# Coke Plant Operation Experience at CSN [1]

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**ABSTRACT:**

This paper presents the operation techniques developed at CSN Coke Plant and the evolution of the coking process control and coke quality, reducing costs and in accordance with the environmental regulations.

The costs of constructing new coke oven batteries and the continuos increasing of coke demand due to the high productivity with high coal injection rates at CSN Blast Furnaces have obligated us to develop new projects to extend the productive life of our batteries.

**KEY WORDS:** Coke Plant, Operation

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**INTRODUCTION:**

Companhia Siderúrgica Nacional ( CSN ), privatised in 1993, is Brazil's leading steelmaker. Our crude steel production is about 5 million tons per year.

The President Vargas Steelworks , located in Volta Redonda in the state of Rio de Janeiro, is the largest integrated steel works in Latin America. CSN is self-sufficient in iron ore and fluxes ( limestone and dolomite ), its iron ore comes from Casa de Pedra mine, located in Congonhas, Minas Gerais state; limestone and dolomite are extracted from Bocaina mine, located in Arcos, Minas Gerais.

Export shipments are carried out through the ports of Rio de Janeiro and Angra dos Reis while the port of Sepetiba is used for importing all of the Company's coal requirements. In the third quarter of 1999, CSN started exporting part of its products through the port of Sepetiba.

The plant produces 4 800 tons of coke per day from 180 coke ovens comprising 04 batteries. All the coke is used in CSN two blast furnaces.
The batteries at CSN are grouped in two operating units : Battery 1 is separated of Batteries 4 A, 4B and 5. Each group has its own gas treatment plant.

Battery 1 is a Brazilian design - COBRAPI - with 75 ovens, 4,5 meters high.
Its start up was in 1990, underjet gas system .

Batteries 4 A, 4B and 5 are Dr .C. Otto design , with 105 ovens , 6 meters high– comprising : Battery 4 A, 30 ovens, started up in 1982; Battery 4 B, 30 ovens , started up in 1983 and Battery 5, 45 ovens, started up in 1984.
Battery 2 and Battery 3 are already shut down.( Figure 1 )

The plant has 3 Quenching Stations, 4 coke wharves, 3 coal bin towers.
The coal yard storage capacity is 270.000 tons of coal, with , 4 coal crushers, 2 stacker / reclaims, 08 coal blending bins, 2 coal mixers.

The coke handling facilities are: 2 coke screens, 1 stacker, 1 reclaim, 4 small coke screens, coke yard capacity of 30.000 tons.

During the last years, since CSN has become a private company, all the works has realised a series of changing and investments to guarantee the competitiveness necessary to improve the position of the company in the Brazilian and world steel market. The Coke Plant Department has been continuously developed its state-of-art to achieve , with higher levels of quality and according to the more restrictive and more stringent environmental regulations , the coke demanded to supply the blast furnaces , working with a high coal injection rate and higher levels of pig iron quality.

Besides that, the ageing of our batteries , mainly 4 A, 4B and 5, and due the high costs of constructing new coke ovens, have mandated the need to extend the productive life of our existing facilities.

To achieve a 40 years operational life of the batteries, CSN has developed several projects and methods aiming an adequate operational rhythm , the improvement of the heating and avoiding accentuated refractory structure deterioration.

**COKE OVEN BATTERIES DIAGNOSIS**

CSN has been developing its own method to verify the ageing of the batteries.

Coke Oven Battery deterioration is a process that can be accelerated by working with a high number of pushers, inadequate operational practices, inadequate or insufficient maintenance and inadequate coal blending charging.

The CSN diagnosis model consist in evaluate and quantify the effects of the battery deterioration and determine the actions on the causes.
A diagnostic survey, realised every six months, gives an overview of the battery condition. This survey includes, oven walls existence of cracks and bricks deterioration, oven walls carbon deposits , raw gas leakage from the chambers to the heating flues and the thermal distribution.( Figures 2,3,4 )

From this survey you can determine probable causes to the existent problems:

- lost of the embracing system
- high deviation on the flues temperatures
- high levels of coal pressure
- high operational rate
- thermal shock
- pushing difficulties
- inadequate coking time
- low level of the charged coal
- air inlet during coking
- falling of liquor or water into the ovens
- pusher ram misalignment
- irregular vertical temperature distribution, etc..

Based on the analysis we define a maintenance program and correction of the operation process standards ( figure 5 ).

Based on the quantification of the verified problems , by means of some calculations considering different weights for the influencing of each one in the battering age , we can obtain figures that can be used as parameters to determine how fast the battery is ageing and if the corrective actions are influencing positively on reducing this ageing.

The purpose is not to affirm how old is the battery in relation to the estimated design life, but we can determine the ageing level of the battery from one survey to the next one.

## BATTERY PRESERVATION PHILOSOPHY

An effective Battery preservation program began in 1990. At that time CSN batteries was in a critical moment with the premature shutting down of battery n° 3.

The oldest battery n° 2 with the age of almost 40 years was operating in bad conditions , with high levels of maintenance and heating problems.

Batteries 4 a, 4 b and 5, were with embracing problems, bend buckstays , great deal of gas leakage and fire at the oven doors.

Those facts demanded an urgent action to regularise the existing situation, and that was done with the creation and implanting of a Battery Preservation program. ( Figure 6 )

The phases of the elaboration of the Program were the definition of the necessary activities, scheduling of the activities, tasks simulation, manpower dimensioning, external contracting and adapting the internal personnel to the new demanding reality.

As a result of the success of such implemented program we had:

- extending of battery n°2 life for more than five years than the preliminary expectation
- a better technical dominion
- conciliation of the preservation activities with the operational rhythm
- reducing of emergency interventions
- achievement of the production targets
- progressive reduction of the preservation costs
- reduction of the gas leakage to the atmosphere

## DEVELOPING OF A NEW PHILOSOPHY TO OPERATE AS ONE BLOCK BATTERIES 4 A, 4B AND 5

The Batteries 3 , 4 a, 4 b and 5 are in line and have the same height ( 6,0 meters ) being operated with the same type of machines.
We had 3 sets of machines to realise the operation of 150 ovens , when battery 3 was still operating.
The distribution was as follows:
- one set operating battery 3 and 4 A, total of 75 ovens.
- one set operating battery 4 b and 5, total of 75 ovens.
- one set as stand-by for both blocks.

After Battery 3 shut-down in 1990, we kept working with the three existing set of machines , but with a new distribution as follows:
- one set operating battery 4 A and 4 B, total of 60 ovens.
- one set operating battery 5, total of 45 ovens.
- one set as stand-by for both blocks.

In 2000 CSN decided to operate the three batteries as one block, what would mean 105 ovens with just one set of machine operating and 2 sets as stand-by.( Figure 7 )
The target was to achieve this level of operation with the less investment costs as possible.
It was realised an action plan to solve all the demanded implications that was constituted mainly for:

- Reducing the Cycle time of the machines, by means of a retraining of all operators in new operational standards .It was not necessary any change in the machine themselves, since the new cycle time necessary, 9 minutes, could be achieved with the existing equipment capacity
- Reducing the time for quenching, by means of an upgrade in the existing water pump system
- Reducing the problem of coal sticking at the coal bins, by means of installation of new internal coatings
- Improving the coke transportation capacity , by means of the reactivation of our coke wharf number 4 that was inactive
- Implanting of a new pusher schedule

As results of this succeed new philosophy we could achieve:

- a reduction 15 % of power consume,
- a reduction of 30 % in maintenance costs,
- a reduction in our cleaning and preservation contract,
- a reduction of 23 operators,
- a reduction in our global door leakage , since with no more simultaneous pushers the action for readjusting the doors after charging is more effective
- a higher stability in our coke route to the blast furnaces, since we eliminated the production intervals

- reducing of the emergency level of interruption of production for machines stopping
- a better thermal control of the battery due the more stable operation
- and we also could reduce the purchasing of one of the three new charging cars that CSN was realising to improve the environmental conditions at that time

## IMPROVEMENT OF THE COKING TIME CONTROL

In order to reduce thermal losses due variations of coking time was developed a study to reduce the dispersion of the ovens coking time.
In this study was considered that some improvements in thermal control, coal handling , machines availability , coke transportation availability would generate the appropriated conditions to guarantee a more stable operational process.
We used to work before considering a coking time average variation of 30 minutes.
It was determined as a target to be achieved after the necessaries improvements a coking time average variation of 15 minutes.
Since 1998 CSN has been working succeed with each time less variation, and now you may consider that this variation is almost zero.
This target has been the main operational control where the production is not recuperated anymore in detriment of achievement of the expected coking time.
With this philosophy the maintenance problems are well determined and the machine availability was increased.
The coke quality targets have been easily achieved and the thermal consume was reduced.
Besides the coking time control , aiming to avoid future damages to the batteries structure, it was determined and agreed that the operational rate will be always 140 % , even with an increasing of coke demand.

## IMPROVEMENT OF THE COMBUSTION FLUES THERMAL PROFILE

In 1999 due a coke quality deviation in CSR, was initiated an improvement process of the combustion thermal profile in all CSN batteries.
It was realised a series of actions aiming an increasing of the percentage of flues with their temperature in the expected target.
The main causes to a low combustion performance were:
- High combustion flues pressure variation
- Obstructed or clogged combustion flues
- Irregular combustion

- Slide plates in irregular situation
- Obstructed or clogged regenerators checker bricks

It was done an revaluation of the routine process standards and an increasing in the cleaning and maintenance actions aiming to correct the existing problems.
The main affected region was the Battery 1 coke side flues ( 23 to 28 )
It was identified a deformation of the checker bricks on the top of the gas regenerators( Figure 8 ).
To solve this problem CSN developed a procedure to replace part of the checker bricks of all 38 battery 1 gas regenerators ( figure 9 )
It was done a new chemical specification for the new checker bricks in order to resist to the premature deformation, that was occurring due the reaction of blast furnace gas impurities ( iron oxide ) with the silica presents in the checker bricks at the high temperature on the top of the regenerator.
As a result of all these efforts we could increase the percentage of flues with the expected temperature from 45 % in 1999 up to 75% in 2001 ( Figure 10 ).

## COKING PRESSURE REDUCTION BY MEANS OF USING LESS AMERICAN LOW VOLATILE COALS

The blended coal contraction is one of the main factors to be concerned in the battery life extension.
The coals having highest levels of coking pressure are the American low volatile coals. It can be seen in the Hoogovens at its pilot ovens tests where when the percentage of American low volatile is increased the coal pressure against the wall is increased.( Figure 11 )
That fact could be confirmed at the laboratory tests realised at CSN laboratory pilot coke oven where the American low volatile blending participation increasing from 10% to 25% , increased the pressure on the oven movable wall in 0,4 p.s.i.
A continuously work done at CSN, changing the blended coal profile, allowed us to reduce the coking pressure levels using less American low volatile coal in the charged blended coals.
In 2001 we also could significantly reduce our costs with coal purchasing reducing the participation of American High Volatile , that nowadays are with high prices at the international coal market.
The careful control of pushing and blended coal gas pressure allows us a more wall brickwork integrity and will collaborate decisively with our battery extension useful life .

## CONCLUSION

CSN Coke Plant Department has been producing coke at the quantities and with the quality demanded by the Blast Furnaces .
But it also has concentrated its efforts to stabilise the operational process and to do the maintenance and repairs necessaries to guarantee the state-of-art of its batteries .
The next step for the forthcoming years is to determine the investments that are still necessaries to be realised for the extension of the useful life of the equipment up to 40 years.

## References

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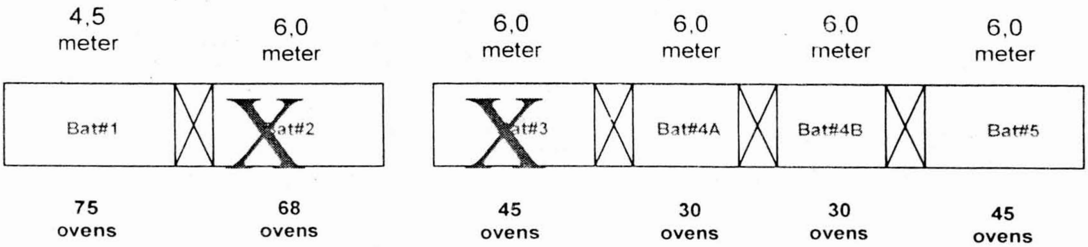
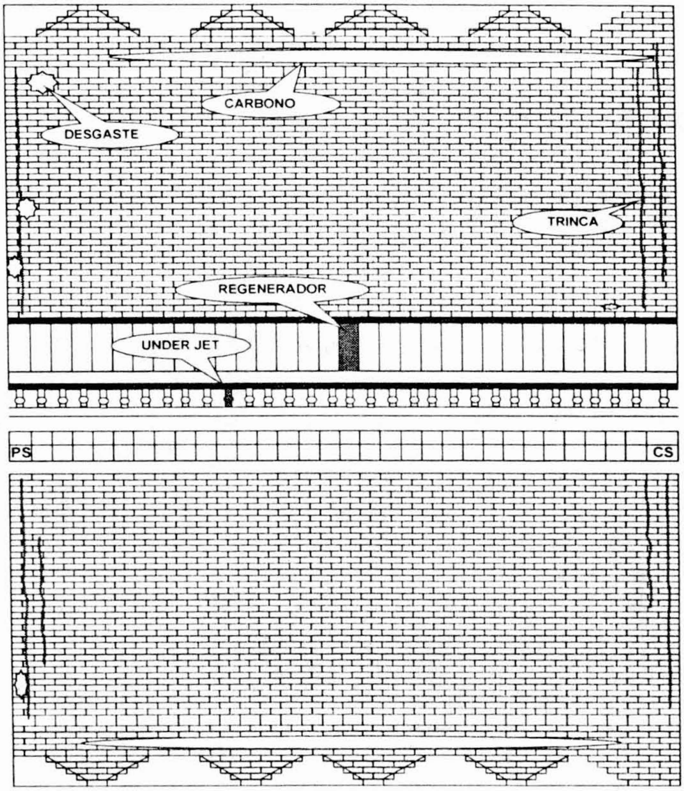
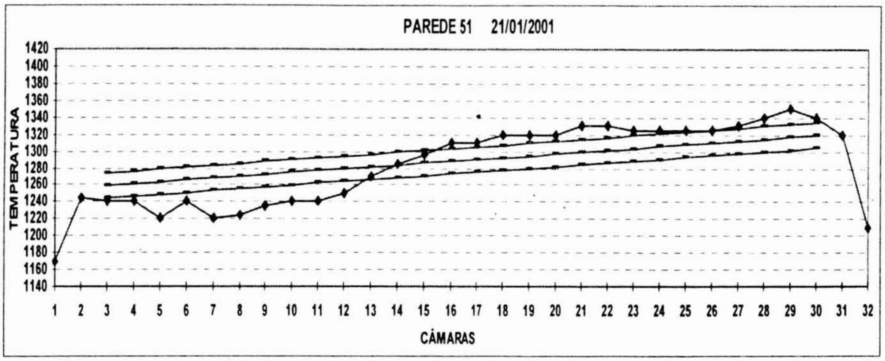



- Figure 1
CSN´s Batteries




- Figure 2
Data sheet showing coke oven wall, regenerator and underjet inspections


• Figure 3
Data sheet showing gas leakage from ovens to combustion flues




• Figure 4
Data sheet showing the cross wall thermal profile

**HISTÓRICO DOS PRINCIPAIS REPAROS**

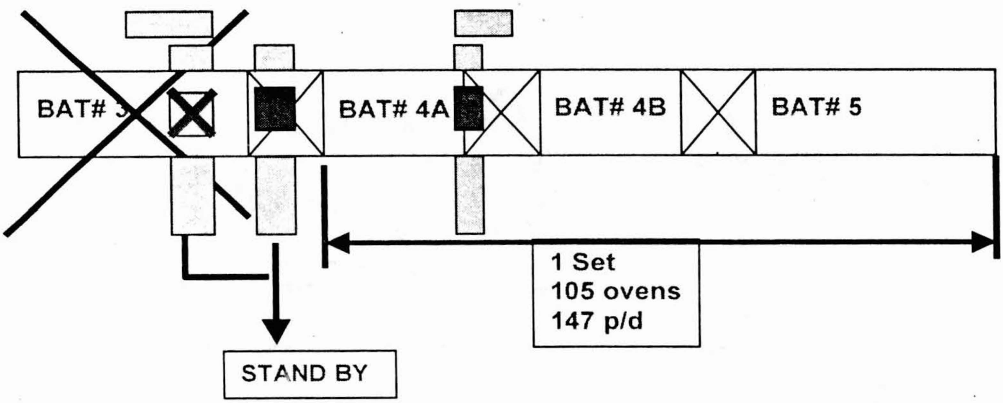
| | 2000 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN | FEV | MAR | ABR | MAI | JUN | JUL | AGO | SET | OUT | NOV | DEZ |
| TROCA DO REFRATÁRIO | | | | | | | | | | | | |
| GUNNING | | | | | | | | | | | | |
| SOLDA CERÂMICA | | | | | | | | | | | | |
| DRY-SEALING | | | | | | | | | | | | |
| REJUNTAMENTO | | | | | | | | | | | | |
| TROCA TIJOLO CHECKER | | | | | | | | | | | | |
| INJEÇÃO ARGAMASSA | | | | | | | | | | | | |
| TROCA BUCKSTAY | | | | | | | | | | | | |
| AJUSTE PARAFUSO | | | | | | | | | | | | |
| TROCA JAMB | | | | | | | | | | | | |
| CORDA | | | | | | | | | | | | |
| MOLA | | | | | | | | | | | | |
| TIRANTE | | | | | | | | | | | | |

• Figure 5
Data sheet showing the historical of the main repairs

| ITEM: | CSN - REQUISIÇÃO DE SERVIÇO EXTERNO<br>ANEXO I - ESCOPO DE SERVIÇO<br>SERVIÇO A SER EXECUTADO<br>REFRATÁRIO | UNIDADE | FOLHA<br>**6 DE 6**<br>QUANT. TOT. |
|---|---|---|---|
| 701 | REPARAR BOCA ( CABECEIRA ) DO FORNO | BOCA | 960 |
| 702 | REJUNTAR CX DE AR | CAIXA | 298 |
| 703 | RAJUNTAR CAIXA DE GÁS | CAIXA | 298 |
| 704 | REJUNTAR CAIXA DE FUMAÇA DA BAT. 1 | CAIXA | 144 |
| 705 | REJUNTAR CAIXA DE FUMAÇA DAS BAT. 4A,4B E 5 | CAIXA | 226 |
| 706 | REJUNTAR PAREDE DO REGENERADOR DA BAT. 1 | PAREDE | 152 |
| 707 | REJUNT. PAREDE DO REGEN. DAS BAT. 4A,4B E 5 | PAREDE | 452 |
| 708 | REJUNTAR GOOSENECK/VÁLVULA PRATO | GOOS/VALV. | 576 |
| 709 | LIMPAR E CALAF. JAMB DA BATERIA 1 | JAMB | 288 |
| 710 | LIMPAR E CALAF. JAMB DAS BATERIA 4A,4B E 5 | JAMB | 576 |
| 711 | REJUNTAR ESTUFA/PINNION WALL DA BATERIA 1 | EST / PINN. | 20 |
| 712 | REJUNT. ESTUFA/PINNION WALL DAS BATERIAS ALTAS | EST / PINN. | 96 |
| 713 | REPARAR TESTA DO FORNO | TESTA | 1248 |
| 714 | REJUNTAR BASE DO TUBO DE ASCENSÃO DA BATERIA 1 | TUBO | 96 |

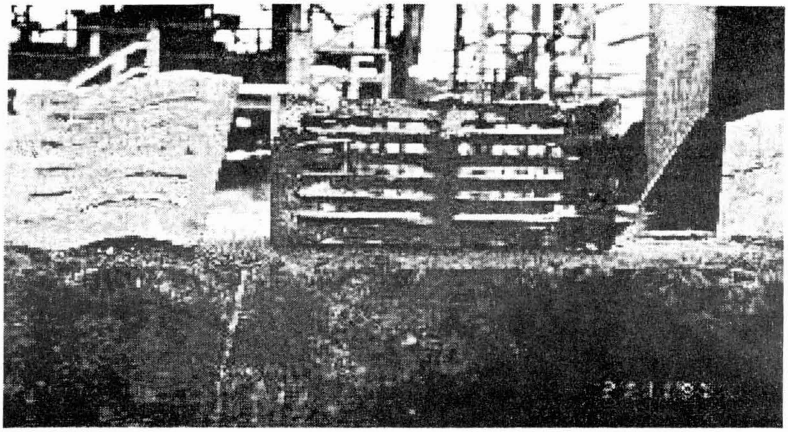
- Figure 6

Example of a Preservation Program sheet

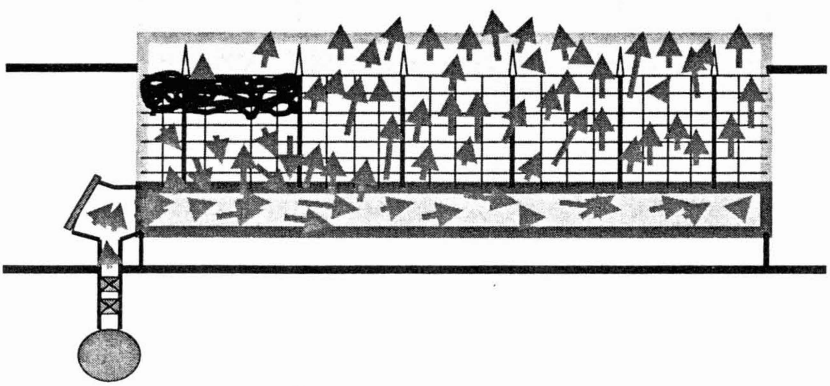



- Figure 7

High Batteries new Machines Distribution



▪ Figure 8
Picture Showing the gas regenerator checker brick deformation



▪ Figure 9
Drawing showing Battery 1 gas regenerator problem

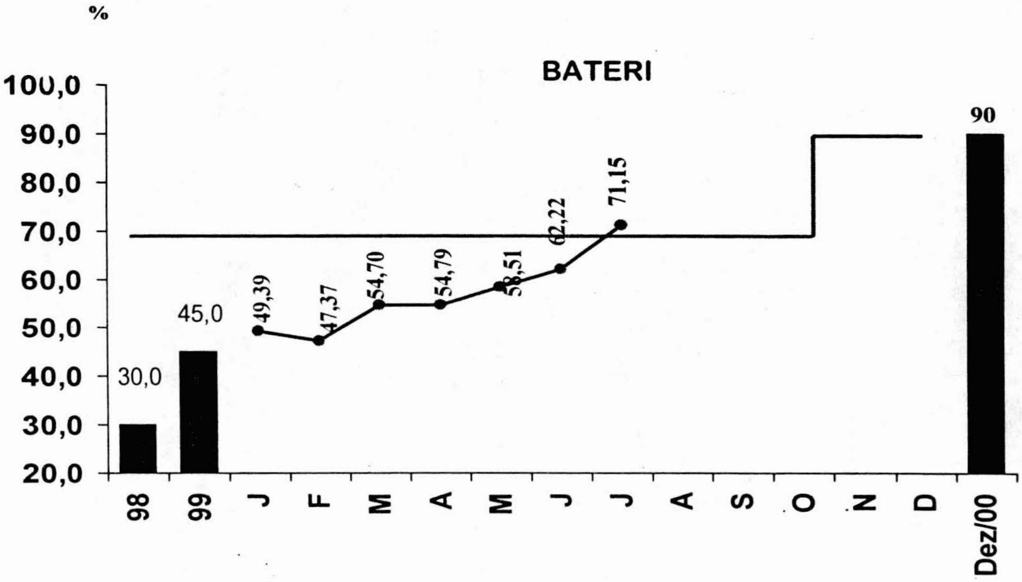
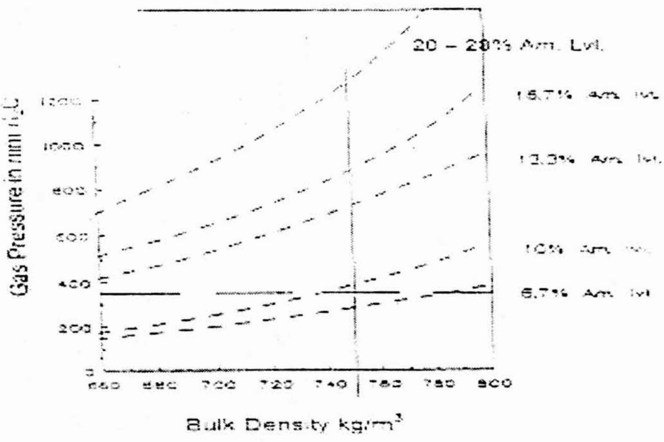



Figure 10
Showing the Battery 1 thermal evolution




- Figure 11

Graphic showing the relation between low volatile coals and pressure