# SUCCESSFUL RELINE AND START UP OF CSN # 2 BLAST FURNACE[1]

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**ABSTRACT**

This paper presents the successful reline and start up of CSN, Brazil, # 2 blast furnace completed in December 2001 to prolong its campaign for 8 more years. The activities of preparation for furnace shutdown and contingency plans are described, focusing on the operation procedures and salamander tapping.

The basic reline scope, upgrades, project schedule, construction methodology and the sequence of the main activities are discussed in detail. The furnace blow in and post reline operation are also discussed. This revamping was planned in only 6 (six) months and carried out exactly according to the schedule in 20 (twenty) days consisting in a world siderurgy land mark.

Key-words: Reline, Blast Furnace, Refractories.

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## 1. INTRODUCTION

CSN BF 2 has been operating in its 5th campaign since February 1991. The project campaign was 10 years or 12 millions of hot metal. In November 2000, after 9 years and 9 months in operation and an accumulated production of 12.5 millions of hot metal, CSN BF 2 was blown out for a partial repair.

Table I presents the main project data of CSN BF 2 in the present campaign.

**Table I – CSN BF 2 Main Design Data (5th Campaign).**

| CSN BF 2 (5th Campaign) | Main Project Data |
|---|---|
| Inner Volume | 1653m$^3$ |
| Burden Distribution | Bell Less (Rotating Through) |
| Burdening | Screening of Sinter, Iron Ore and Coke<br>Conveyor Belt<br>2 Burden Bins<br>3 Burden Level Probes<br>Equalization with Semi-Clean Gas and Nitrogen |
| Hot Stoves | 3 Units with Internal Combustion Chamber<br>Hot Blast Temperature: 1100°C |
| Cooling System | Cooling Plates: Stack, Belly and Bosh<br>Spray: Hearth |
| Gas Cleaning | Top Pressure Control: Bischoff System (1,100 kgf/cm$^2$)<br>Gas Washing: Venturi |
| Cast House | 2 Tapholes<br>Conventional Slag Granulation<br>24 Tuyeres<br>Hearth Diameter: 9m<br>Natural Gas Injection System<br>PCI (Since June 1997): 200 kg/t |
| Control Systems | Top Gas Analysis: CO, $CO_2$, $H_2$<br>Uptakes Temperature<br>Top Gas Temperature: Fixed Probe<br>Throat Temperature: Skin Flow<br>Stack Gas Temperature and Analysis: Penetrating Probe<br>Refractory Lining Temperature: Stack, Belly, Bosh and Hearth.<br>Furnace Pressure Gages: 11 |

The operational results of CSN BF 2, 5th campaign, have completely overcome the project parameters. It has been presenting operational index comparable to the best blast furnaces all over the world as showed in Figure 1.

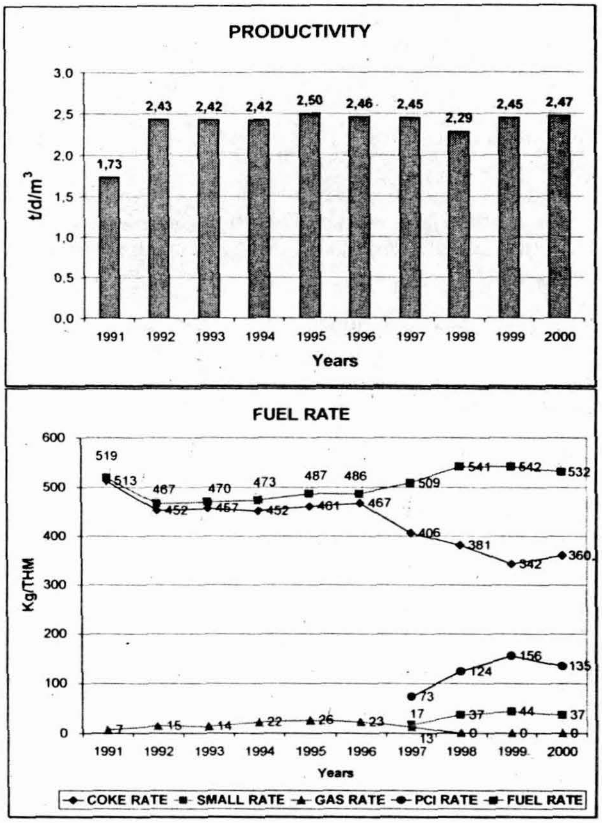



**Figure 1 – Main Operational Parameters of CSN BF 2, 5th Campaign.**

From 1997 to 2000, after the start Up of PCI Plant, the furnace has had skull formation in lower stack and belly regions. This phenomenon has disturbed the operation results. As consequence, it was necessary to develop special operation procedures in order to regularize the burden descent and clean the skulls adhered to the refractory walls.

## 2. BASIC RELINE SCOPE AND UPGRADES

Since 1997, CSN BF 2 refractory maintenance strategy was to carry out a cold gunning repair from the top to the tuyere level every 12 months. Table II presents the main characteristics of these cold gunning repairs.

**Table II – Main Characteristics of CSN BF 2 Cold Gunning Repairs.**

| Repaired Area | Period | Duration | Remarks |
|---|---|---|---|
| From the top to the tuyere Level | April 1997 | 9 days | No Salamander Tapping |
| From the top to the tuyere Level | April 1998 | 15 days | No Salamander Tapping |

In 1999, the results of the core drilling study showed that there was a critical area around tapholes with a brittle zone. Based on this fact and considering the excellent condition of the shell (no deformation), it was decided to plan a partial repair to prolong its campaign for 8 more years[1].

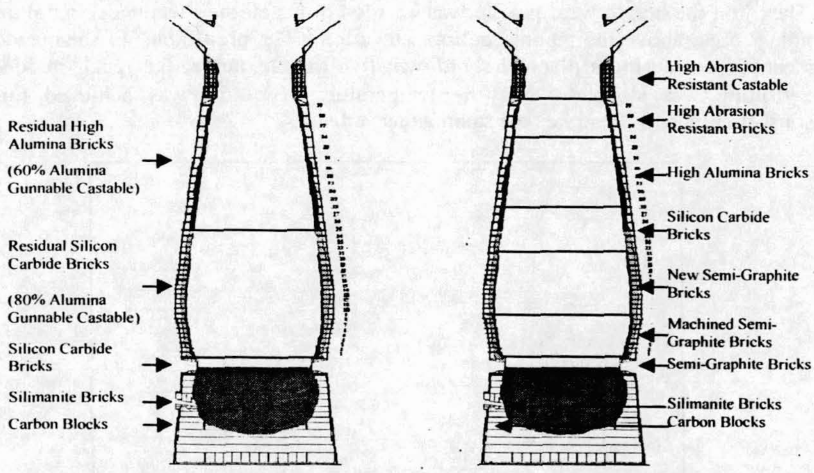
The main targets of this November 2000 partial repair were:

- Injuries: Zero accident
- Quality: 8 years of campaign life
- Schedule: 20 days
- Cost: Obey to the budget

The basic reline scope and upgrades were:

- Repair of a 105° sector of the hearth refractory lining from the tapholes bottom elevation, including the replacement of the two tapholes.
- Total replacement of the refractory lining from the tuyere to the top.
- Assembling of a new throat armour.
- Assembling of a new gear box.
- Install a new slag runner, repair the slag granulation pits and assemble a tilting runner in the cast house.

Figure 2 shows schematically the former and present CSN BF 2 refractory lining design.




**a) Former** **b) Present**

**Figure 2 – Former and Present CSN BF 2 Refractory Lining Design.**

## 3. SCHEDULE

The original schedule of CSN BF 2 partial repair, from blow out to blow in, showed a total duration of 26 days. Considering that expected Brazilian demand for steel was growing during 1999-2000 period and CSN BF 3 would be repaired in 2001, it was convenient for economical reasons to minimize the duration of this repair.

After a deep technical discussion with all partners involved in this project, a new repair schedule was planned with only 20 days of duration, consisting in a big challenge for everybody.

This reduction of 6 days in the original schedule was fundamentally due to the introduction of the mechanized demolition technique. In this case, it was not necessary to wait, for finishing all demolition services anymore to start assembling of the fixed platforms.

In order to assure that this new revised schedule would be achieved, the repair plan included some key-points:

- Pre-Assembling of salamander holes
- Blow Down operation procedures
- Mechanized demolition
- Multi-level work platforms / brick rings
- Bricklayers training
- Contingency plans

### 3.1 Pre-Drilling of Salamander Holes

Based on the hearth wear profile was decided to install the salamander spool under the taphole 2 area, above the taphole bottom elevation. The pre-drilling of salamander holes was carried out during a planned shutdown, five months before the repair in June 2000. The drilling was stopped when the temperature of 500°C was achieved for safety reasons[2]. Figure 3 illustrates the salamander holes.

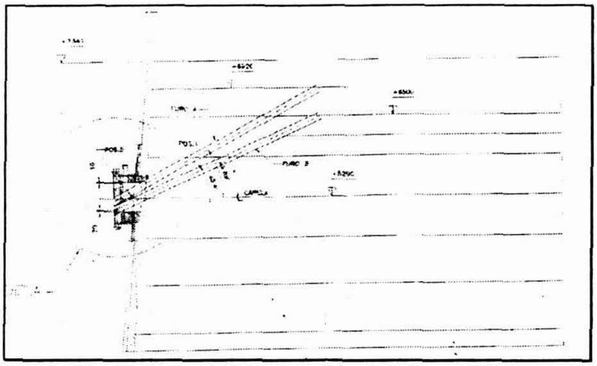


**Figure 3 – CSN BF 2 Salamander Holes.**

### 3.2 Blow Down Operation Procedures

CSN BF 2 Blow Down Plan, involving the furnace emptying until tuyere level and complete outflow of the hearth hot metal, had the following steps:

- **Cleaning of the Refractory Walls**

It consists of a special operation procedure to clean the skulls adhered to the refractory walls, including a modification in terms of burden distribution.

- **Preparatory Shutdown**

The purpose of this preparatory shutdown is to connect the necessary utilities (stream and nitrogen) that will be used during the burden descent to control the furnace atmosphere.

- **Operation Stabilization Period**

It refers to the period immediately before the blow down whose purpose is to stabilize the operation conditions to guarantee a safe stoppage.

- **Burden Descent**

It consists of monitoring and controlling the operation parameters during the burden descent. Figures 4, 5 and 6 show the behavior of the main operation parameters during the burden descent period.

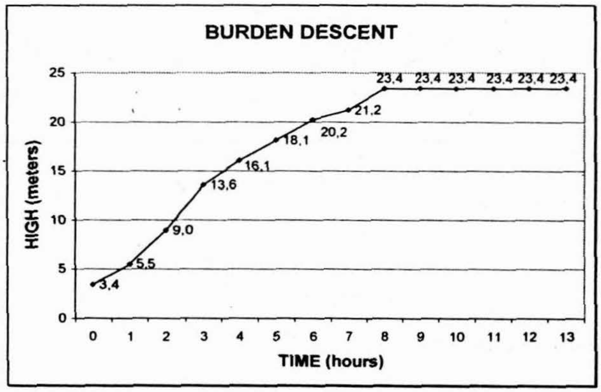



**Figure 4 – Burden Descent Vs Time**

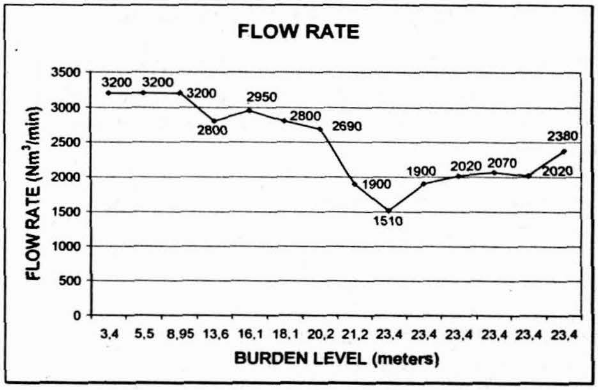



**Figure 5 – Hot Blast Flow Rate Vs Burden Level.**

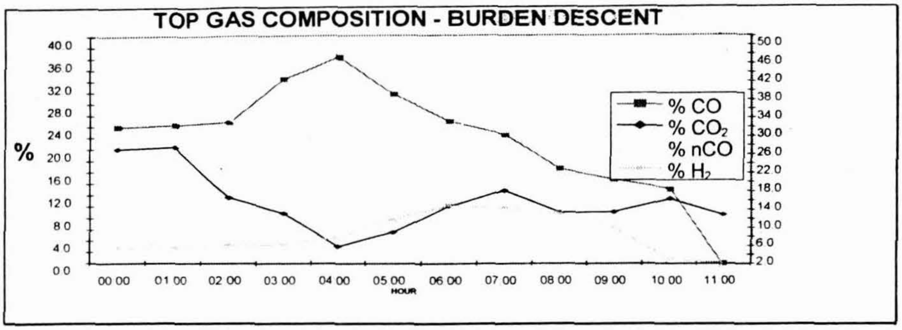



**Figure 6 – Top Gas Composition Vs Time.**

- **Hearth Outflow**

It refers to the salamander tapping after last heat through the taphole.

- **Burden Ignition and Blow Out**

It consists to ignite the gas from the hearth residual burden (coke) through the blowpipes after completing the burden descent until tuyere level.

### 3.3 Mechanized Demolition, Multi-Level Work Platforms and Brick Rings

As mentioned before, the mechanized demolition technique allowed to start assembling the fixed platforms immediately after the wrecking machine achieved the appropriated elevations. In other words, it was possible to demolish the furnace and assemble the platforms in parallel.

Besides, two additional factors contributed to reduce the duration of all re-brick activities.

- Multi-Level Work Platforms

It was planned to assemble three fixed platforms:
- Platform 1: Throat bottom (at elevation of cooling plates row 39).
- Platform 2: Lower stack (at elevation of cooling plates row 19).
- Platform 3: Bosh (at elevation of cooling plates row 6).

- Brick Rings

In between the fixed platforms were installed tubular scaffolds (Figure 7). Some special brick rings were also installed (Figure 8) allowing to carry out several re-bricks activities simultaneously.

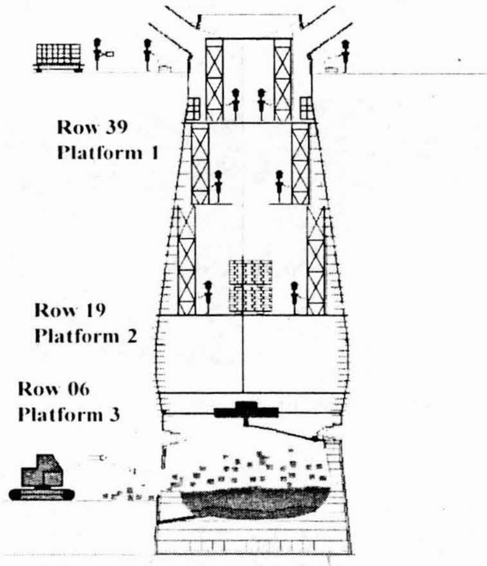



**Figure 7 – Location of the Fixed Platforms.**

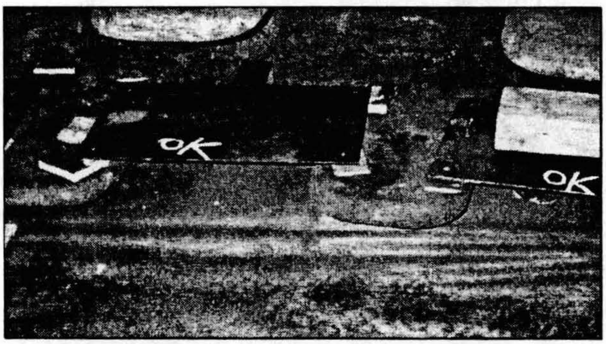



**Figure 8 – Detail of the Brick Rings.**

### 3.4 Bricklayers Training

In order to guarantee the quality and duration of the refractories activities, all bricklayers (around 250) were trained. A BF shell sector with cooling plates and tubular scaffolds was assembled simulating the true service conditions (Figure 9).

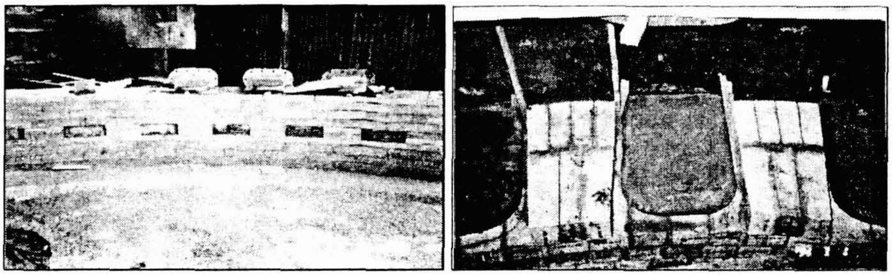


**Figure 9 – Area for Bricklayers Training.**

### 3.5 Contingency Plans

Considering that the production losses are the main component in the repair costs matrix, it is imperative to elaborate a contingency plan to manage some possible problems. Table III presents the main actions included in this contingency plan.

**Table III – Contingency Plan.**

| Possible Problems | Action |
|---|---|
| Residual Skulls adhered to the refractory wall. | Be prepared to use explosives. |
| Defects or unsatisfactory performance of the wrecking machine. | Be prepared to use movable platform. |
| High temperatures inside hearth. | Be prepared to apply insulating gunnable castable. |
| Strong summer rains. | Install special covers to prevent against rains. |
| Interruption of the refractory materials feeding. | Create alternative routes for refractory materials feeding. |
| Area to be repaired in the hearth bigger than the planned one (105° sector). | Be prepared to ram carbon material |

## 4. SAFETY

Risk analysis for all activities were carried out based on technical procedures.

## 5. BUDGET

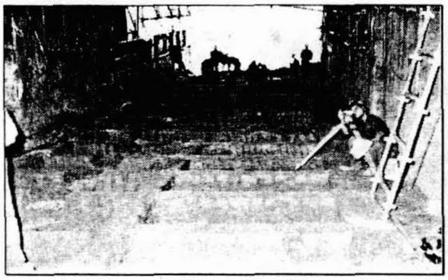
In order to reduce the total cost of the repair and obey to CSN budget, it was necessary to develop some special technical procedures:

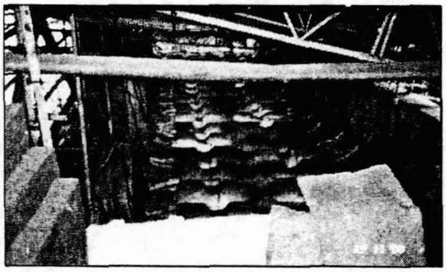
- **Machining of the Existing Semi-Graphite Bricks and Carbon Blocks**

There was some stock at CSN of semi-graphite bricks and carbon blocks from BF 3 partial repair. These semi-graphite bricks and carbon blocks had to be machined to adjust its geometry to BF 2 refractory lining design.

- **Salamander Tapping into Clay Boxes**

The salamander boxes were built in the emergency slag pit by using clay boxes (Figure 10). After compacting the clay, the boxes were excavated. Finally, a thin layer of refractory gunnable castable was applied in the internal surfaces of the clay boxes.





**a) After Excavation** **b) During Drying and Heating Up**

**Figure 10 – Salamander Boxes After Excavation (a) and During Drying and Heating Up (b).**

## 6. Repair Plan Evaluation

### 6.1 Safety

No serious accident during all repair period.

### 6.2 Blow Down Operation Procedures

After blow down operations, it was observed that:

- The burden had achieved the tuyere level around all hearth periphery strongly reducing the residual burden to be removed.
- The refractory walls were completely clean proving the efficiency of the cleaning procedure.

- After removing the burden, it was verified that there was not residual hot metal until the lowest elevation of the hearth area to be repaired allowing fast and safe access inside the hearth.

### 6.3 Schedule

The repair was carried out exactly according to the schedule in 20 days.

### 6.4 Budget

The total costs of the repair obey to CSN budget.

## 7. Blow In Operation Procedures

The blow in operation procedures included the following steps:

- **Start Up Plan**

It consists of an operational plan to start Up the furnace and stabilize the operation parameters.

- **Tapholes Protection**

It refers to the special protection wall built in front of the tapholes before the blow in. The purpose of this wall is to protect the taphole area during the first heats. Figure 11 illustrates the taphole protection wall with fireclay bricks.

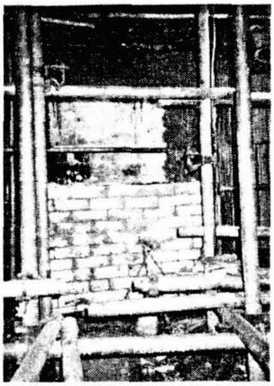


**Figure 11 – Taphole Protection Wall.**

- **Burdening**

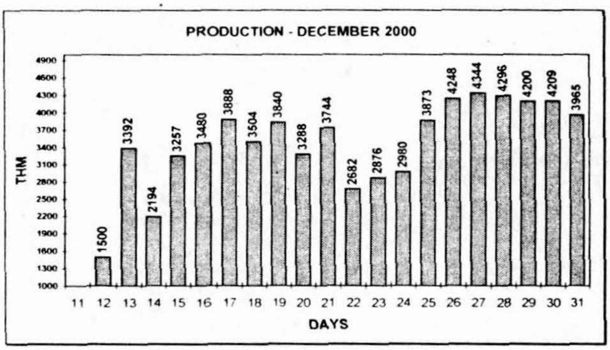
It refers to the start Up burden.

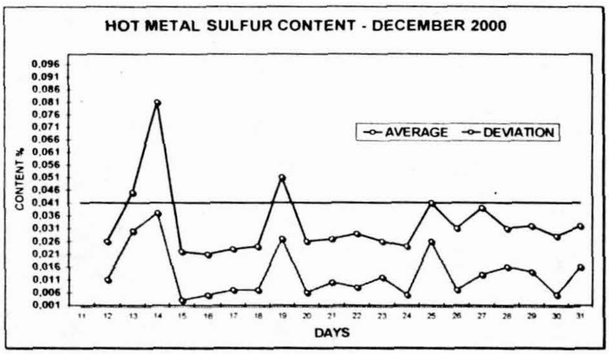
- **Ramp Up**

It consists of the planned production curve after blow in to recover the normal production rhythm.

## 8. Post Reline Operation

Figure 12 shows the behavior of the main operation parameters after the start Up.



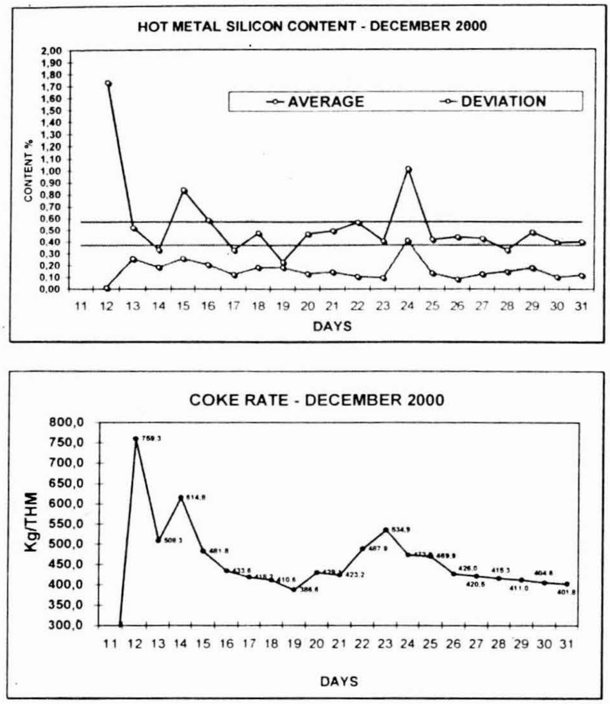



**Figure 12 – Main Operation Parameters after the Start Up.**

Table IV presents some important operational results achieved after blow in.

**Table IV – Important Operational Results Achieved after the Blow In.**

| OPERATION PARAMETERS | IMPORTANT RESULTS |
|---|---|
| Productivity ≥ 2 t/d/m$^3$ | 4 (four) days after blow in |
| Hot Metal Initial Silicon Content | 2.12% |
| Hot Metal Standard Silicon Content (≤ 0,50%0 | 2$^{nd}$ day after blow in |
| First Heat | 13,5 hours after blow in |
| Hot Metal to BOF | 18 hours after blow in |
| PCI Start Up | 4$^{th}$ day after blow in |

## 9. CONCLUSION

CSN BF 2 partial repair was planned in only six months and carried out exactly to the schedule in twenty days consisting in a world siderurgy land mark.

- **References**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