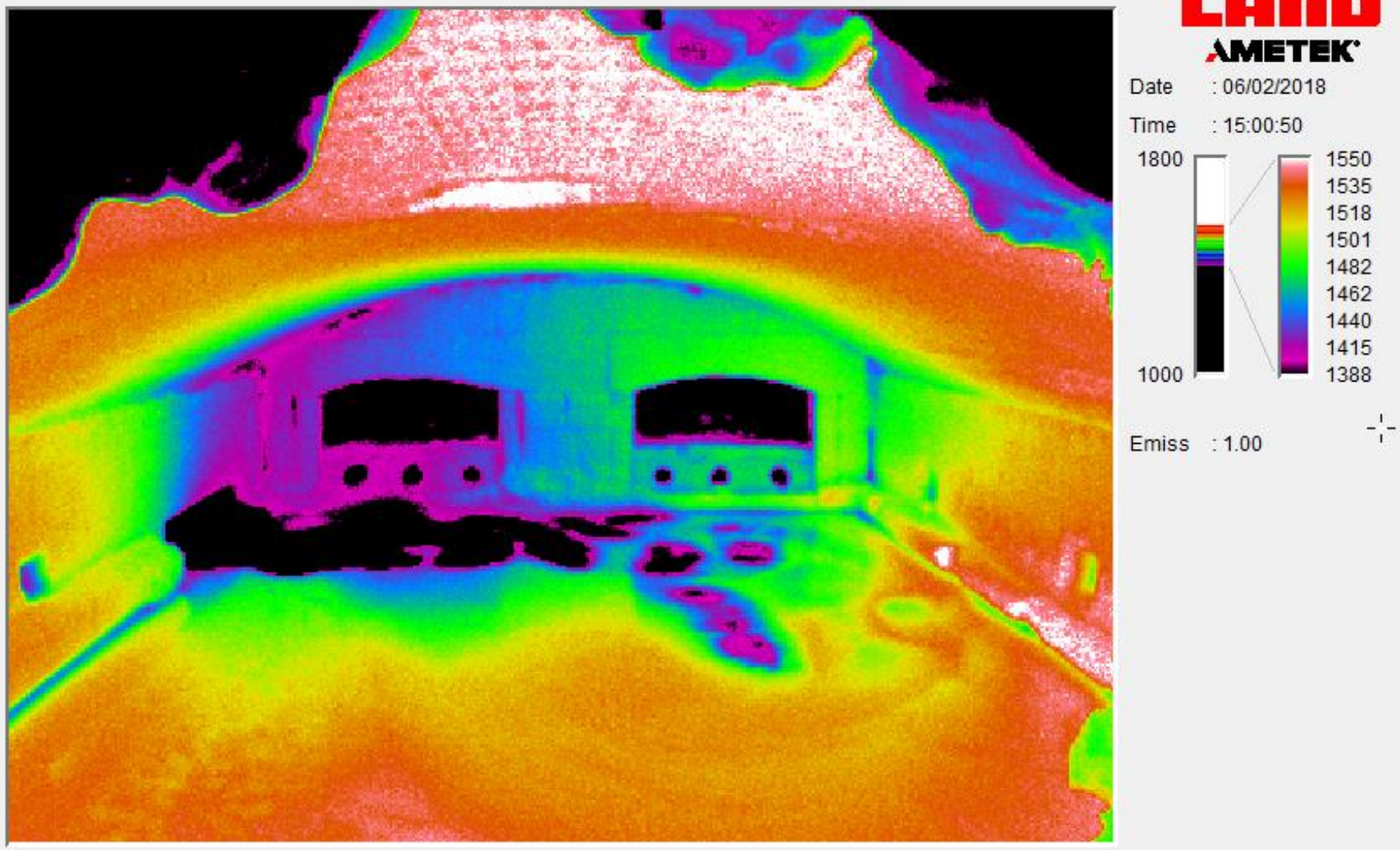
Delta 100C
firing R-L

End L-R Target Wall Temps Same!!



Is there a regenerator problem on LHS?

P3 End R-L 1.5 zoom



Shows crown repair and possible flame licking touch

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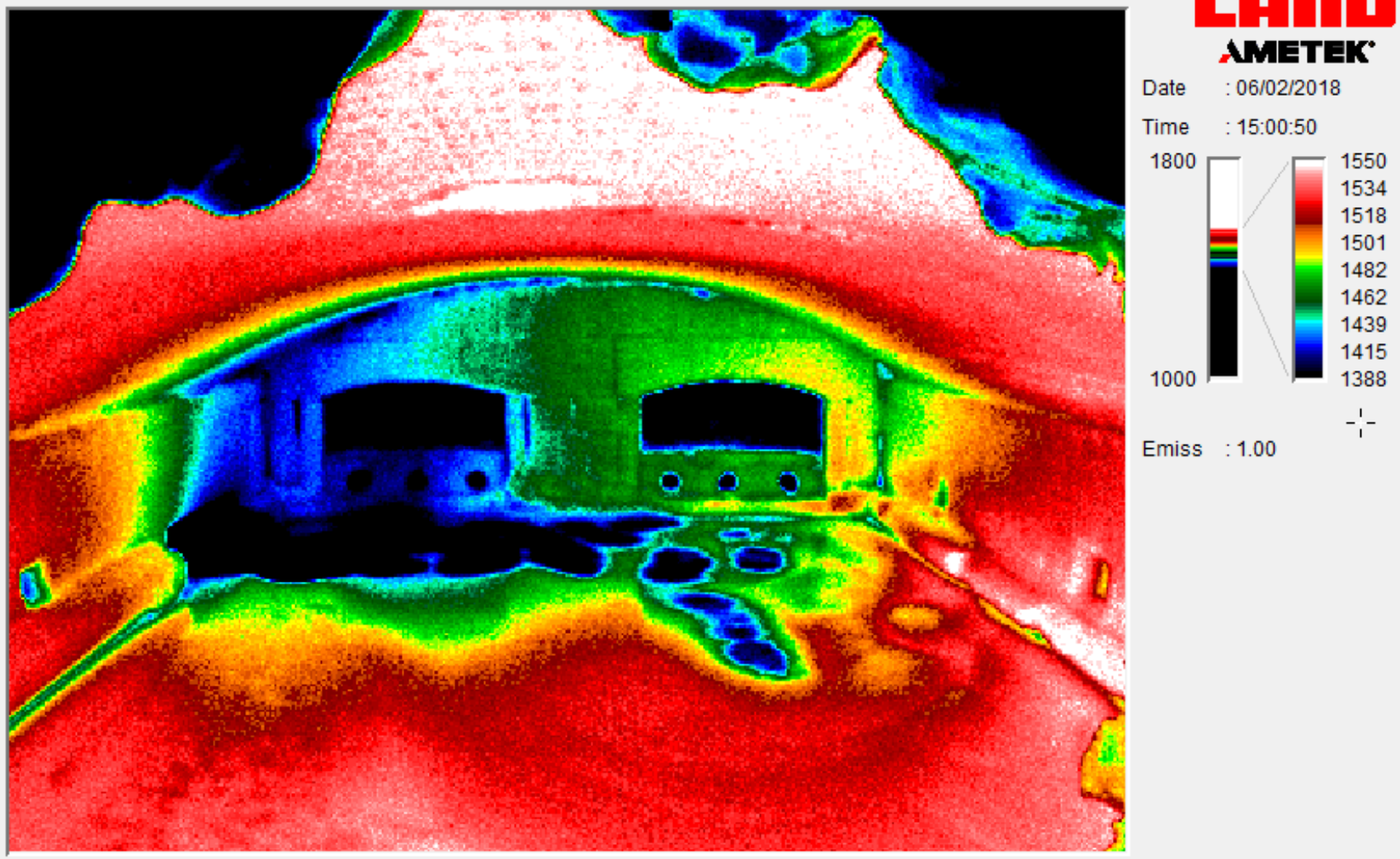
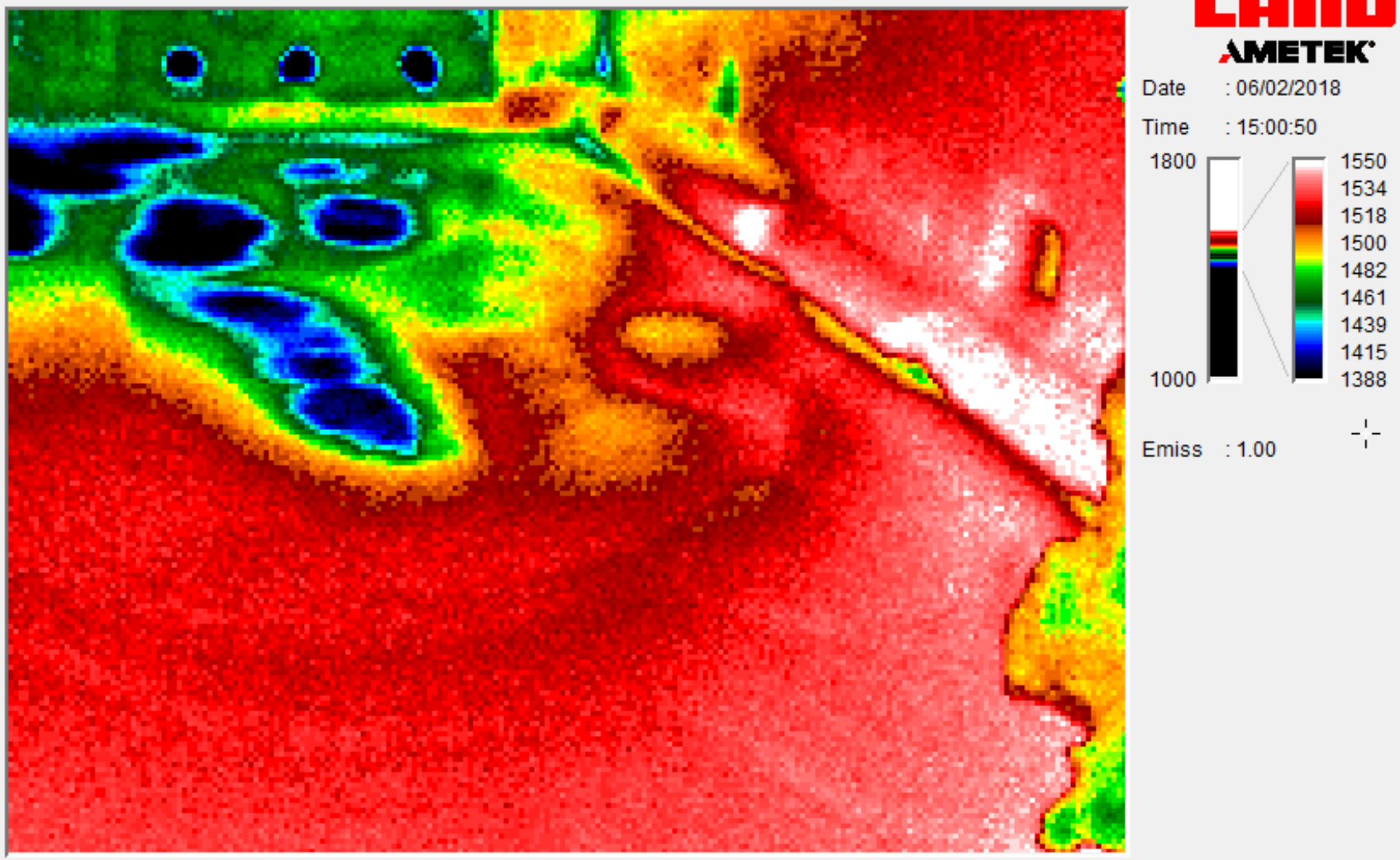
P5 End R-L 1.5 zoom



Shows crown repair. Expansion joint possible flame licking touch stones and leakage

3* Zoom End

L-R



Looks like a hole at metal line.

NOx Slides

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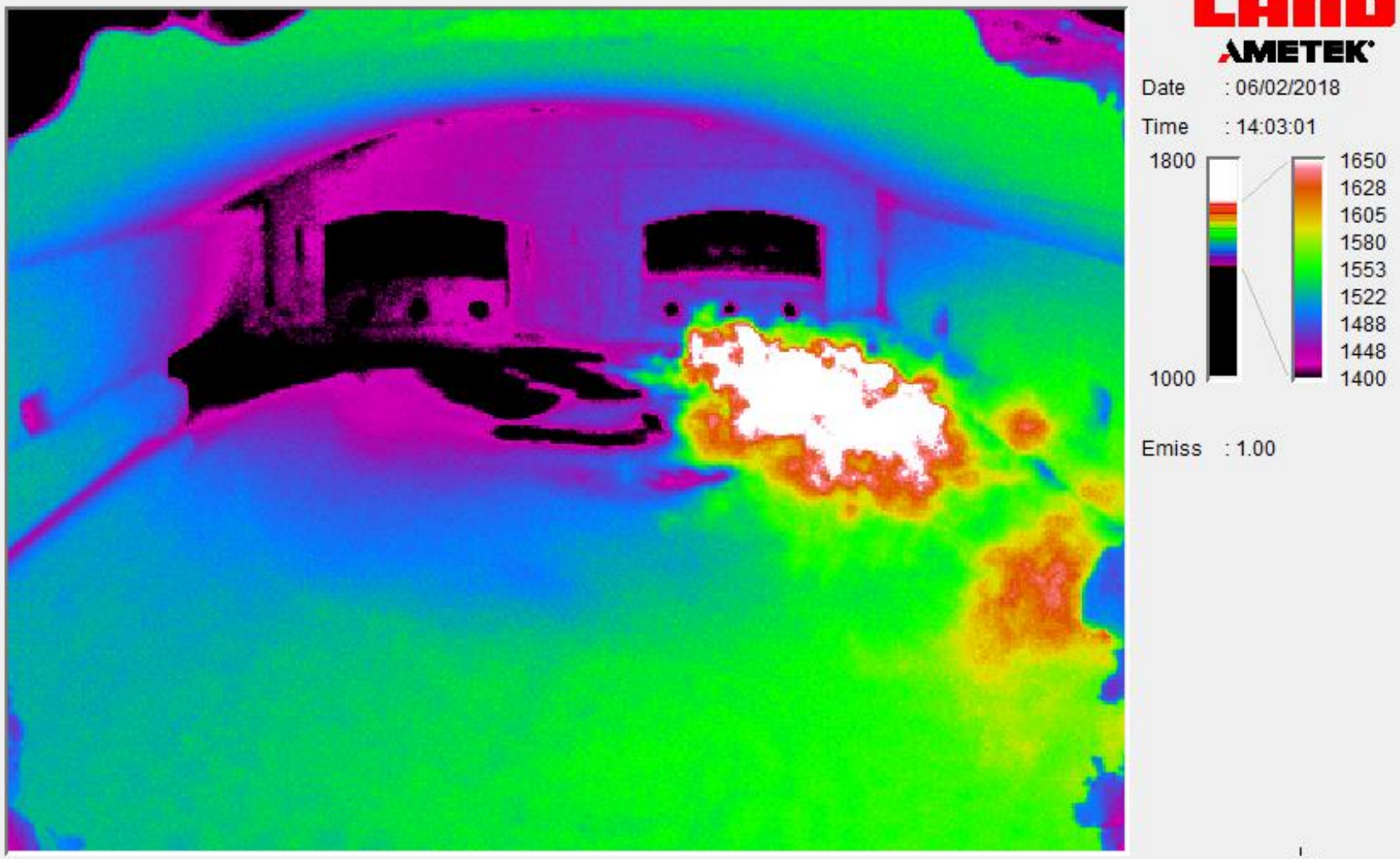
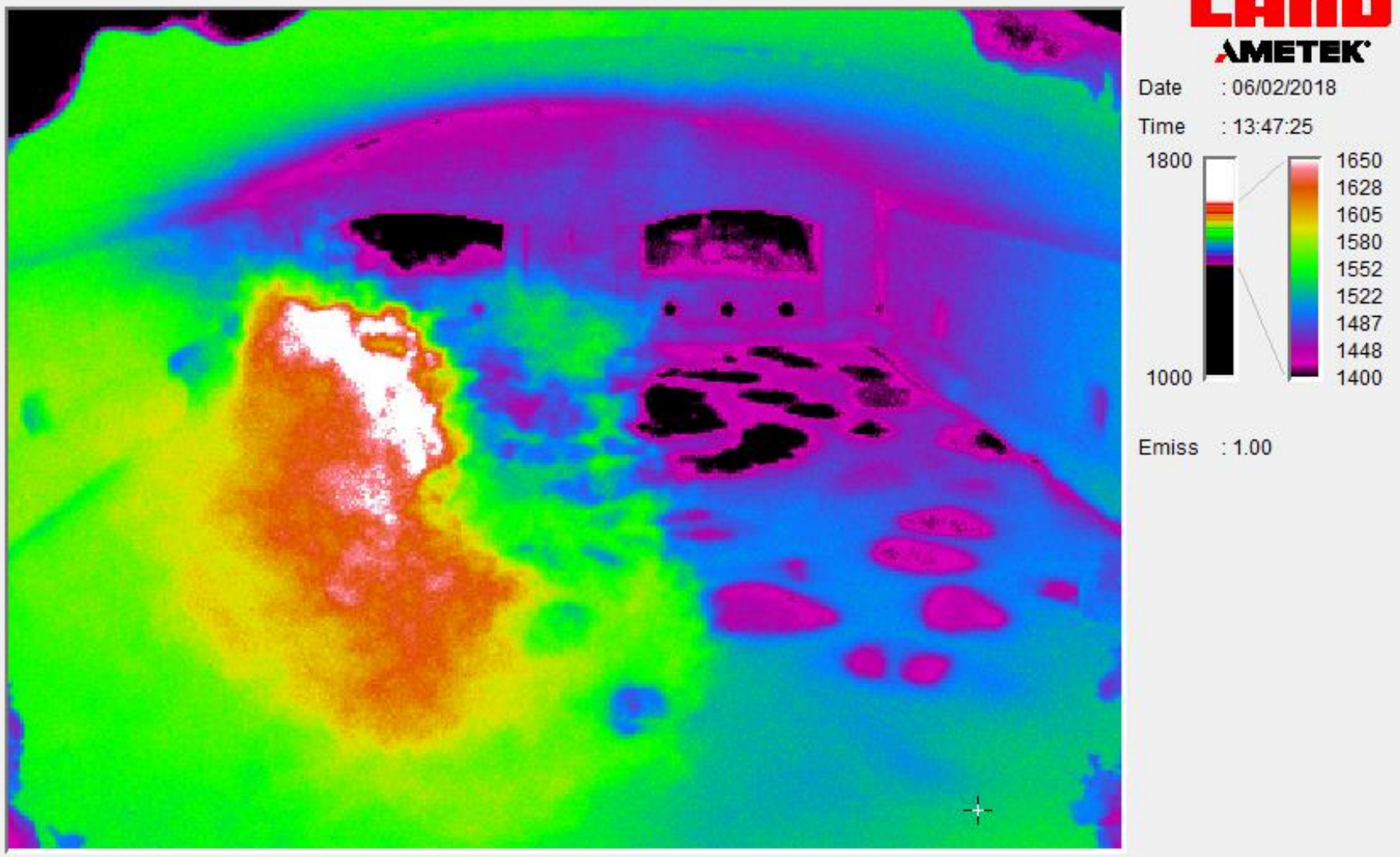
1.5 Zoom NOx mode 1400-1650



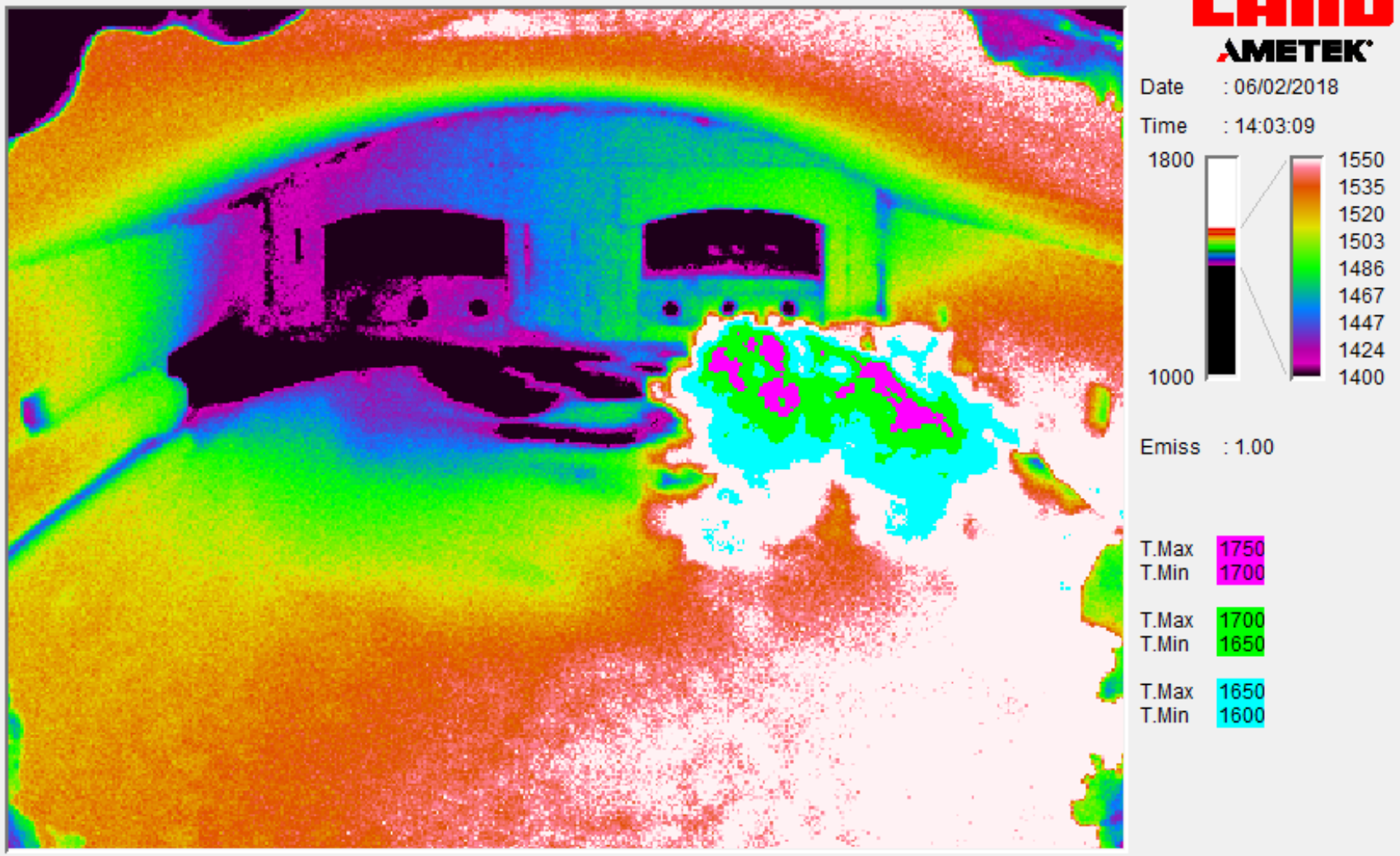
Flame very short
Intense core
+1650

1.5 Zoom NOx mode 1400-1650



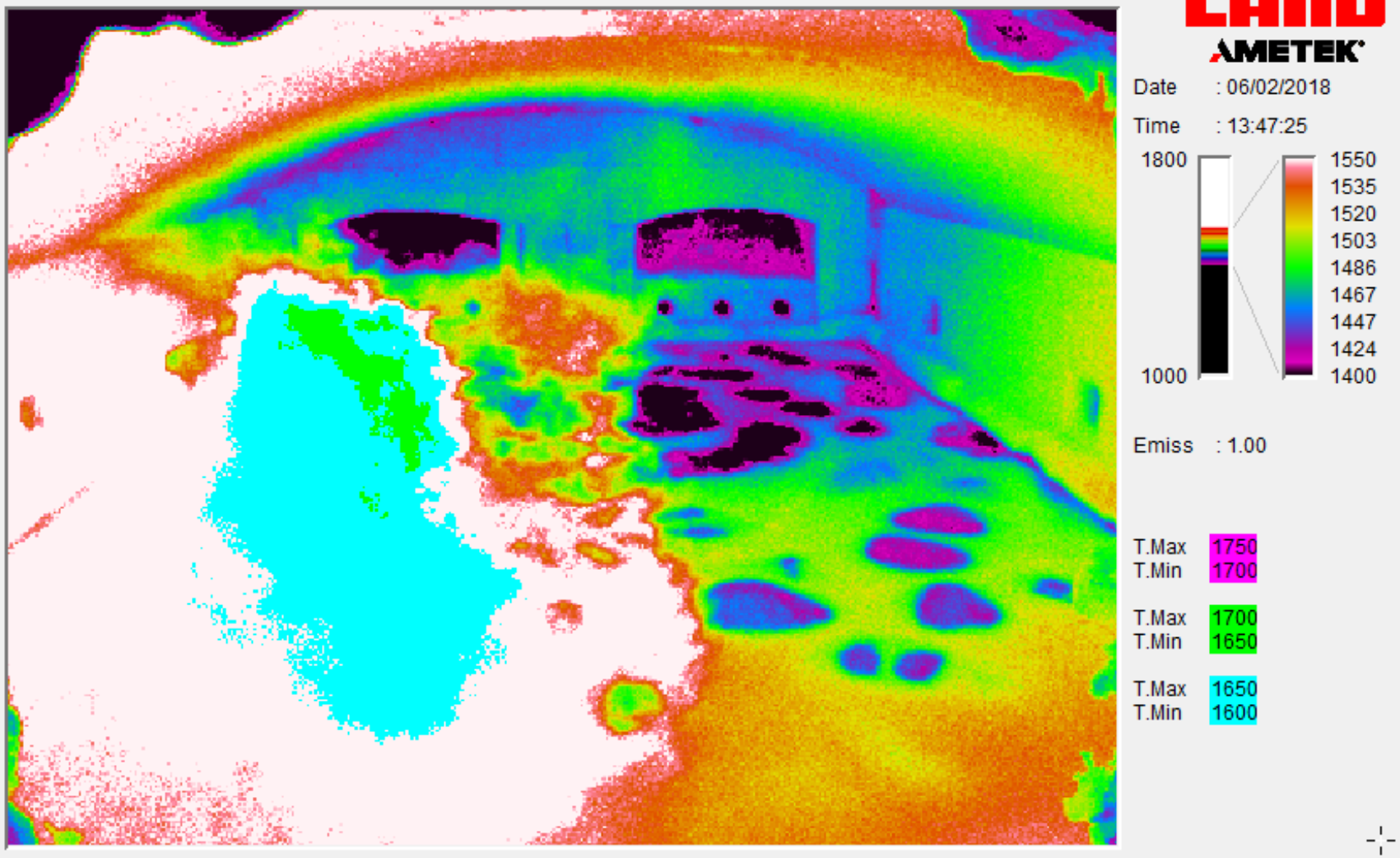
Long loose flame with less intense flame.

1.5 Zoom
1400-1550
NOx + 50C
Isotherms



A lot of flame at 1650-1750

1.5 Zoom 1400-1550 NOx + 50C Isotherms



All of flame below 1700C majority 1600—1650C – R-L is lower NOx

Observations From 3 Hour Demonstrations

- There appears to be a problem with the LHS regenerator performance.
- Unbalanced batch pattern
- Instability/problems with combustion air flow
- Significantly higher NOx firing L-R with corresponding short and intense flame.

Suggested Next Steps

- Address combustion air flow and control
  - Resolved following day
- Investigate regenerator condition and consider cleaning and/or repair
- Consider temporary rental of NIR b to optimise flame conditions.

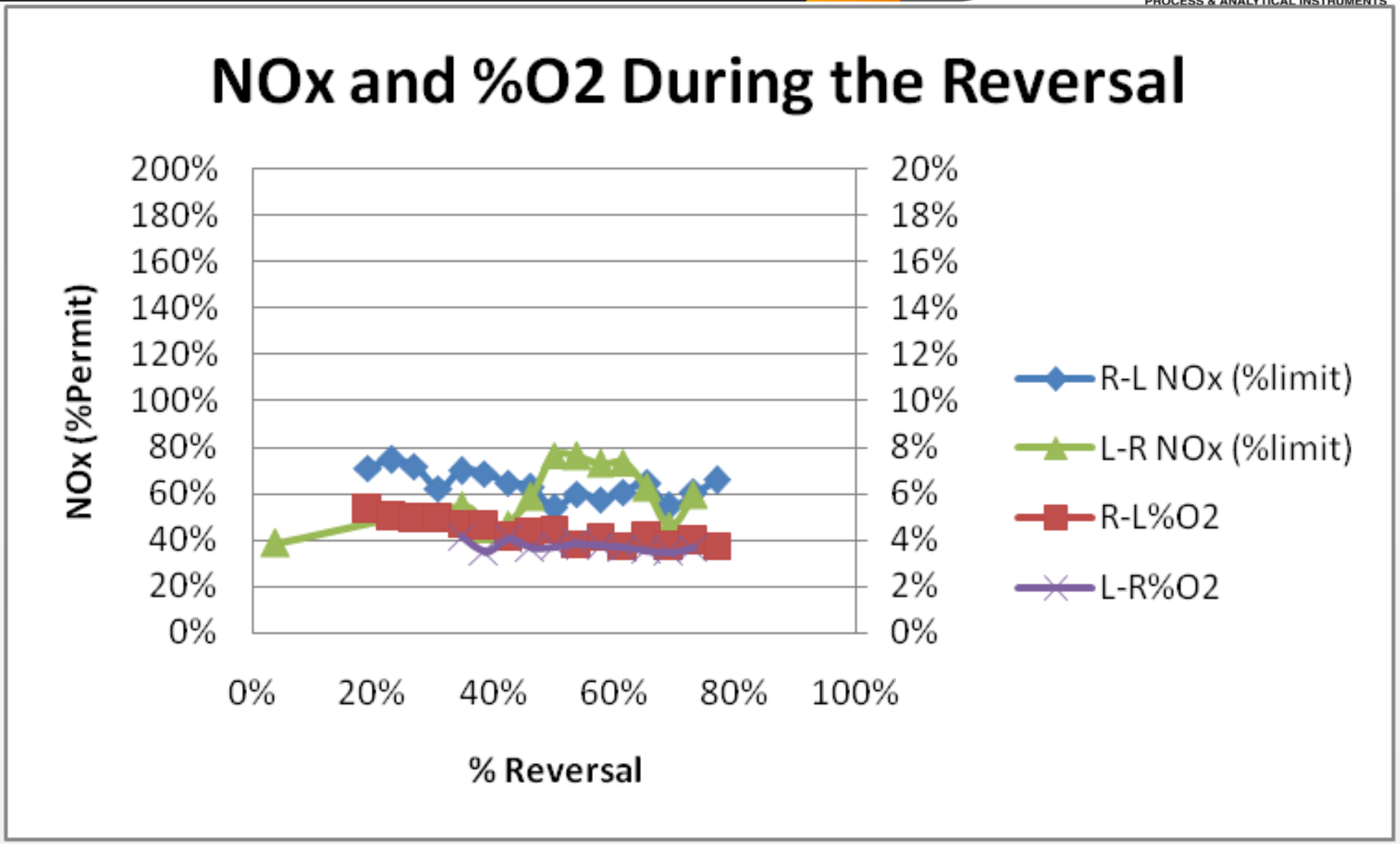
Phase 2

- Combustion air control and lambda control now operational
- NIR B installed on 21st March
- Regenerator cleaning in progress.

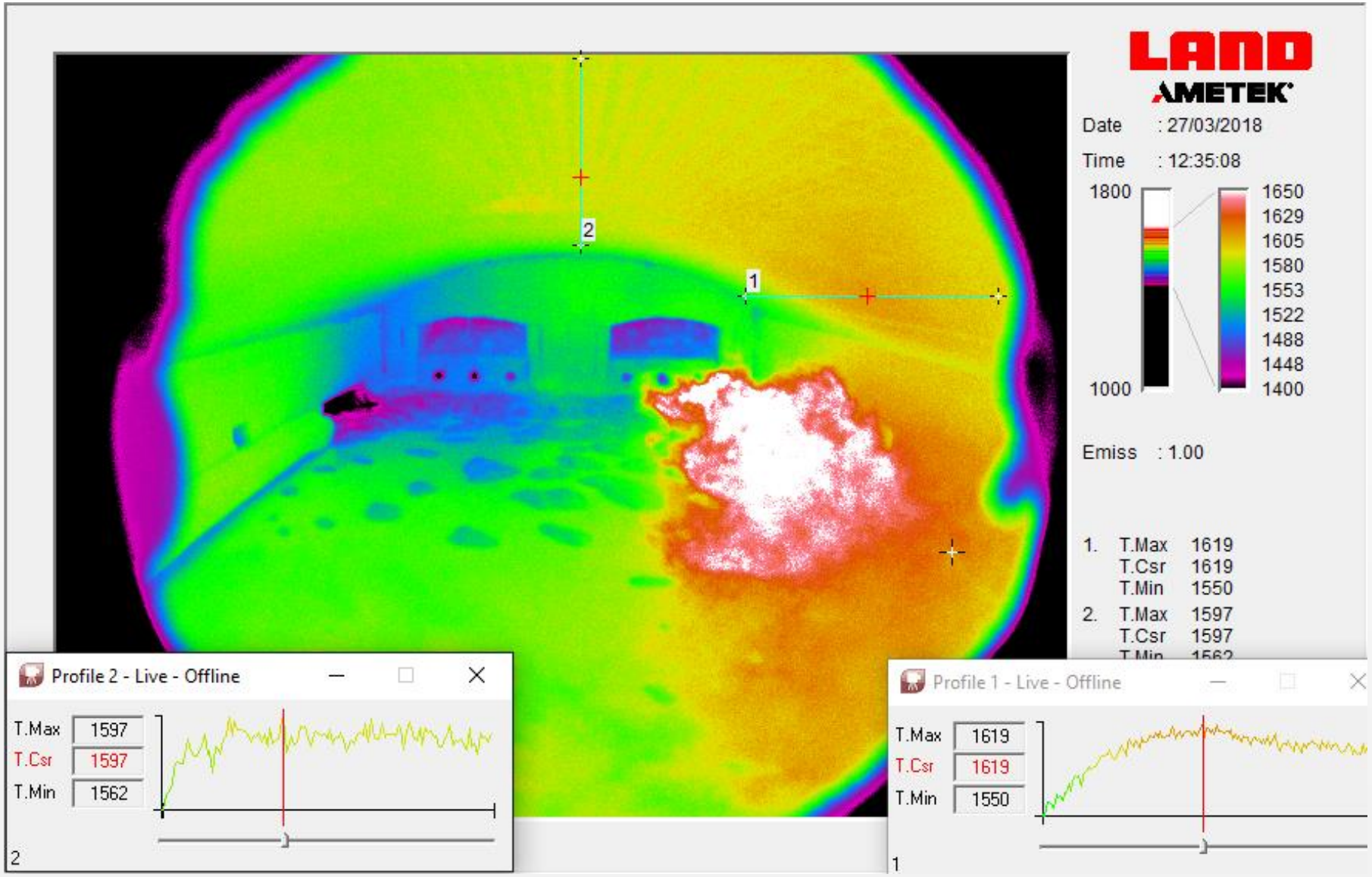
Phase 2 Continued

- After 6 days of furnace optimisation by customer and operators the following NOx measurements were taken.
- NOTE Neil Simpson NOT involved

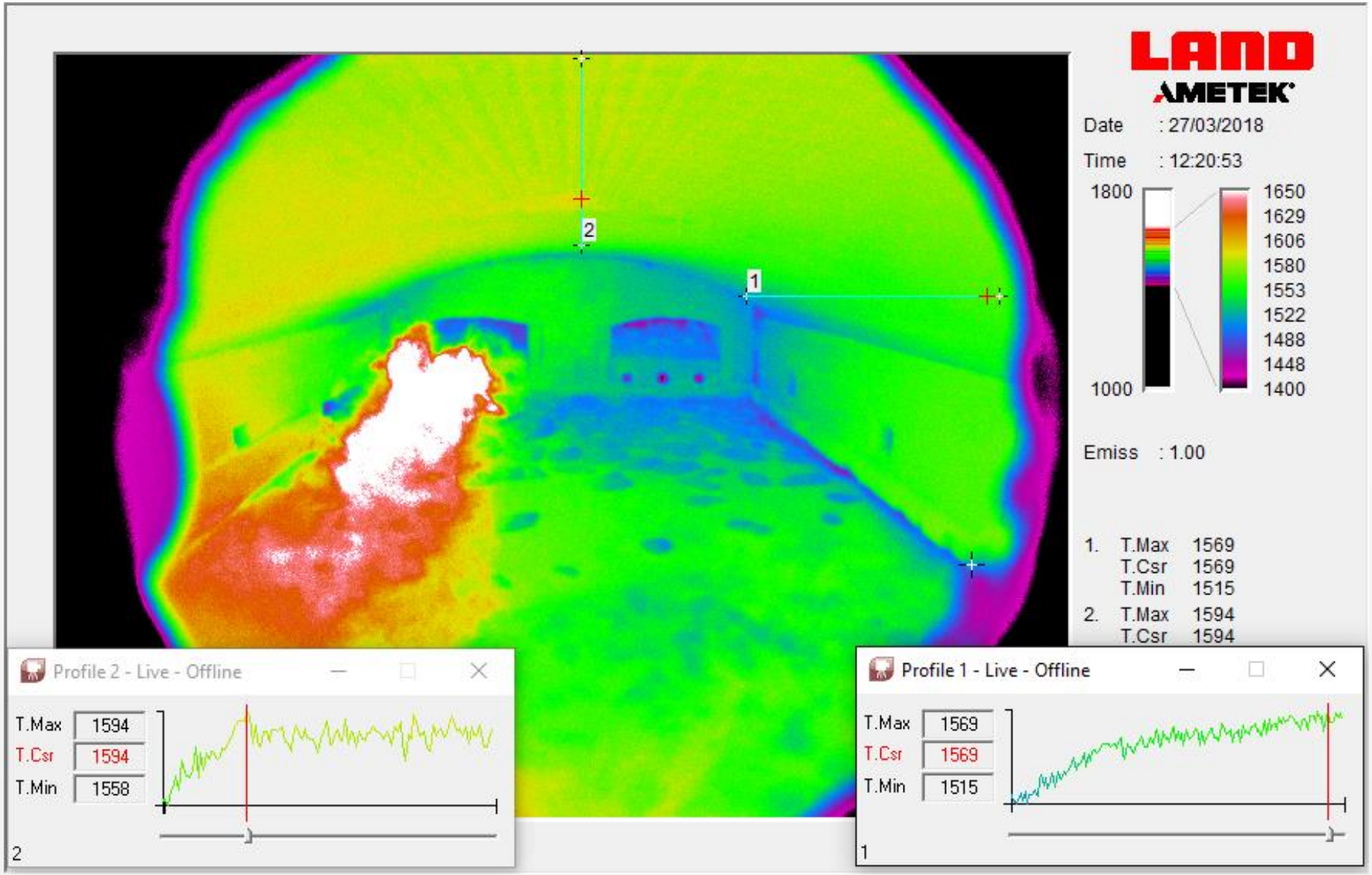
27th March NOx now in Compliance!



27/3 NOx
1400-1650



27/3 NOx 1400-1650



Conclusion

- In February at 3 hour demonstration the in-balances regenerator temperature and in NOx were obvious.
  - DH side NOx was lower
- Air flow control and lambda probes were then serviced and Regenerator cleaning started.
- On 21st March an NIR b rental unit was installed and thermal profile problems visible.
- By 27th March customer and operators had optimised furnace thermal profile and NOx
- Furnace operating within NOx permit (no additional technology)
  - DH side NOx now higher

Industry 3.9

- **The preceding end-fired case study has shown the ability to interpret the NIR B data to improve the control of the furnace.**
  - Correlation between thermal profile and batch pattern
    - Ability to control thermal profile and hence batch pattern
  - Analysis of target wall temperature indicates issues of potential regenerator blockage
    - additionally ability to use for automatic reversal control for energy and emission reduction
  - Repeatable correlation between peak flame temperature and NOx
    - Identify burner creating problem and enable optimisation
- **The need to have accurate, calibrated temperatures for control**


Any questions?
LAND
AMETEK
1800
1000
1695
1663
1626
1585
1537
1479
1403
1289
<1000