glass WORLDWIDE

# Thermal imaging hots up

The ability to extract and analyse data from critical locations is essential for efficient control and optimisation of the glass melting process. Philippe Kerbois and Neil Simpson demonstrate how the latest infrared temperature measuring equipment is being used in oxy-gas borosilicate furnaces to optimise production and quality.

Ensuring consistent temperatures and thermal profiles in glass melting tanks is an essential part of maintaining high quality glass production and extending the campaign life of a furnace.

Within the furnace, there are a variety of temperature measurements that can be taken in different locations and it is important to be able to trend temperature measurements at points such as the crown, ports and burner blocks. Also, temperature visualisation of cold spots should be carried out in the refractories as a precaution against air leaks typically caused by structural issues or the condensation of volatiles.

The latest technology, including the Near Infrared Borescope (NIR-B) in-furnace thermal imaging system developed by Ametek Land, has taken the glass industry to another level of understanding of glass furnace operations. This is true for many end-fired or cross-fired regenerative furnaces where glass producers have demonstrated the potential of using data obtained from the NIR-B to further develop controls to meet the needs of Industry 4.0 and the optimisation of furnace processes.

NIR-B provides a true-temperature radiometric image, enabling live continuous temperature values to be obtained 24/7 from >324,000 pixels (and three million pixels with the latest high definition NIR-B-2K).

Utilising ImagePro software, it is possible to measure the temperature of the melt line, the batch coverage and batch transit time for recording and comparison.

The NIR-B delivers many benefits that ensure a short return on investment including:

- Thermocouple verification.
- Thermal profiling with hot spot locations.
- Air ingress and batch control.
- Combustion optimisation for energy efficiency.
- Emission optimisation.

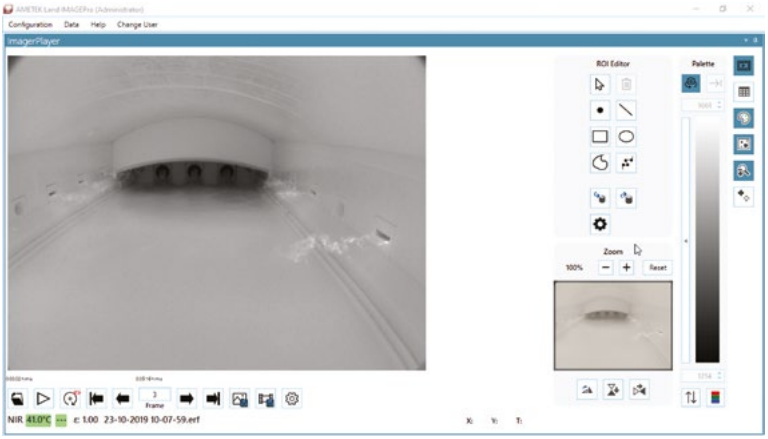
## Oxy-gas furnace project

Following a rebuild in 2019, glass packaging manufacturer SGD Pharma installed an Ametek NIR-B in-furnace thermal imaging system on its furnace in St Quentin Lamotte, France, to replace its existing CCTV system. The company's 50 tonnes/day oxy-gas furnace is dedicated to the production of borosilicate glass for pharmaceutical packaging.

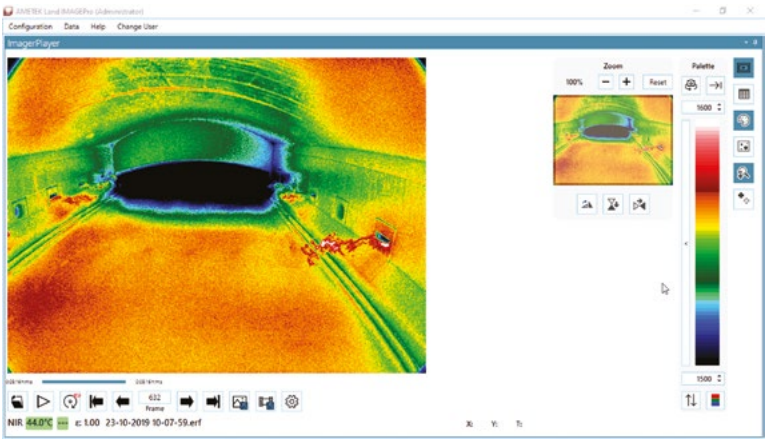
The original purpose of the system was to obtain clear higher resolution images to monitor batch line/flow and improve the setup of the batch line. There is an inherent risk of damage to oxy-fuel burner blocks in oxy-fuel furnaces when borate condensate/rundown can start to deflect the flame and potentially damage the burner blocks.

Utilising an over-temp alarm function, it is possible to include the monitoring of hot spots and burners. Receiving temperature data from the NIR-B with additional thermal profile data to improve the overall efficiency of the process was essential for SGD Pharma.

Benefits of using the NIR-B for daily operation in an oxy-gas furnace include the combustion side for flames' heat deflection to prevent overheating. Since there are no regenerators with a reversal, the solution allows long-term data trending for flames optimisation, ▸

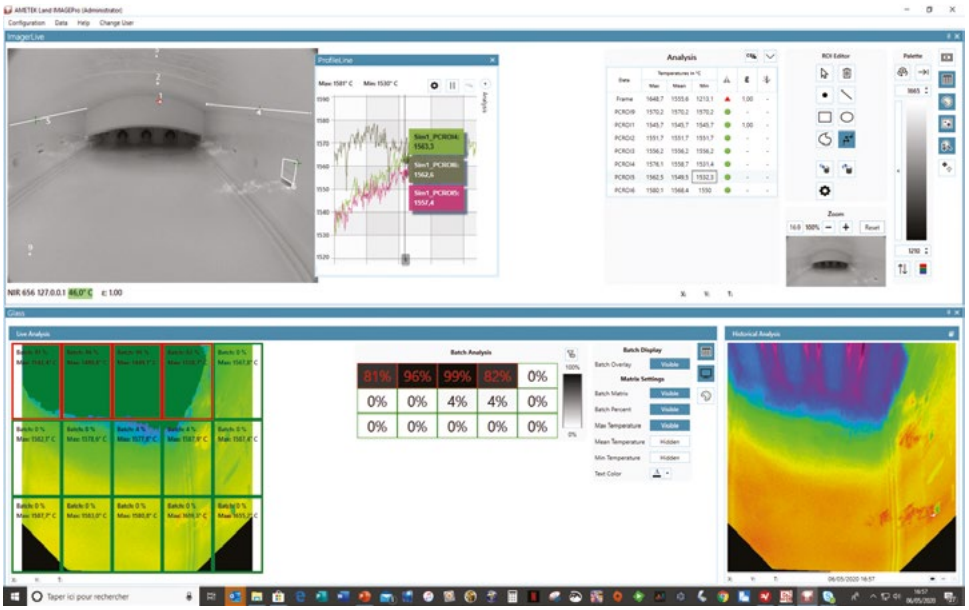


Black and white NIR-B thermal image. NIR-B offers the operator the same views as a typical CCTV system.

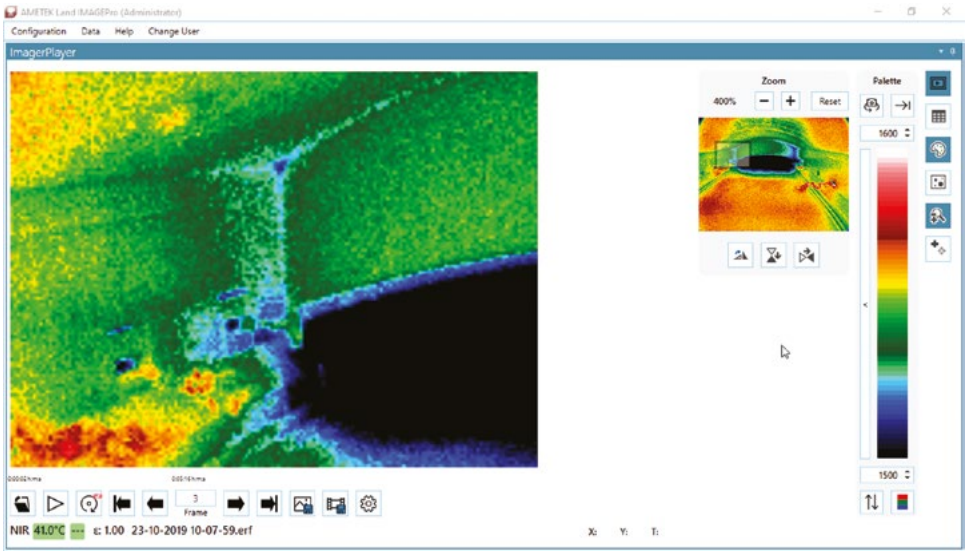


An NIR-B thermal image.

Lower temperature band 200°C greater resolution shows run-down on the L4 batch line is skewed and longer on LHS.



Batch line location and thermal profiling with Ametek's ImagePro software.




Crown 400% above R2 is hotter.

plus it enables thermal optical profiles to be measured continuously, which is ideal for oxy-gas borosilicate furnaces with continuous operation.

SGD Pharma has used its latest infrared temperature measurement equipment to highlight best practices within a glass melt tank, enabling the company to make necessary repairs and then optimise flames to achieve desired pull rates.

Isotherms provided by the NIR-B tool are highlighted to show cold and hot locations. Alarms and temperature isotherms also provide the manufacturer with long-term asset protection against over-heating and condensation zones. On the firing side, burners block cleaning and inspection will be shown as the flame risk of impact on refractories.

At this stage at SGD Pharma, there is no direct data exchange for thermal zones of interest to the DCS (Digital Control System) of the furnace or to a system for optimisation. This is a potential future option for SGD, as the NIR-B is already able to collect temperature data based on 100 zones of interest and send all the data to any DCS or expert systems.

## Implementation on borosilicate glass furnaces

In the past, the implementation of CCTV for an oxy borosilicate glass furnace was always a challenge due to the highly aggressive furnace atmosphere. Clearly, this is a harsh environment, often resulting in blurry images and inconsistent measurements or videos.

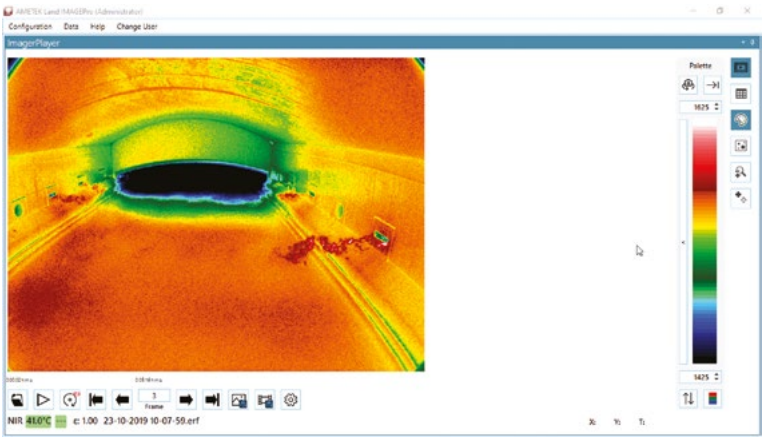
However when using the NIR-B a clear image is visible due to the high quality of the lens. Proper installation is essential for robustness and dedicated infrared shields have been created for the protection of the NIR-B's retraction mechanism against the infrared radiation coming from the whole camera block and the glass working zones around the instruments.

The most suitable location for installation on a small furnace is above the throat in the centreline of the furnace to provide a good field of view of the refractories including crown, sidewalls, burner blocks and batch line.

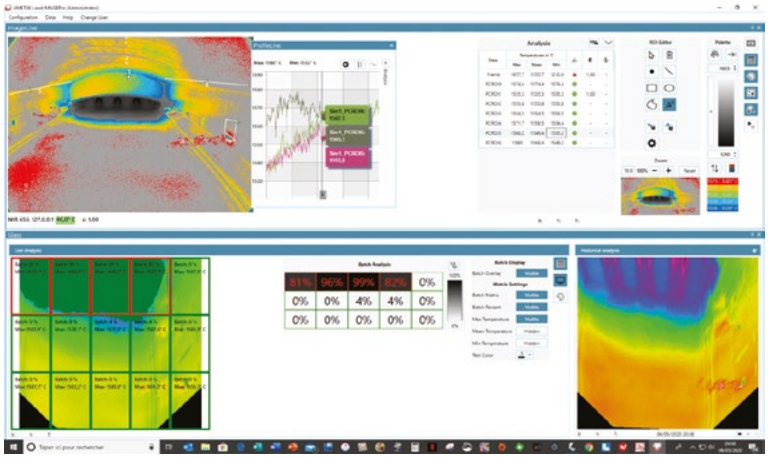
## Optical measurement and batch flow focus

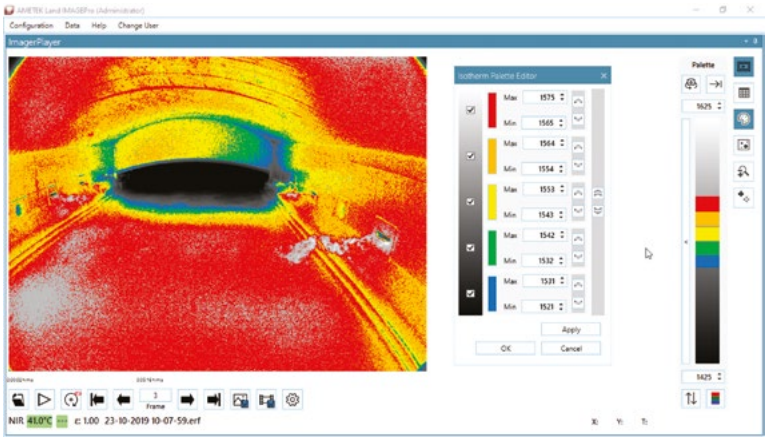
Accurate and repeatable temperature measurement is essential for efficient control and optimisation of glass manufacture and processing. This is even more critical within oxy-gas furnaces where the temperature of the flame is significantly hotter – measurements are typically performed only at critical locations. Point measurements can be obtained using thermocouples, either embedded in the walls or intermittently by using a hand-held portable infrared (IR) pyrometer.

Focusing on visual images, operators can forget that there are 320,000 thermocouples with temperature data that can be used to optimise the furnace and validate CFD models. Ametek Land's software enables points of temperature measurement to be exported to a ▸

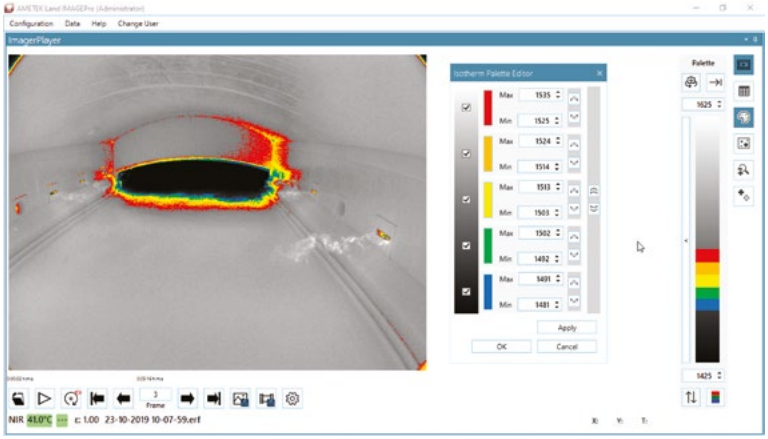



Rainbow palette RHS glass flow is hotter than LHS cold spot in the crown skew corner – cold spots on tuck stone joints.





Above: B&W plus isotherms shows RHS hotter; possible crown overheating above R2.



Refractory cold spots.

furnace control system.

By setting minimum or maximum temperature, it is possible to have an alarm function. When an alarm is triggered, a snapshot is taken of the whole image and stored for future analysis. An 'area' function of the software also enables multiple areas to be configured. Examples could include the crown, port/target wall, tuck stones, breast walls and skew line. In some applications the corresponding crown thermocouple location temperature is measured within the image to verify the accuracy of thermocouples, which decay and ultimately fail through time.

The most important initial benefit of the NIR-B is the ability to obtain a furnace thermal profile continuously in oxy furnaces and confirm that hot spot locations are well aligned with the furnace design and batch line. This is probably the most powerful tool from an operation's perspective.

By drawing profile lines at desired points such as crown and/or skew, it is also possible to obtain a thermal profile continuously.

## Batch patterns

Batch flows are initially impacted by charging control and potentially the flames. However, flow patterns are driven by the thermal flows/convection currents. In the same way that heat flows from hot to cold, thermal currents follow the same thermal vectors.

The primary purpose is always looking at the batch pattern. Time-lapse recording can be used for reviewing batch flows as a conventional CCTV. Ametek's ImagePro software provides batch coverage based on a grid with rows and columns for better batch tracking.

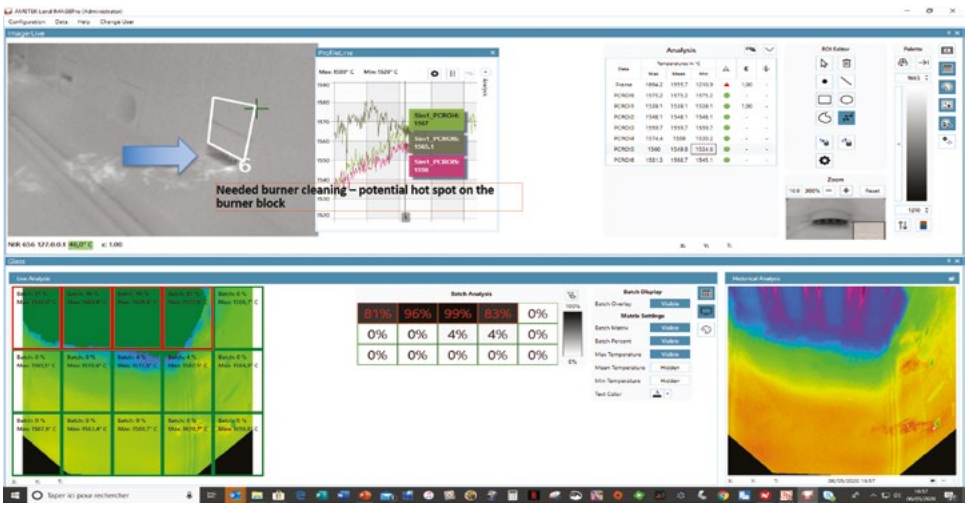
Since the image is based on thermal data, it is possible to add areas and apply alarms if the cold batch reaches a certain point. Whenever an alarm is triggered, the image is recorded for QA and troubleshooting purposes.

By utilising a specific thermal palette and adjusting temperature bands, it is possible to identify which flames and which blocks are the most intense or hottest, therefore generating the optimal flames pattern and heat transfers.

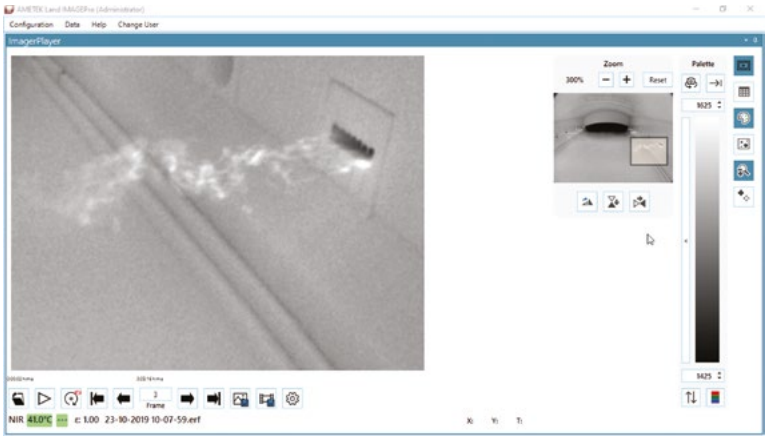
From an asset protection perspective, one of the most important analytical tools is the negative image, which can be instantly displayed. This function shows the areas with the greatest cooling. Utilising an up to 400x zoom function, the NIR-B can accurately determine the relative location of the small hole and assist in determining its absolute location. It could also be employed to identify over-cooling of the metal line, which leads to increased wear due to the Marangoni effect [mass transfer along an interface between two fluids due to a gradient of the surface tension] and cold batch piles scraping along the furnace length.

## Data analysis

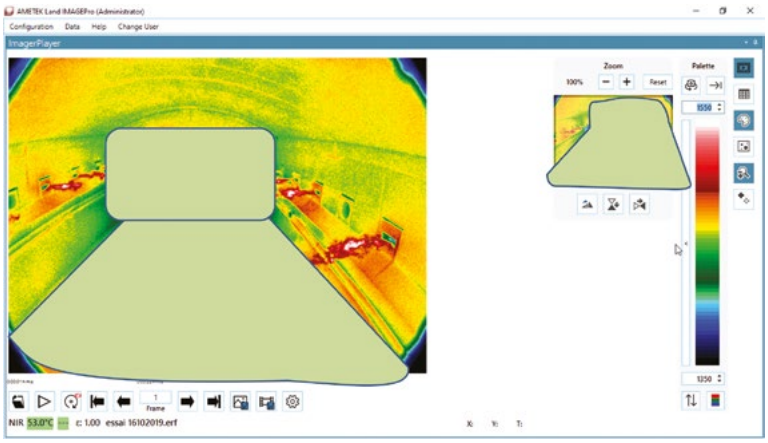
One of the challenges of the NIR-B system is the massive amount of data captured and how it should best be interpreted. While it is suggested that operators use some of the functions in real-time, other functions are better suited to off-line analysis by batch and furnace managers. ▸



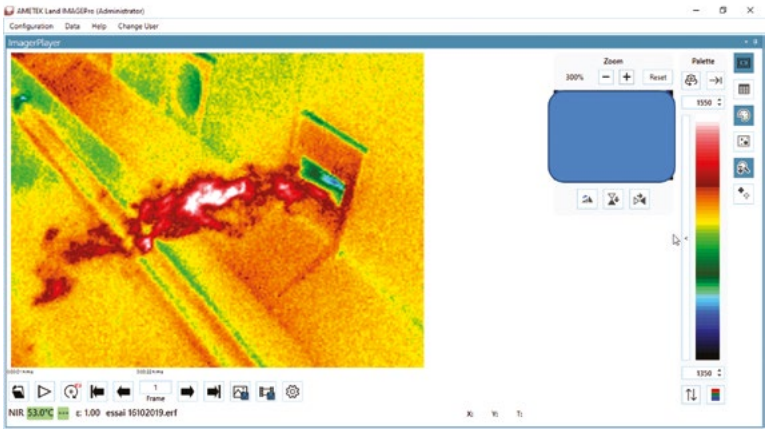

L4 block 300% zoom. The last frame shows the hottest part on an L4 block.



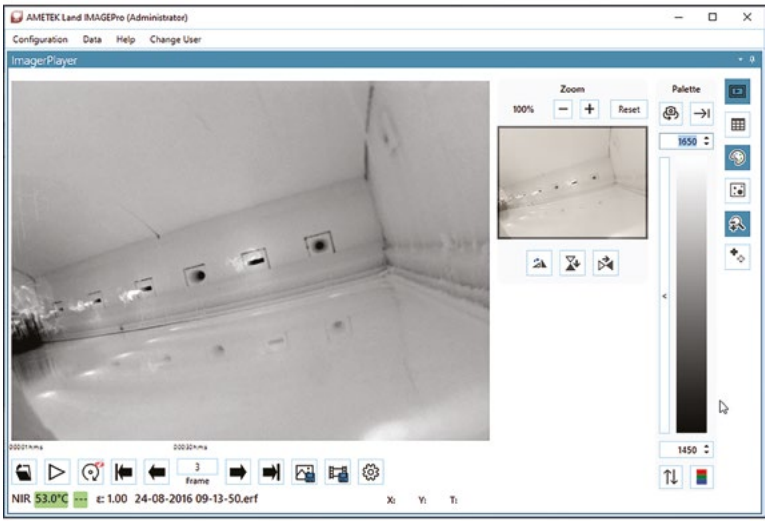

Continued operation will most likely see damage to the L4 block on the bottom downstream corner.




Furnace heat-up at the start of a fill.




Heat-up fill showing early damage on L4.




Survey mode with transportable NIR-B via an existing peephole.

It is suggested that every day at given times, snapshot images are taken of the furnace. It is then possible to compare data from 24 hours, one week, one month, three months, six months and 12 months previously to identify short-term problems and long-term changes in the asset. With this data, it is possible to prepare a long-term preventative maintenance schedule and more importantly, a short-term reaction.

## Isotherms for hot and cold spot locations

By utilising a specific thermal palette and adjusting the temperature bands, it is possible to identify refractory temperatures to see which flames and blocks are the most intense or hottest, therefore generating the best suitable flames pattern and heat transfers.

## Burner block Inspection

The NIR-B zoom enables the identification of potential refractory damage, especially on burner blocks requesting actions for cleaning or repair.

## Furnace heat-up

The NIR-B is a powerful tool during heat up in which to review the expansion and gain reference images of the melt tank before and during filling. See some snapshots from the existing location above the throat are presented as part of this article.

## Survey mode from existing peep holes

A transportable NIR-B model is available, providing the possibility to use the tool temporarily for thermal surveys. In addition, a thermal survey has been undertaken to explore other locations in the furnace. Available peepholes are used and snapshots of the refractories taken, revealing many other details on flames, batch pattern, electrical boosters and glass temperatures.

## Conclusion

Data from the NIR-B was used at SGD Pharma to reduce labour input, improve response times, identify and then troubleshoot furnace operations to improve yield or achieve higher pull and lower specific energy. Utilising 32in LCD monitors could be the best way to achieve a clear furnace image that could become the focus of attention of the operators' team and during customer visits.

While this should result in increased asset life, it has helped support the team with the potential for future energy optimisation and cost reductions. What can clearly be seen is that temperature measurement at critical locations in the production process is essential for efficient control and optimisation of the glass melting process and today, the technology to enable glass producers to do this is better than ever. ●

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