

Glass Futures' Frozen Throat

Causes, Problems, Lessons and Solutions

Aston Fuller General Manager, Glass Futures
Glass Problems 2026

St Helens pilot furnace · 30 tpd multi-fuel hybrid line



**GLASS MANUFACTURING
INDUSTRY COUNCIL**



About me

- Aston Fuller — General Manager, Glass Futures.
- Directly involved through the design, build and commissioning period: operational and technical decision-making, stakeholder coordination and risk management.
- Focused on protecting a high-value R&D asset, ensuring the business succeeds and ensuring stable glass flow to deliver planned experimental activities.
- This is a first-hand, practical account — not an abstract technical paper.



Aston Fuller

General Manager · Glass Futures

Glass Futures

A global, independent, industry-led research and technology organisation based in St Helens, providing a shared industrial-scale asset to de-risk innovation away from commercial production lines.
Working across our members which span the entire glass supply chain

01

Decarbonisation

Lower-carbon melting pathways

02

Alternative fuels

Hydrogen, biofuels & blends

03

Electrification

Boosting & hybrid melting

04

Digitalisation

Data, modelling & control

05

Process optimisation

Yield, quality & efficiency

06

Technical consultancy

Member & industry support

Background to the furnace design and build

ST HELENS PILOT LINE — NOMINAL 30 TONNES/DAY

- Multi-fuel hybrid glass furnace with oxy-fuel and super-boost.
- Electric throat boosting and main tank bubblers
- No installed throat bubbling on day 1
- End to end digital control system from batch to forming
- Forming assets with routes to flat and container manufacturing
- Started our 1st campaign on the flat (rolled plate) line

Design priority

Experimental flexibility, industrial relevance and instrumentation access — not simple replication of a commercial furnace even though it followed typical design approach for furnaces — nothing completely unknown or untested



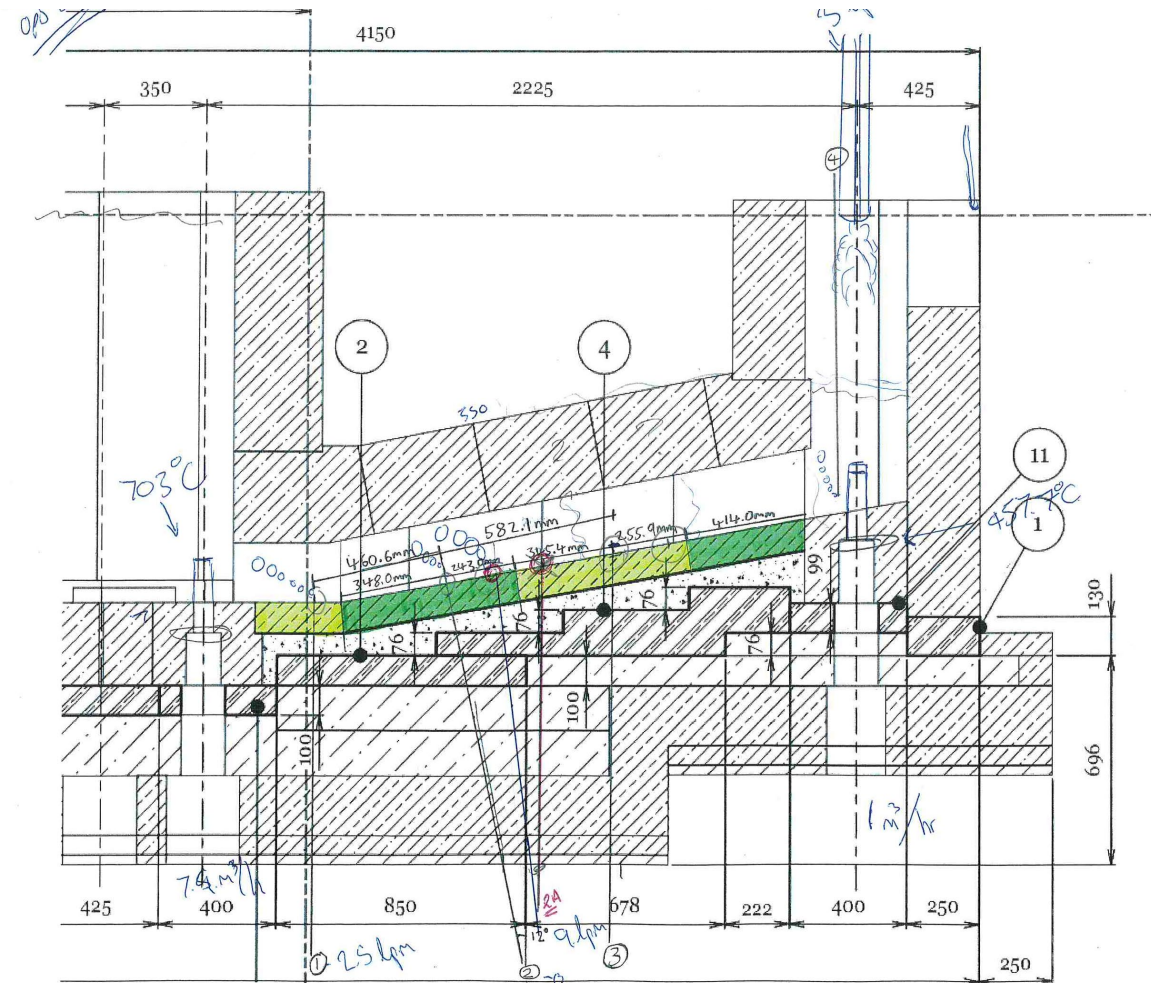
Why the throat design mattered

FUNCTION

- Submerged passage connecting the melting end to the working end.
- Controls molten glass flow and supports conditioning.
- More like a container line design – not a waist like a float line

WHY LONG & NARROW — AND SENSITIVE

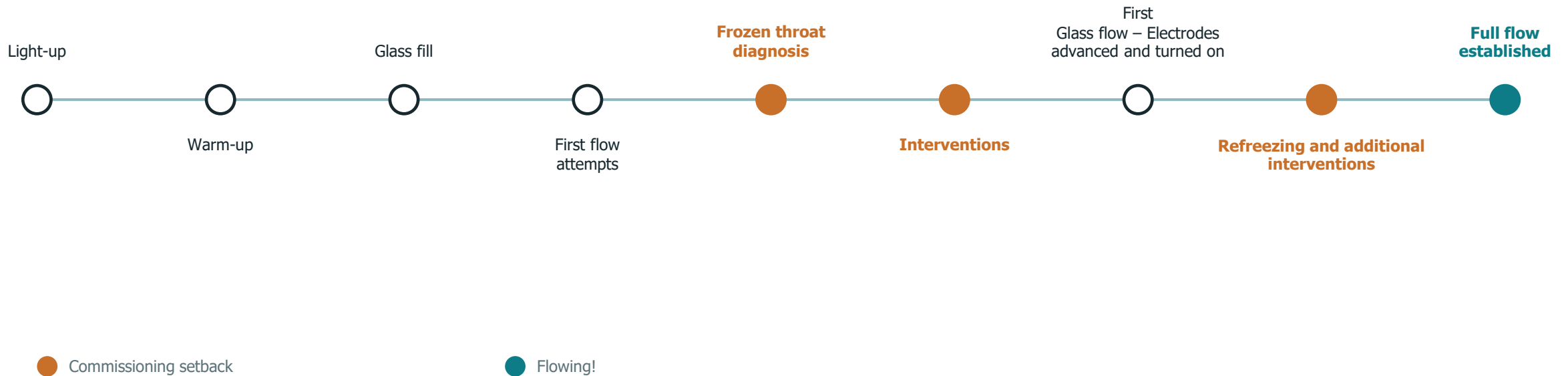
- Enables access!
- Front wall burners need the working end to be set back
- But local heat balance/loss, access and heating become critical at fill and start-up.



Start-up and fill: what wasn't supposed to happen!

PLANNED SEQUENCE

Controlled warm-up → staged checks → burner transition → glass fill → flow through the throat → stabilise working end & forehearths → baselining and trials.



The problem: what actually happened

- During start-up and fill, local throat temperatures were lower than required for reliable flow.
- Very difficult to see actual temps within the local throat zone
- The furnace is up to temp ready for fill on, but couldn't get higher temps in the working end than circa 1000DegC
- Fill on begun, but due to slower fill rate (fill at melt rate) we just couldn't keep the level increasing at a desired rate to push molten glass through the throat
- Good old thermodynamics beat us! Lost too much temp and flow stopped
- Loss of gas flow from furnace to working end under high pressure meant temps likely crashed as soon as the throat was sealed with glass
- Restoring stable glass flow became the critical commissioning constraint.

THROAT THERMAL PROFILE — COLD ZONE



Viscosity trap

As local temperature falls, glass viscosity climbs steeply. Below the flow threshold the throat behaves as a semi-solid plug — hot furnace, no flow.

Theory versus practical reality

DESIGN THEORY

- Heat transfer would keep the throat above the flow threshold.
- Glass movement establishes steadily once fill completes.
- Electric boost delivers energy where needed.
- Burner influence reaches the critical region.
- Fill dynamics behave close to the design model.

PRACTICAL REALITY

- Local cooling outpaced heat input in the narrow passage.
- Glass coverage and timing changed heat transfer abruptly.
- Throat boost (using installed electrodes) requires molten glass to push and begin conduction!
- Boost was ineffective while the glass stayed cold and resistive.
- One-sided burner reach could not clear a deep restriction.
- Instrument position and access limited what could be seen.
- Clear need for more local heating in this design setup

Initial diagnosis and working hypotheses

Working hypotheses considered by the team as the picture developed:

H1

Insufficient heat in the centre of the throat during fill on and a slower than expected fill

H2

Uneven heat distribution during start-up – Tank at 1400 and throat exit at 1050 DegC

H3

Long, narrow geometry creating a high surface-area cold zone and no real space for glass to convect

H4

Inadequate burner coverage at the critical point – smaller focused burner required at the throat exit

H5

Cooling from steelwork, refractories or local conditions

H6

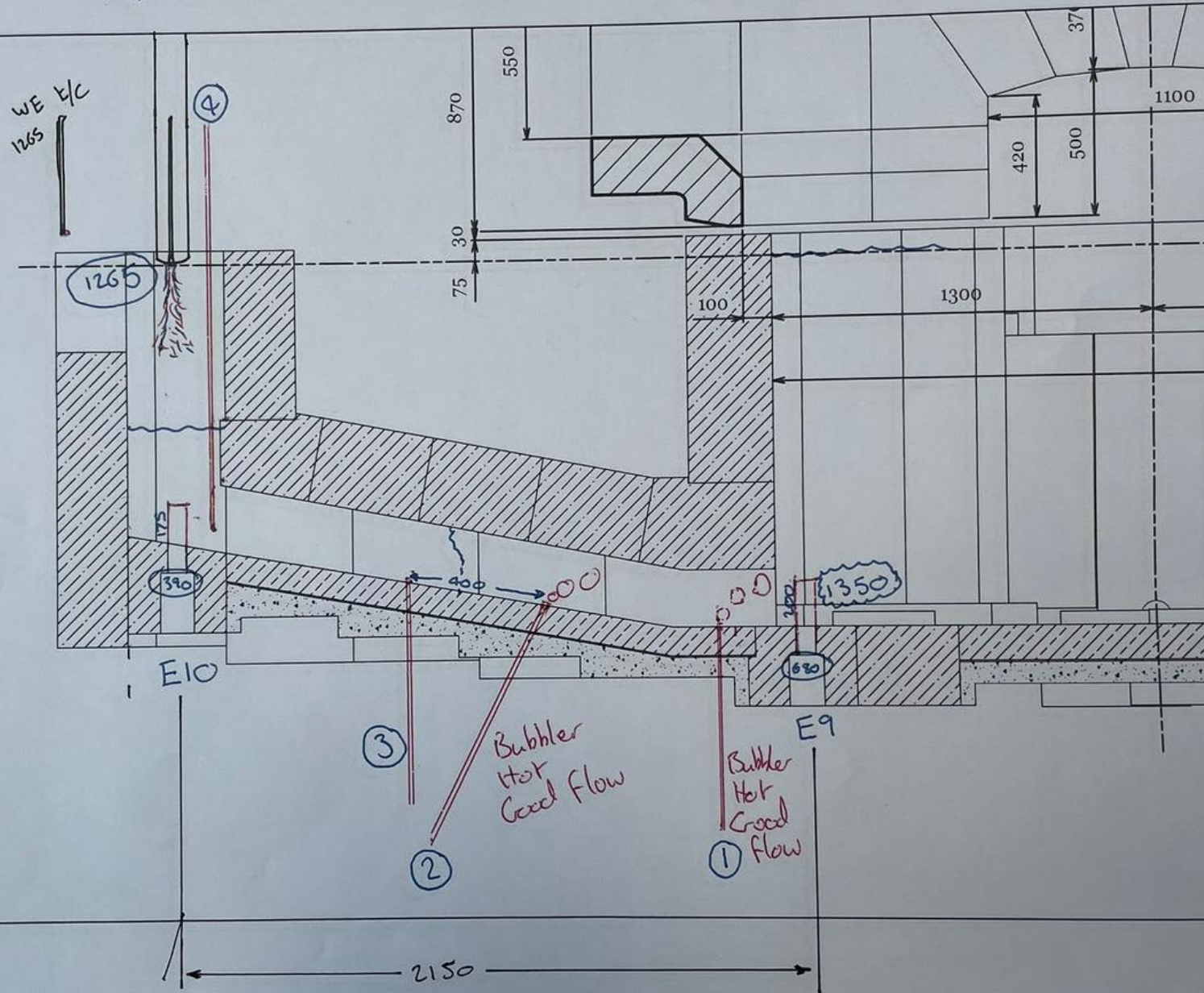
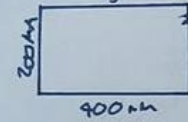
Slow or interrupted glass movement – sure we saw some initial flow but then stopped

H7

Boost wasn't effective initially limited by high resistance in cold glass

Pipe in Pipe burner

Throat
Dimensions



Intervention 1 — Local burner heating

THE LOGIC

Apply targeted burner heat from the throat/forehearth side and working-end areas to raise local heat input at the restriction.

Fashioned a manual air/gas burner as no oxy/gas solution could be sourced

Used a smaller burner from another piece of kit, water cooled and small so could be installed locally very well

WHAT IT ACHIEVED

- Logical first response — more energy at the critical zone.
- Raised temperatures around the throat exit
- Certain some glass flow was seen initial boost electrodes were advanced but then weren't effective and couldn't get moving again

WHERE IT WAS LIMITED

- Heating from one end may not overcome a solid or semi-solid restriction deeper in the throat.
- As Glass got deeper, still didn't fully flow and created an additional cap of hot glass top but with colder glass bottom
- Manual control and poor access made this solution an operational challenge with a number of additional safety checks
- Had to move the burner quickly when glass flowed – boost earth risk and submerged water cooled jack a safety risk



Burner installation



Intervention 2 — Bubblers and progressive throat access

THE LOGIC

Drill access points and install bubblers progressively along the throat to agitate glass, create local movement and improve heat transfer.

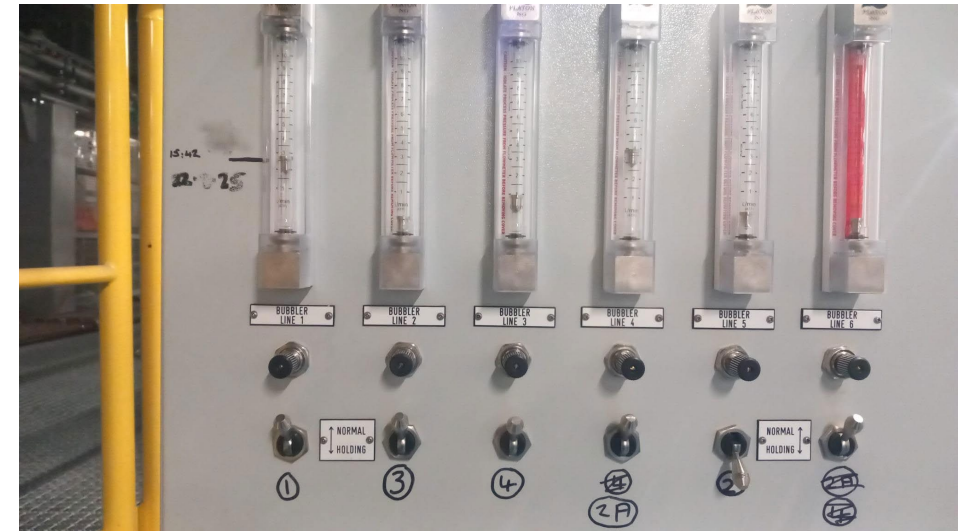
Move bubblers down as each one flowed, encouraging glass flow and convection using main tank glass temperature to pull heat into the throat

WHAT IT ACHIEVED

- Bubbling agitates glass and improves local heat transfer.
- Helps map molten versus frozen zones, working toward the blockage.
- Definitely worked! BUT VERY SLOW and difficult to get a read on exactly what was going on

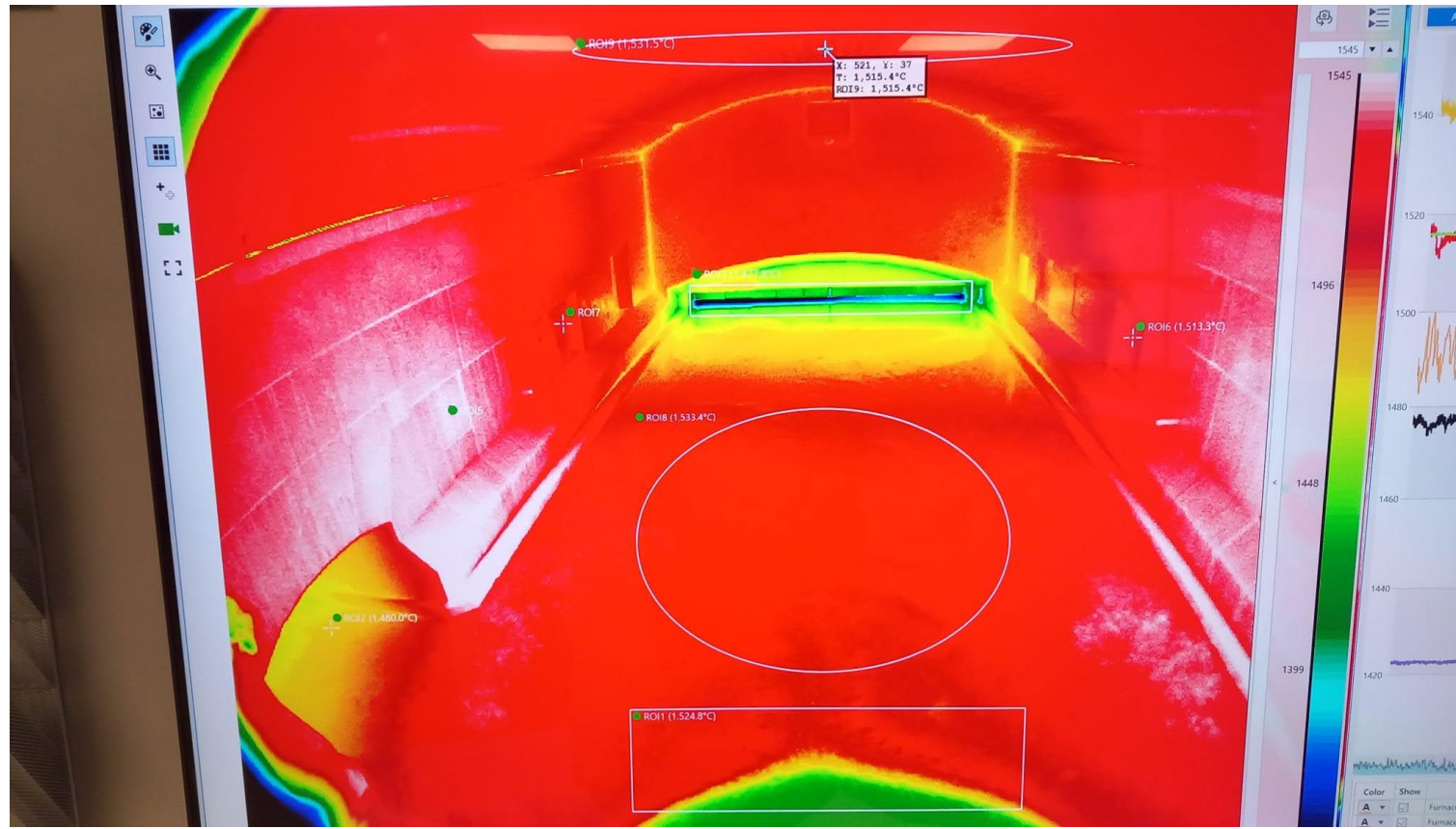
WHERE IT WAS LIMITED

- Steelwork access and drilling limits.
- Drilling bought risk of local cooling & damage to the throat.
- STOPPED BEING EFFECTIVE ONCE GLASS FLOWED!
- Caused a glass leak – air-lifted glass into the working end – had to stop this approach – leading to second frozen throat!



FIC Bubbler Panel

Bubbling visible – LAND camera



Intervention 3 — Electric boost across the throat

HIGH VOLTAGE – SAFETY!

THE LOGIC

Use electric boost as both an intervention and a diagnostic — resistance across the throat indicates whether glass is becoming more conductive, hotter and more mobile.

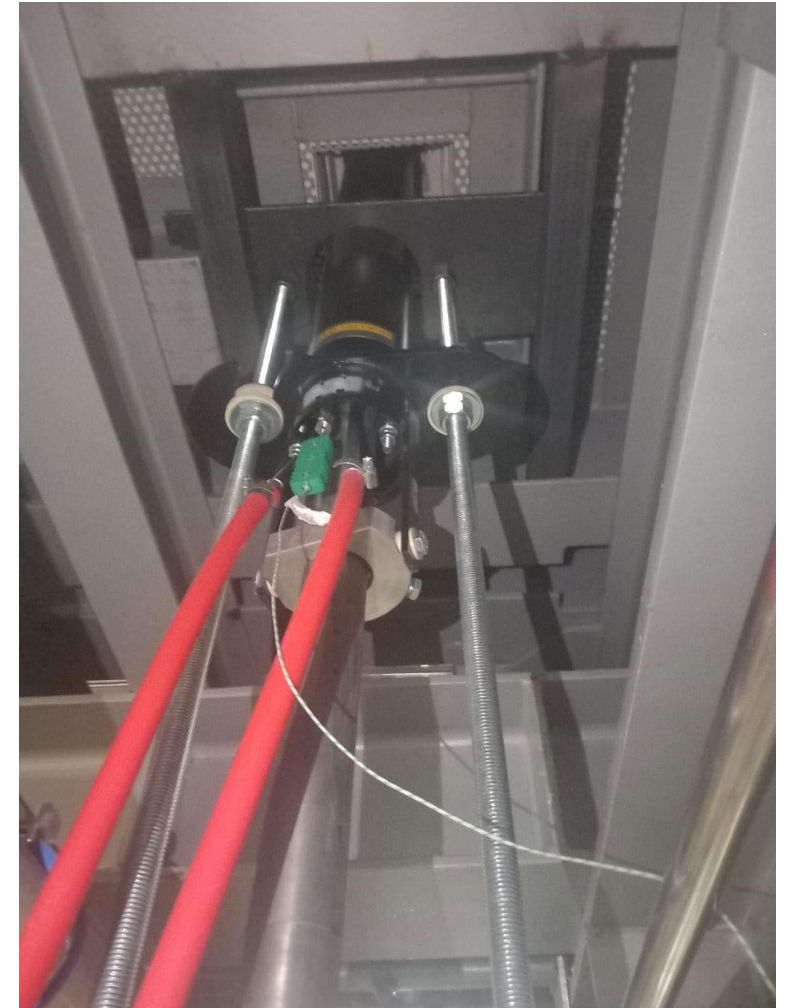
System was always installed as a safety measure – should use as intended!

WHAT IT ACHIEVED

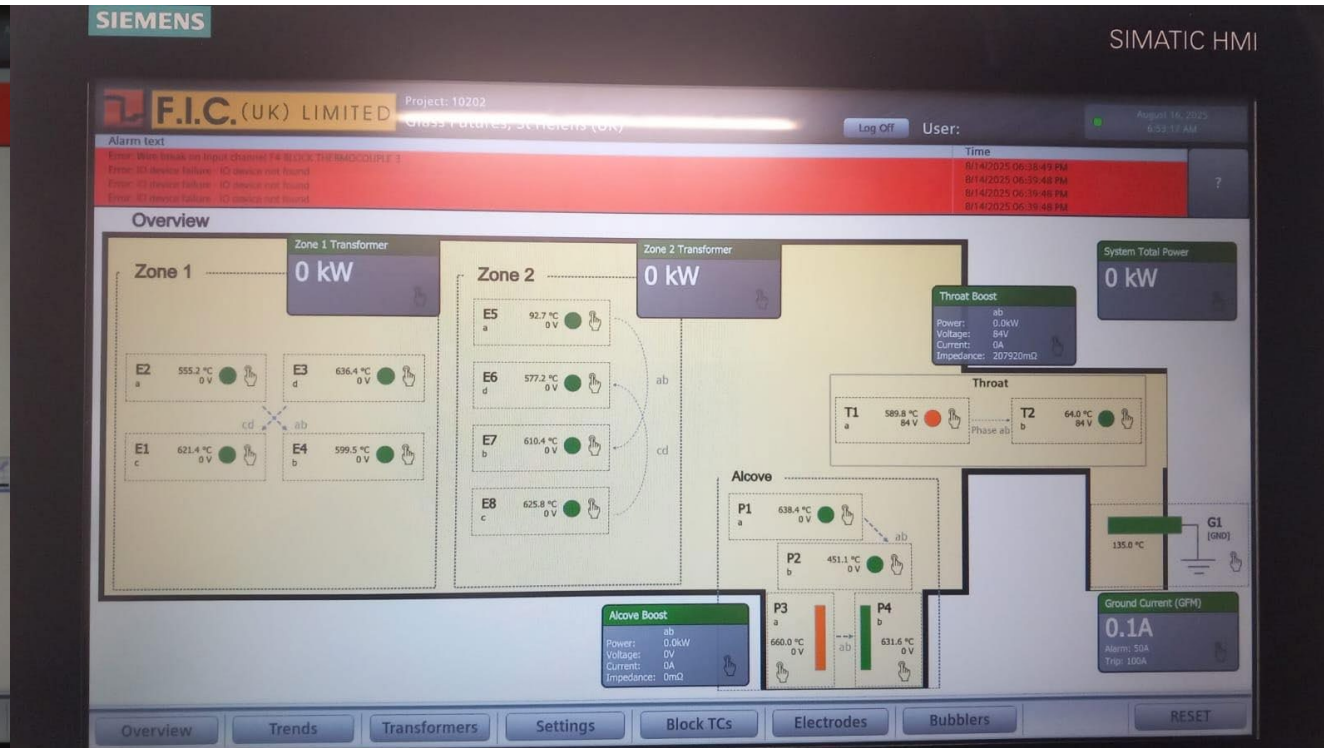
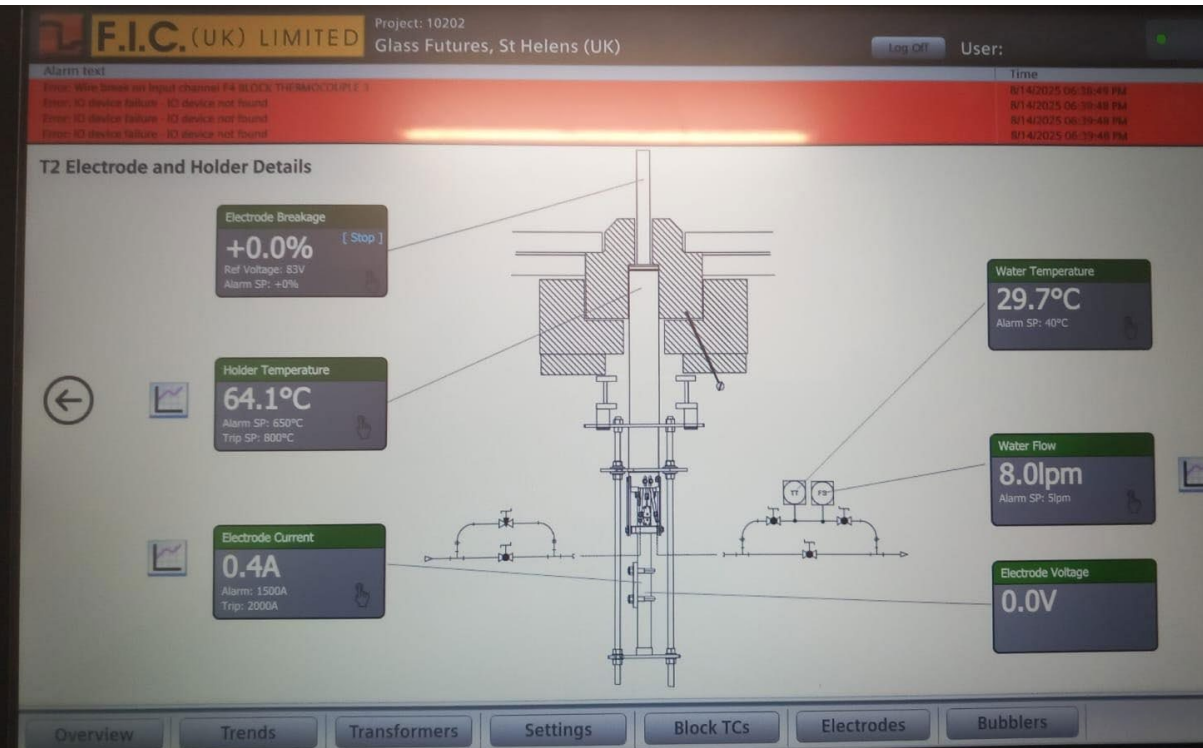
- Doubles as a live diagnostic of glass condition.
- Grows more effective as temperature and conductivity rise.
- Not just local heating, very direct between throat entrance/exit offering heating across the blockage

WHERE IT WAS LIMITED

- Least effective when glass is cold and highly resistive — exactly the starting condition.
- Lower voltage higher amps system is not good with cold glass – needed a jump start to be effective!



Comprehensive boost system - FIC



Intervention 4 — Ceramic heating mats and insulation

THE LOGIC

Apply external ceramic heating mats and insulation to raise local throat temperature in a controlled way while cutting heat loss.

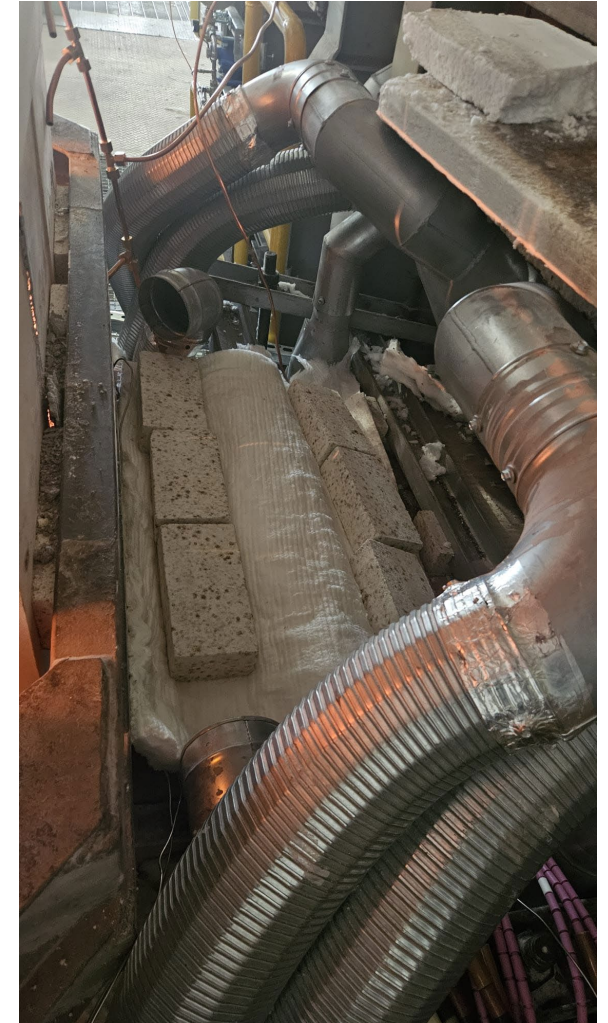
Claims of people using burners outside the throat was concerned about this risk/manual intervention/max temp increase

WHAT IT ACHIEVED

- Sustained, controllable local heating.
- Manages the risk of thermal shock to refractories.
- Ensured minimum heat loss across unheated throat area

WHERE IT WAS LIMITED

- External heat must still conduct inward to reach the core of the restriction
- Worried about steelwork temps
- On/off nature of the control posed a small risk – but overall very happy with this as a heating solution
- Would highly recommend in local areas requiring heating



Ceramic Mats



Intervention 5 — Step-up transformer & higher-voltage boosting

THE LOGIC

Increase voltage via a step-up transformer to drive more voltage at lower amps into high-resistance glass — a practical workaround from supplier advice and on-site problem-solving.

Installed stainless steel rod as a basic electrode for localized heating in former bubbler locations

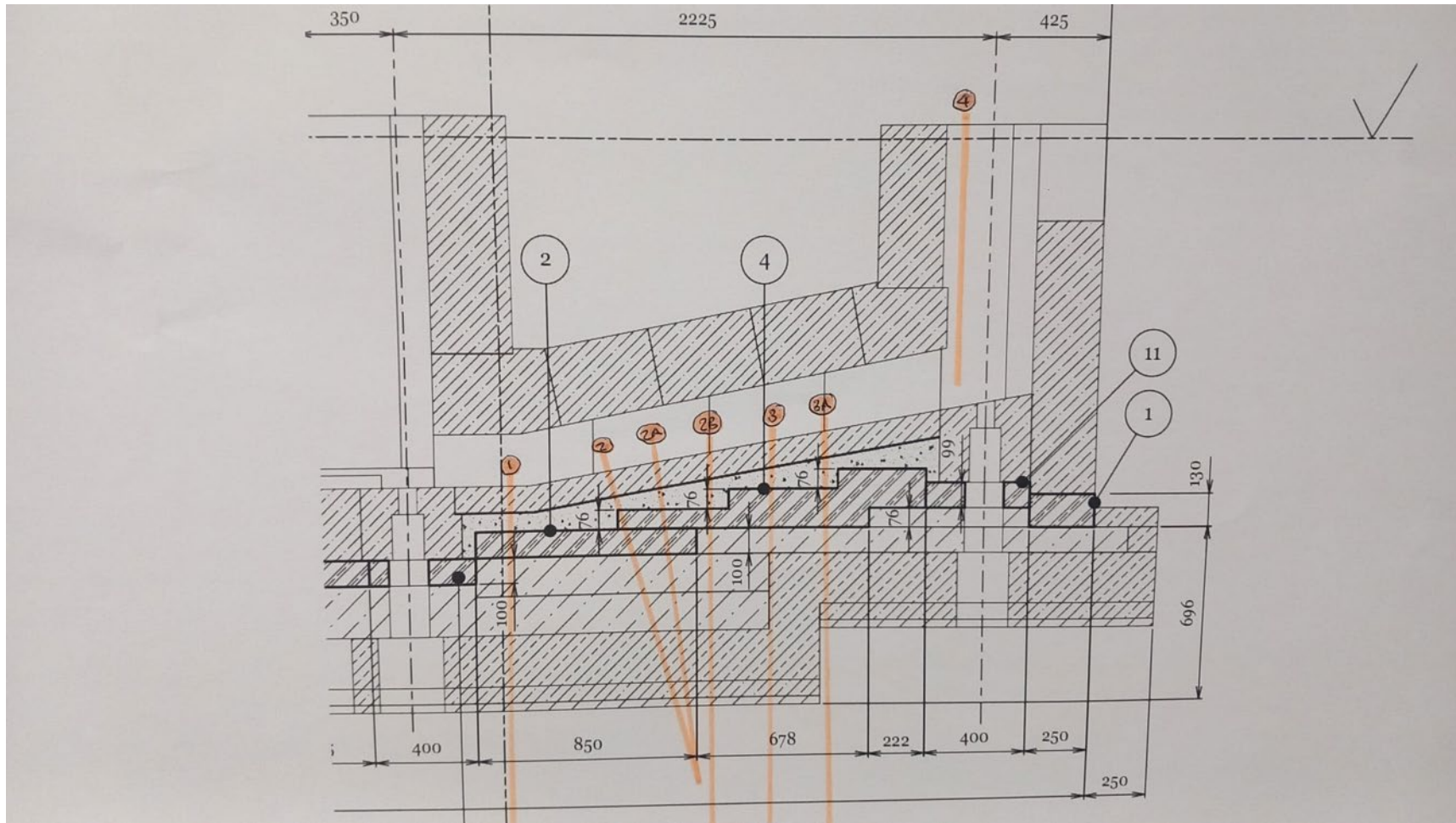
WHAT IT ACHIEVED

- Old re-conditioned transformer worked to give this advantage
- Improved energy delivery and penetration into resistive glass.
- Produced early signs that glass was beginning to move.
- Moved to a specific transformer designed to do the job – much more controlled and effective

WHERE IT WAS LIMITED

- Must watch voltage, earth leakage and safety limits carefully.

Locations available for electrodes!



Locations available for electrodes!



When you just can't catch a break!



Intervention 6 — External expert support

THE LOGIC

Engage furnace suppliers, member experts and wider industry specialists for troubleshooting and specialist intervention.

WHAT IT ACHIEVED

- Drew on collective industry experience at speed.
- A strength of the Glass Futures shared-asset model.

WHERE IT WAS LIMITED

- Industrial problem-solving needs a network — avoid over-crediting or over-reliance on any single party.
- Different people recommended different things based on their own experience
- EACH GLASS PROBLEM IS UNIQUE!



What worked, what did not — and why

Intervention	Primary role	Practical observation	Contribution
Local burner heating	Raise local heat	Reached ends, not the deep core	Partial
Bubblers + access	Agitate & map zones	Movement + molten/frozen mapping	Enabling
Electric boost	Heat + diagnostic	Weak cold, stronger as temp rose	Growing
Ceramic mats + insulation	Sustained local heat	Raised & held local baseline	Supporting
Step-up transformer	Deeper energy delivery	Early signs of glass moving	Key to unlock!
External expert support	Network troubleshooting	Rapid specialist input	Decisive

Key point Ultimately higher boost unlocked the issue. Persistent monitoring and adapting the plan as the throat's physical condition changed with support and team-work!

The human and operational dimension

THE PRESSURES

- A new team on a new plant.
- A delayed trial programme and high-value assets at risk.
- Technical uncertainty and wide stakeholder interest.

THE DISCIPLINE THAT MATTERED

- Safety first, with clear escalation.
- Written shift instructions and controlled decisions.
- Frequent, honest communication.
- Not rushing interventions that could damage the furnace.

"The fastest route is not always the best route — protecting the asset was a decision, made repeatedly, under pressure."

Lessons for furnace design and commissioning

01

Treat throat geometry and access as commissioning-critical, not just operating-critical.

02

Plan heat-up and fill around the exact moment glass seals the throat and changes heat transfer.

03

Instrument for real-time local glass condition, not only bulk furnace condition.

04

Boost needs sufficient glass temperature and conductivity before it becomes effective.

05

Treat bubbling, local heating and boosting as one integrated recovery toolkit.

06

Review physical access for drilling, inspection and emergency intervention at design stage.

07

Build supplier and industry-expert engagement into commissioning governance from the outset.

Lessons for troubleshooting and decision-making

Start with hypotheses

but let measured behaviour challenge the theory.

Every intervention is data

use each action as a diagnostic opportunity.

Track small improvements

resistance drops, temperature movement, bubbling and visual cues all signal progress.

Progress $\neq$ breakthrough

no immediate breakthrough does not mean no progress.

Protect the asset

the fastest route is not always the best route.

Communicate often

especially when uncertainty is high.

From frozen throat to campaign mentality

The furnace is best understood as a campaign-based R&D asset — run in planned campaigns when industrial trials, member needs and technical programmes justify hot operation.

BETWEEN CAMPAIGNS

- Site assets, data and technical expertise stay in use.
- Consultancy capability supports the wider industry.
- Engineering, modelling, training and maintenance continue.

What campaign operation enables

01

Aligned operation

Furnace runs match funded or commercial trial demand.

02

Disciplined readiness

Structured readiness planning before hot operation begins.

03

Bundled trials

Alternative fuels, boosting, raw materials, product & digital work together.

04

Lower asset risk

Avoid running a high-cost asset without technical or commercial use.

05

Productive downtime

Engineering, modelling, training, consultancy and member support between campaigns.

Final takeaways

- 01** A severe but valuable commissioning lesson.
- 02** It exposed the gap between design assumptions and real start-up behaviour.
- 03** The fix took layered interventions, careful monitoring, external expertise and operational discipline.
- 04** The learning supports future furnace design, commissioning and troubleshooting across the industry.

The bigger lesson

Glass Futures is not only a furnace operator — it is a practical industrial learning platform for de-risking the future of glass manufacturing, developing, learning and teaching.

Glass makers – Understand glass makers problems!