



**Marathon  
Petroleum Company LP**



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**Drive Organization and Control Improvements Through MVC KPIs**

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- MVC Performance KPIs
- Inferential Calculation Performance KPI
- Organizational Alignment
- 2016 and 2017 MVC Performance Results
- Q1, 2018 Inferential Calculation Performance Results
- Control Objectives
- Before and After MVC Performance KPIs
- States can Create Actual Benefits
- Continuous Improvement (Kaizen)
- Summary

# MVC Performance Based on Four KPIs



- KPIs based on MV Utilization (Robertson 2009)
  - percent of time application is ON (KPI1),
  - percent of MVs cascaded to the application (KPI2),
  - percent of MVs not at limits (KPI3)
  - distance of active MV limits from their respective engineering limits (KPI4).
- KPIs rolled up into Overall Performance KPI
  - $26.27 * \left( KPI1 * KPI2 * (KPI3 + (100 - KPI3) * \frac{KPI4}{100}) / 10,000 \right)^{0.2881}$
  - coefficients chosen so overall KPI value has similar magnitude as individual KPI values
- >80% is acceptable performance and >90% is desirable or good performance.
- MVC performance provides a fairer comparison.
- KPIs calculated with SQLPlus, and Aspen Watch is used for history, trends and email reports for area process and control engineers.

- User specifies inferential error corresponding to four KPI values
  - KPI = 100% when inferential error equals lab reproducibility
  - KPI = 90% when inferential error equals expected minimum accuracy of good inferential
  - KPI = 80% when inferential error equals threshold where improvements to the inferential are necessary
  - KPI = 0% when inferential provides no value for prediction or control.
- *Inferential Error = [95th percentile inferential - lab] - [5th percentile inferential - lab]*
  - 10% of data discarded to reject outliers
- KPI is calculated by interpolation of four (KPI, inferential error) points defined above.
- 80% is acceptable performance and 90% is desirable or good performance.
- KPIs are planned to be used for quarterly monitoring and annual reports.
- KPIs leverage Aspen IQ history to calculate inferential prediction errors.



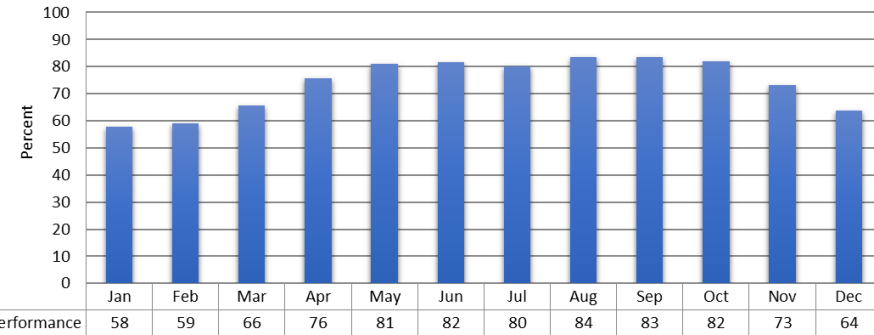
- Good management support in Technical Services was important for success.
- 2016 and 2017 Goals for APC engineers and Area Process and Control engineers were aligned to the MVC Performance KPIs.
- Area teams and technical services include MVC performance KPIs in the monthly reports and goals.
- Area teams include MVC performance KPIs in their quarterly presentations to the refinery leadership team.

# 2016 MVC Performance (First year)

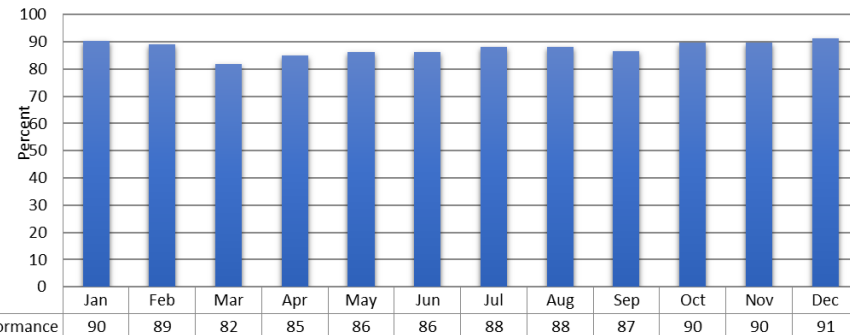


- Scope included 333 manipulated variables.
- TAR was in Q1 and late Q4.
- August, 2016 was highest performance at 84%.
- 2016 average was 74%.

### 2016 GBR Site Overall MVC Performance



### 2017 GBR Site Overall MVC Performance

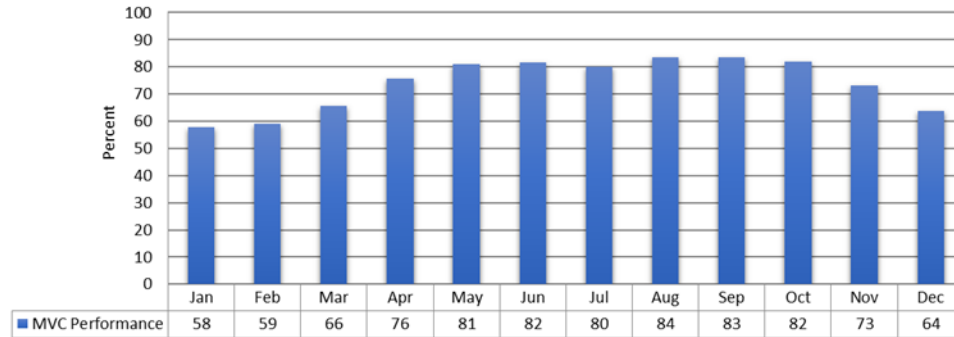


# 2017 MVC Performance (Second year)

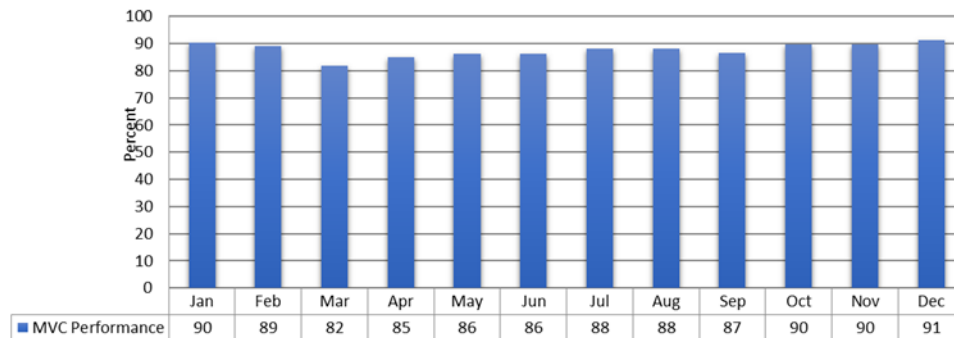


- Scope included 357 manipulated variables.
- TAR was in Q1.
- December was highest performance at 91%.
- 2017 average was 88% (14% improvement over 2016)
- Potential and actual benefits increased from 2016 to 2017.

### 2016 GBR Site Overall MVC Performance



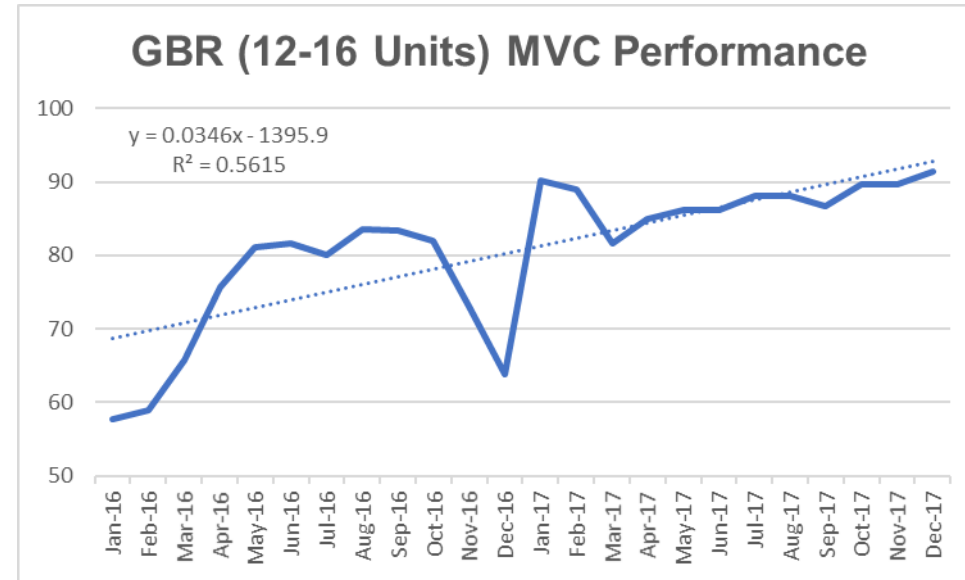
### 2017 GBR Site Overall MVC Performance



# GBR (12-16 Unit) MVC Performance



- One unit was removed in 2016.
- Five units were added in 2017.
- TARs lowered utilization each year.
- Overall improvement was one percent per month over the two years.



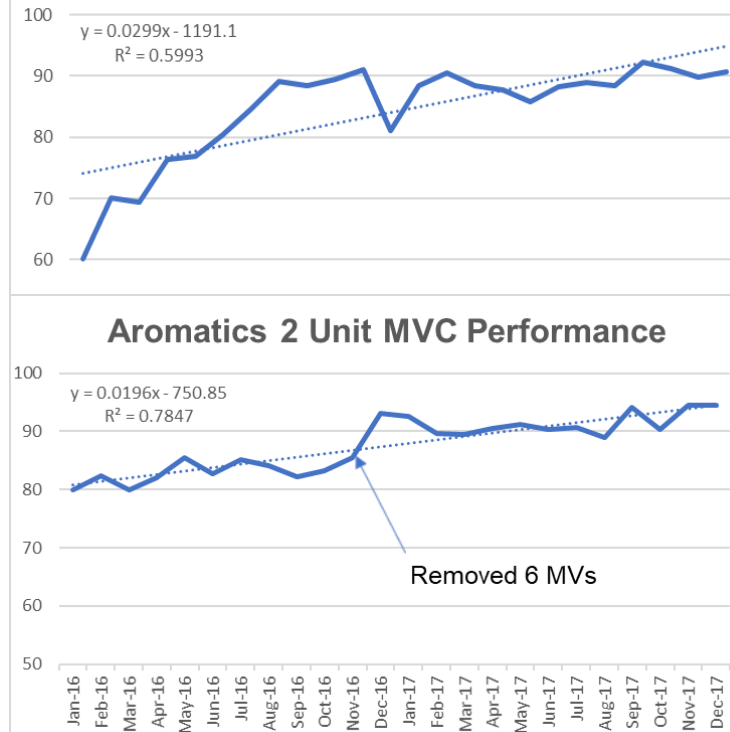


# Four Unit and one Unit MVC Performance

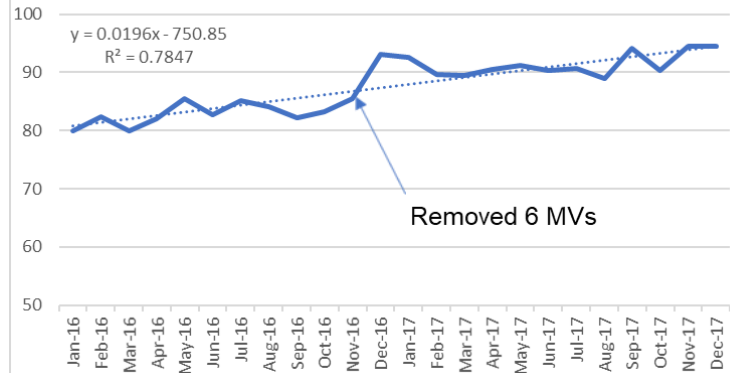


- Four unit MVC performance includes light ends separations, aromatics 2, crude and reformer units.
  - Twelve MVs were removed. One MV was added.
  - Focused on most valuable MVs being able to move freely to more economical limits.
- One unit MVC performance includes the aromatics 2 unit.
  - Six unused MVs were removed.
  - MV limits were adjusted to improve recovery.
  - MVC Performance improved fourteen percent over two years.

## Four Unit MVC Performance



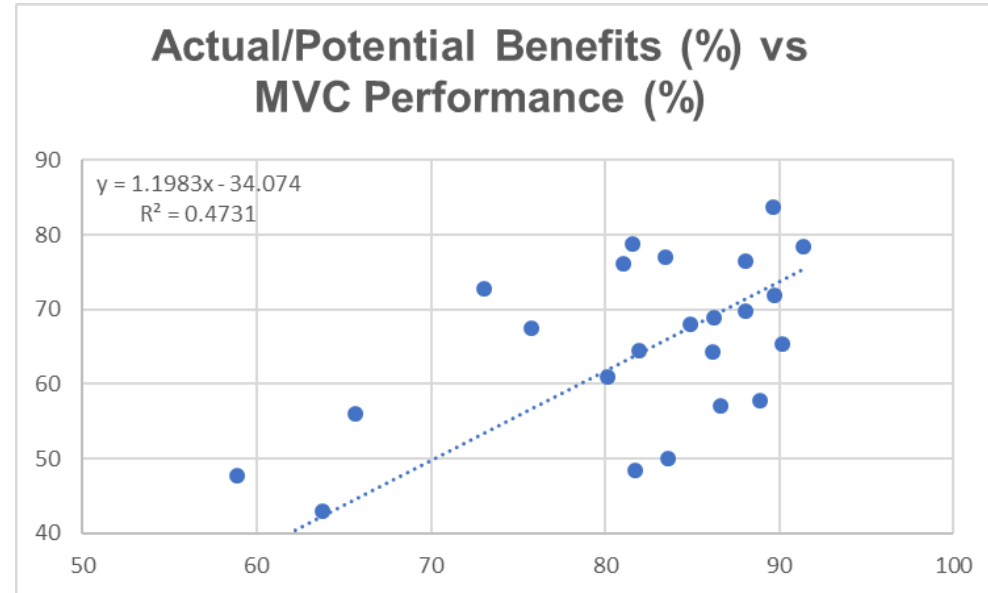
## Aromatics 2 Unit MVC Performance



# Effectiveness or Actual/Potential Benefits (y) versus MVC Performance (x)



- Effectiveness or Actual Benefits/Potential Benefits (%) shows a gain of one to MVC Performance (%).
- Resource plans and work schedules are based on value of time spent on building and supporting applications.
- Eliminating unused MVs improves MVC Performance.



# Q1, 2018 Inferential Calculations Performance



- Scope included 54 out of a possible 142 Inferential Calculations.
  - Focus is on the inferential calculations updated with laboratory and used for control.
  - Overall inferential calculation KPI was acceptable. 41 of the inferential calculations were acceptable. 29 of them were good or desirable.
  - The unacceptable inferential calculations are updated based on their relative performance, their economic value and APC resource availability.
- Whiteness test is completed each quarter to optimize the lab bias factors.
  - Bias factors are changed when inferential prediction error is auto-correlated.
  - Moving average biases are expected to fail this test.
  - Analyzer or DCS calculation updates are more frequent which reduces prediction error.

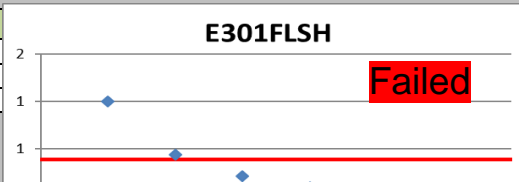
# January, 2018 Inferential Calculations Whiteness Test



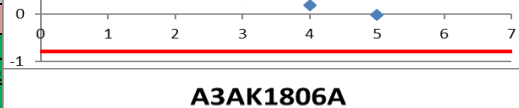
## Whiteness Test Summary Sheet

Green Cells:	Pass Test
Red Cells:	Prediction error sequence is auto-correlated, increase bias factor or decrease moving average window
White Cells:	No data available

DDU	
E101FLSH	DD3PSULFSS
E201FLSH	D3PRODSULFSS
E301FLSH	D3PSULFSS



Coker's	
CKBLCGOFBPIQ	CKCLCGOFBPIQ
CKBLCGOFBPIQ	CKCNAPHFBIQ
CKBNAPHN2IQ	CKCNAPHN2IQ



ULC	
DSL_FLASH	ULCONVIQ
HUC90PRED	A12131PRED
A12122PRED	ULHM104BIQ



Alky 3		
A3OCTANE2	A3NC4F	A3OCTANE4
A3OCTANE	A3AK1806A	
A3AK1820A	A3OCTANE3	

PS3A		
PAAK7051_D1FBP	PA_KERO_FREEZE	PA_KERO_TBP98
PAAK7281_HVN90	PA_DSL1_TBP98	PA_DSL2_TBP98
PAAK7553_K_FBP	PA_HVN_TBP90	PAAK7642AB_C4
PAAK7661C_C5	PAAK7681D_MCP	PAAK7681B_BENZ
PAAK7681A_C4	PAAK7661B_C3	PAAK7692_RVP
PAAK7554_D2FBP		

PS3B		
AK8285_FBP	AK8284_FBP	AK8283_90
A8681RVPPRED	DSL_TBP98	KERO_TBP98
HVN_TBP90	DSL_TBP98_M	KERO_TBP98_M
HVN_TBP98_M	AK8641C	AK8641A
AK8641B	AK8681D	AK8681C
AK8681B		

Samples have not been taken since March

AU2	
A8403FINF	A8361AINF
A8402CB	A8400BINF
AU2CONVSS	A8361BINF
F8002INF	A8403DINF

UU3		
AVGCKLD1	A3372INF	A3423AINF
AVGCKLD2	A3614DINF	A3403INF
AVGCKLD3	U3312F_PNS	A3513INF
AVGCKLD4	A3486INF	A3523INF
AVGCKLD5	307EFLSHINF	A3305INF
AVGCKLD6	A34284INF	A3484INF
305_6EC6PLUS	U3318F_PNS	A3423BINF

RHU		
RHAK6115A	RHAK6071C	RHAK6116A
RHIHNFBP	RHAK5331I	RHAK6116B
RHAK5265	RHIHNN2	RHLHNRVP
RHAK5266I	RHHHNN2	RHAK6115B
RHAK6137B	RHN601BDUTY	

# APC Controller Objectives



- Maximize charge subject to constraints.
- Shift to more valuable products subject to constraints and quality limits.
- Minimize energy at fixed feed rate or product rate.
  
- Provide advanced regulatory controls to adjust for process and gain changes.
  
- Over 100 benefit mechanisms are updated monthly with planning prices.
- Modes of operation are updated if margins change direction on product shifts.
- Controller descriptions, targets and limits are aligned to daily refinery plan.

## ● Before MVC Performance KPIs

- APC utilization was the KPI.
- APC benefits were calculated once before and once after the APC project.
- Area teams included APC utilization in reports.
- Some MVs are turned off.
- MV operator limits tended to be set too tight which lost benefits.
- CV limits were set too tight or night note language did not align with APC variables.

## ● After MVC Performance KPIs

- MVC Performance uses four KPIs including KPI1 or APC utilization.
- APC benefits are calculated monthly with planning square matrix prices.
- Area teams include MVC Performance in goals and reports.
- MVs effect KPI2 and are either turned back on or eliminated.
- MV operator limits are challenged since they impact KPI3 and KPI4.
- CV limits are aligned to product control and operations night notes.

# States Can Create Actual Benefits

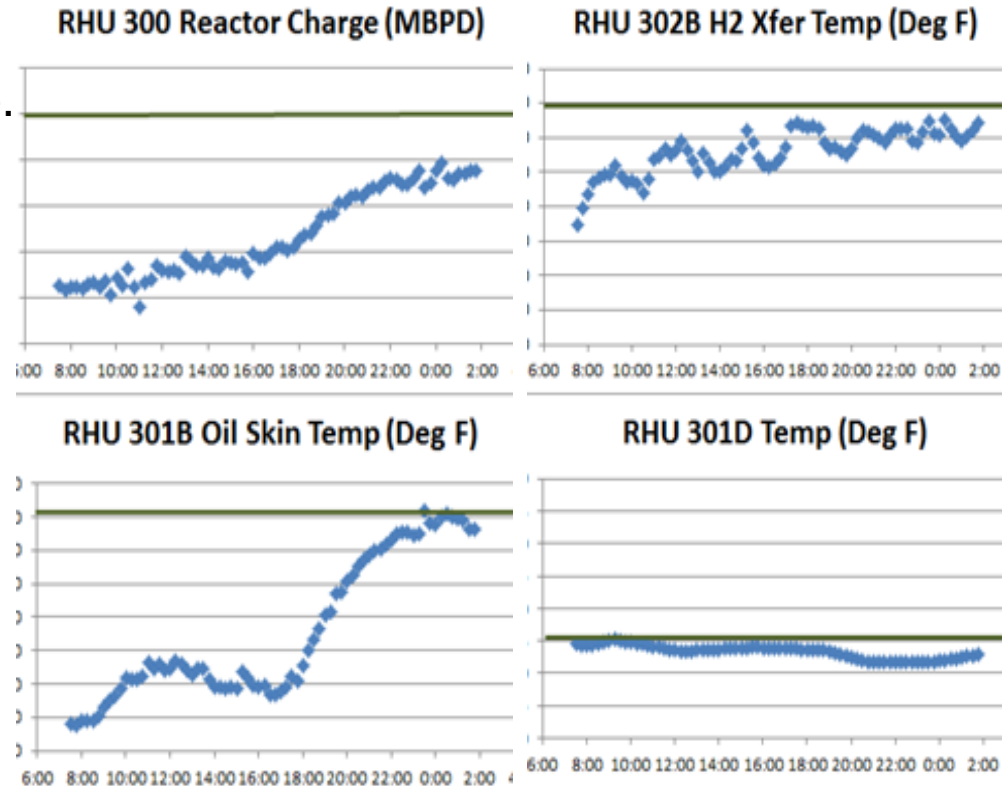


- Benefit mechanisms can only provide actual benefits when certain sets of constraints (states) are active.
- Product shifts can be limited by MV limits or CV limits. MV moves with limits are not much different than normal operator setpoint moves. CV limits when set correctly can maximize most valuable products.
- Feed shifts can be limited by MV limits or CV limits. If there is a shadow CV for feed, then the external target can be used to push feed against more important constraints.

# Feed Maximization (RHU APC, Optimize 2017)



- Use feed flow controlled variable external target when feed is available.
- Push to oil heater skin temperature high limit and hydrogen heater transfer temperature high limit at average reactor temperature target.
- 93% of the Potential Benefits.
- This benefit can only be included when there is a **state** of three controlled variable constraints.





# Continuous Improvement (Kaizen) for Control: Maximize Economic Value



- Eliminate unused manipulated variables and inferential calculations.
- Adjust limits to go to controlled variable limits instead of MV limits.
- Focus on most valuable benefit mechanisms first.
- Benefits are updated monthly with prices from planning model.
- Modes of operation are updated if margins change direction on product shifts.
  
- Controller targets and limits are adjusted based on daily refinery plan.
- Qualities, calculations and descriptions are aligned between plan and control.
- Support existing applications ahead of new applications by a factor of five.
- Meet with process, control and product control (planning) engineers.

# Continuous Improvement (Kaizen) for Inferential Calculations: Minimize Prediction Errors



- Improve inferential calculations by saving the correct data and time for samples.
- Dynamically compensate process measurements to sample point.
- Review results of whiteness test to update bias factors each quarter.
- Update inferential calculations based on their KPI values.
- Focus on inferential calculations that deliver most economic value.

- Over one hundred inferential calculations are used for quality and constraint control.
- Over one hundred APC Benefit Mechanisms were identified.
- Resource planning for improvements depend on economic value and effort.

- KPIs provide drive and feedback to organization to continuously improve.
- Alignment of operations and technical services goals to MVC Performance KPIs improves APC utilization and benefits year after year.
- Expanding APC applications and updating existing applications increases the APC potential benefits.
- Relaxing manipulated variable limits, adjusting controlled variable limits to refinery plan and adjusting operating objectives daily to refinery plan and weekly to monthly on prices improves actual benefits.
- Focus on reducing inferential calculation prediction errors improves quality control and allows more shifts to more valuable products.
- MVC performance and actual APC benefits can improve one percent per month by leveraging KPIs calculated from Aspen Watch and Aspen IQ history.

# Questions?

