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# Maximizing vs Making Diesel : DMC3 Implementation at the Valero Quebec City Refinery

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# Presentation Outline

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- Project Description
- What did we want to achieve with APC?
  - Meet the operating objectives
  - Consistent service factor
- How did we achieve it?
  - Controller design
  - Operator training
- The benefits

# Project History

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- First project started 2012
  - Completed step testing
  - Commissioning suspended due to upcoming shutdown
- Atmospheric tower internals replaced in 2013
- Another project started in 2015
  - Completed step testing
  - Commissioning suspended due to technology change
- Final work (2016/2017)
  - Controller re-design
  - Some final step testing
  - Operator training
  - Commissioning

# Crude Unit Description

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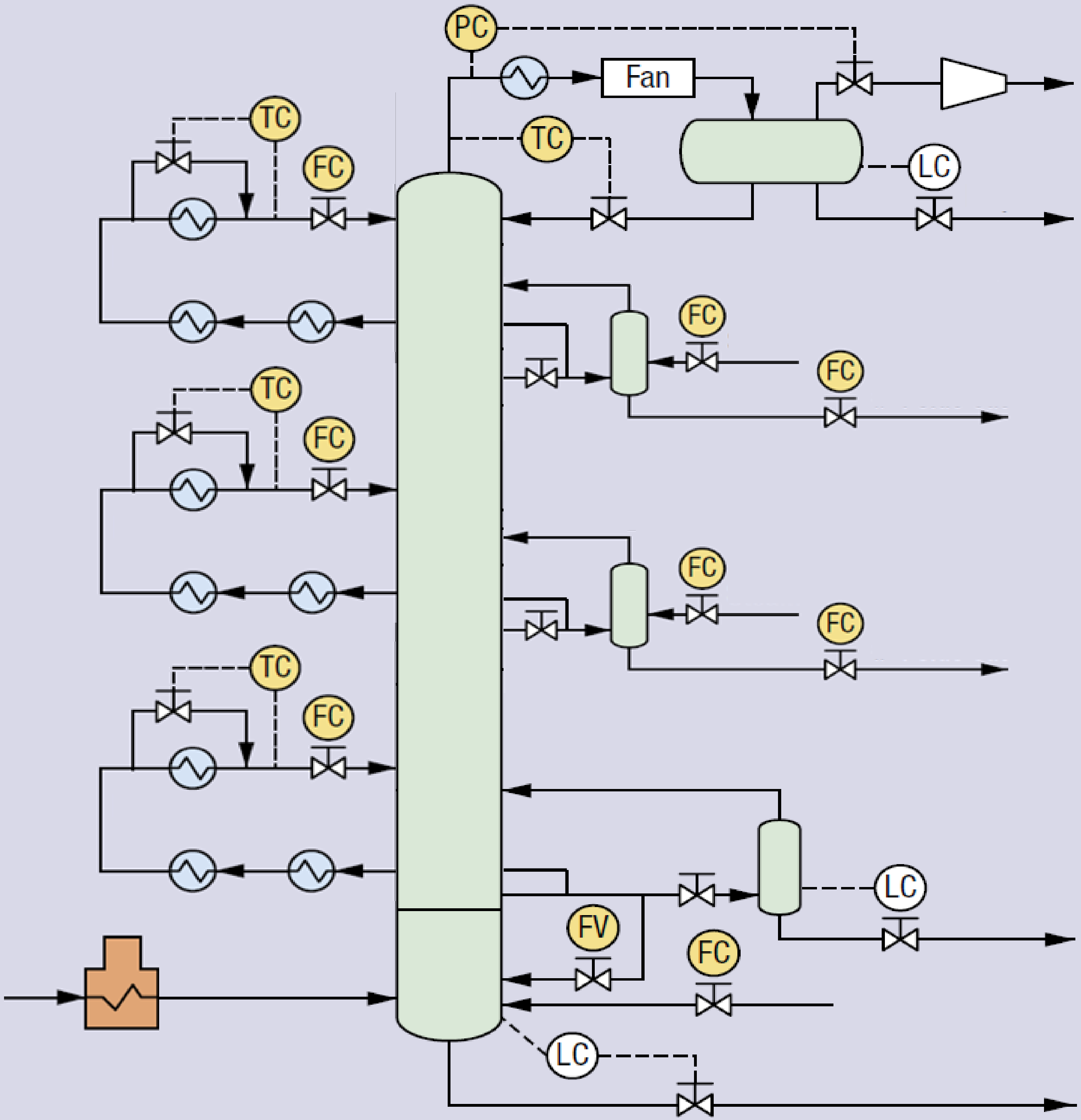
- Major Equipment
  - No preflash tower
  - 1 Atmospheric tower and two Naphtha towers
  - 2 feed heaters
  - 3 product side draws
  - 3 pump arounds

- What are we calling 'Diesel'.....
  - Diesel is the combined production of Kerosene and Light Gasoil which are sent to the same downstream operations most of the time.


PC
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# Crude Unit Description

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- Main operating challenges
  - Overhead cooling limitation in the summer
  - Hydraulic limitation on the Kerosene draw
  - Diesel modes : Normal and Jet
  - Furnace coking when running Eagle Ford crude
  - Heat integration with Naphtha separation columns

  - The specific operating challenges for this unit made it a good candidate for APC but also made it a good candidate for the Diesel maximization strategy that is the topic of this presentation.

# What did we want to achieve?

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- Main operating objectives
  - Maximum feed rate
  - Maximum Kerosene production

- Most of the other objectives were secondary
  - Kerosene flash point control
  - Minimize pressure
  - Maximize stripping steam

- Thus far, we have been focused on Diesel maximization via Kerosene maximization

# Some Project Notes

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- Heat removal in the P/A's is done using duty controllers that are based in the DCS.
  - Linearizes the controller model
  - Localizes any nonlinearity in the P/A variables

- Product qualities are estimated using IQ
  - Use the Kerosene 90% as input for other properties
  - Flash Point is pressure compensated boiling point

# Making versus Maximizing Diesel

- Making Diesel
  - Crude vaporized in heaters
  - Crude vapor travels up the tower
  - Liquid is condensed in P/A's and overhead
  - Remove liquid in the side draws
- Maximizing Diesel
  - Maximize the heaters
  - Let as much vapor up the tower as possible
  - Condense liquid where it is most valuable
  - Maximize the Kerosene side draw

# Making versus Maximizing Diesel

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- Without the proper design, an LP cost on the Kerosene draw MV is just a stripper level control output maximizer…. not a production maximizer.
- A proper design for this application will maximize the Kerosene on the draw tray while the product flow MV is maximized.

- It would be advantageous to have a controller that knows how to line up all the other MVs when there is an objective to maximize Kerosene production.

# Making versus Maximizing Diesel

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- The Making Diesel design will typically use something like the stripper level control output as an indication for the hydraulic limit.
  - The output is not a consistent indication.
- The Maximizing Diesel design will drive all MVs in the direction that produces as much liquid on the draw tray as possible.
  - Another key would be to provide a more consistent proxy for the hydraulic limit.

# How did we achieve it?

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- It started with trying to find a better way to predict when the hydraulic limit was reached.
  - The stripper level control output doesn’t do a good enough job.
  - Obviously, this hydraulic limit is a function of how much liquid is available on the draw tray.
  - To calculate (estimate) how much liquid is on the draw tray, a simple heat balance of the top section of the tower was used.
  - The percentage of the total liquid drawn as product seemed to be a more consistent (but not perfect) indicator of the hydraulic limit. 60%.

# Top Section Heat Balance

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- The heat balance is not overly accurate but does give decent magnitude and direction information.
  - Heat removed in the P/A's and overhead coolers is used to condense liquid.
  - Vapor is cooled from the Kerosene draw tray to the top tray.
  - Vapor enters the top section at "measured" temperature.
  - Naphtha product is accounted for.
  - Calculates total Kerosene tray liquid.
  - Diesel draw used to calculate percent of total drawn as product.
  - This percentage is included in the design as a CV.

- Thanks to Zak Freidman

# So what does the Heat Balance give us?

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- The heat balance gives us all the information we need to maximize the Kerosene production.
- Step testing data gave us models between the "percentage of Kerosene drawn as  product" CV with :
  - Top temperature
  - All pumparound duties
  - Feed rate
  - Diesel draw
  - Furnace temperatures
  - Pressure

# So what does a Making Diesel design give us?

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- If we are just using the stripper level control output as the CV to represent the hydraulic constraint….
- Step testing would give us Kerosene production models for :
  - Top temperature - NO
  - All pumparound duties - NO
  - Feed rate - NO
  - Diesel draw - Yes
  - Furnace temperatures - NO
  - Pressure – NO
- The controller is basically blind to maximizing the Kerosene.

# The Making Diesel design hole

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- We would need to supply LP costs (or SmartTune priorities) for all of those handles to drive them the right way.
- If any of the MVs that affect Kerosene production (at the draw tray) become constrained, the controller will not know how to compensate with other MVs to ensure Kerosene production remains persistently maximized.

# Operating Example

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- When the operator increases the Kerosene flash point target, the controller knows that the amount of Kerosene product that will be drawn is reduced. We make more Naphtha.
- Since we are making less Kerosene, we don’t need to condense as much of it.
- The controller will start to increase the lower P/A duty to provide additional preheat.
- Shifting heat removal up the tower is useless since we aren’t able to pull it all out as product.
- Reducing the flash point target results in the opposite response.

# Tackling the Hydraulic Constraint

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- Despite being a more consistent indicator of the tray drying out than the level control output, the percentage of Kerosene drawn as product is still imperfect in doing so.
- We added a calculation that adjusts the high limit on the percentage Kerosene CV based on the observed conditions.
- When we detect insufficient liquid on the draw tray, we reduce the limit.

# Hydraulic Constraint Limit Logic

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- The logic works as follows :
  - Always looking at stripper level control to detect the problem
  - If level control output starts to take off, reduce the limit
  - Once the level has started moving back toward the setpoint, set the limit to the current value and wait
  - If the level control has been stable for a specified length of time, increase the CV high limit by a specified amount if conditions are stable
  - The logic is able to detect the hydraulic constraint within 5 minutes of it starting to become apparent.

# Hydraulic Constraint Limit Logic

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- Prior to the APC project, the operators would reduce the product draw and leave it there for hours.
- The logic doesn’t wait that long. The CV high limit starts to increase again after things have stabilized.

- Wait a minute…. Doesn’t this create a problem with a sawtooth problem?

# Hydraulic Constraint Limit Logic

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- Answer – NO!
- There is a sawtooth, but it is of zero consequence.
- When we start to lose level control, there is insufficient liquid on the draw tray. Reducing the product draw simply fills the tray back up and does not affect operation of the lower sections of the column. The logic removes control models for the Kerosene product MV on CVs in the lower sections until level control is re-established.
- The adjustments to the Kerosene draw do affect downstream operations but there is sufficient surge capacity to absorb the normal adjustment (which is much smaller than the typical operator adjustment).

# Hydraulic Constraint Limit Logic

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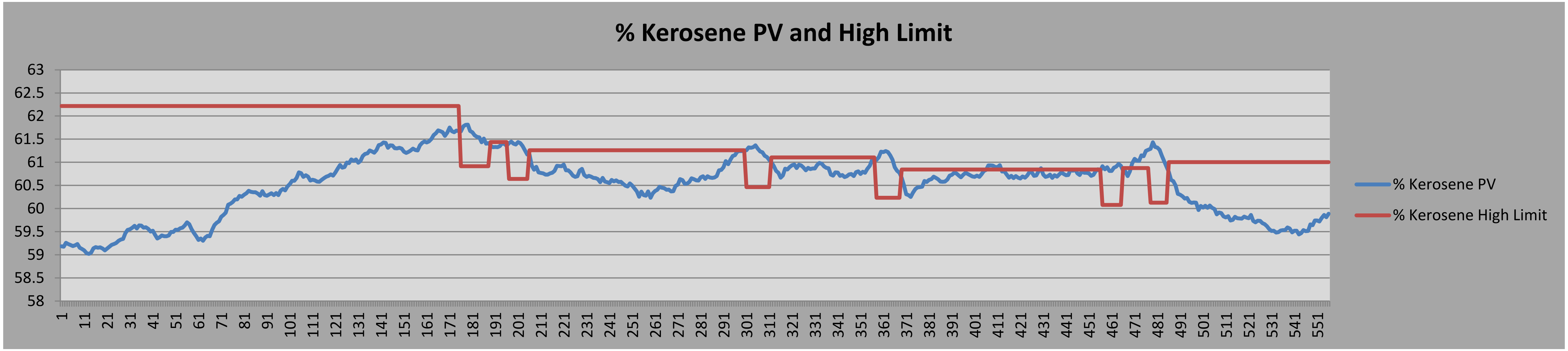
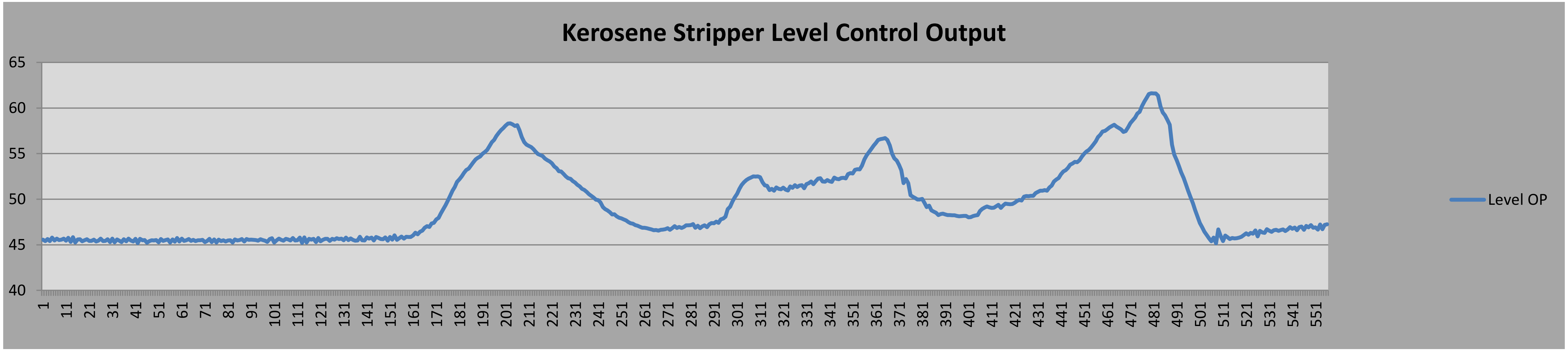
- The controller does not always cut the Kerosene product draw to address the hydraulic problem.
- Sometimes, depending on what constraints are active, it will make moves to produce more liquid at the tray.
- Or it will use a combination of Kerosene draw and other handles.

# Hydraulic Constraint Limit Logic



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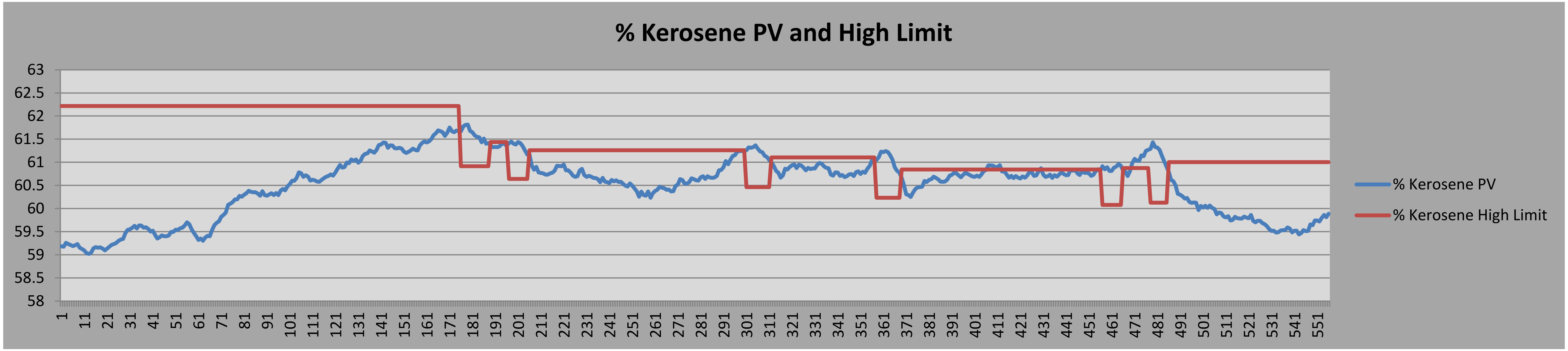


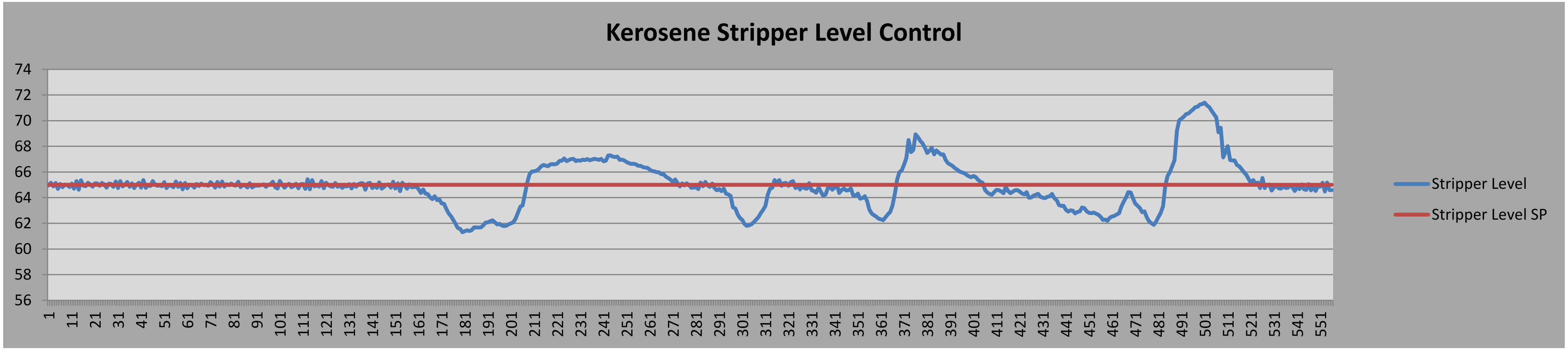

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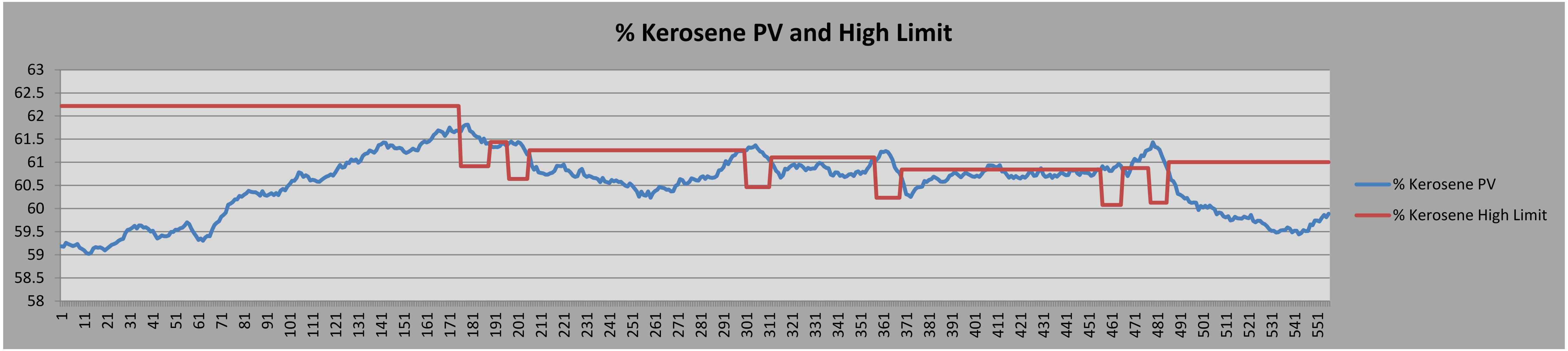


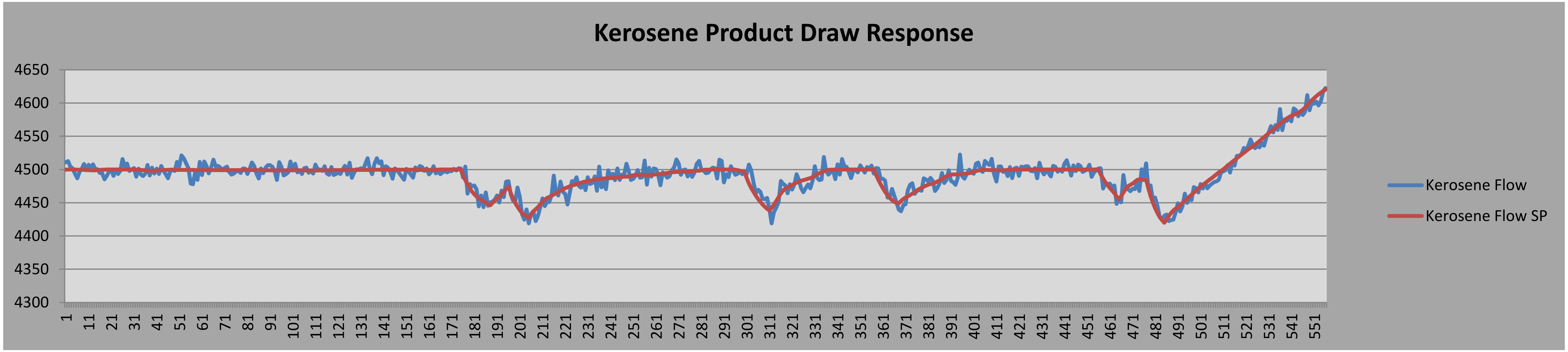

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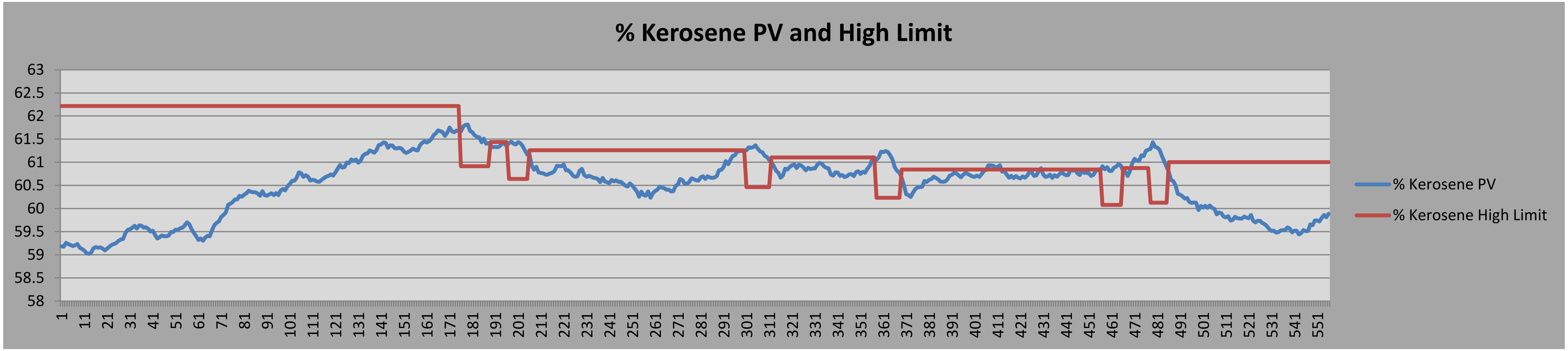


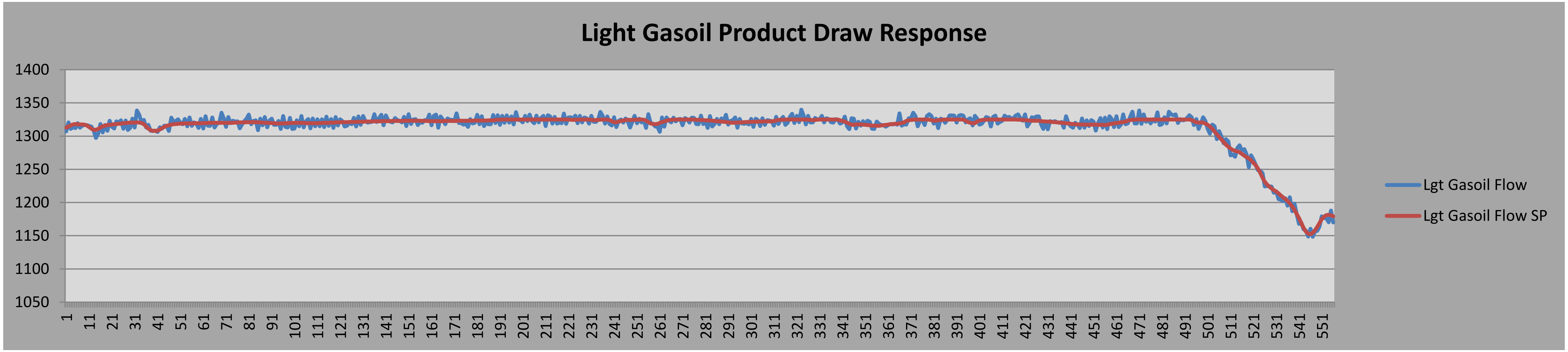

# Hydraulic Constraint Limit Logic

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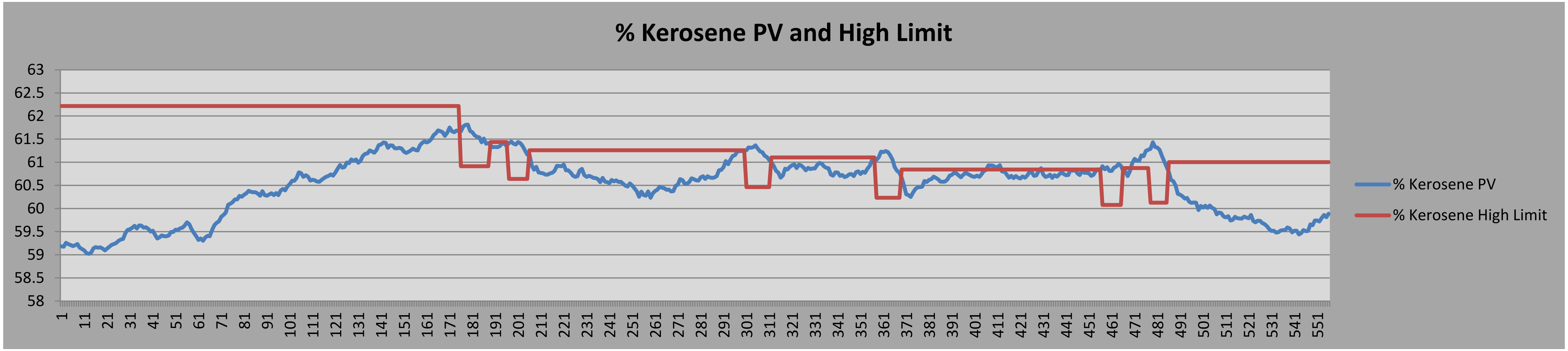


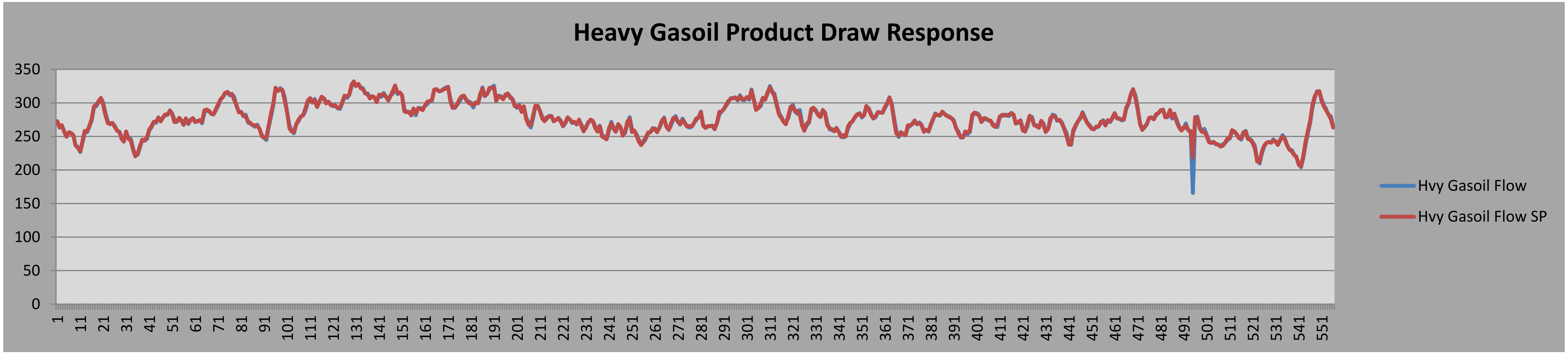

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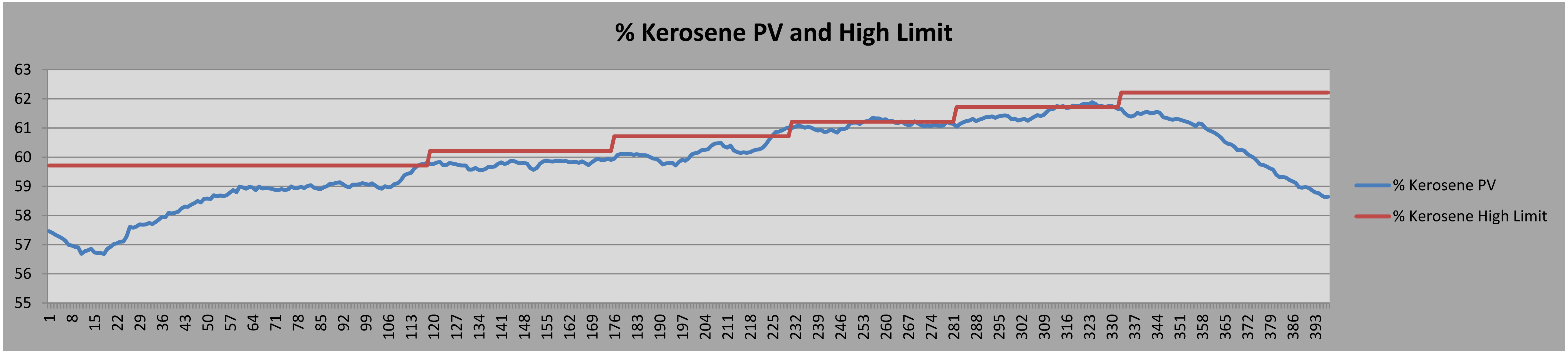


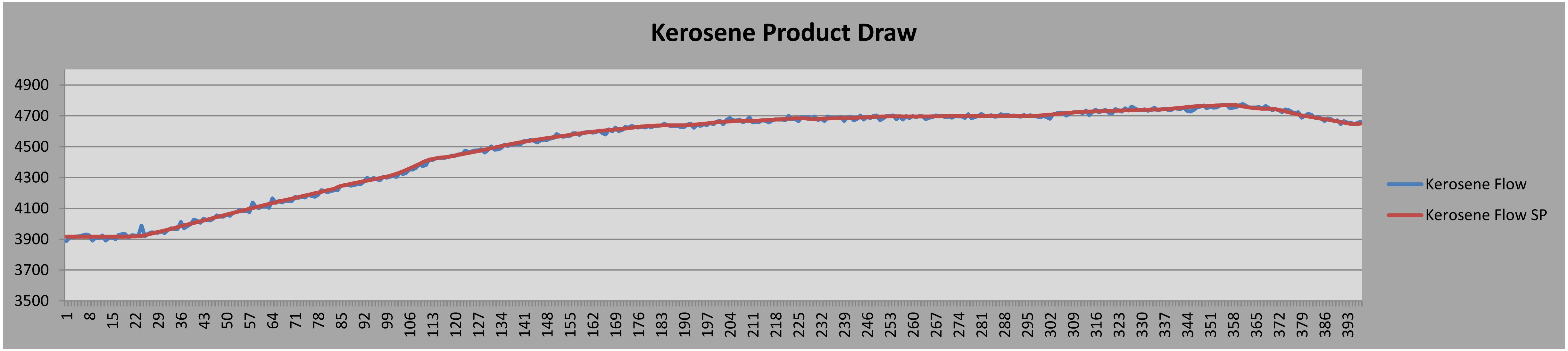

# Operator Training

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- More important than any design consideration is the operator training.
  - Virtually no APC experience amongst the operators.
  - Not done at the board. Avoid normal distractions.
  - Scheduled 4 hours. Many asked for more.
  - Worked with the training department.
  - Generic introduction to APC, DMC and PCWS.
  - Unit Specific training to go through the details of the strategy.
  - Thanks to Charles Vanbrugghe.

# DMC3 – What features did we leverage?

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- SmartTune
  - Matrix density is ~27%
  - Only one adjustment from the initial priorities to change the way flash point is controlled
  - LP cost trial/error/simulation would have taken a longer time
- Constrained model ID
  - Address collinearity at the model ID stage
  - P/A duty MVs have same gains on several CVs
  - Mass balance the tower using product quality models
  - Preheating energy balance

# Atmospheric Tower Control Matrix

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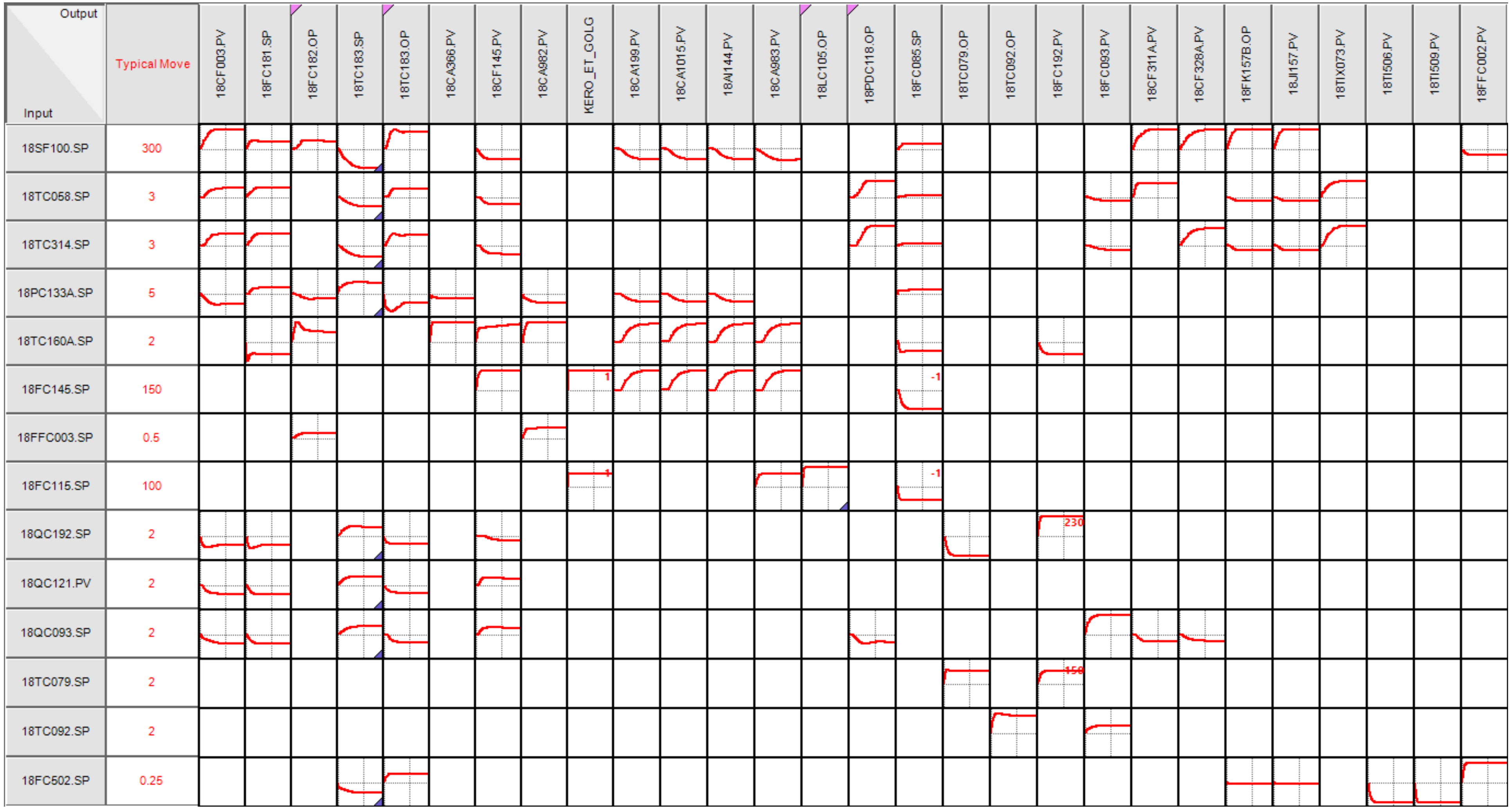

# The Benefits

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- Comparing November 2016 to March 2017 with November 2017 to March 2018
  - Assumes similar crude slate, similar ambient conditions and similar seasonal product specification
- Some issues that can make direct comparison difficult :
  - Overhead condenser is fouled
  - Middle P/A exchanger (with return TC) is fouled
  - Feed rate is slightly lower due to downstream units
  - Product targets on the other crude unit which feeds the same downstream units

# The Benefits

| Metric | Improvement |
|---|---|
| Overhead Duty to Feed Ratio | -0.8% |
| Average Overhead Condenser Outlet TC Output | 54% to 70% |
| Top P/A Duty to Feed Ratio | 18.8% |
| Combined Top P/A Overhead Duty to Feed Ratio | 7.4% |
| Bottom P/A Duty to Feed Ratio | -38.6% |
| Feed Rate | -4.0% |
| Feed Heater Outlet Temperatures | +1.5 Deg C |
| Kerosene Yield | 10.2% |
| Light Gasoil Yield | -10.8% |
| Combined Kerosene and Light Gasoil Yield | 6.0% |
| Reflux / Kerosene Differential | 307% |
| Total Kerosene Tray Liquid | 3.9% |
| Percent Kerosene Tray Liquid drawn as Product | 1.8% |

# Benefits Monitoring

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- Things to consider :
  - Generic monitoring metrics are not 100% trustworthy
  - Try to maintain apples-to-apples comparison
  - Should be kept reasonably simple
  - Should be treated like a periodic post audit update
  - Changes may be required for changes in operation

- The intent is to verify that the initial degree of improvement is sustained.

# Benefits Monitoring – Yield Benefits

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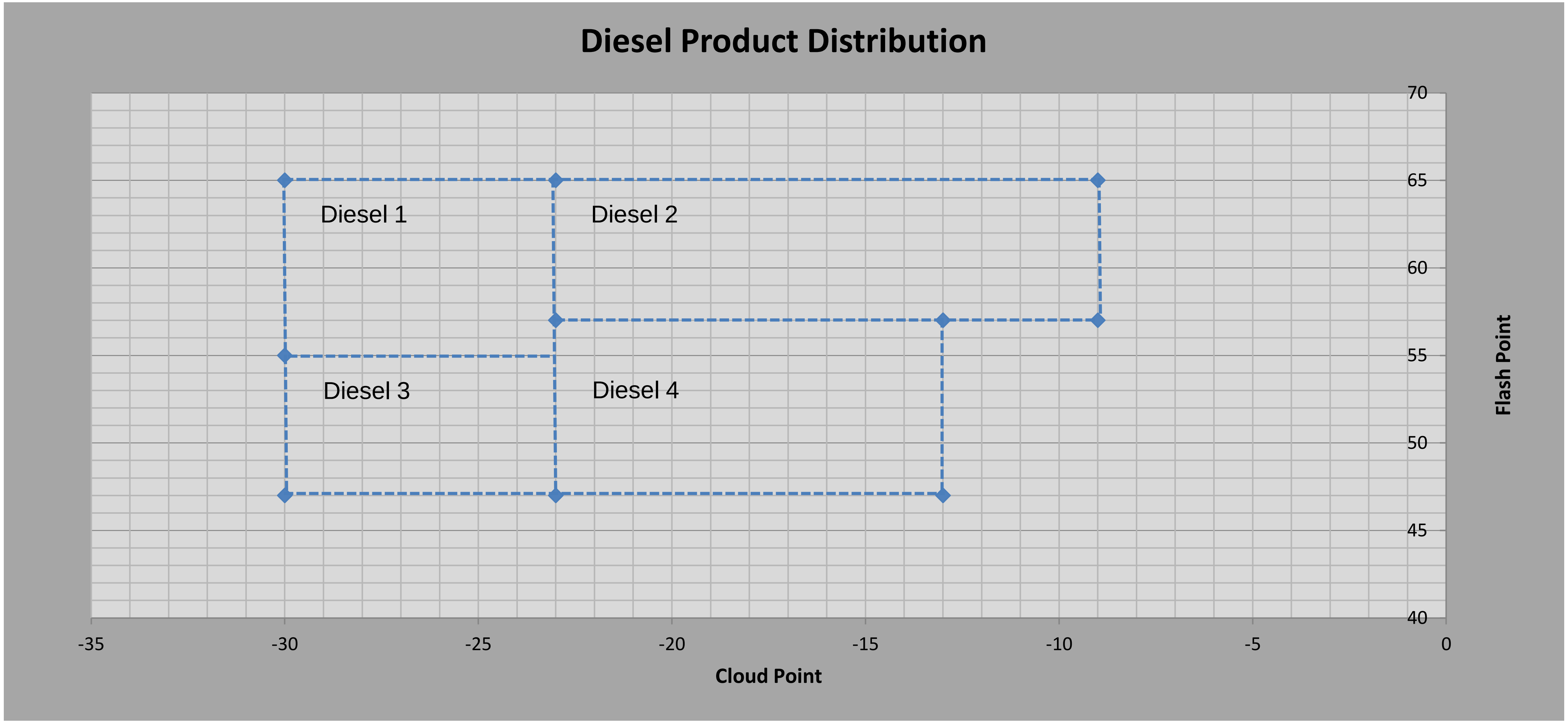

# Benefits Monitoring – Feed Maximization Benefits

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- Since the main feed limitation is cooling related, feed maximization benefits will likely be measured using some metric related to heat removal.
  - Overhead condenser TC output
  - Pumparound duties
  - Baseline metrics will have to reflect warm weather conditions

- Reduced crude pumping limitation can be measured by simply looking at proximity to the CV limit.

# The Last Slide

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Thank you for coming!

Questions?