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QUENCHING AND *PREHEATING* OF COKE DRUMS: A DEEP LOOK

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REFCOMM GALVESTON
May 4-8, 2015

Objectives

- To present a case study of a drum that experienced a through-wall crack after few years in operation.

- To describe the main deviations that were found to have the most impact on the sudden temperature change of the drums.

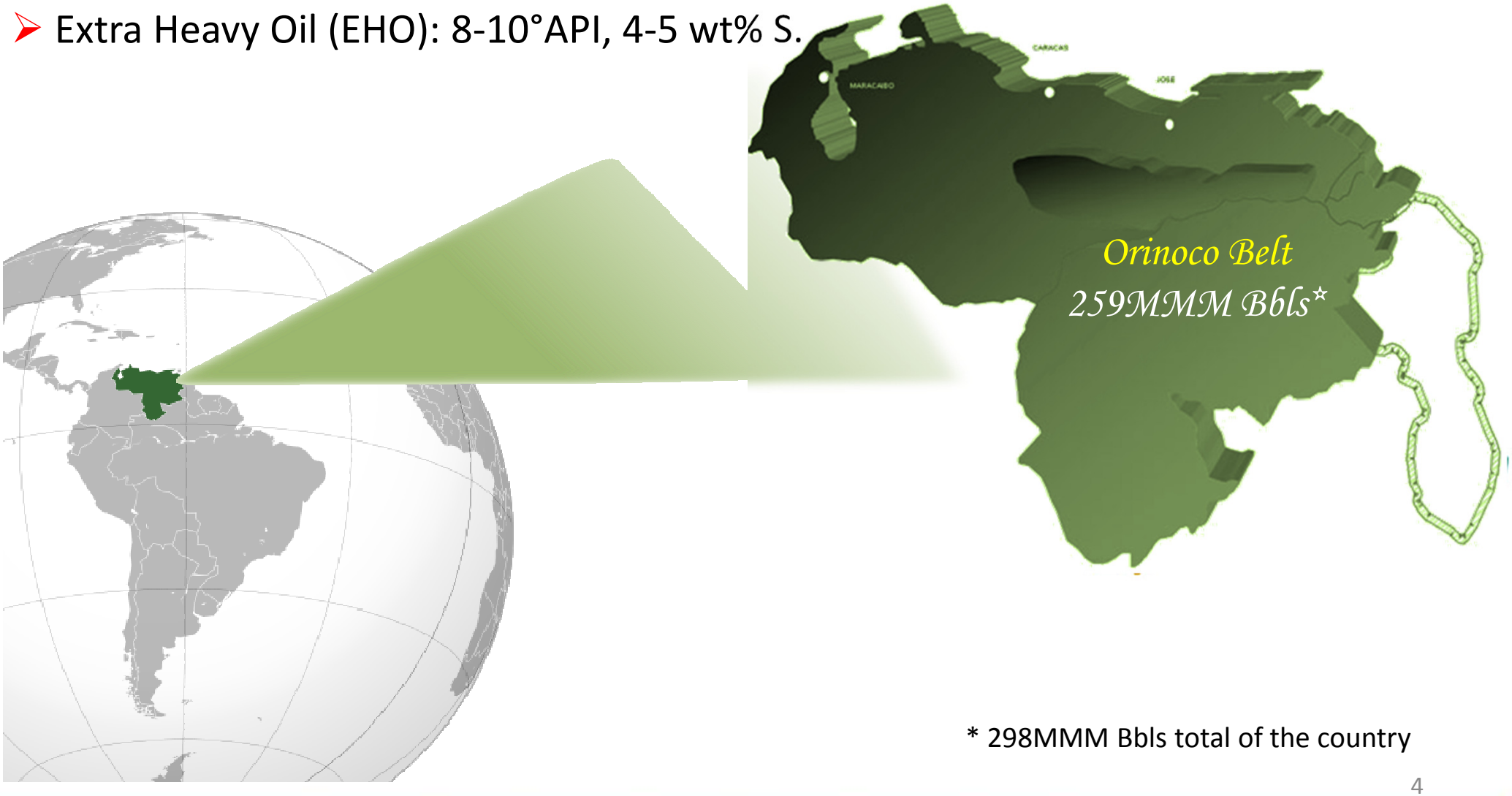
- To propose a series of operational actions to improve the quenching and preheating stages.

Presentation Outline

- Introduction
- Background
- The findings
- The actions
- Discussion
- Conclusions

Introduction

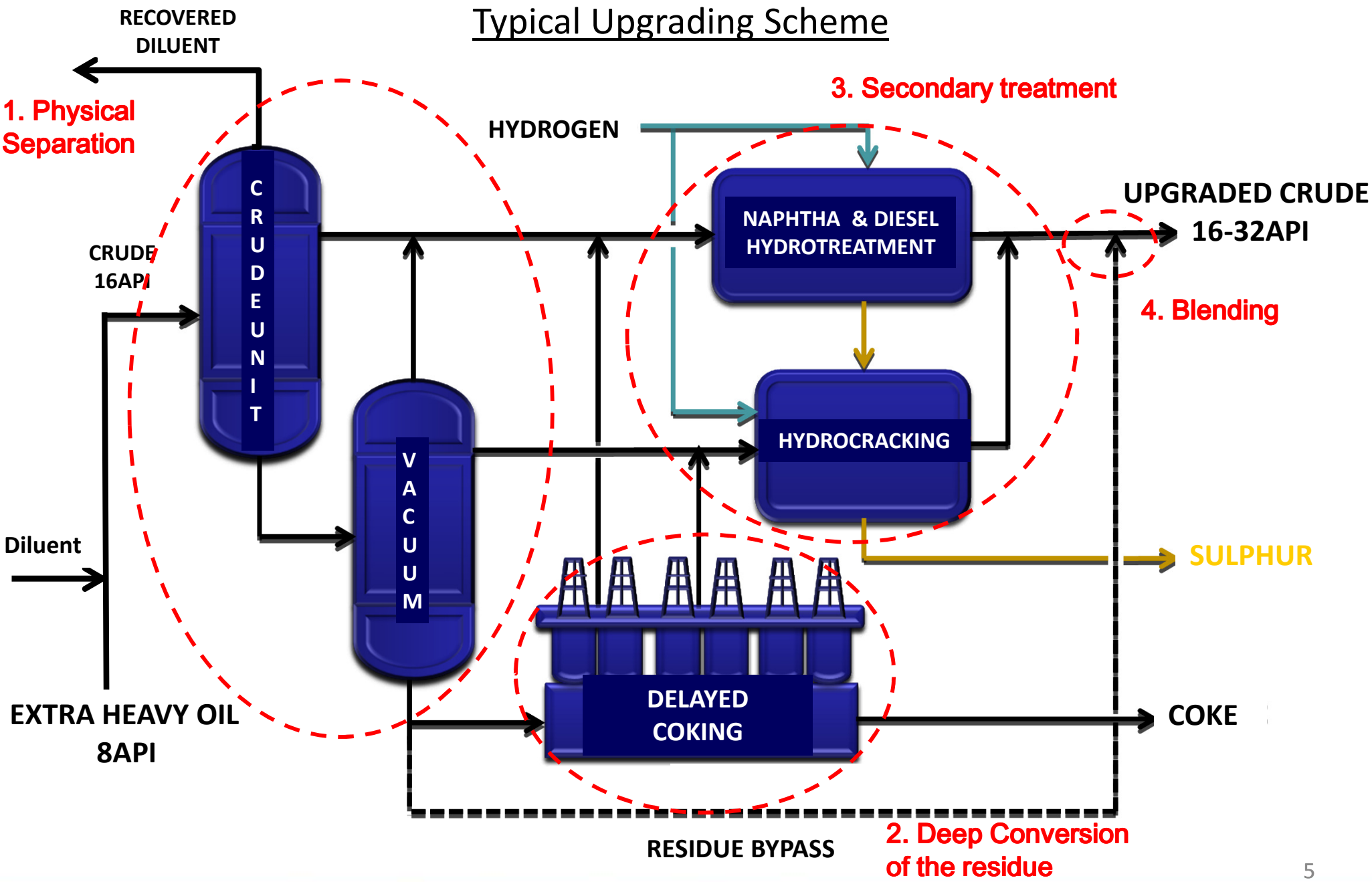
- The Orinoco Belt "Hugo Chávez": The largest oil reserve of the world.
- Extra Heavy Oil (EHO): 8-10°API, 4-5 wt% S.



* 298MMM Bbls total of the country

Introduction

Typical Upgrading Scheme



Introduction

A Common Belief…

- *"I have worked in coker units for 30 years Francisco, and I can tell you, these drums are gonna crack anyway. Why do you wanna change that quenching ramp over and over again?"*

Pedro M. , Field Operator

- *"This bottom flange is a real pain in the neck. Besides, I have to wait 2 or 3 hours for the maintenance people to come and help us close the drum. But I'm not putting this unit on circulation because of that. Not even cutting a single barrel of charge. Not on my shift."*

José D. ,Shift Supervisor

- *"After this crack, the only thing you can do is installing one of those strain monitoring systems, that will predict when you have to repair or replace your drums."*

Benito A., Technical Advisor

Background

- Upgrader started operations in 2002
- 6-drum DCU(1) was revamped 3 years later. Capacity increased from 89 to 106 thousand barrels a day
- Coking cycles shortened from 19 to 16 hrs
- Unreliable semi-automatic unheading system caused frequent delays in the decoking process

(1): Delayed Coking Unit

Background

The first crack…

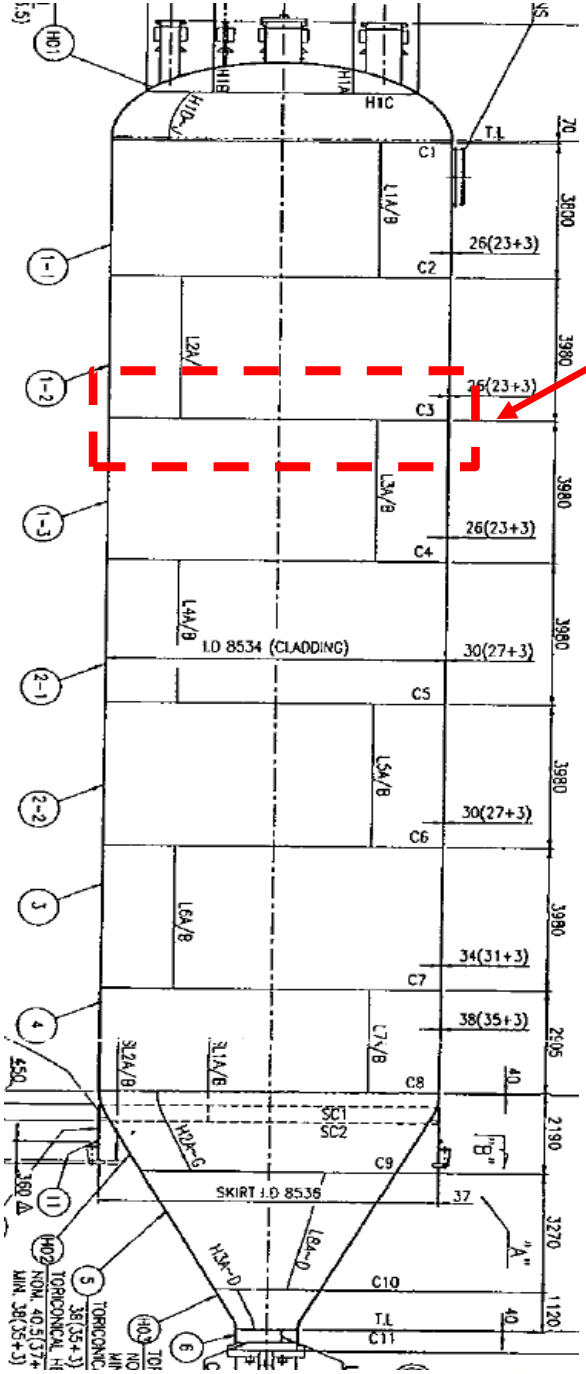
- A through-wall crack appeared in one of the drums after 9 years of operation and 3360 cycles

- Located at the weld seam C3, on the upper section of the vessel

Fig 1. External view

Fig 2. Internal view

Background



Location of the crack

Fig. 3. Bulged drum

The Findings

As part of the study that was conducted to determine the root cause of the event, the Quenching and Preheating stages were thoroughly examined.

A summary of the findings is described below:

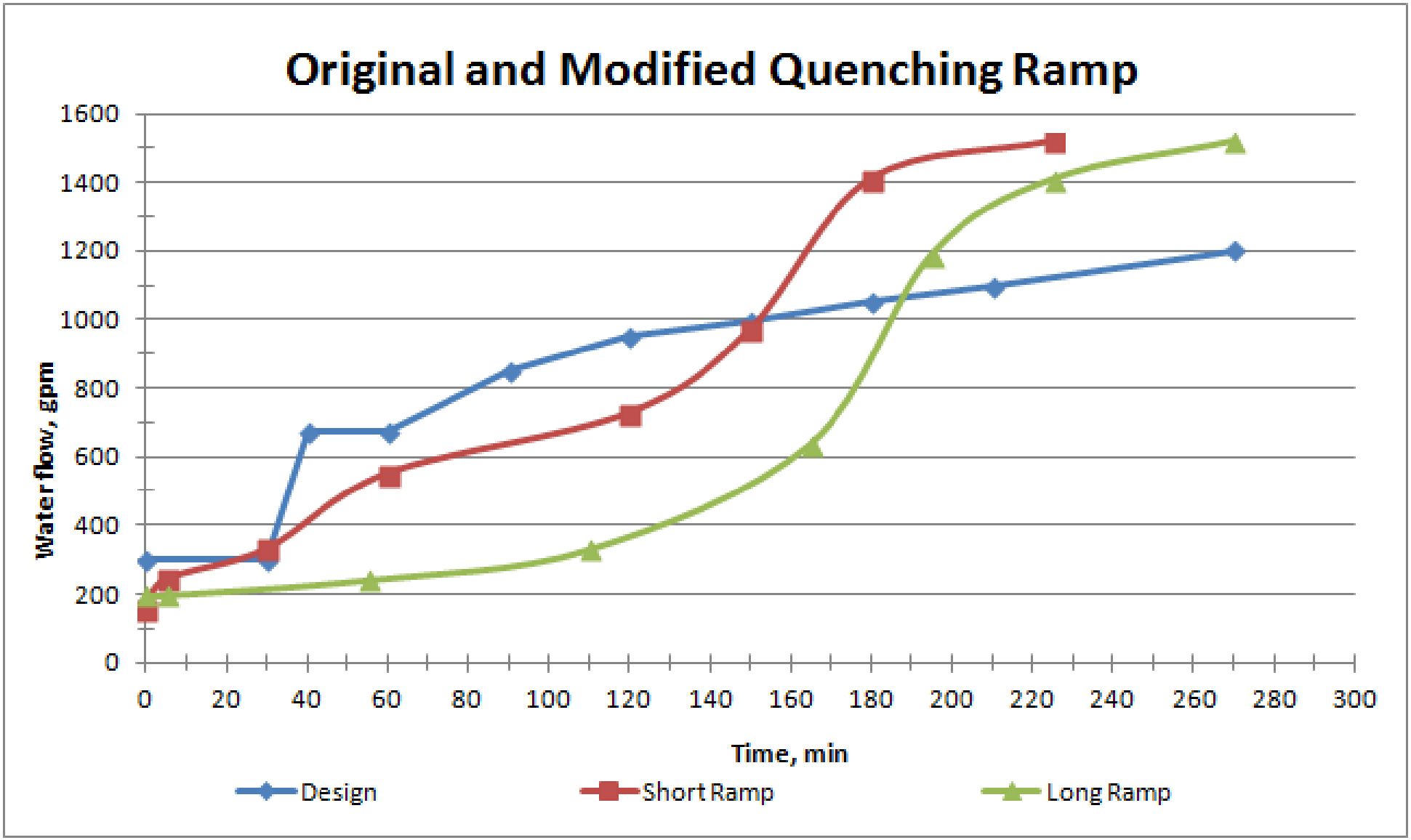
- **QUENCHING**

When the unit was revamped, due to the reduction of the coking cycle, a new quenching ramp was created (Short ramp).

- Quenching time reduced from 4hrs and 30min to 3hrs and 45min
- Total amount of water reduced in 20%

The original quenching ramp (Long ramp) was kept but it was also modified.

The Findings



The Findings

Although both ramps were available, it was found that almost always the Short Ramp was used.

The temperature profile of the drum during quenching showed the following behavior in almost all cycles studied:

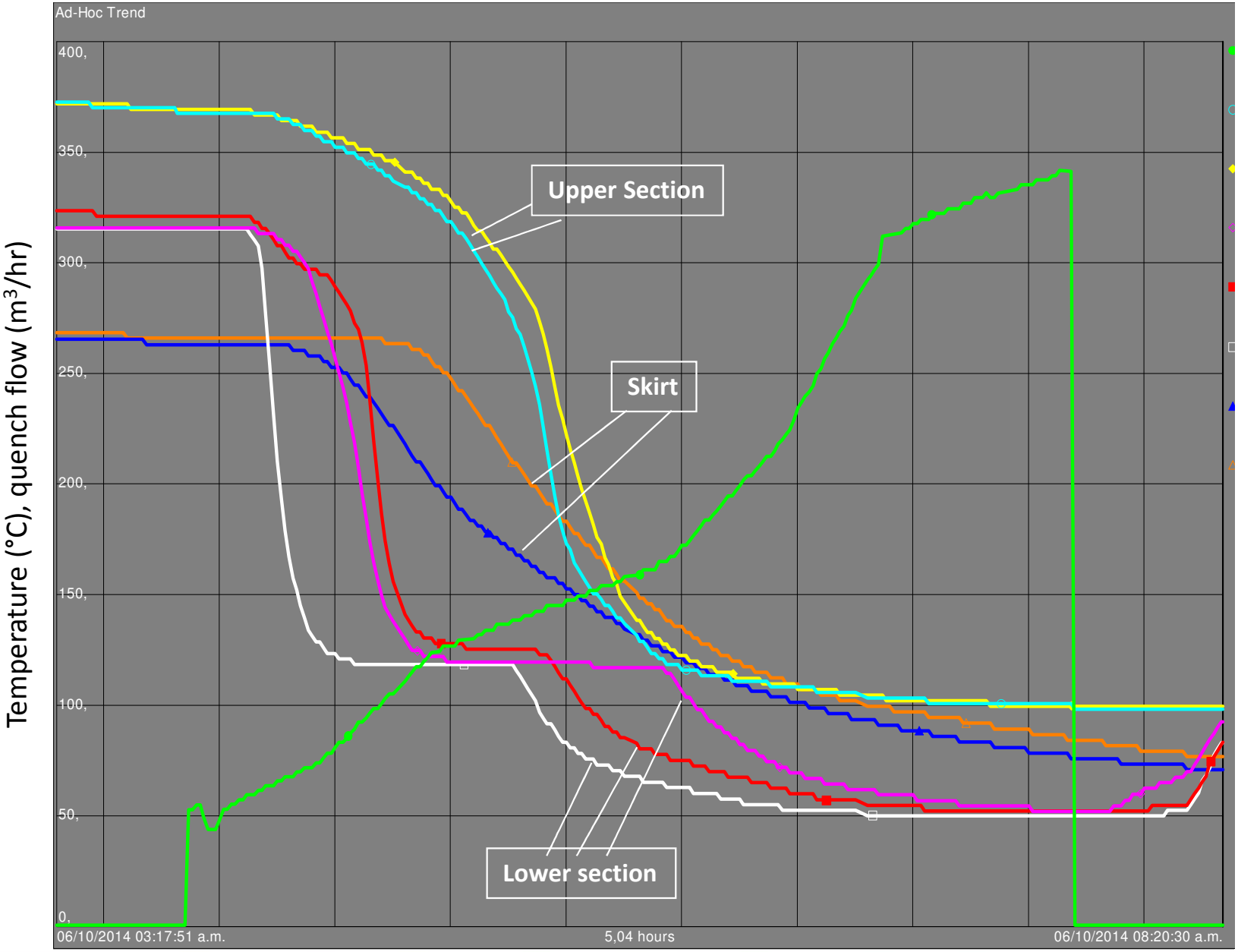
- The Temperature Indicators (TI) located at the bottom of the drum started to see a decrease in temperature after 20-25min of the initial water injection.

- The TIs of the cylindrical section started to see a slight decrease in temperature after 20min of the beginning of the ramp, but then a sudden decrease was perceived after 60min.

- The TIs of the skirt detected a reduction in temperature at the same time that those of the cone, but the rate was much lower.

The Findings

Typical behavior during quenching stage (using Short Ramp)

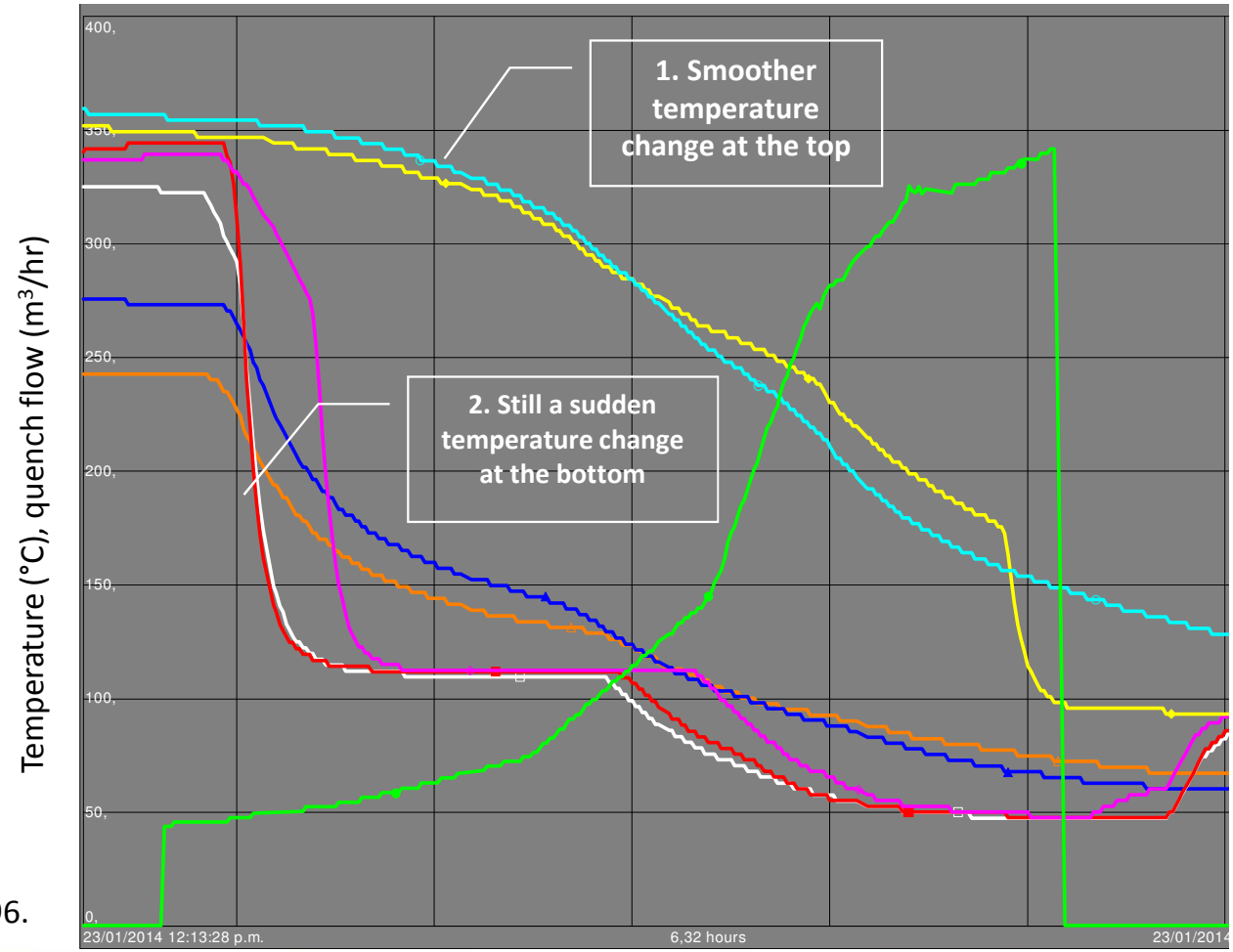


The Findings

Number of Cycles to have a through-wall crack = f (Initial Quench Flow Rate)[2]

However, when the Long Ramp was used (which has a lower water flow throughout the first hour and a half), the temperature decrease rate was less drastic.

Typical behavior during quenching stage (using Long Ramp)

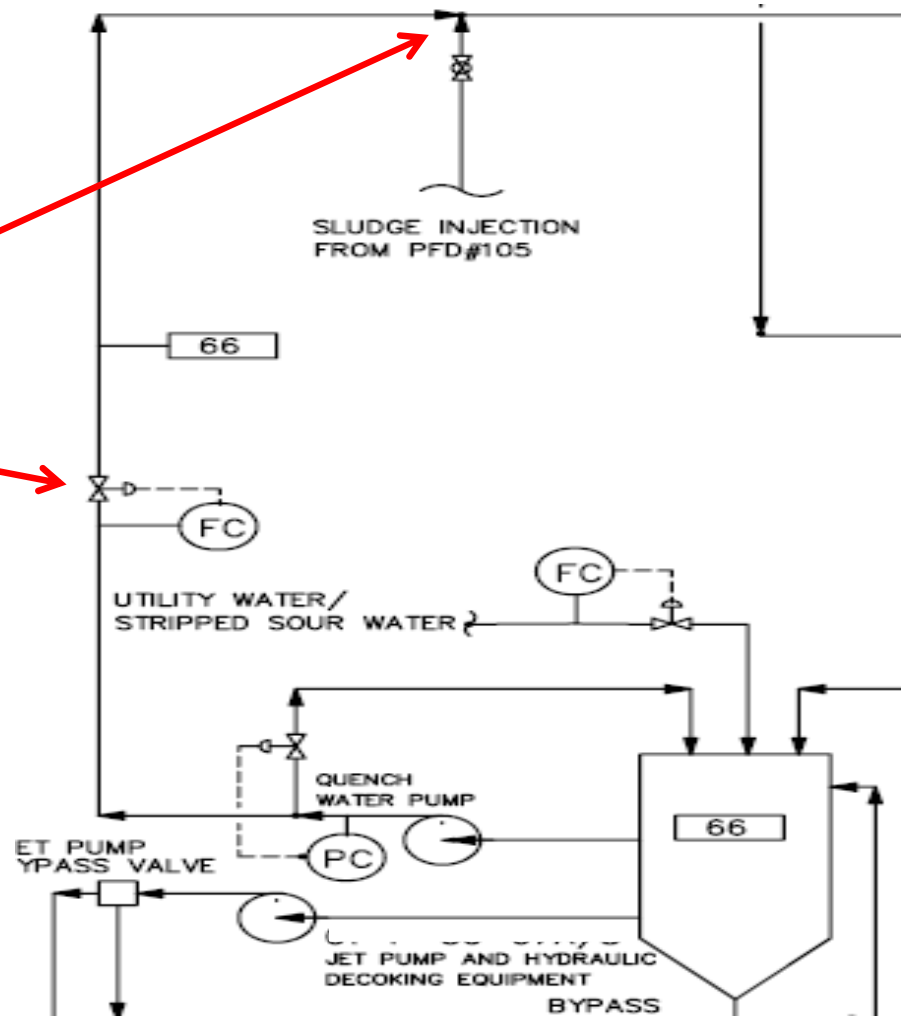


(2) API Coke Drum Survey, 1996.

The Findings

Sludge injection: It was not being considered in the quenching ramp, because the water flow meter was located upstream of the connection of the sludge line.

Sludge injection downstream of quench water controller

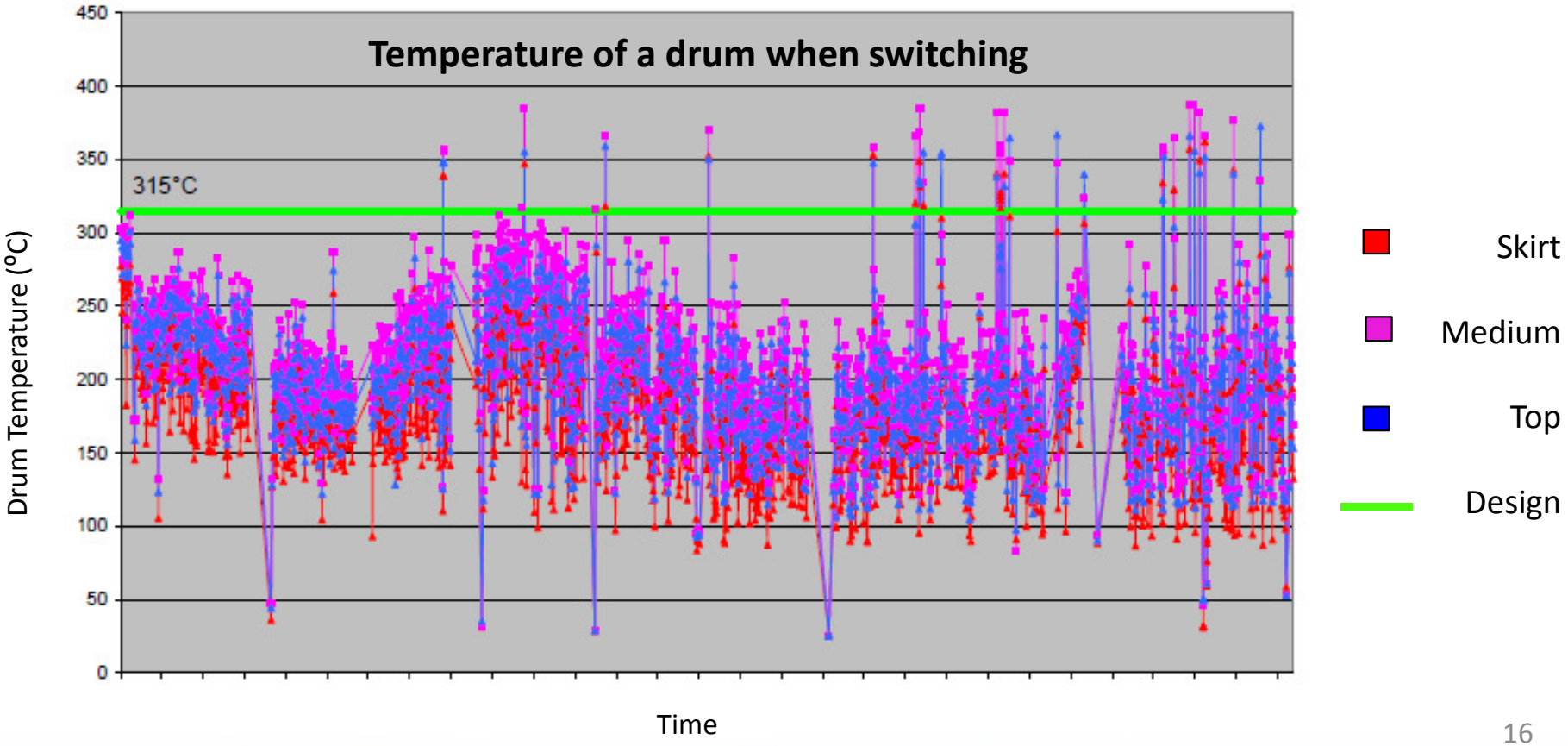


Sludge is typically injected during the first hour of the quenching, and it accounts for approx. 50% of additional water flow to the drum.

The Findings

- **PREHEATING**

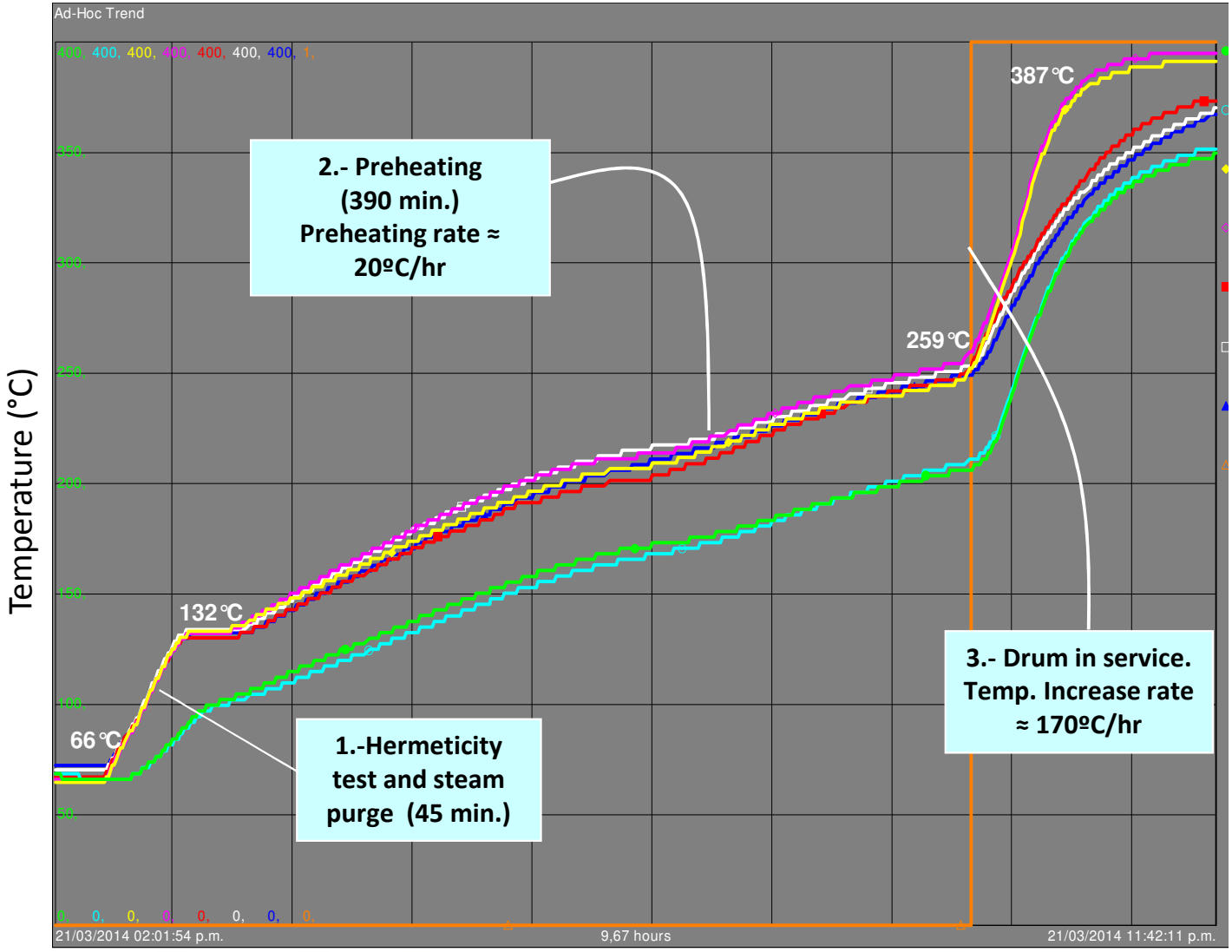
Due to delays in other stages of the decoking cycle, the preheating stage was often reduced or even completely skipped. Drum temperature when switching was from as low as 120°C, to an average of 220°C, versus 315°C according to the recommended procedure.



The Findings

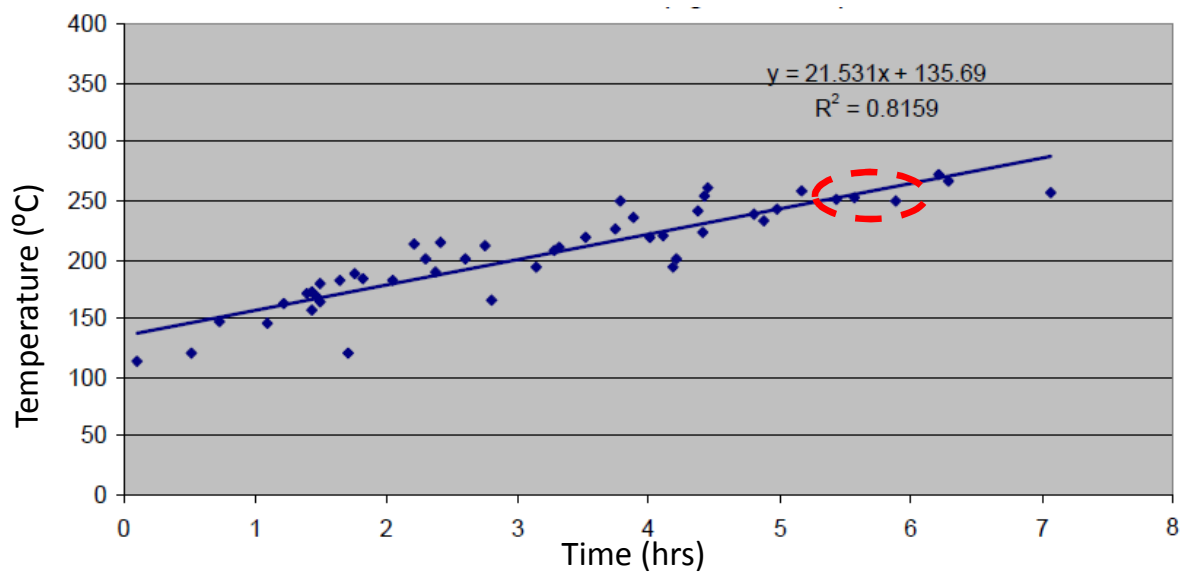
It was also noted that it was required at least 5 hours to get a drum temperature of around 260°C.

Typical behavior of the Preheating stage



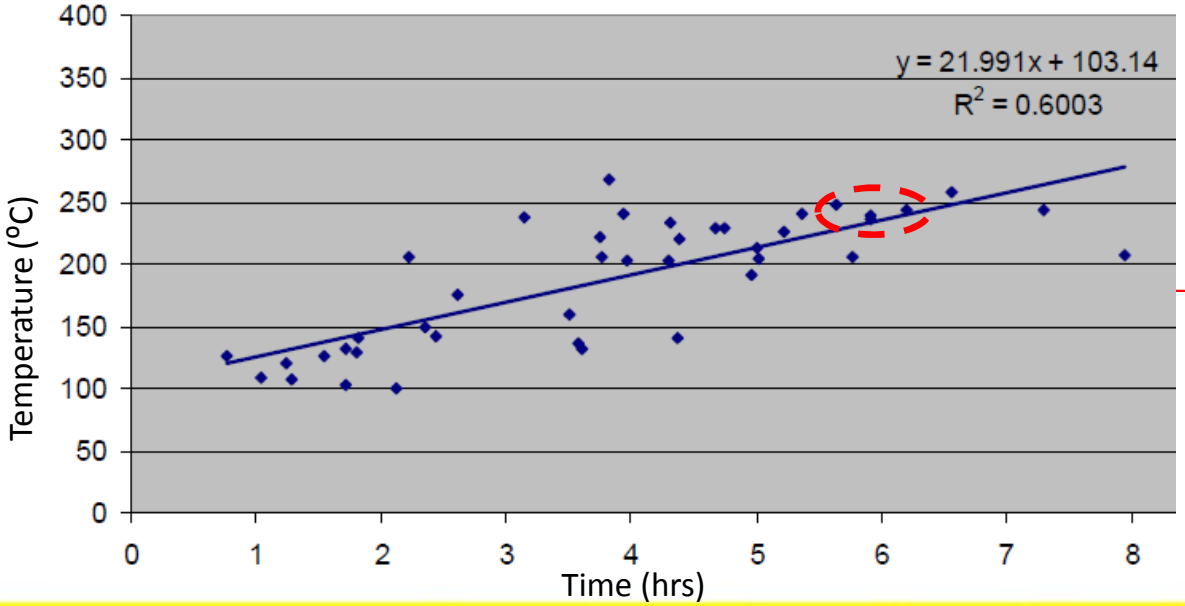
The Findings

In addition, the failure of the backpressure valve (SP3) in one of the trains allowed testing the influence of that valve in the preheating performance. It was surprising to see that throttling the SP3 seemed to have no effect at all on the temperature reached by the drum.



Drum A: SP3A 100% open

Time required to get 250ºC≈ 6hrs



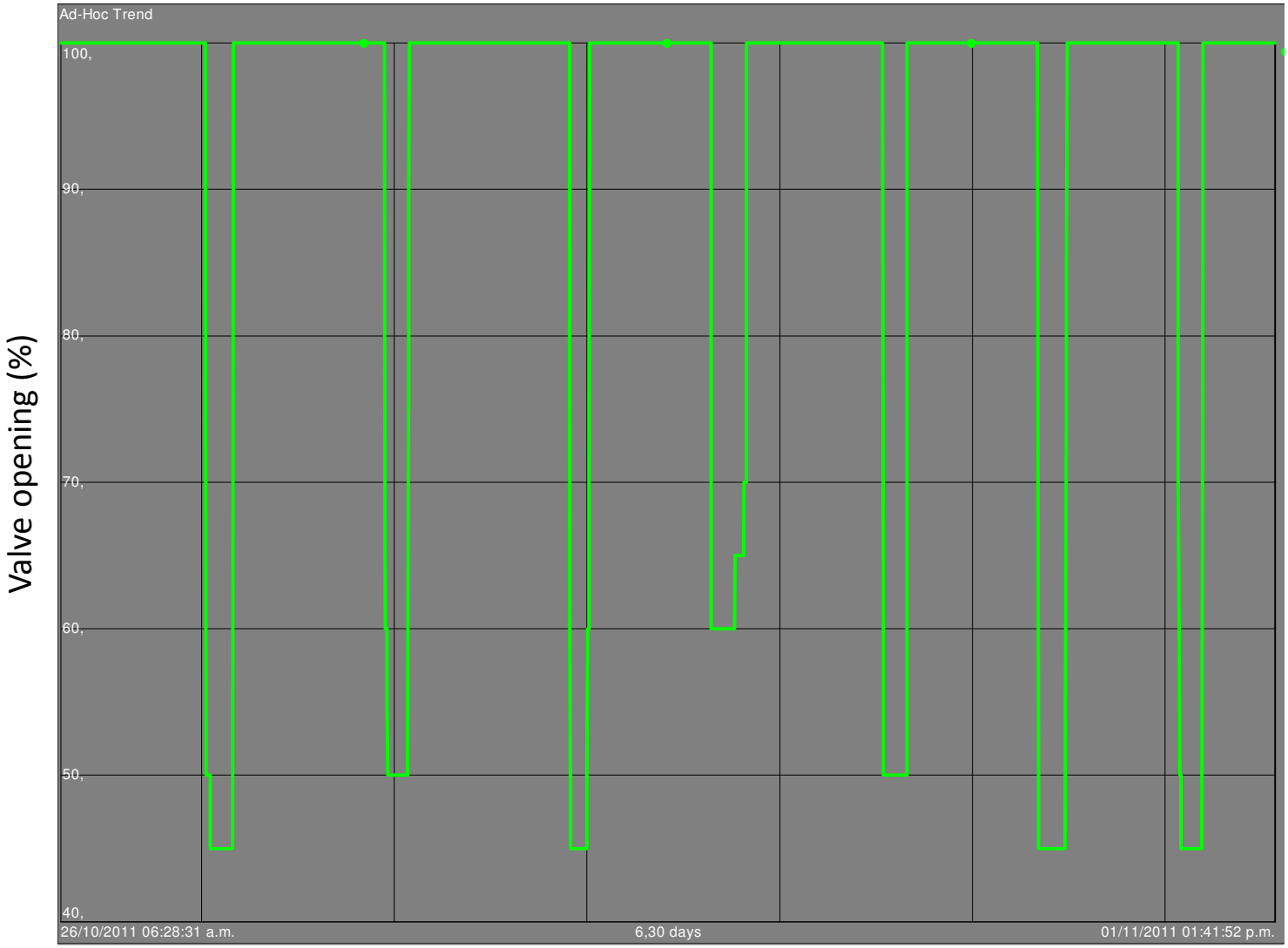
Drum E: SP3C fully operative

Time required to get 250ºC ≈ 6hrs

The Findings

A review showed that the SP3 valve was usually closed up to 45-50%

Opening percentage of backpressure valve SP3



The Findings

Considering that the particular design of the backpressure valve (ring valve) prevents it from going to full closure, it could be safely throttled even to 100%. An investigation of the reasons why it was not applied indicated the following reasons:

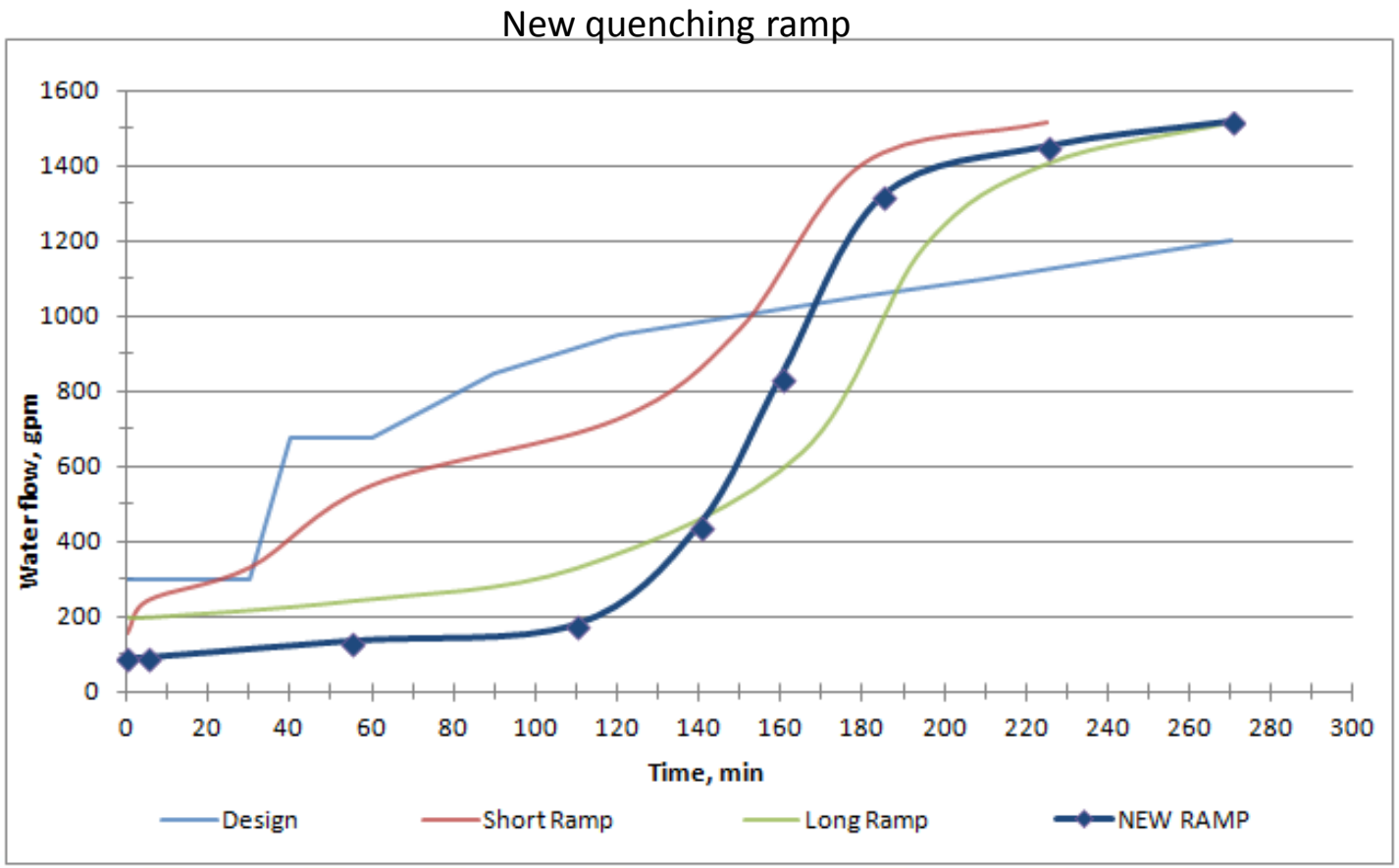
- It was not clear in the procedure.
- The non-closure feature of the valve was not well known by everybody.
- The blowdown reprocessing line to the fractionator was plugged, and the condensate vapors could not be recovered.

Example of a Ring Valve, similar to the installed in the plant.

The Actions

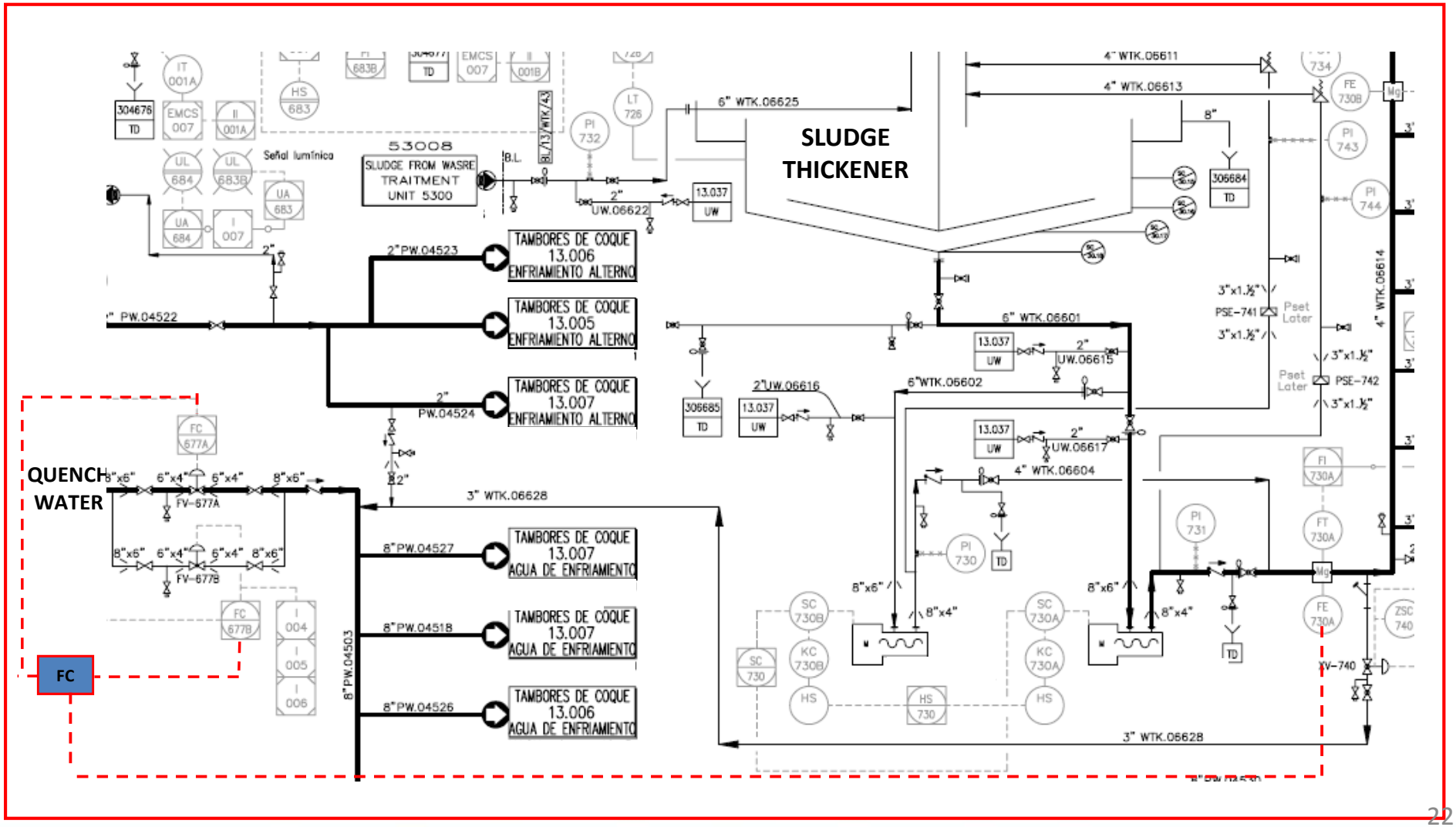
▪QUENCHING

A new quenching ramp was developed. The idea was to keep the water flow as low as possible (max.60gpm) during the first 60-80minutes, and then increase it to fill the drum within the same total time than the original one:



The Actions

The sludge injection was linked to the quench water flow. When sludge was injected, a flow calculator included the amount of sludge into the total flow, and the quench water was adjusted accordingly.



The Actions

When testing the new ramp…

- Problem identified: The quench water valve was too big to handle the small flow desired, and behaved unstably at that flow. Steady operation of the valve was achieved at 100-120gpm.

- Problem 2: Unreliable measurement of sludge flow has made it difficult to link it to the quenching ramp.

- Problem 3: The quench valve…again. Sludge injection needs to be reduced to avoid unstable behavior of the valve at low flows.

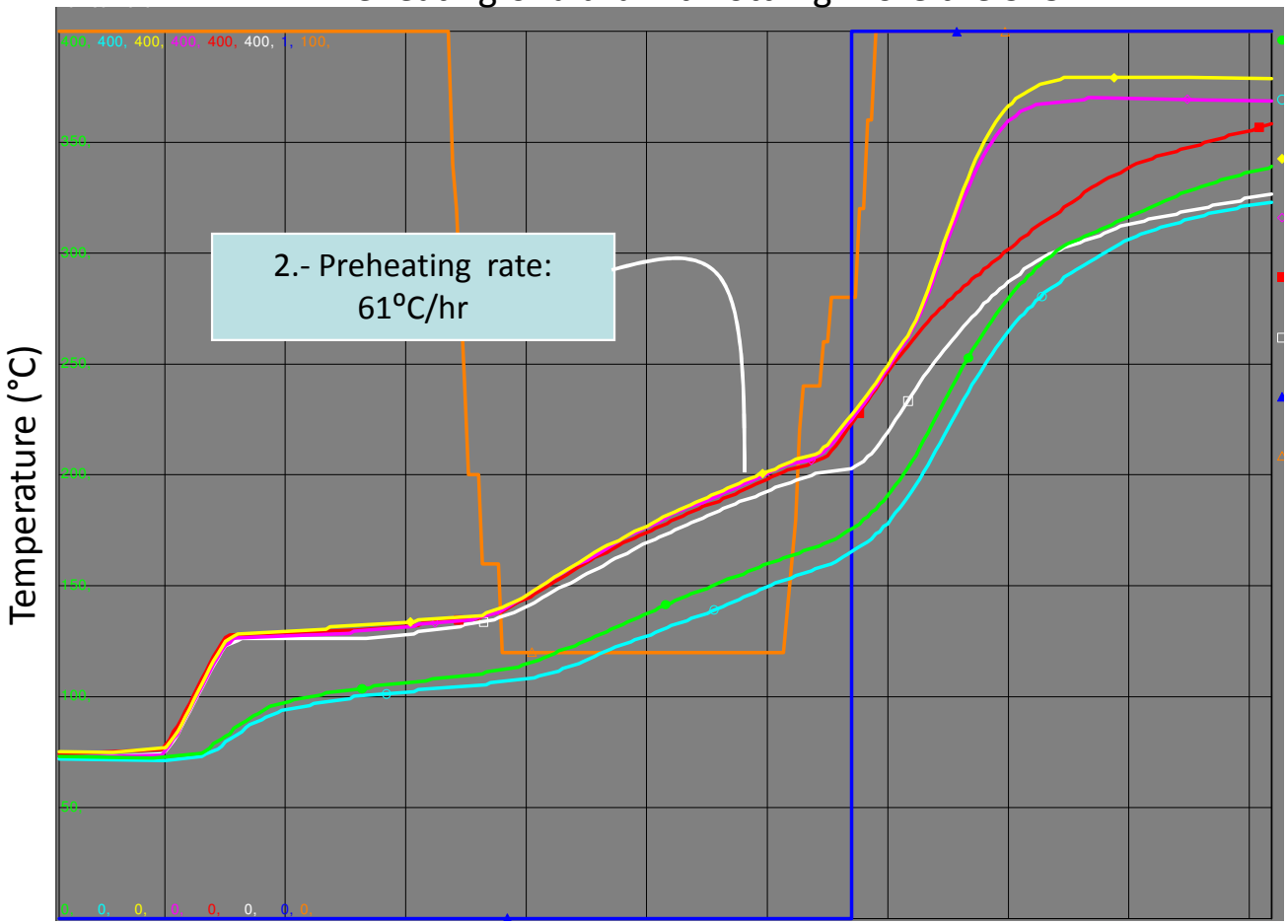
Only by shifting to the Long Ramp, the rate of decrease in temperature in the upper section has been seen to be reduced in approx. 30%

The Actions

▪PREHEATING

Operating procedure was updated, to allow the operators to close the SP3 *as required* to get the desired temperature. Test were performed at 30% opening:

Preheating of a drum throttling more the SP3



- Time required to get 250°C:

2hrs

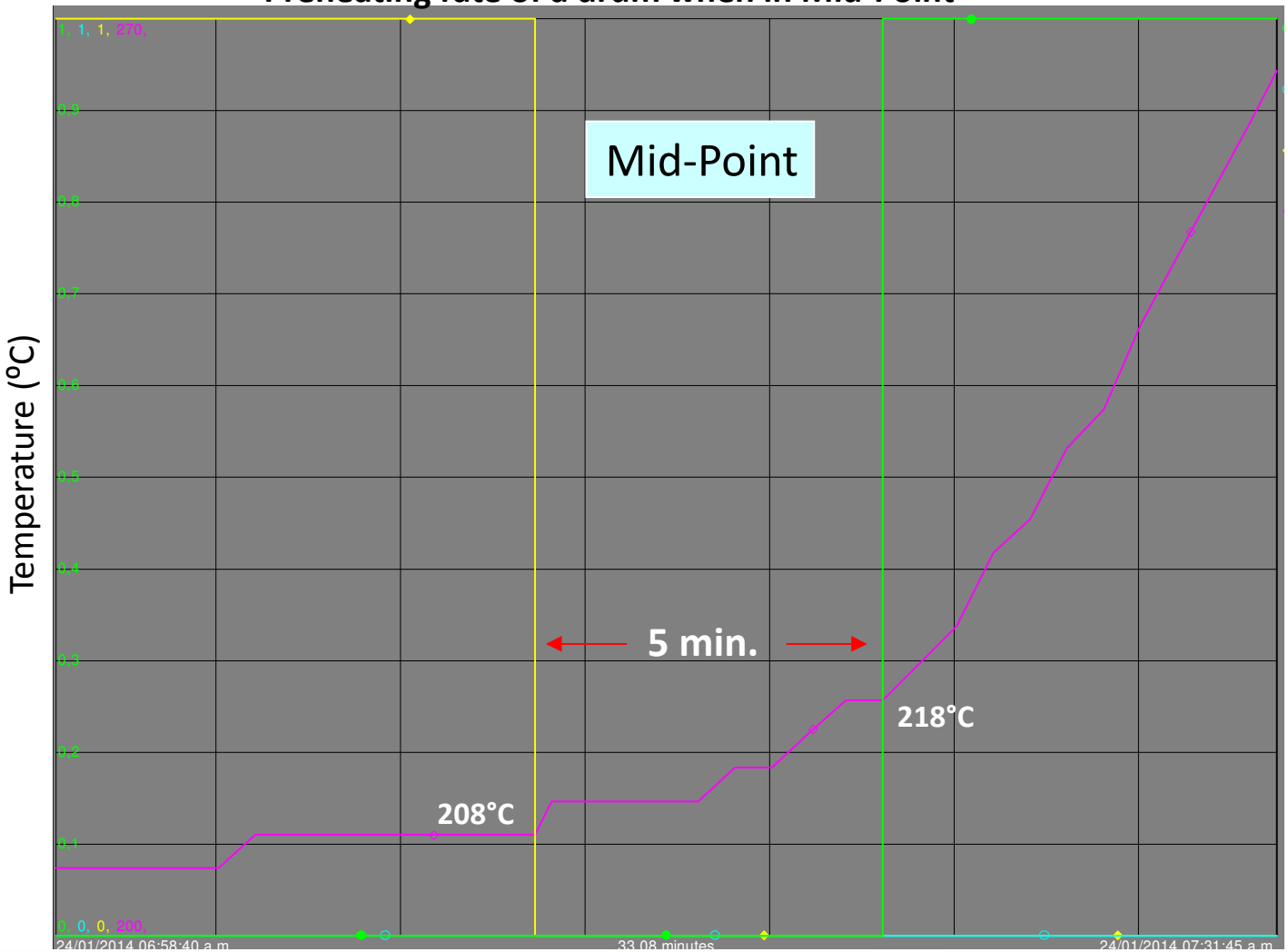
- Temperature reached with 3hrs of preheating:

310°C

The Actions

Placing the 4-way valve at mid-point proved to be another way to reduce the sudden temperature change when switching. Tests performed showed that that increase in temperature was 33% slower when keeping the valve at mid-point.

Preheating rate of a drum when in Mid-Point



- Temp. Increase rate at mid point:

120ºC/hr

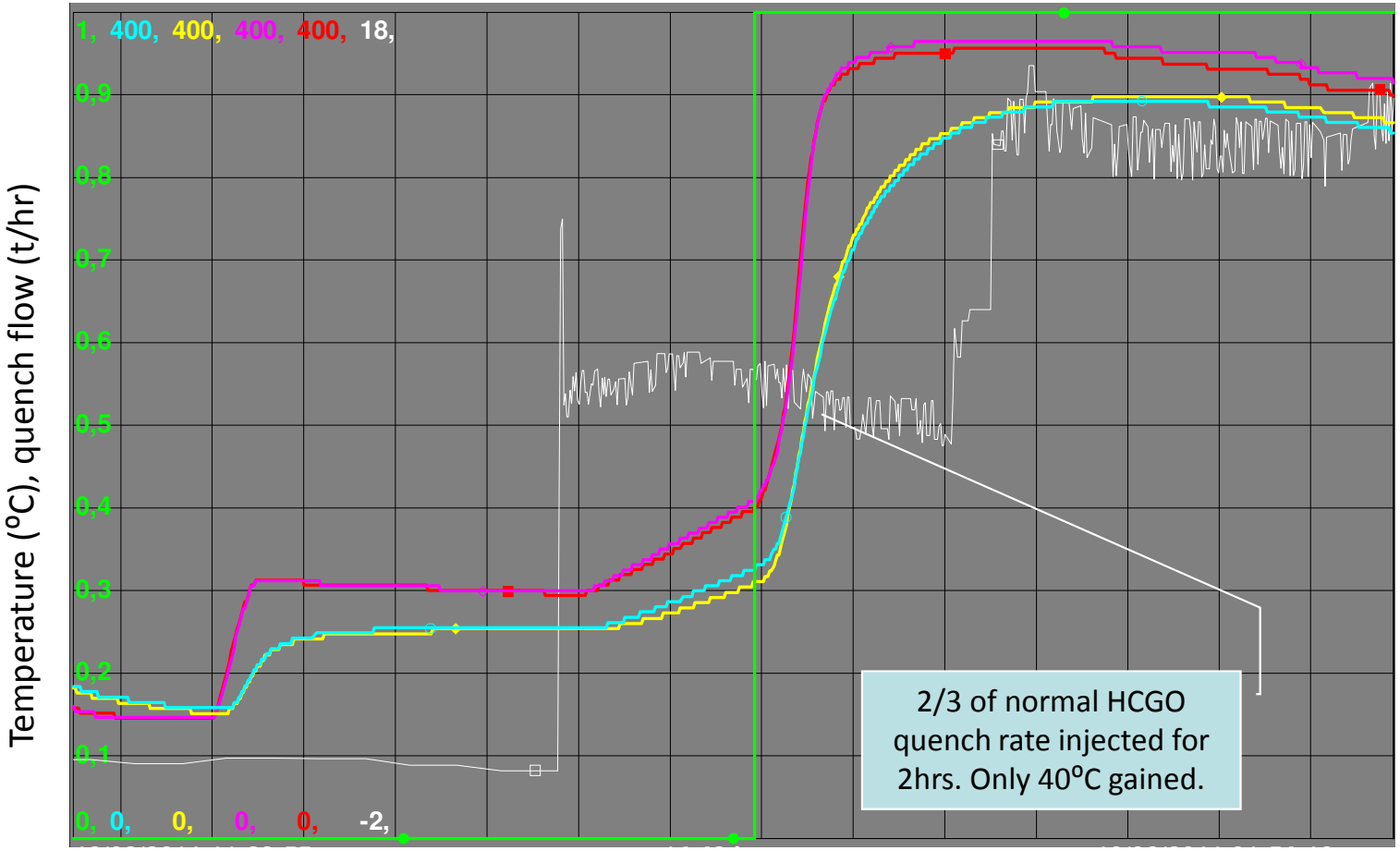
- Temp. increase rate after switching:

180ºC/hr

The Actions

On the other hand, test performed to try to preheat the drum when the unit was on circulation (and there were no vapors from the other drum) were unsuccessful. Only by using HCGO quench a slight warm up was achieved, but the amount of gasoil required was so high that it was considered impractical.

Preheating of a drum without vapors from the other drum

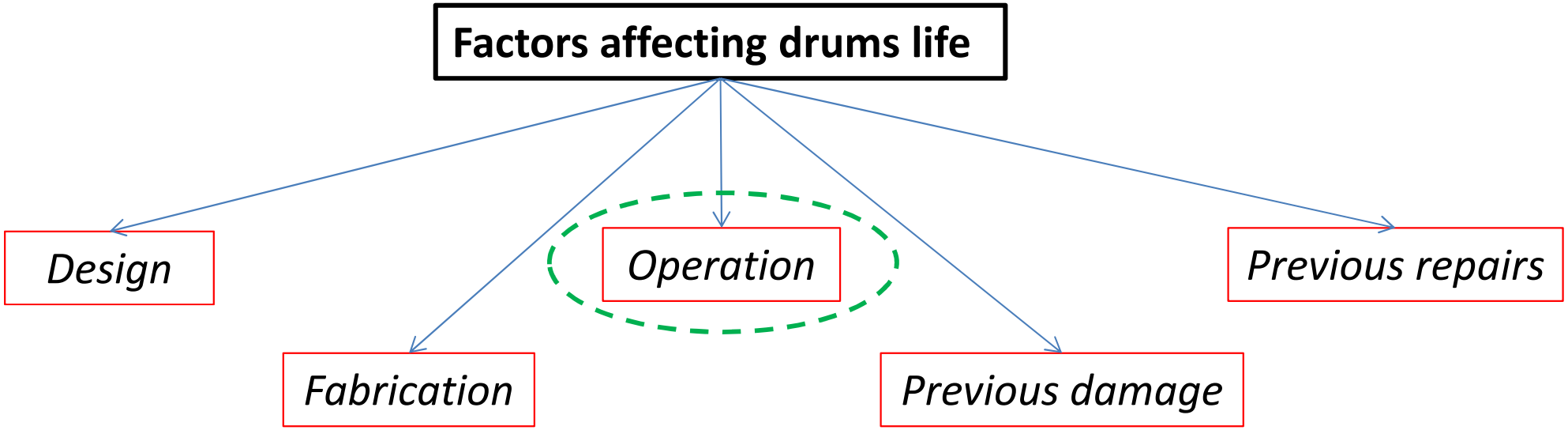


Discussion

Is it really worth it?

The extent to which the thermal stress of the coke drums can actually be reduced is topic of discussion.

Reducing the drop temperature rate in 30% or preheating the drum 50ºC higher will certainly be beneficial for the drum…but how much?



Discussion

How to measure the impact of the changes on drums life?

API Technical Report 934G[3] analyzes the effect of changes in operating practices on drum reliability.

However, it only considers the impact of changing the coke cycle time on the drum life (also taking into account a change in the amount of damage that occurs during each cycle). It does not cover the scenario where cycle time is kept but damage that occurs during each cycle is reduced.

Assuming (as a rough estimation) that an improvement in the operation of 30% can be seen as a reduction of damage in 30% and also equivalent to an increase in cycle time of 30%, multiplying factors of the API 934G can be used to estimate the impact of the operational changes on the time between downtime repairs:

9 years * (1.20 to 1.53) = 10.8 to 13.77 years → 1.8 to 4.7 years more

(3) Design, Fabrication, Operational Effects, Inspection, Assessment and Repair of Coke Drums and Peripheral Components in Delayed Coking Units. 2014 (DRAFT)

Discussion

More accurate estimations...

Strain gauges can be used to estimate the drum life and the amount of damage that occurs during each coking cycle.

Utilizing those devices, a good comparison can be established between the damage that occurs to the drum with different operating conditions or procedures.

This equipment has been installed recently in one of the drums of the Upgrader. Data of the base case has been started to be collected.

Full profit of the strain gauges can be obtained if they are used not only to monitor the remaining drum life, but to evaluate the impact of the changes in the operating conditions.

Conclusions

- Pedro was right. Coke drums will crack. But through a proper operation during quenching and preheating, the occurrence of those cracks can be greatly retarded.

- The sudden temperature drop during quenching depends not only on the initial quench flow rate, but on the flow rate used during all the first hour.

- Sludge injection must be considered in the quenching ramp as it can account for a significant percentage of the total quench flow.

- It must be operationally determined how much the backpressure valve must be throttled in order to speed up the preheating stage. Significant improvement was found at 30% opening.

Conclusions

- José was also right. Partially. From the preheating point of view, it is worst to put the unit in circulation. Any delay in the decoking process must be quickly identified and rate must be reduced to allow enough time for preheating.

- Benito was right too. To some extent. Strain gauges will certainly provide better information to monitor the condition of the drum. But they must be accompanied with changes in the operating procedures.

Acknowledgements

This work would not have been possible without all the support of the field operators, control panel technicians, supervisors and engineers of the plant that worked together selflessly to improve the operation of the unit, only because they love their coker unit as much as we do.

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