FURNACE AUDIT

Budapest 2014

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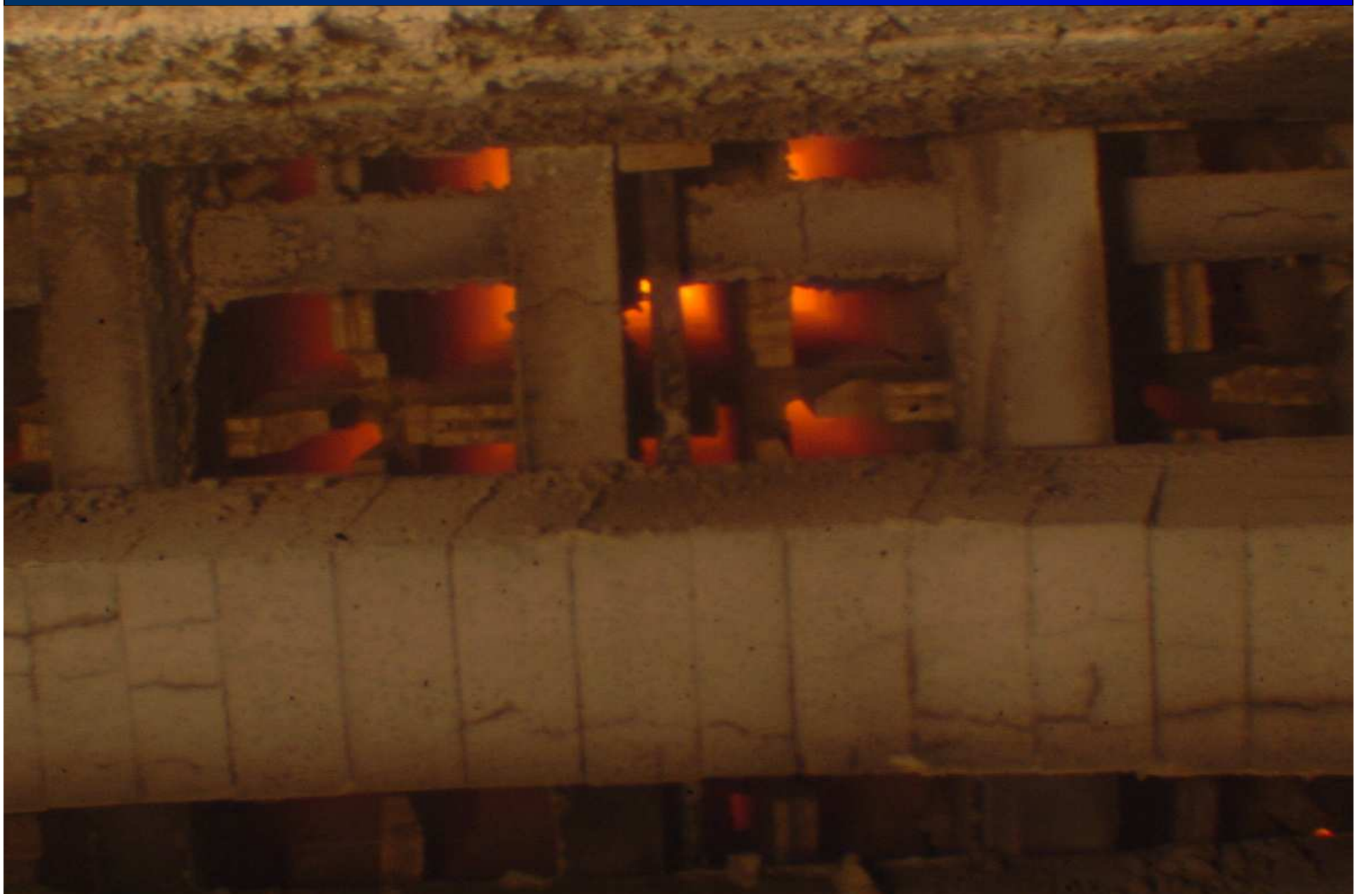
FURNACE AUDIT

- Visual observation of regenerators
- Survey of furnace superstructure by periscope
- Survey of outside temperatures by infrared camera
- Complete Heat Balance of the furnace: - Use of suction pyrometers and optical pyrometers
  - Measurement of pressure profiles and draughts
  - Measurement of O2
  - Calculation and analysis of heat losses
  - Evaluation of combustion and electric heating

Visual Observation of Regenerators

- Unique method of digital VCR observation of regenerators
- Visual observation up to 3 meters from the head of the regenerator chamber
- Digital record (DVD)

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Periscope Observation of Furnace Interior

- Use of 70° periscope for observation of:
  - Crown - joints, rat holes and condensate presence
  - Superstructure - corrosion, chipping, material failure, shifting of refractory blocks
  - skew back - joint and corrosion
  - tuck stones
- Video and photography record
- Technical report with evaluation of furnace status
- Proposal with measures
  - patching of the crown
  - ceramic welding

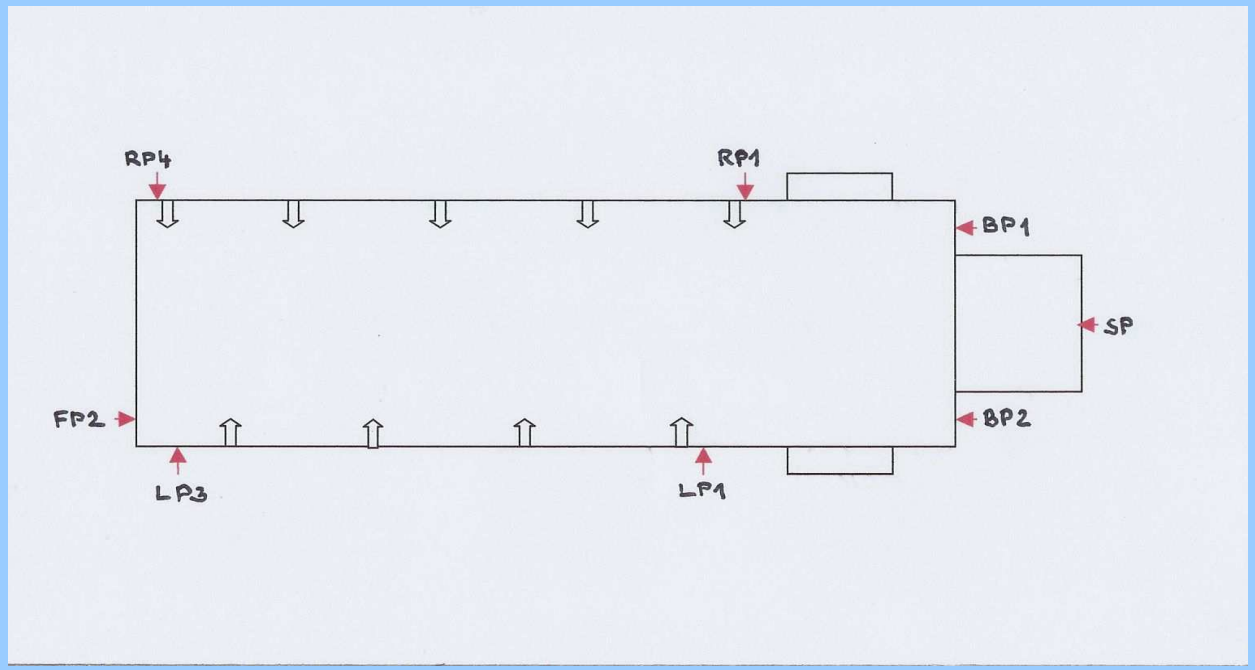
ENDOSCOPE PHOTO DOCUMENTATION OF GLASS MELTING FURNACES

(TYPICAL EXAMPLES)

Furnace endoscope inspection

- Cross fired furnace
- Glass fibre
- Oil + oxygen fuel

Scheme

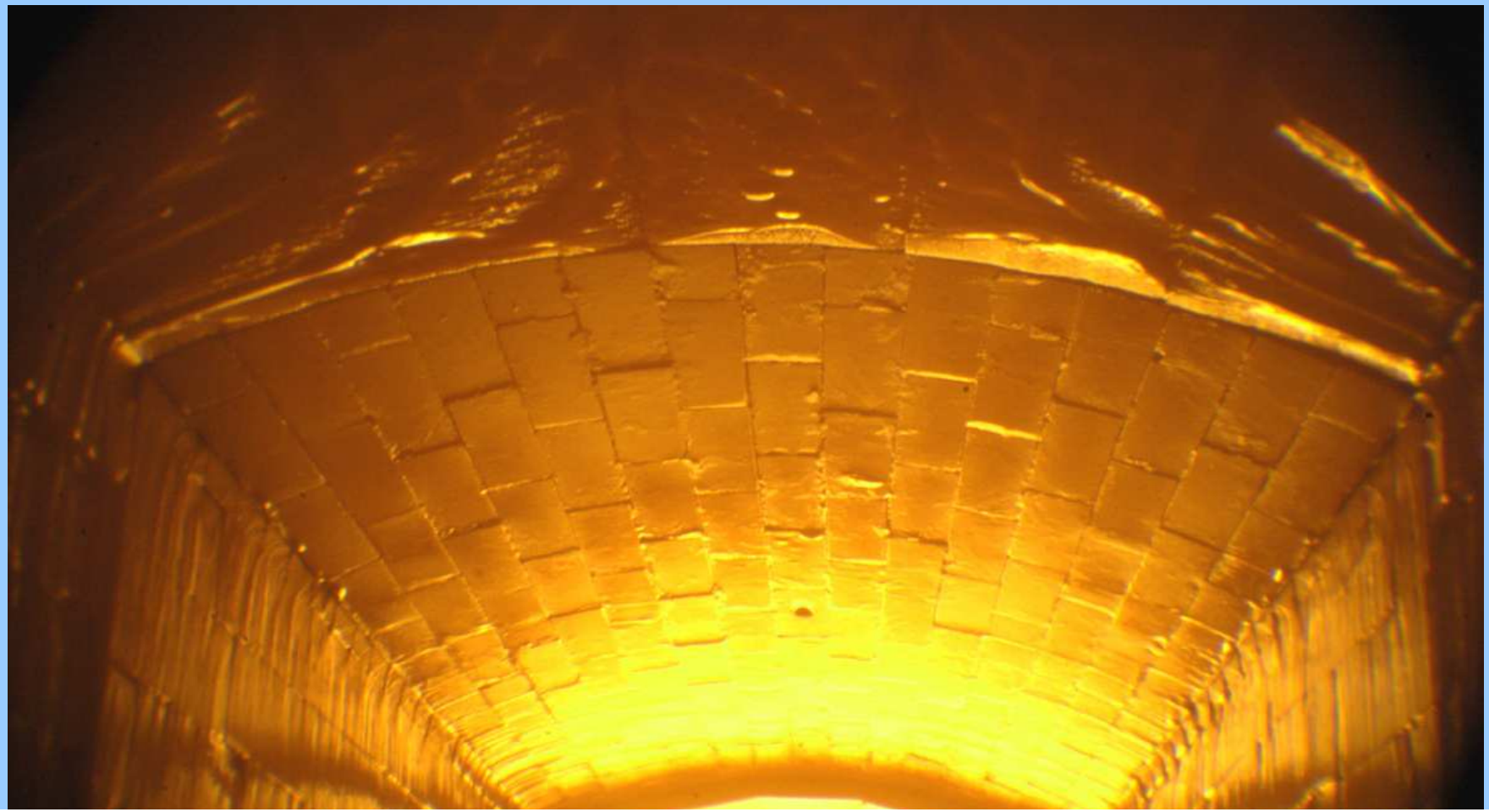


Left doghouse

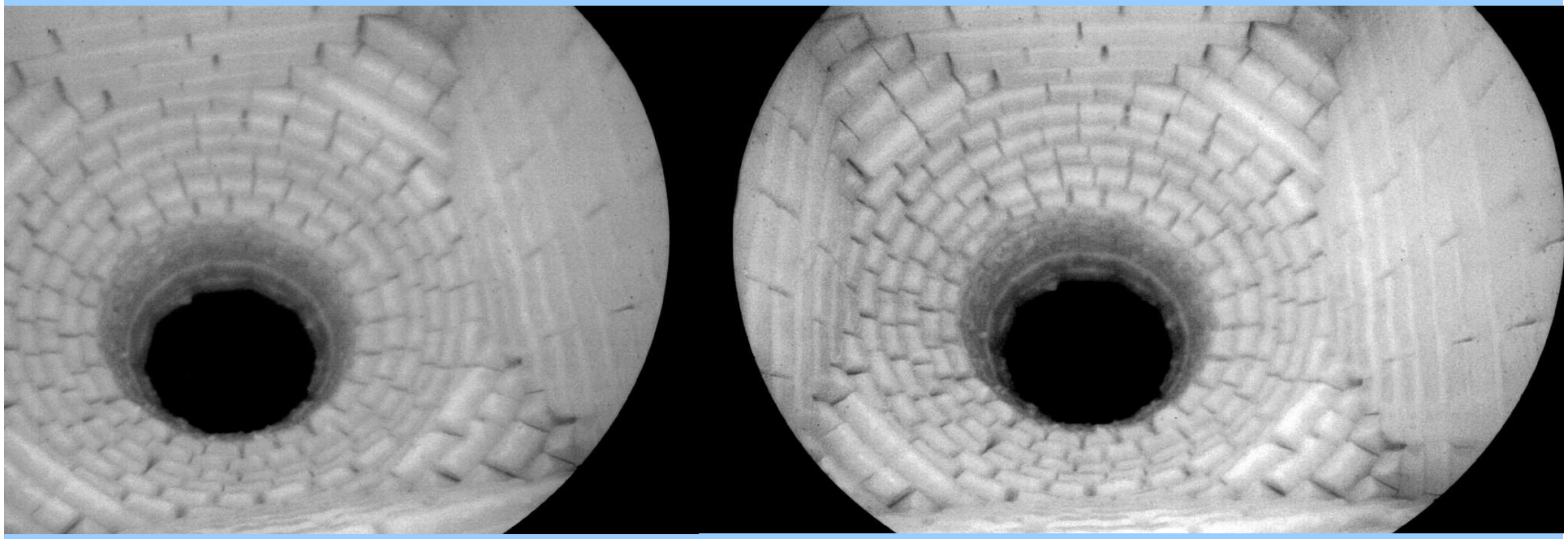
Right doghouse

Right side

Stackport – the crown



Exhaust port under the recuperator



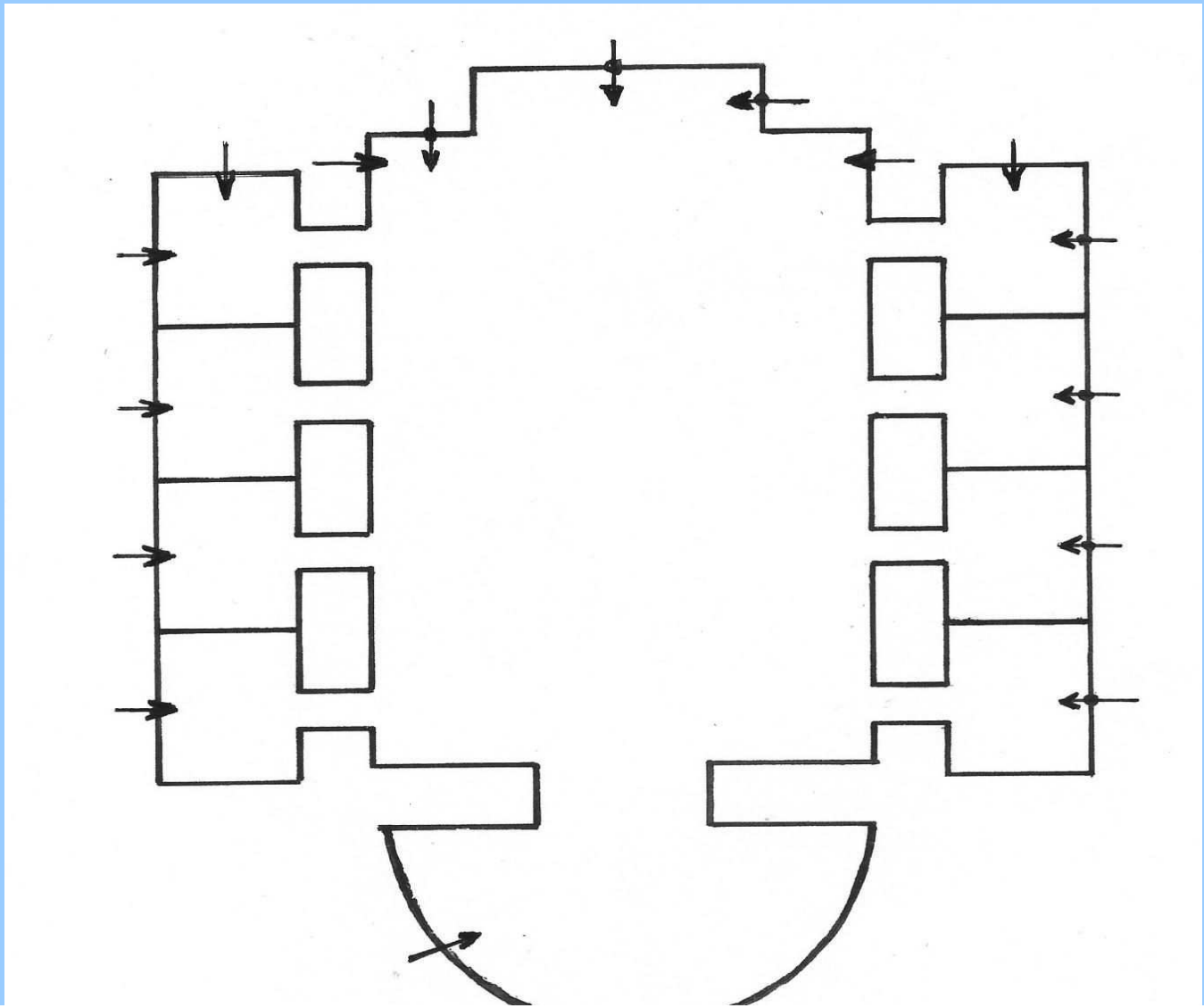
Recommendation for:

- Left side of the furnace
- The main crown and the joints
- Right side of the furnace
- Outlet wall
- Outlet channel

Furnace endoscope inspection

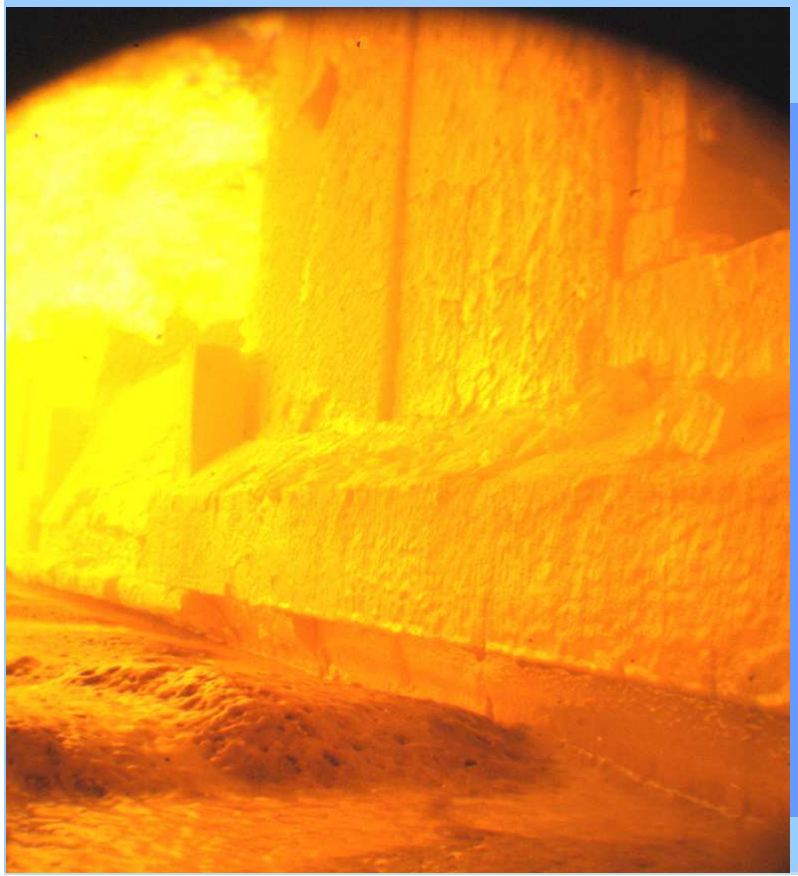
- Cross fired furnace
- TV Glass
- Heavy oil fuel
- Five years in operation

Scheme of used peepholes



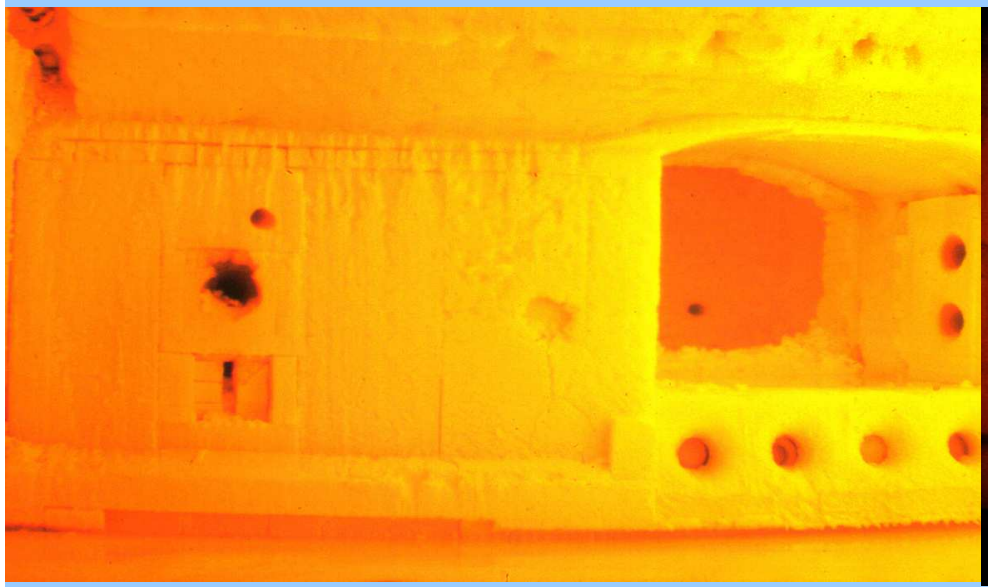
Doghouse – right side

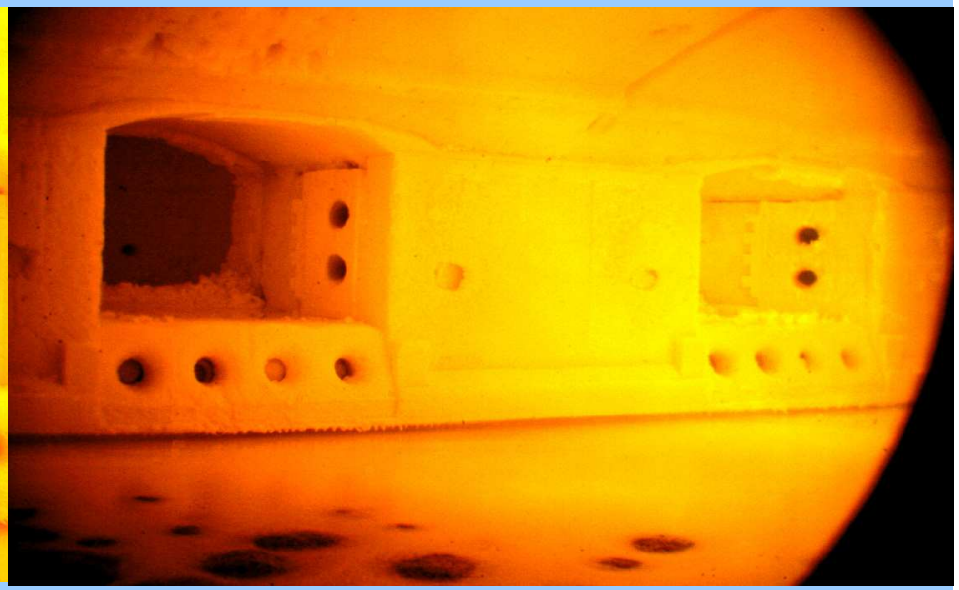
Right side wall – glass level corrosion



Right side wall

Left side wall 2





2nd left chamber

2nd left chamber - checkers

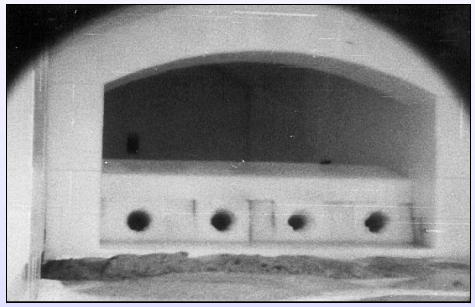
Recommendation for:

- Charging wall and doghouse
- Dividing joint
- Throat wall
- Left and right side walls
- Main crown
- Chambers
- Refiner

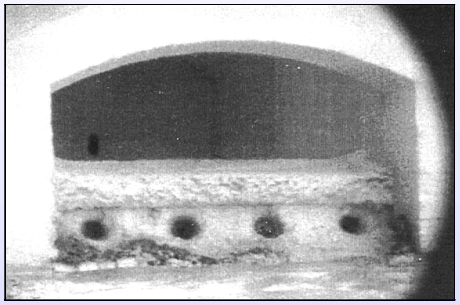
ENDOSCOPE PHOTO DOCUMENTATION OF GLASS MELTING FURNACES

(TYPICAL EXAMPLES)

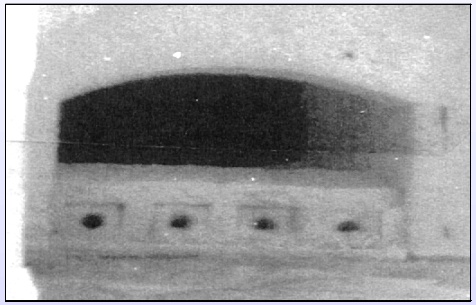
Progress of Port Corrosion



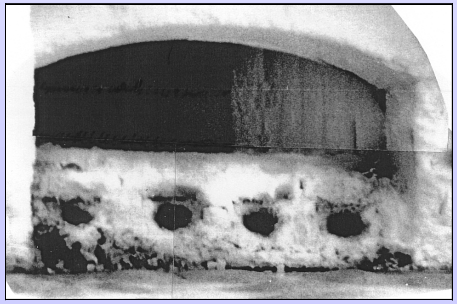
First inspection



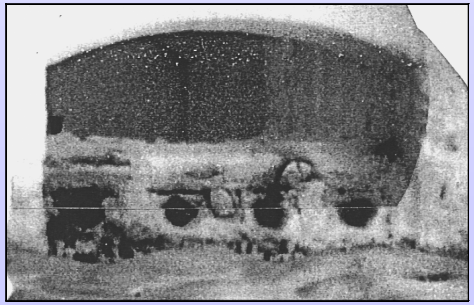
After 50 months



After 21 months



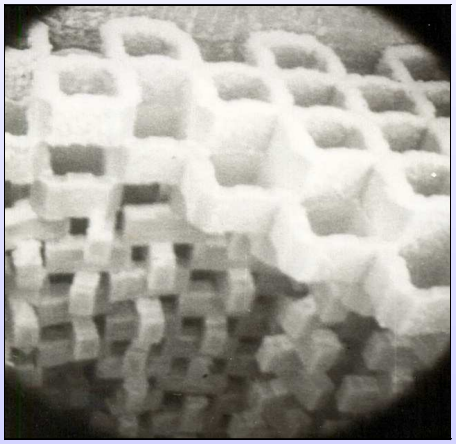
After 102 months



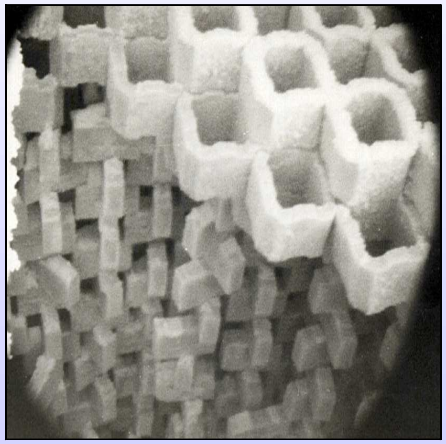
After 105 months

Progress of Corrosion of Chamber

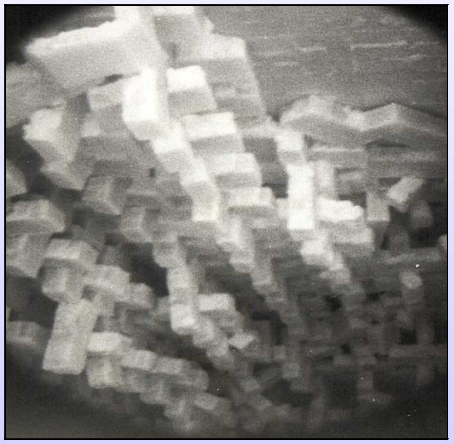
First inspection



After 6 months

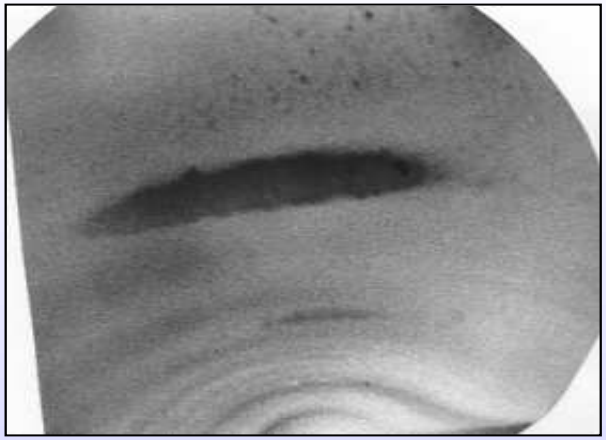


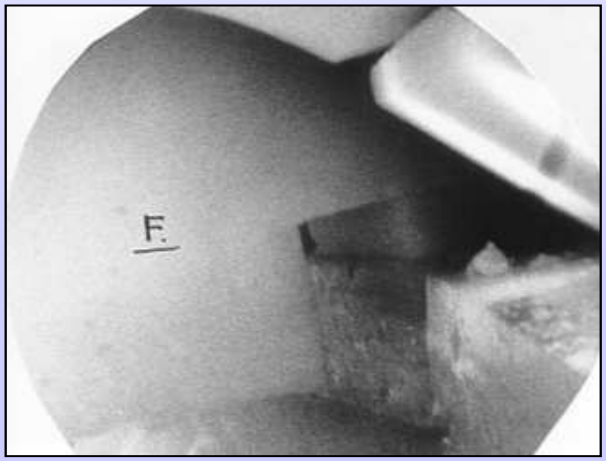
After 9 months

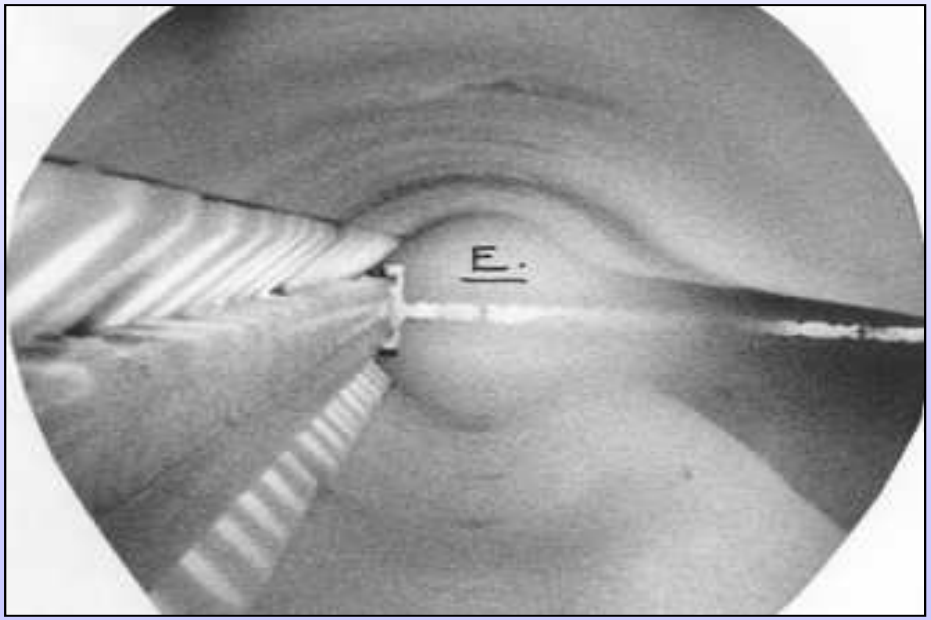


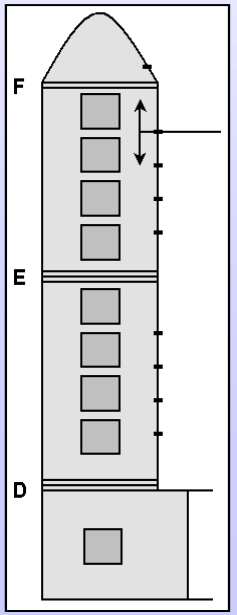
After 14 months

Feeder









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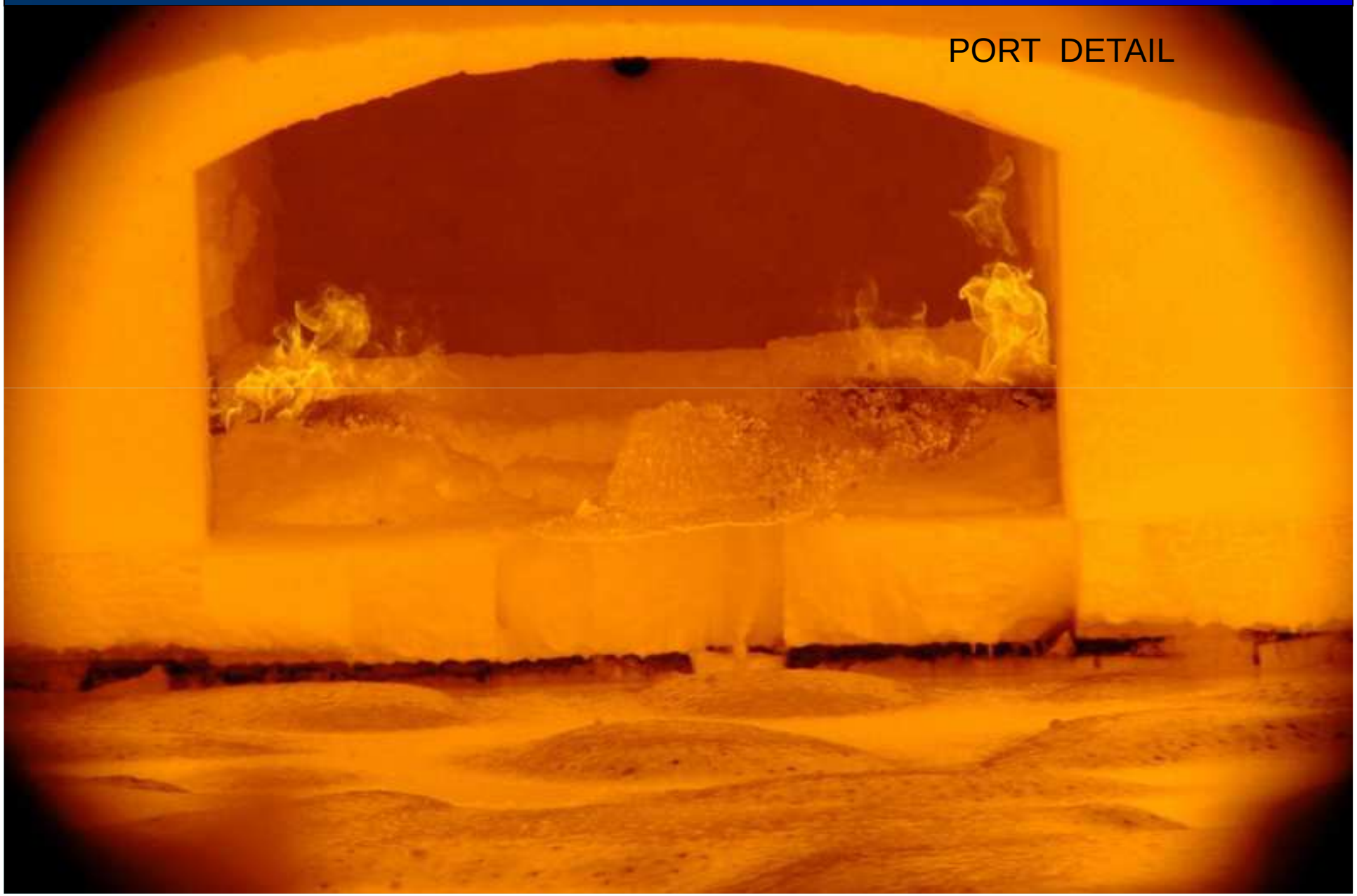
PORT DETAIL

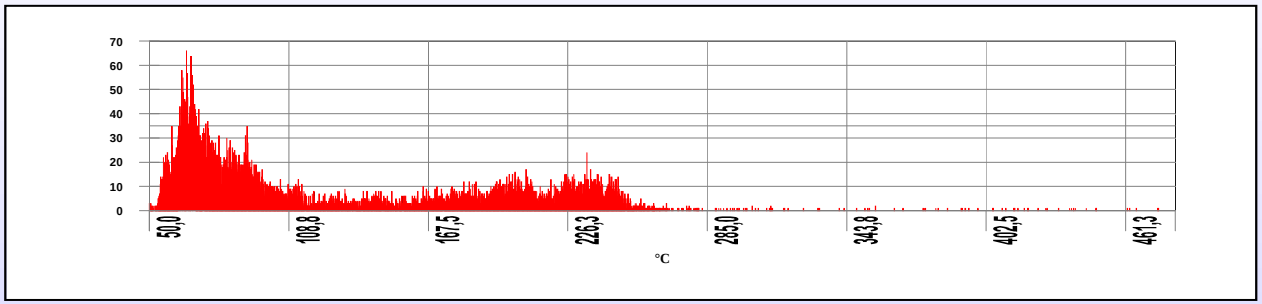


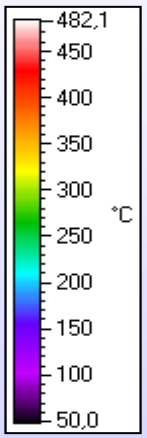
Survey by Infrared Camera

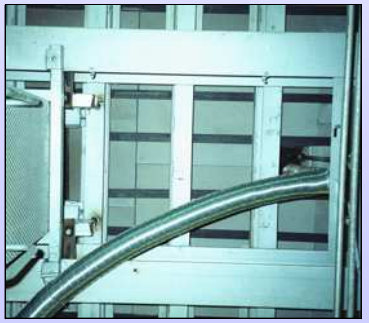
- Infrared camera is used for measurement of outside surface temperature:
  - Furnace bottom, throat and sidewalls
  - Superstructure and crown
  - Ports and regenerators
  - Burners, air ducts and recuperator
- Survey is analysed in technical report
- Analysis of critical places is provided together with recommendations for furnace lifetime and energy efficiency

Infrared picture on bottom

IR00145.ISI







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Temp Unit	Celsius
User	Our Satisfied Customer
Location	Everywhere
Target	Bottom of furnace

Data:

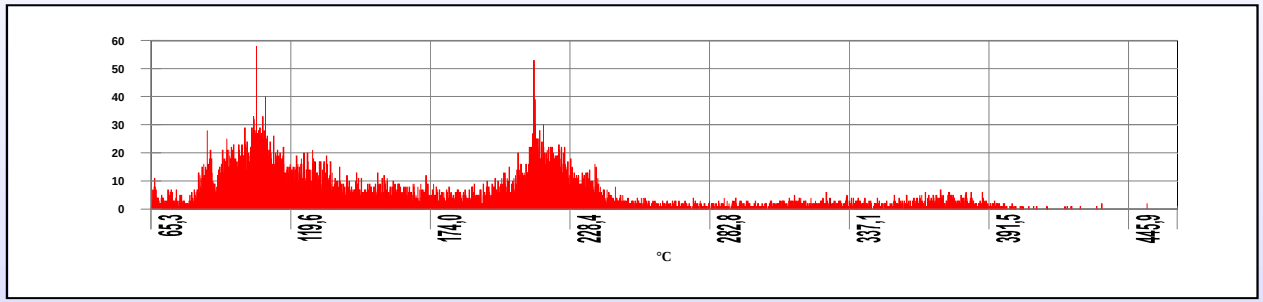
Label	Emissivity	Background	Average	Std Dev	Max	Min
A1	0,9	30,0	233,72	2,05	238,3	229,0
A2	0,9	30,0	206,58	3,94	212,5	199,0
P1	0,9	30,0	482,14	.	.	.

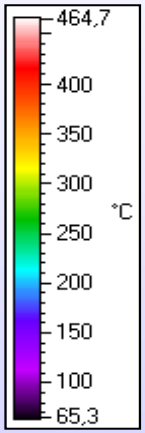
Comments:

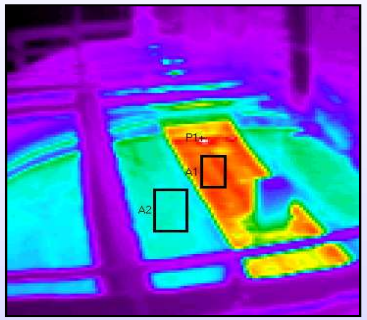
Bottom of furnace - the third section from recuperator (the central part with thermocouple).

Infrared picture on crown

IR00134.ISI







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Temp Unit	Celsius
User	Our Satisfied Customer
Location	Everywhere
Target	Crown of furnace

Data:

Label	Emissivity	Background	Average	Std Dev	Max	Min
A1	0,9	30,0	381,71	7,82	398,3	365,0
A2	0,9	30,0	223,82	3,13	230,6	214,6
P1	0,9	30,0	464,71	.	.	.

Comments:

Crown of furnace - the first section (from the recuperator).

Furnace audit

Thermal balance

Thermal balance outputs

- Table of combustion
- Heat flows
- Calculation of glassmelt
- Production heat of glass melt
- Thermal coefficients
- Comparative study of periodical measurements

Thermal coefficients

- Thermal efficiency
- Internal efficiency
- Specific heat consumption
- Regeneration or recuperation coefficient
- Coefficient of fuel utilization
- Energy economics
- Furnace ageing

CALCULATION OF GLASSMELT

Glassmelt from Batch/1 kg Dry Batch	0,85	
Glassmelt from Batch/1 kg Wet Batch	0,85	
Glassmelt from Charge/1 kg Dry Charge	0,94	
Glassmelt from Charge/1 kg Wet Charge	0,94	
Amount of Wet Charge/1 kg Molten Glass	1,06	
Amount of H2O from Charge	0,27	Nm3.h-1
Amount of H2O from Charge	0,00	nm3.Nm-3
Amount of CO from Charge	8,52	Nm.h-1
Amount of CO from Charge	0,06	Nm3.Nm-3
Amount of glass from Charge in Relation to Charge	37,13	%
Amount of H2O/1 kg Melted Glass	0,00	Nm3
Amount of CO2/1 kg Melted Glass	0,03	Nm3
Amount of Cullet/Dry Charge	59,10	%
Amount of H2O/1 kg Wet Charge	0,00	Nm3
Amount of CO2/1 kg Wet Charge	0,03	Nm3
Specific Heat of Glassmelt	0,89	KJ.kg-1.K-1
Temperature of Glassmelt Outgoing into Working Part	1280,00	°C

Combustion table

Air Excess	Composition of Dry Waste Gases [%]				Air [Nm3.Nm-3]		Waste Gases [Nm3.Nm-3]	
n	O2	CO2	N2	Dry	Wet	Dry	Wet	
1,000	0,000	12,290	87,710	9,604	9,714	8,670	10,781	
1,050	1,000	11,700	87,300	10,040	10,155	9,106	11,221	
1,150	3,000	10,530	86,470	11,057	11,184	10,123	12,250	
1,280	5,000	9,350	85,450	12,330	12,472	11,396	13,538	
1,450	7,000	8,170	84,830	13,970	14,130	13,036	15,197	
1,680	9,000	7,000	84,000	16,161	16,346	15,227	17,413	
2,000	11,000	5,820	83,180	19,237	19,458	18,303	20,524	
2,490	13,000	4,650	82,350	23,871	24,144	22,937	25,211	
3,300	15,000	3,470	81,530	31,646	32,009	30,712	33,025	
Real Composition of Waste Gases								
1,210	4,000	9,940	86,060	11,656	11,790	10,722	12,856	
1,390	6,300	8,580	85,120	13,345	13,498	12,411	14,565	

HEAT FLOWS

	Mcal.h-1	MJ.h-1	%
RECEPTION OF HEAT			
Heat Supplied with Charge	1,10	4,80	0,09
Heat Supplied with Air	17,50	73,50	1,34
Heat Supplied with Fuel	1291,10	5405,40	98,57
Primary Supplied Heat	*1309,80*	*5483,70*	*100,00*
REGENERATION OF HEAT			
Heat in Preheated Air	231,3	968,6	17,66
Preheating Total	*231,3*	*968,6*	*17,66*
GIVING OFF OF HEAT			
Heat in Glassmelt	84,3	352,7	6,43
Losses through Upper Structure	390,8	1636,1	29,84
Heat Drawn Off in Waste Gases	1059	4433,6	80,85
Heat for Heating of Gaseous			
Charge Product	7,1	29,8	0,54
Stack Losses	*777,7*	*3256,2*	*59,38*

PRODUCTION HEAT OF THE GLASSMELT

	kcal.kg-1	kJ.kg-1
Reaction Time of Glassmelt	46,419	194,346
Evaporation Heat of Water	0,491	2,057
Heating of Gaseous Charge Product	26,796	112,190
Heating of Glassmelt	270,570	1132,823
Theoretical Heat for Melting	**344,276**	**1441,416**

INDEXES

Thermal Efficiency	6,98	%
Internal Efficiency	36,81	%
Specific Heat Consumption	4936,00	kcal.kg-1
	20664,00	kJ.kg-1
Specific Melting Output	545,00	kg.m-2.d-1
Fuel Heating Value	8600,00	kcal.Nm-3
	36006,00	kJ.Nm-3
Fuel Power Input	150,00	Nm3.h-1
Preheating of Combustion Air	439,00	°C
Preheating of Fuel	20,00	°C
Outgoing Waste Gases (Upper Port)	1462,00	°C
Waste Gases Back to Regenerator (Rekuperator)	990,00	°C
Melting Output	6,37	t.d-1
Melting Area	11,68	m2
Regeneration Index	0,217	
Fuel Utilization Index	0,359	

Benefits of Regular Furnace survey

- Furnace is measured each year since start up
- Critical places are continuously monitored:
  - Fuel consumption
  - Ecology
  - Lifetime
- Regular service can be provided on right place in right time
- The problem is fixed before it can become very serious
- By avoiding furnace failures the glass quality is improved
- Detailed data about furnace operation are used for better design