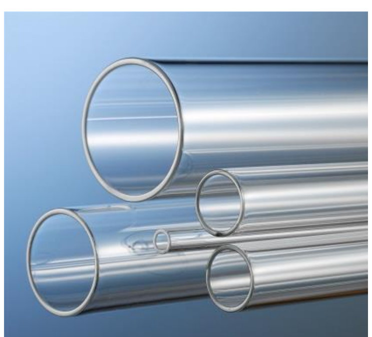
43rd ASEAN GLASS CONFERENCE

Glass: Inspiring New Frontiers of Development

Benjamin Köster




Furnace Draining

-Environmentally friendly

-full recycling of glass cullet

-full recycling of water

-highest safety standards / procedures

-high safety due to use of cooled water

-fully closed circuit, no overflow

-plug and play installation

-all equipment tested and certified

Furnace Heat Up

-The “Hotwork” method is worldwide standard

-Over 1.000 successful Furnace Heat Ups and Draining's

-Engineers with over 15 years of experience

-Senior Engineers with over 25 years of experience

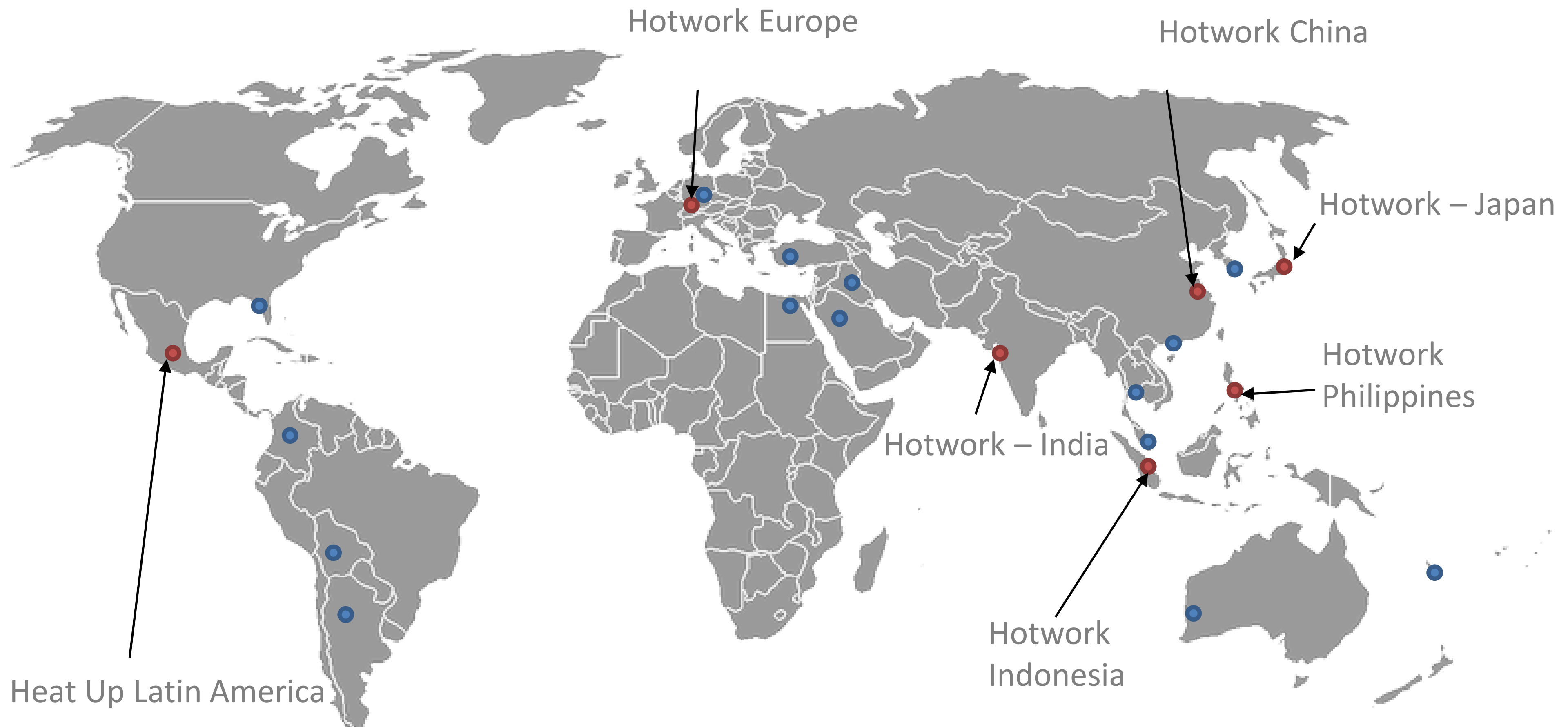
-Experienced with all types of furnaces:

-Float/Container/Fiber/LCD/Electric/Oxy-fuel/Special Glass

-International Crews

-Over 16 spoken languages

Being an International company, we reach out to any location worldwide…
doesn't matter if its in the Jungle, Dessert or the cold north of Siberia.



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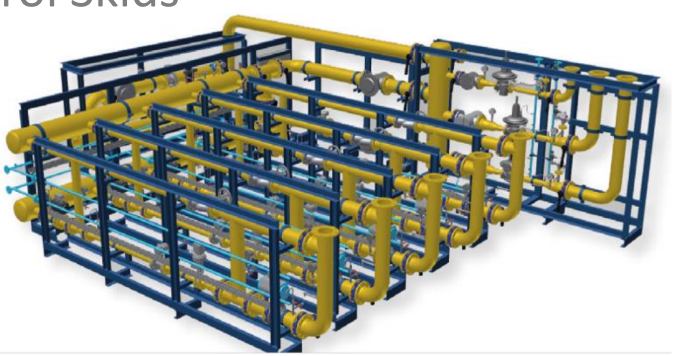
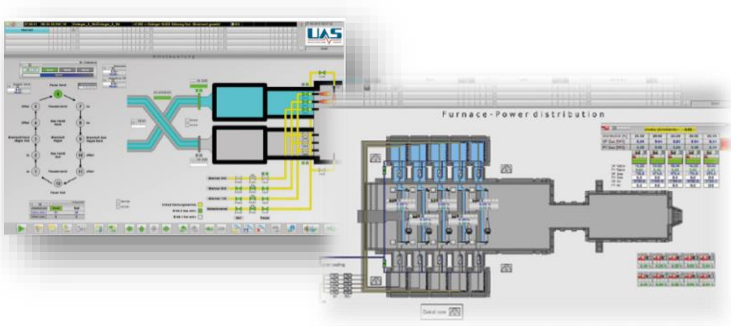
Hotwork
INTERNATIONAL

Innovative Combustion Systems

Control Skids



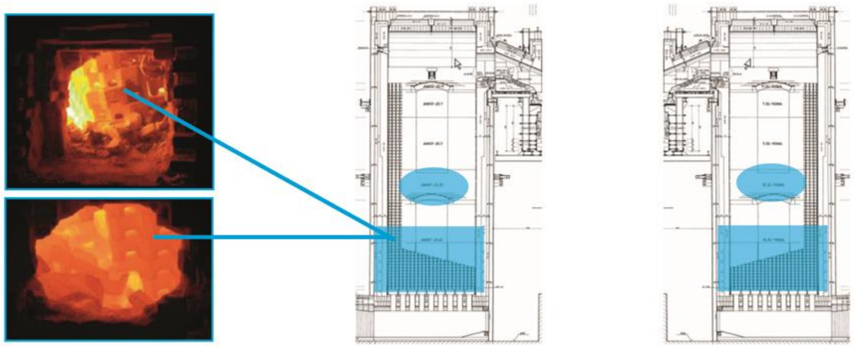
Furnace Controls / DCS



Gas/Oil/Oxygen
Burner

Regenerator Repair without production loss, possible?

Regenerator Repair without production loss, possible?



Correct regenerator function is vital for efficient furnace operation

Regenerator checker blockage and collapses result in:

- *Increased gas consumption*
- *Increased furnace pressure*
- *Increased refractory corrosion and potential for defects*
- *Reduced furnace pull and thermal efficiency*
- ***Increased costs….***

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Regenerators – main issues

Crown:
~ 1350 – 1550°C

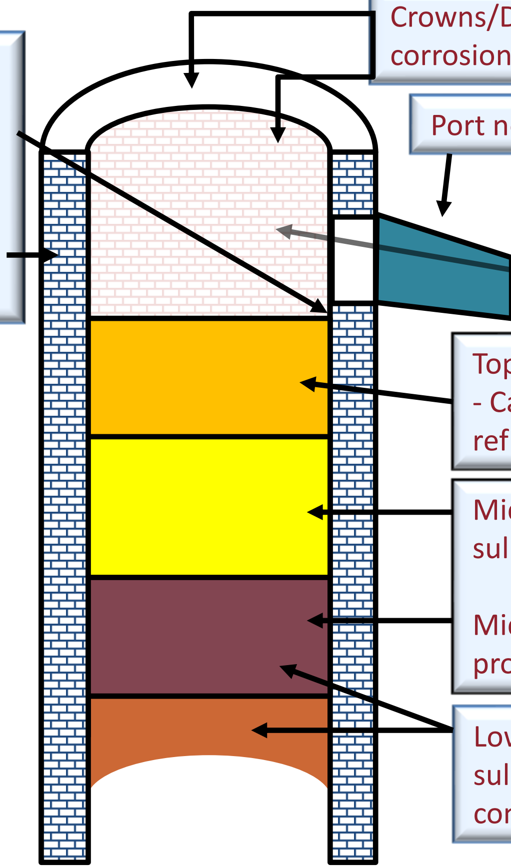
Port neck:
~ 1400 – 1600°C

Top Checkers:
~ 1350 – 1550°C

Rider arch
~ 500 – 800°C

Target wall and Port sill: Carryover erosion and corrosion

Target wall – movement inwards due to creep & forsterite growth



Crowns/Dividing walls: Thermal Creep; alkali corrosion; shelling

Port necks – refractory shelling/blockage

Particulate carryover (batch/cullet) Alkali gases (e.g NaOH), CO

Top checkers:
- Carryover blockage; forsterite bursting, refractory shelling, V_2O_5 corrosion

Middle checkers: blockage (from above), sulphate attack, collapse due to overheating

Middle/Lower checkers – reducing conditions promoting Na_2CO_3 attack

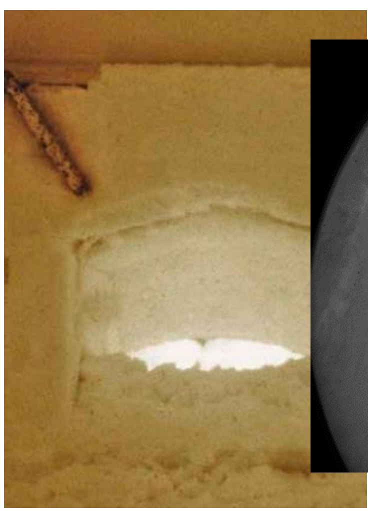
Lower checkers/Rider arches: sodium sulphate blockage (oxidising conditions)/Spalling, Thermal cycling

Regenerators - useful process variables to monitor

- Regenerator crown temperatures (daily – linked to SCADA)
- Rider arch/lower chamber temperatures (daily – linked to SCADA)
- Chimney damper position/OP% (daily) – is OP% increasing (suddenly/gradually)?
- Reversal damper operation – reversing and sealing correctly (weekly)
  - Procedure to follow in the event of prolonged reversal failure ?
- External structure – visual/thermographic inspection for hotspots, cracks, sting-out
- Upper and lower chamber pressure; firing and non-firing side (every 2 months)
- Waste gas combustion (manual) analysis – O_2, CO, NOx (weekly/pull change/colour change)
- Smoke/flames at the rider arches?
- Visual inspection of port necks, upper chamber and top checkers (weekly)
- Radiation pattern in regenerator bases (monthly – visual mirror inspection/mapping)
  - Any evidence of broken checker bricks?
- Endoscope inspection of upper chamber structure and checkers (6-12 months)
- Establish baseline trends and monitor regenerator health!

Regenerator problems

So, what are the options when you face major regenerator problems?



Regenerator problems

Option 1: Do nothing…..

Probable results:

- Further deterioration of the checker pack leading to premature furnace shutdown.
- Increasing difficulty in controlling furnace pressure and combustion.
- Pull reductions required.
- NO_x, SO_X, CO emissions increase.
- Glass quality reduction.
- Difficulty in meeting production orders.
- Unhappy management and customers….

Regenerator problems

Option 2: checker removal

- Hot removal of collapsed checker layers/channel creation
- Only helpful if the first 2-3 course are blocked and access available
- **Advantages:**
  - Low cost option
  - Fast implementation.
- **Disadvantages:**
  - Reduced regenerator efficiency and increased energy cost.
  - Short term solution (middle pack exposed to higher temperature, carry over attacks etc.)
  - Increased emissions
  - Increased waste gas temperatures

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Regenerator problems

Option 3: Furnace hot-hold and regenerator repair (e.g. checkers, crown)

- Furnace temperatures are held in the range 1200-1300°C for the duration of the repair using high velocity burners
- Typical repair duration for an end-fired furnace is 17 to 24 days depending on size, access and scope of repair
- Regenerators are isolated from the furnace, cooled down and repaired accordingly

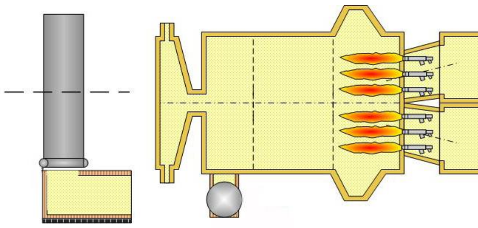
Advantages:

- Re-establish regenerator integrity and restores design thermal efficiency

Disadvantages:

- Increased capital expenditure
- No production during the regenerator repair period
- Difficulty in meeting production orders

Regenerator problems



Option 4: Temporary oxygen-firing conversion and regenerator repair

Furnace is converted to oxygen-firing for the duration of the checker repair

- Typical repair duration for an end-fired furnace is 17 to 24 days depending on size, access and scope of repair
- Furnace temperatures are maintained at normal production settings to allow continued production during the regenerator repair
- Regenerators are isolated from the furnace, cooled down and repaired accordingly

Advantages:

- Re-establish regenerator integrity and restore design thermal efficiency
- Maintain production output and glass quality at normal levels
- Allows a fast response to emergency situations
- Can be used on a longer term basis if refractory materials are not immediately available

Disadvantages:

- May not be justifiable financially, depending on post-repair campaign life expectations

Why Oxygen firing is suitable to regenerator repairs

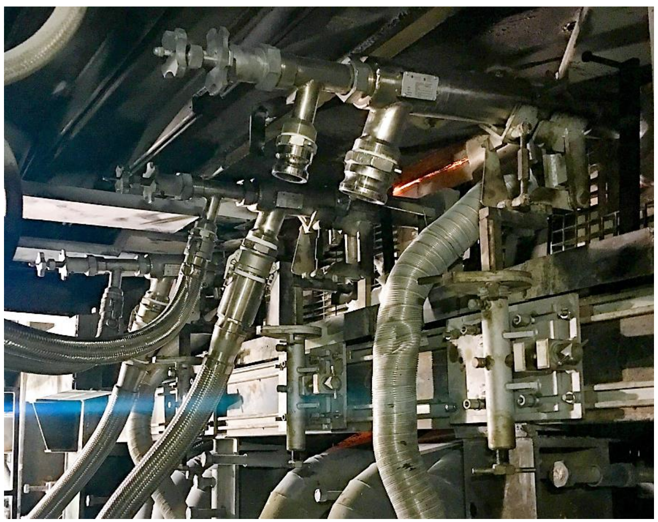
Increased Flame Temperature vs. normal air-fuel combustion

- Flame temperature is determined by calorific value of the fuel and the mass of waste gases generated from the combustion processes
- Compared to air-fuel combustion, oxy-fuel combustion generates a much lower mass of waste gases (and can also be exhausted via temporary flues used in the repairs)
- This means that flame temperatures are higher with oxy-fuel firing compared to air-fuel firing

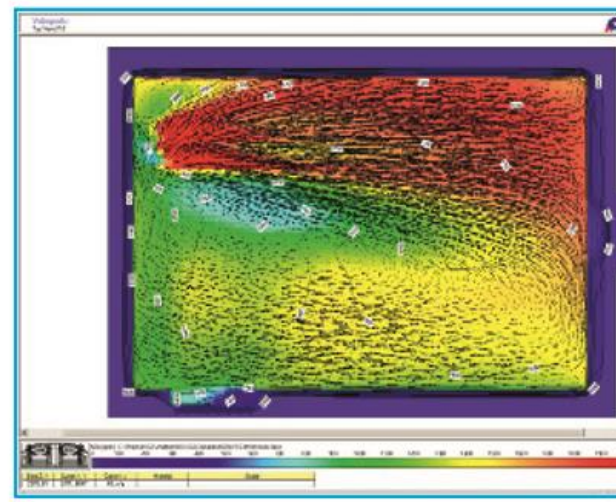
Flame temperature comparisons (stoichiometric combustion)

- Natural gas and ambient (20°C) air: ~ 1950°C
- Natural gas and preheated (1300˚C) air: ~2400°C
- Natural gas and ambient (20°C) oxygen: ~2800°C
- So, with oxy-fuel firing we don't need preheat as we do with the combustion air
- Perfect when we don't have the regenerators available for preheating!

Oxy-fuel burner system – underport firing



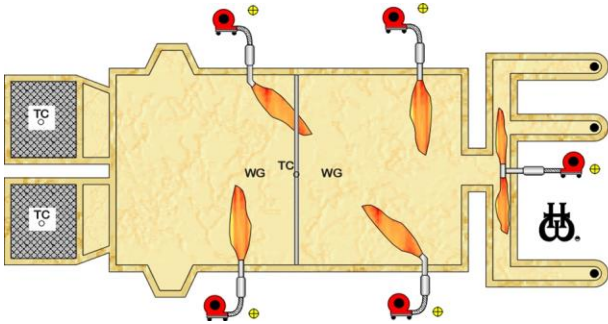
Regulating Oxygen Burners compatible with ~95% of existing underport firing configurations



Regulating Oxygen Burners
Good flame coverage, Low Nox
Adjustable flame pattern

Oxy-fuel burner system – underport firing

- Oxygen Burners normally utilise existing plant natural gas line to connect to burners.
- Alternatively a dedicated Gas/LPG station can be supplied
- Oxygen Burners also compatible with fuel oil
- In an emergency situation, maintain the furnace with heat up burner and hot-hold at short notice, whilst Oxygen equipment and supply are organised
    - *Our group have hot hold burner equipment available at 10 Global locations, also in Mexico*

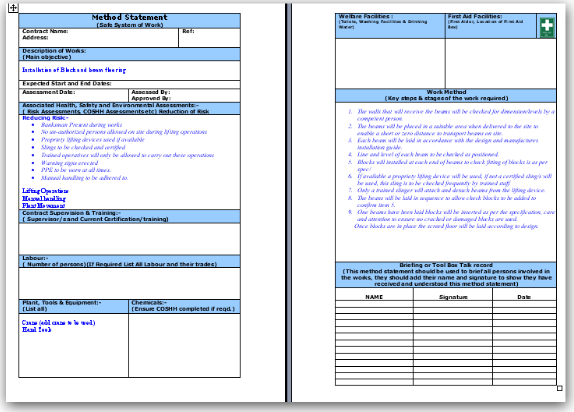


Simple comparison – Oxygen solution vs Hot hold

OXYGEN SOLUTION RUNNING COST VS SALES		
ITEM	QUANTITY	UNIT
GAS	710	NM3/HR
OXYGEN	1600	NM3/HR
GAS COST	€0.22	EUROS/NM3
GLASS PULL	180	TONS/DAY
GLASS SALE	408	EUROS/TON
OXYGEN COST	€0.16	EUROS/NM3
REPAIR COST (EQUIPMENT + LABOUR)	€480,000	EUROS - 24 DAY REPAIR DURATION
REFRACTORY COST	€250,000	EUROS
DAILY OXY + GAS	€9,739	DAILY GAS + OXY COST
TOTAL OXY + GAS	€233,741	24 DAY REPAIR PERIOD
GLASS SALES VALUE PER DAY	€73,440	EURO
GLASS SALES VALUE - 24 DAY REPAIR	€1,762,560	EURO
GLASS SALES MINUS REPAIR COSTS	€798,819	EURO

HOT HOLD RUNNING COST VS SALES		
ITEM	QUANTITY	UNIT
GAS	600	NM3/HR
COMBUSTION AIR	0	AIR FROM HV BURNERS
GAS COST	€0.22	EUROS/NM3
GLASS PULL	180	TONS/DAY
GLASS SALE	-408	EUROS/TON (NEGATIVE, NO PRODUCTION)
REPAIR COST (EQUIPMENT + LABOUR)	€262,000.00	EUROS - 24 DAY REPAIR DURATION
REFRACTORY COST	€250,000.00	EUROS
DAILY GAS COST	€ 3,168.00	DAILY GAS COST
TOTAL GAS COST	€ 76,032.00	GAS COST 24 DAY REPAIR PERIOD
LOST GLASS SALES VALUE PER DAY	-€73,440.00	EURO
LOST GLASS SALES VALUE 24 DAY REPAIR	-€1,762,560.00	EURO
LOST GLASS SALES PLUS REPAIR COSTS	-€2,350,592.00	EURO

Stage 1: Scope definition Engineering, method statements and risk assessments



Method Statement
(Safe System of Work)

Contract Name:
Address:
Ref:

Description of Works:
(Main objective)

Installation of Block and beam flooring

Expected Start and End Dates:

Assessment Date:
Assessed By:
Approved By:

Associated Health, Safety and Environmental Assessments:-
(Risk Assessments, COSHH Assessments etc) Reduction of Risk

Reducing Risk:-

- *Banksman Present during works*
- *No un-authorized persons allowed on site during lifting operations*
- *Propriety lifting devices used if available*
- *Slings to be checked and certified*
- *Trained operatives will only be allowed to carry out these operations*
- *Warning signs erected*
- *PPE to be worn at all times.*
- *Manual handling to be adhered to.*

Lifting Operations
Manual handling
Plant Movement

Contract Supervision & Training:-
(Supervisor/s and Current Certification/training)

Labour:-
(Number of persons)(If Required List All Labour and their trades)

Plant, Tools & Equipment:- (List all)	Chemicals:- (Ensure COSHH completed if reqd.)
Crane (add crane to be used) Hand Tools	

Welfare Facilities : (Toilets, Washing Facilities & Drinking Water)	First Aid Facilities: (First Aider, Location of First Aid Box)

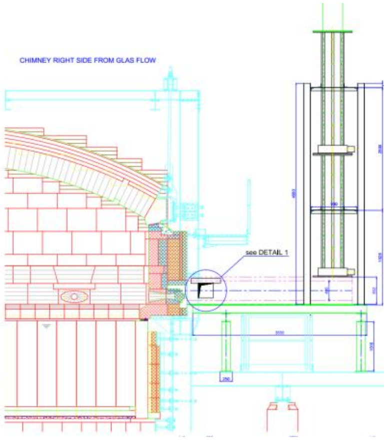
Work Method
(Key steps & stages of the work required)

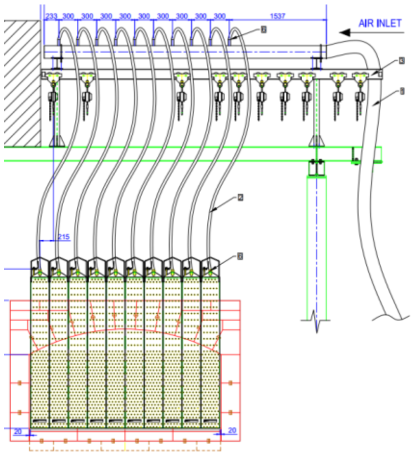
1. *The walls that will receive the beams will be checked for dimension/levels by a competent person.*
2. *The beams will be placed in a suitable area when delivered to the site to enable a short or zero distance to transport beams on site.*
3. *Each beam will be laid in accordance with the design and manufactures installation guide.*
4. *Line and level of each beam to be checked as positioned.*
5. *Blocks will installed at each end of beams to check fitting of blocks is as per spec/*
6. *If available a propriety lifting device will be used, if not a certified sling/s will be used, this sling is to be checked frequently by trained staff.*
7. *Only a trained slinger will attach and detach beams from the lifting device.*
8. *The beams will be laid in sequence to allow check blocks to be added to confirm item 5.*
9. *One beams have been laid blocks will be inserted as per the specification, care and attention to ensure no cracked or damaged blocks are used.*

Once blocks are in place the screed floor will be laid according to design.

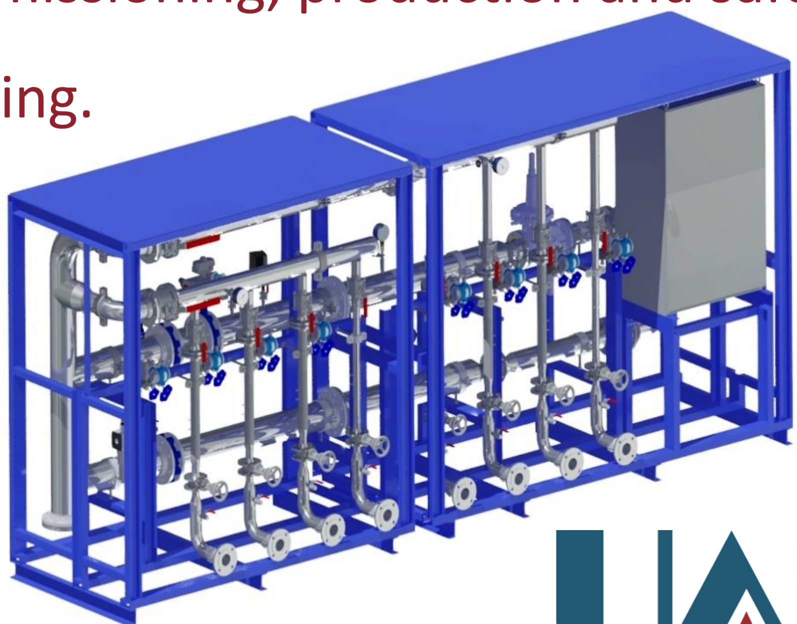
Briefing or Tool Box Talk record
(This method statement should be used to brief all persons involved in the works, they should add their name and signature to show they have received and understood this method statement)

NAME	Signature	Date



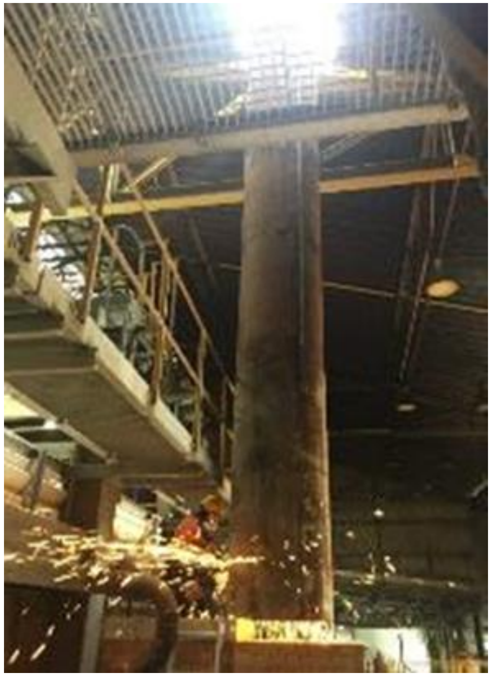


Stage 2: Oxygen storage and station commissioning, production and safety training.



Stage 3: Temporary exhaust flue installation

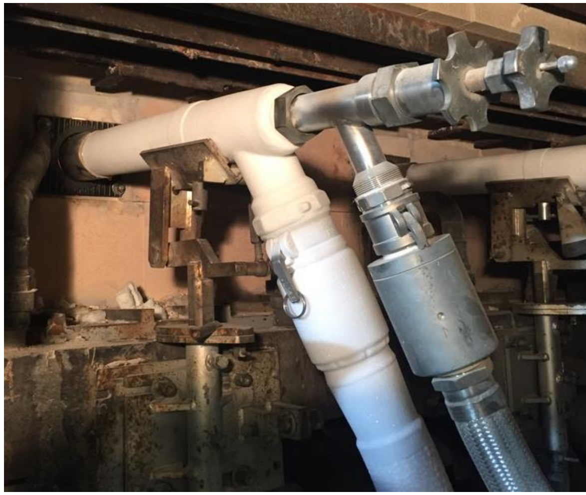
Stage 4A: Port neck isolation with dampers



Stage 4B: Regenerator chamber cooldown;

Stage 4C: Port neck insulation

Stage 4D: Transition to oxygen firing – production support and burner optimisation



Stage 5: Demolition during production

Stage 6: Rebuilding checker/Regenerator

Stage 7: Heat up of regenerator chamber

Stage 8: Port neck damper removal and transition from Oxygen to main fuel firing

Stage 9: Resealing of regenerator expansions and joints

Oxygen firing regenerator repair examples

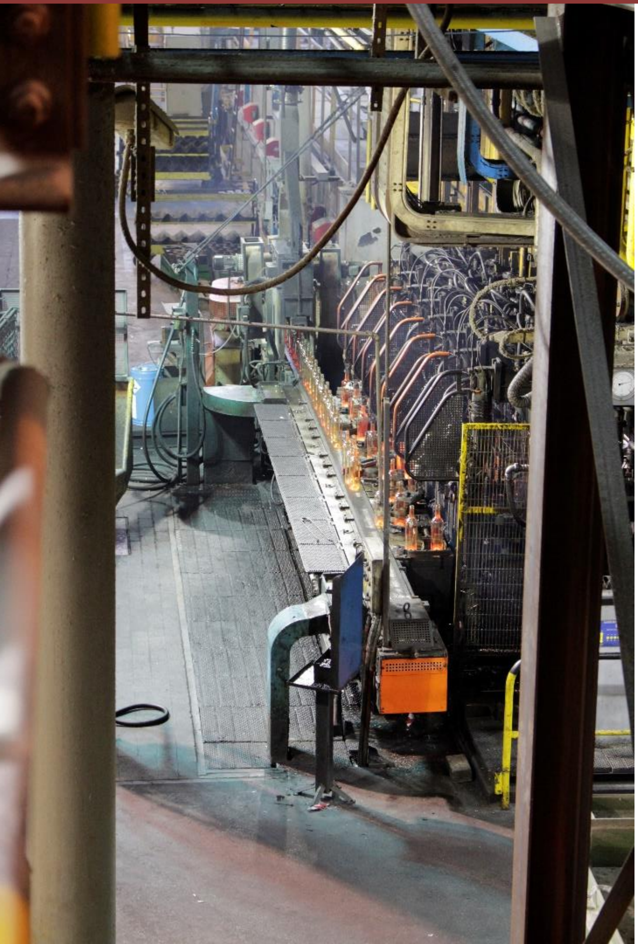
	Furnace A	Furnace B
Furnace Type	Container	Container
Regenerator type	End fired/double pass	End fired/single pass
Repair Type	Emergency:Oxy-conversion	Planned: Oxy-conversion
Pre-repair pull (design)	340 tpd	440 tpd
Pull during repair	260 tpd*	440 tpd
Chambers repaired	2 (Left and right)	2 (left and right)
Scope of repairs	Crowns/target walls/dividing wall/rider arches/checkers	Crowns/endwalls/innerwalls and checkers
Repair duration (Cooldown/demolition/installation/ heat-up)	14 days*	21 days

** Furnace A ran for 6 months on oxygen prior to regenerator repair. LPG supply restrictions at site meant that furnace had to run at reduced load during repair period. Alternative to repair was a furnace cold repair*

Turn Key Solution

- Unique collaboration between **Hotwork International, Lizmontagens Melting & Services** and the **Linde Group** allows us to provide a turn-key solution for oxygen conversion and regenerator repair, leveraging the core-competencies of each company:
- ***Lizmontagens Melting and Services*** *– Project management, engineering, materials refractory demolition and installation services.*
- ***Hotwork International*** *– Oxygen combustion system, combustion engineering, hold hot, cooldown and heat-up management, production support.*
- ***Linde Group*** *– Oxygen supply including temporary cryogenic storage facilities, vaporiser, piping, distribution and oxygen delivery.*

Regenerator Repair without production loss, possible?



Yes!

Thanks for Listening

Special Thanks to:
Mike Rose, Gianni Carbone, Matthias Görisch