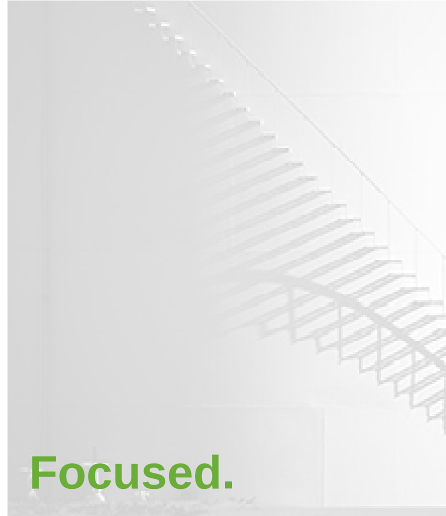
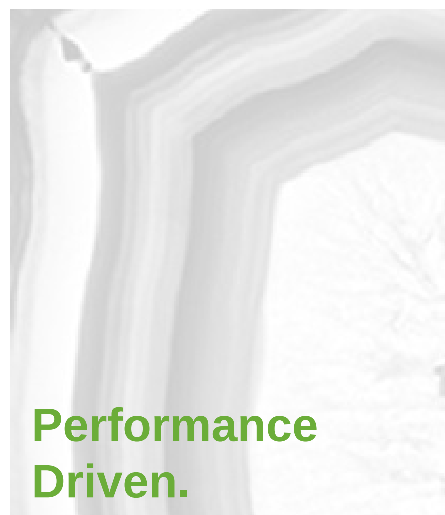
GRACE

Talent | Technology | Trust™

Interpreting ECAT Analyses



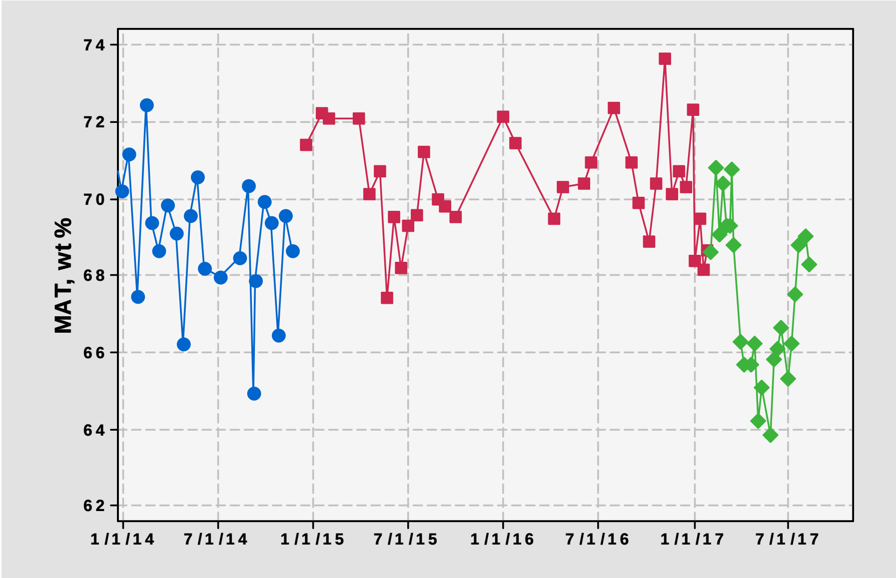


Interpreting ECAT Analyses

- **Important tool for stewarding FCC operation**
- **Frequent sampling is recommended**
- **Fines analysis can be as important as unit ECAT when trouble shooting**

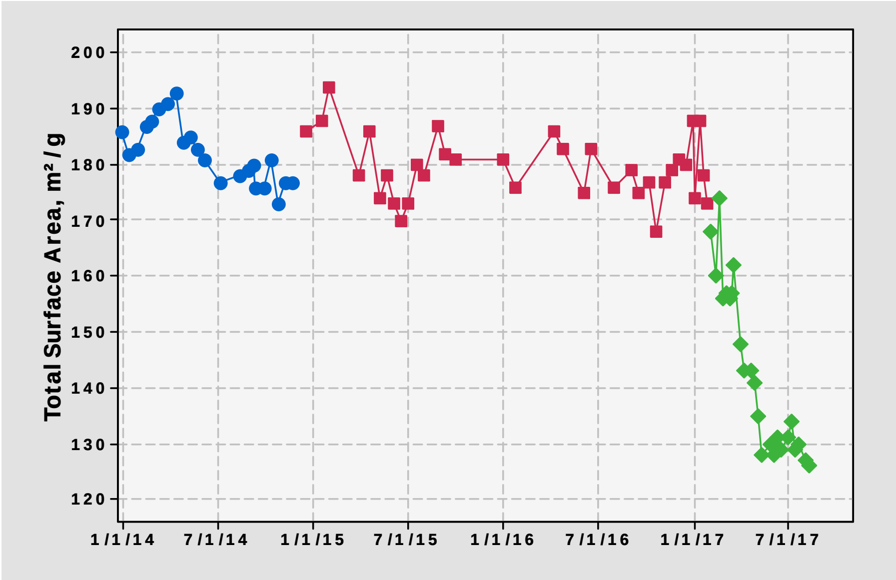
- **MAT**

The Micro Activity Test is a measure of catalyst activity in wt % conversion. MAT activity is affected by the addition rate of fresh catalyst, unit turnover rate, metals contamination of equilibrium catalyst, the fresh catalyst activity and quality. The MAT test is performed on a fluidized ACE (Advanced Cracking Evaluation) machine.



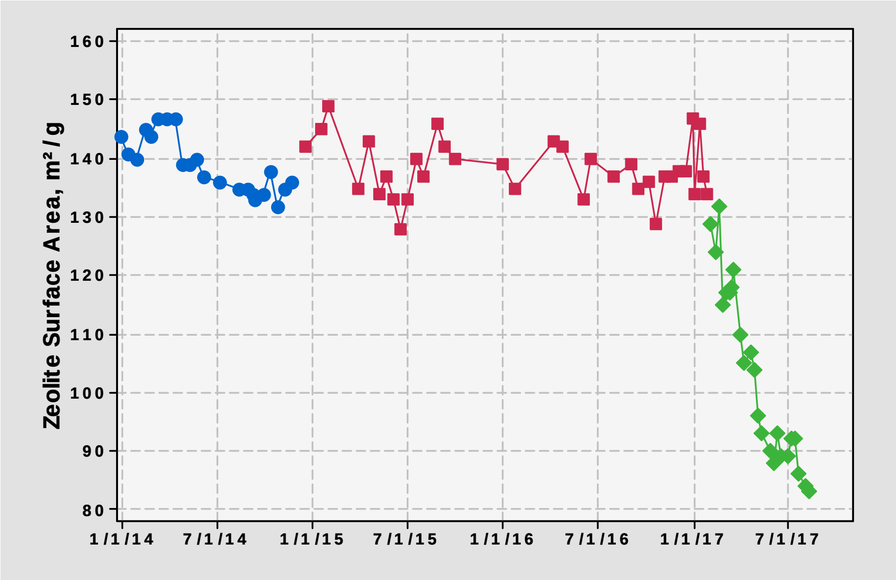
- **Surface Area**

The surface area measurement (m^2/gm) is the total of the zeolite and matrix surface areas. The surface area correlates well with activity for similar catalyst types. Changes in surface area reflect changes in severity in the FCC unit from changes in metals levels, addition rates, or regenerator temperature.



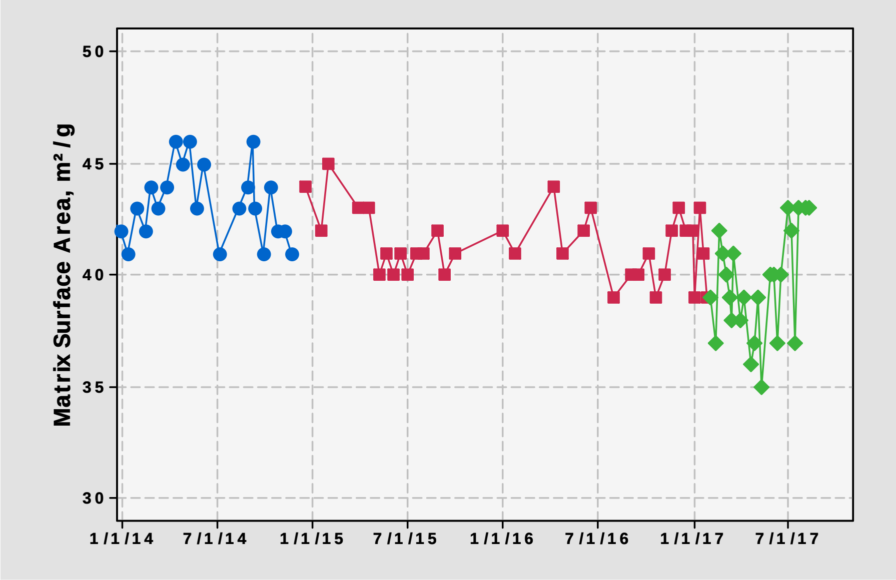
- **Zeolite Surface Area**

  Zeolite surface area (m^2/gm) is the measurement of the small pore surface area associated with the zeolite of the equilibrium catalyst. Zeolite is mainly used to selectively upgrade gas oils to more valuable liquid products.



- **Matrix Surface Area**

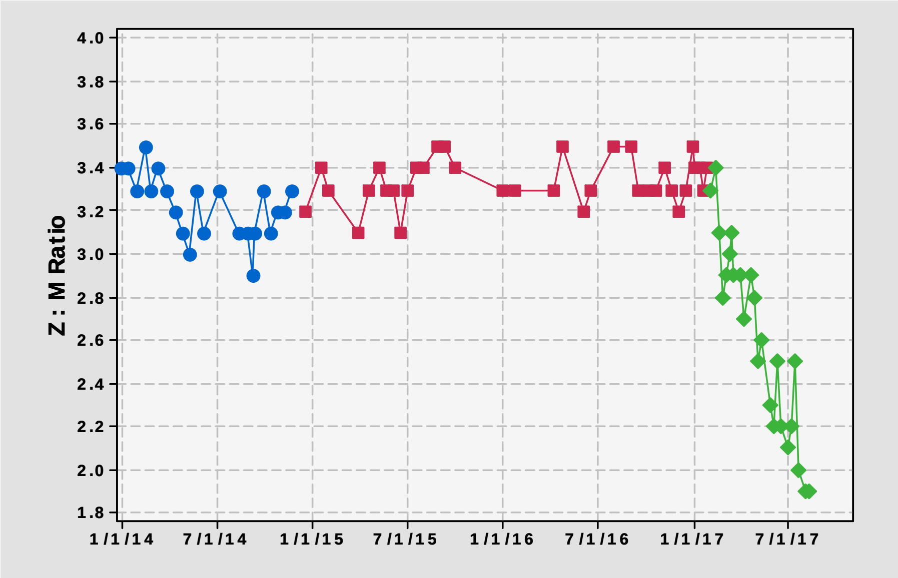
  Matrix surface area (m^2/gm) is a measurement of all non-zeolitic surface area in the equilibrium catalyst. Matrix is added to the FCC catalyst to upgrade high boiling range feed to lighter products that are further upgraded by the zeolite.



GRACE

- **Z/M Ratio**

Z/M ratio is a ratio of the zeolite surface area to matrix surface area. High Z/M ratio catalysts tend to be more coke selective and metals tolerant. Lower Z/M ratio catalysts may crack bottoms better. The refiner generally balances Z/M ratio of their catalyst to meet unit constraints.

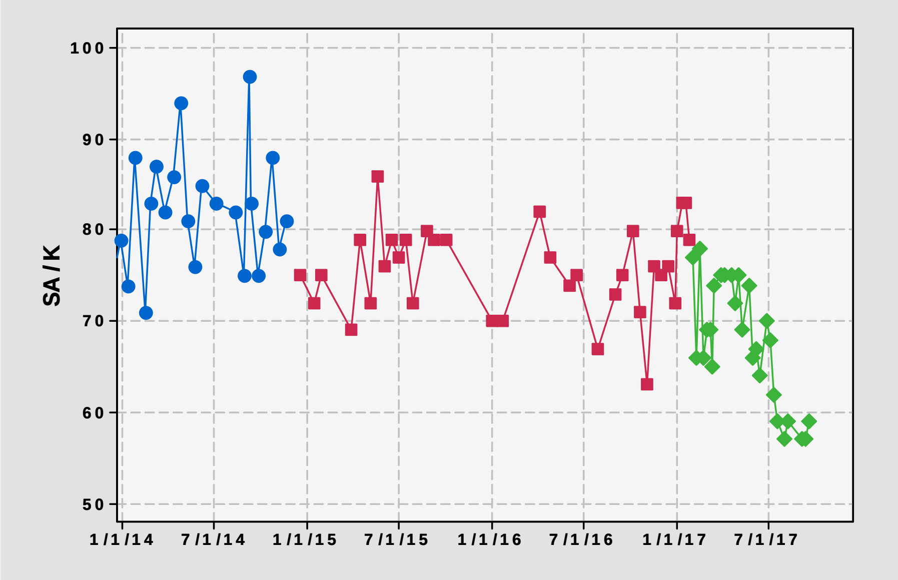


- **SA/K Ratio**

SA/K ratio is a ratio of the total surface area to Kinetic Conversion. Kinetic Conversion is defines as :

Conversion/(100 – Conversion)

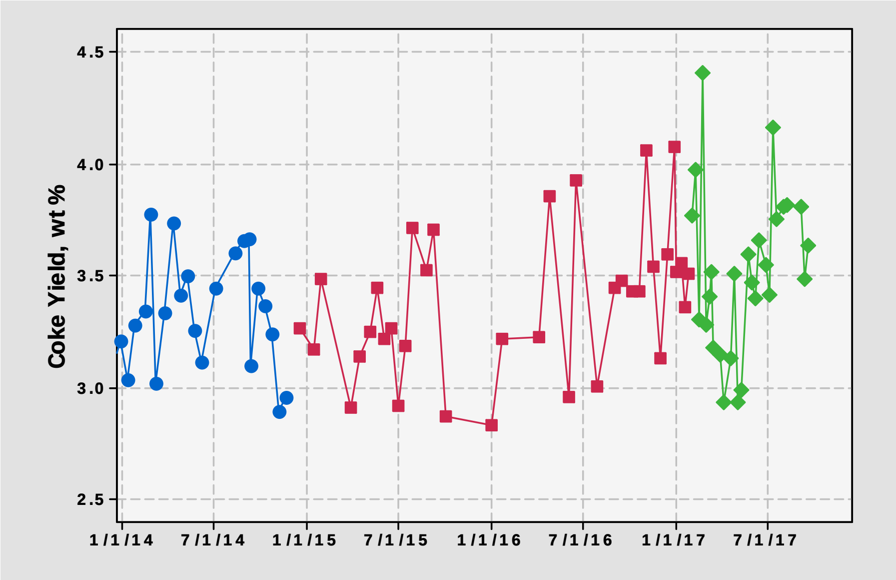
As the name implies; SA/K is a indication of the surface area needed to get 1 unit of Kinetic Conversion.



Interpreting ECAT Analyses

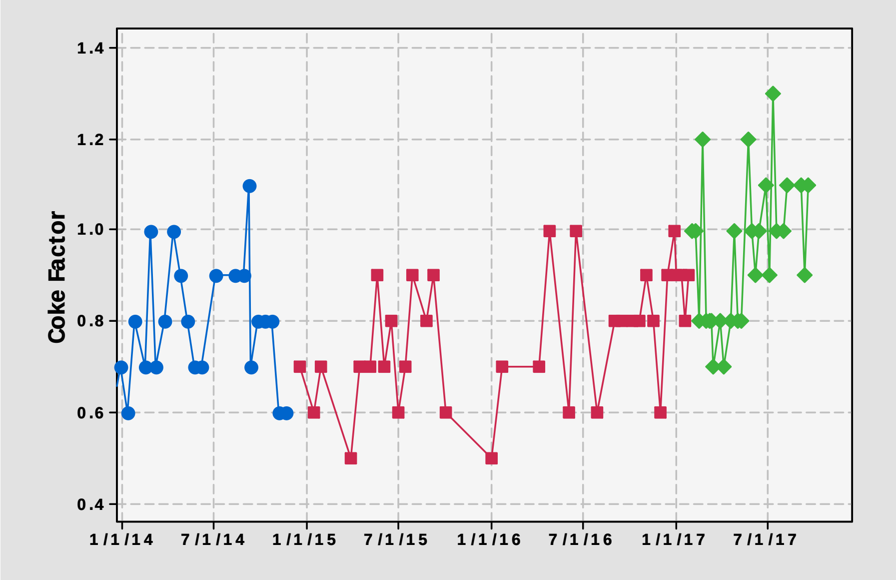
- **Coke Yield, wt%**

  Coke Yield is the Coke on equilibrium catalyst from the MAT test. It is affected by contaminant metals level on equilibrium catalyst and the metals tolerance of the fresh catalyst.



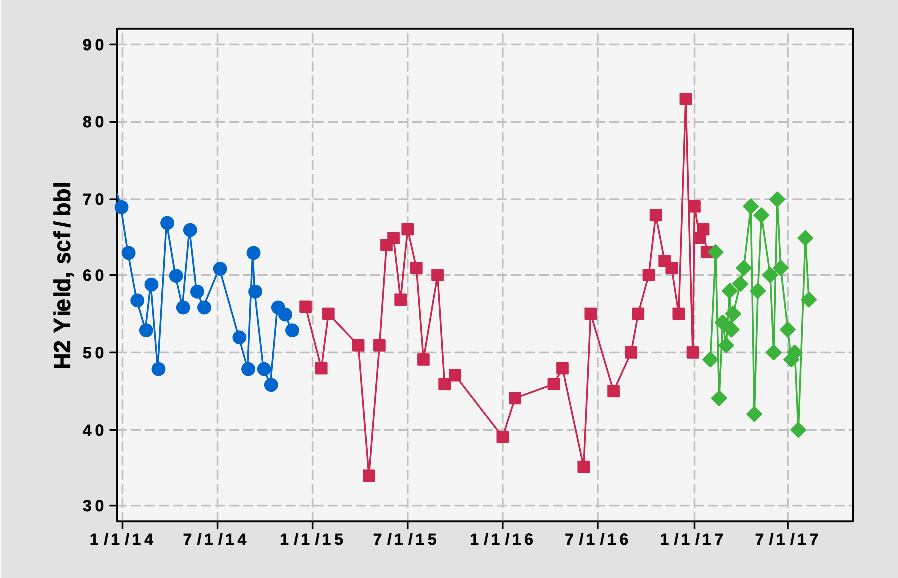
- **Coke Factor**

  Coke Factor is the ratio of Coke Yield to Kinetic Conversion. Its an indication of equilibrium catalyst's Coke forming tendency. It is affected by contaminant metals level on equilibrium catalyst and the metals tolerance of the fresh catalyst.



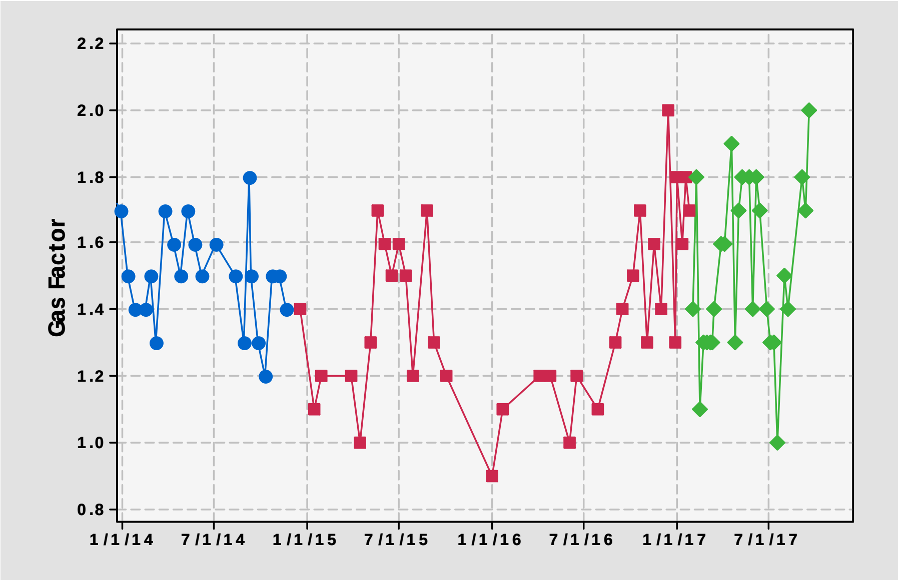
- **H$_2$ Yield, SCFB**

  H$_2$ yield is the measured Hydrogen yield from the MAT test. It is affected by contaminant metals level on equilibrium catalyst, the metals tolerance of the fresh catalyst, and the unit turnover rate. The ACE MAT H$_2$ yield may not equal the H$_2$ yield of the commercial unit, but tracks well with the commercial unit value.



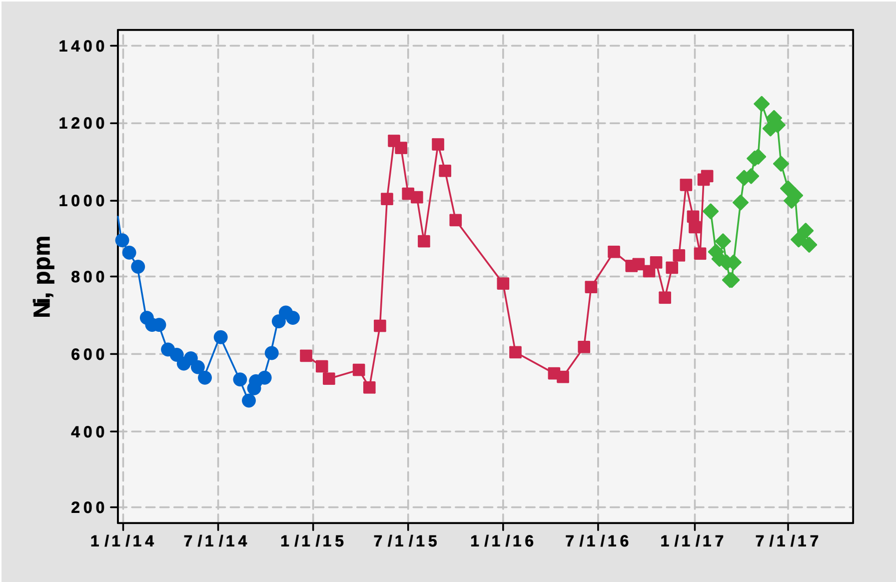
- **Gas Factor**

  Gas Factor is the molar ratio of Hydrogen to Methane. Its an indication of ECAT's hydrogen forming tendency. It is affected by contaminant metals on equilibrium catalyst



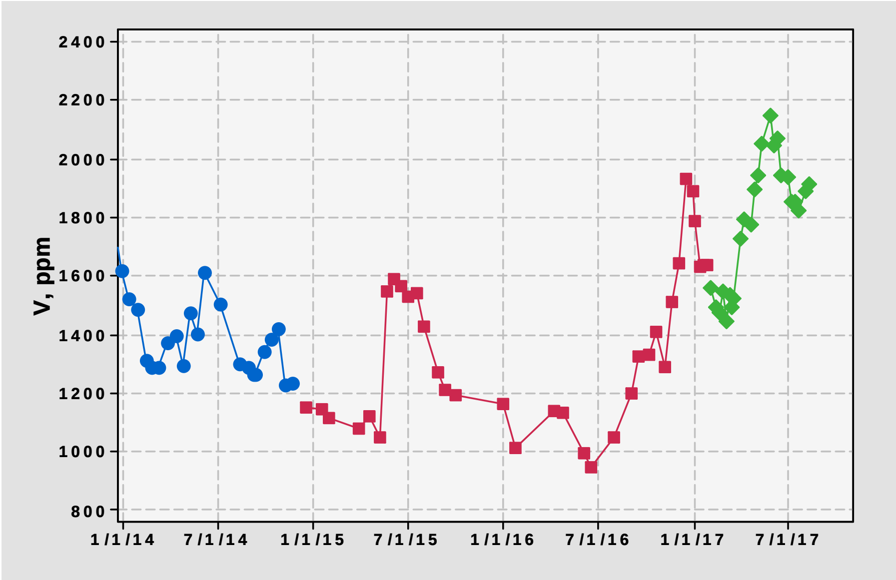
- **Ni, ppm**

  Nickel is a contaminant in FCC feed. Nickel on catalyst causes dehydrogenation reactions which increase hydrogen yield and coke yield in the FCC unit. Nickel has only small effects on catalyst activity.



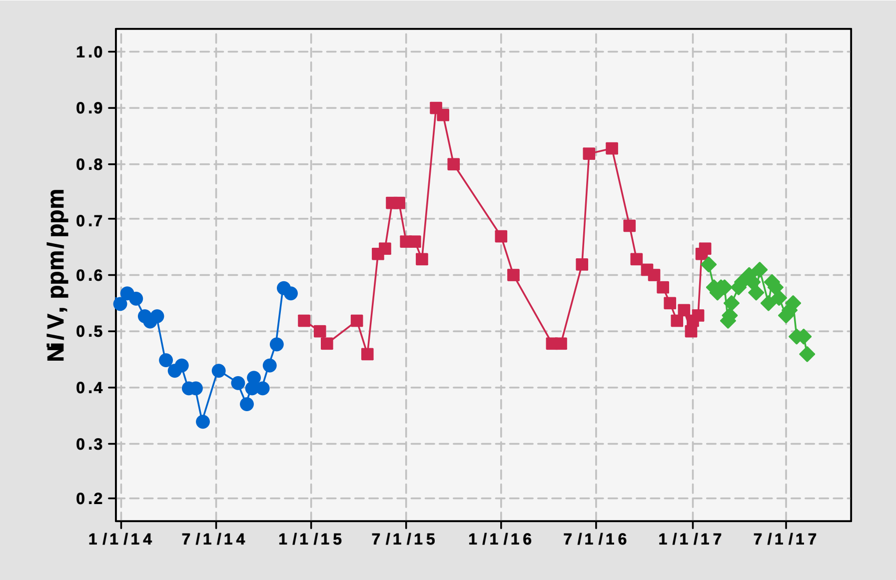
- **V, ppm**

  Vanadium is an FCC feed contaminant. Vanadium deactivates FCC catalyst by destroying zeolite surface area and reducing activity. Vanadium also causes dehydrogenation reactions at 20% to 25% of the equivalent nickel level



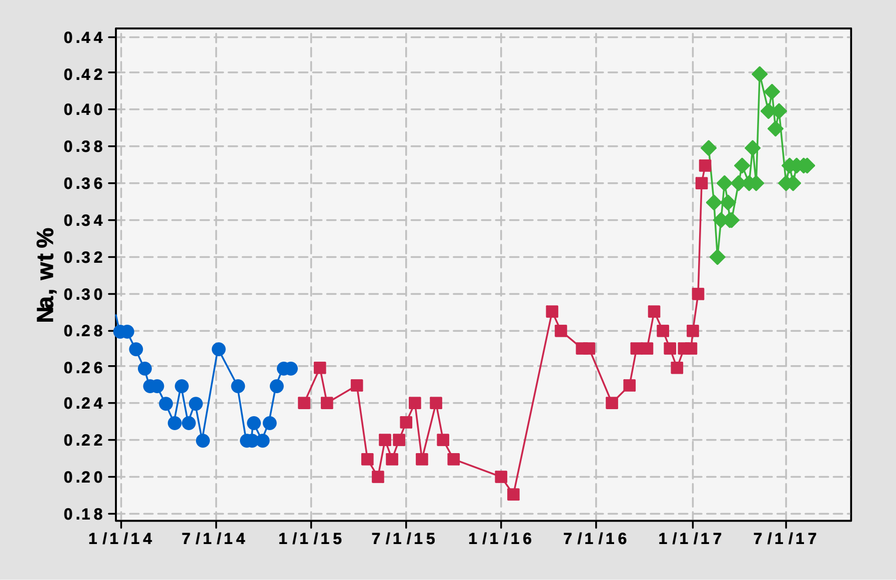
- **Ni/V Ratio**

  The nickel-to-vanadium ratio is used to identify changes in crude or FCC gas oil sources. It can be used to identify changes in FCC operation.



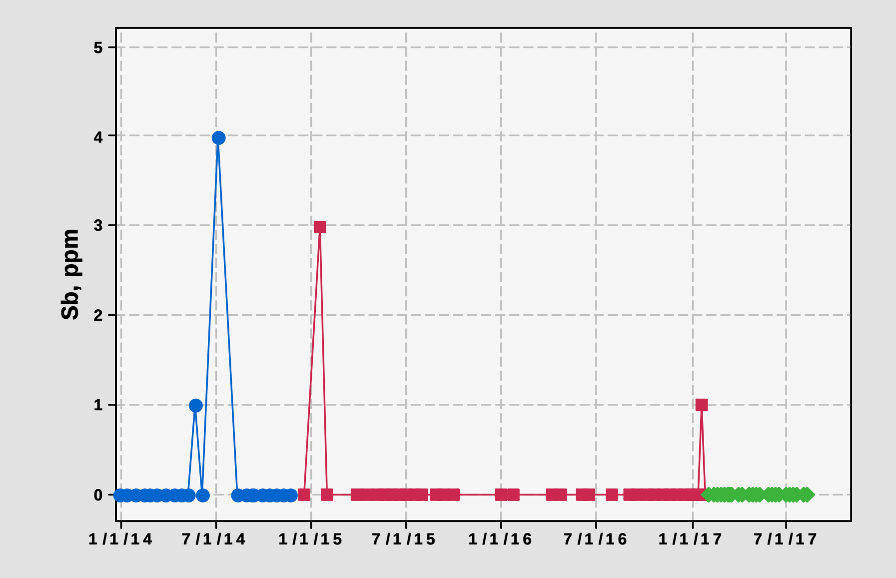
- **Na, wt%**

  Sodium in FCC feed deactivates equilibrium catalyst by destroying zeolite surface area and neutralizing catalytically active sites thus reducing activity. The rate of activity decline increases as regenerator temperature increases.



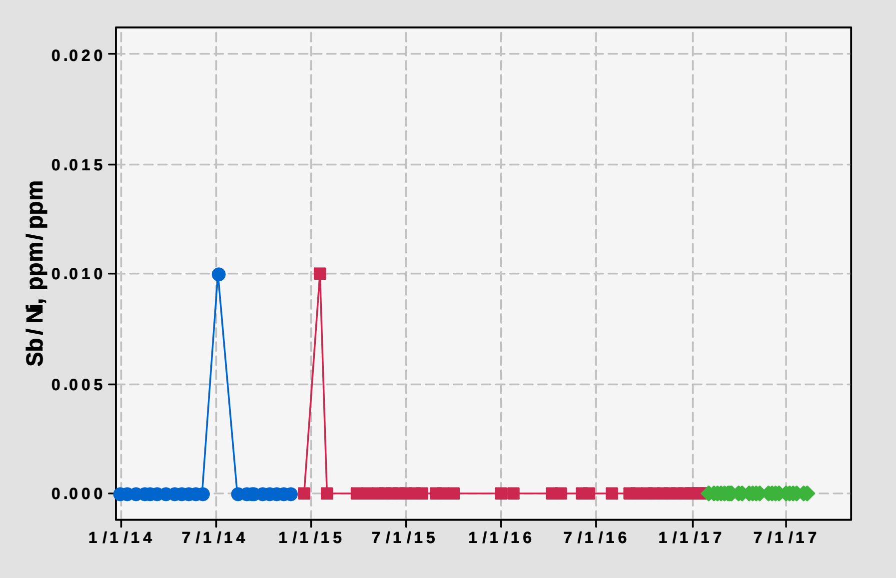
- **Sb, ppm**

  Antimony is a nickel passivator widely used in the FCC industry. In general, antimony can reduce the effects of nickel on coke and hydrogen yield by ~40% when properly applied. Antimony can reduce the effectiveness of platinum in some CO Combustion Promoters. There has been a link between Sb injection and elevated Nox levels in some full burn units.



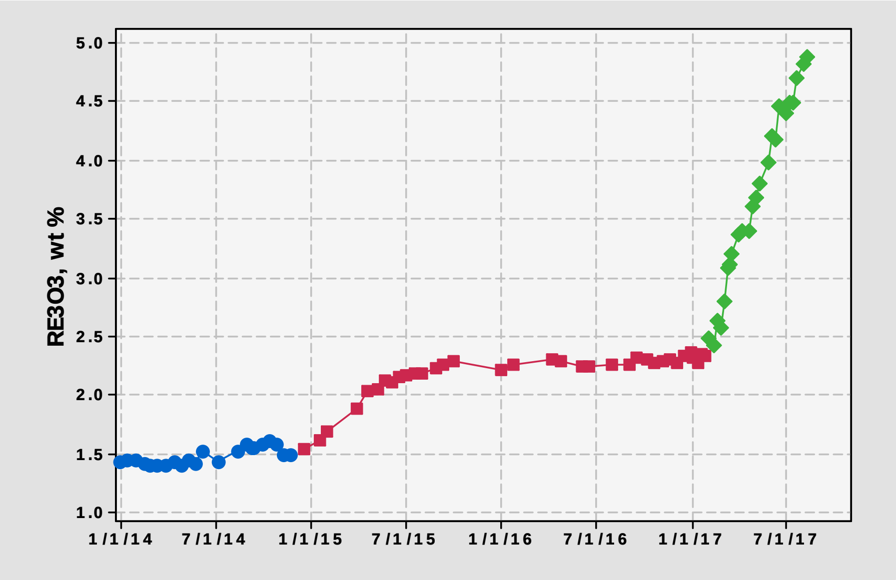
- **Sb/Ni Ratio**

  Antimony is typically added at ~0.3 ppm/ppm ratio. Certain more selective catalysts will allow the unit to operate with an Sb/Ni Ratio of 0.15 or less



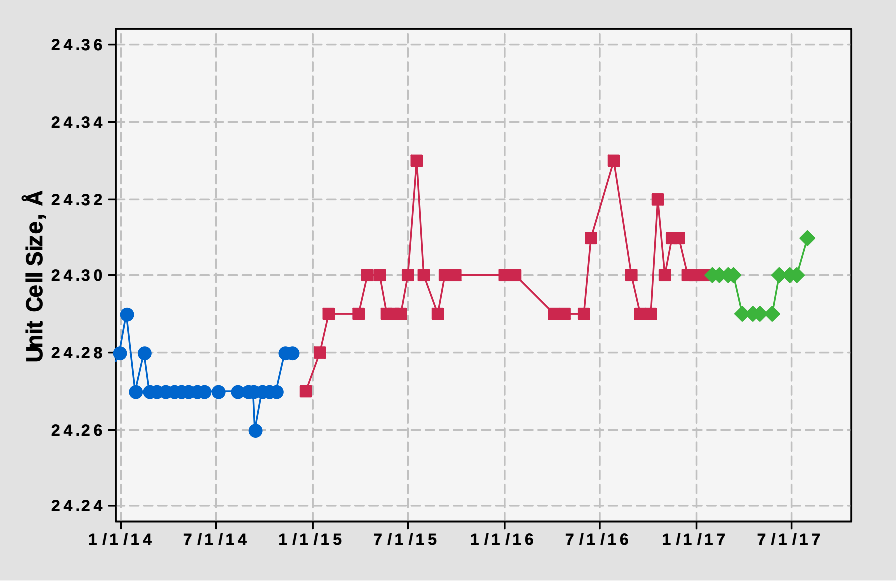
- **Re$_2$O$_3$, wt%**

  Re2O3 is rare earth exchanged into zeolite during catalyst manufacture to affect activity and control gasoline and olefin production in the FCC. Higher rare earth exchange results in gasoline yield-oriented catalysts. Lower rare earth exchange yields higher octane and olefins.



- **Unit Cell Size (UCS), Å**

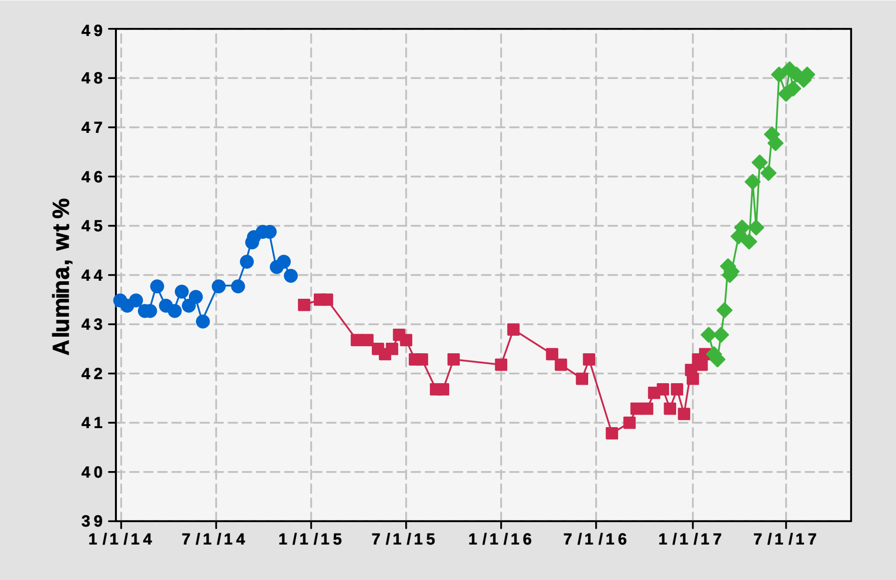
  Equilibrium catalyst UCS is controlled by the fresh catalyst Si/Al ratio and RE$_2$O$_3$ exchange. Catalysts with high UCS (>24.30 Å) yield high gasoline volume and lower olefins. Octane-barrel catalysts have a UCS of 24.27 - 24.30 Å. Octane and maximum olefin catalysts have a low UCS of <24.27 Å.



GRACE

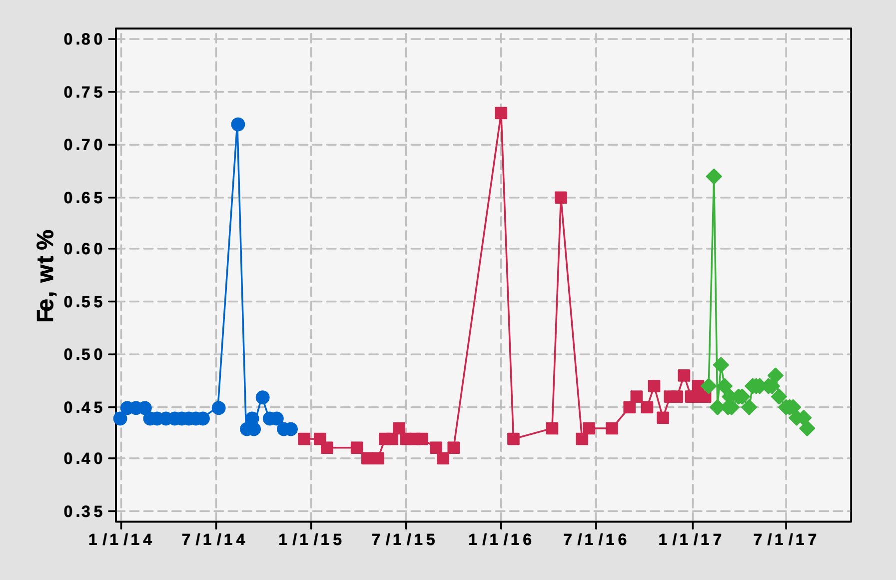
- **Al_2O_3, wt%**

Alumina is useful for tracking the turnover rate to a new catalyst. The alumina content is affected by matrix alumina input, binder level and type and clay input.



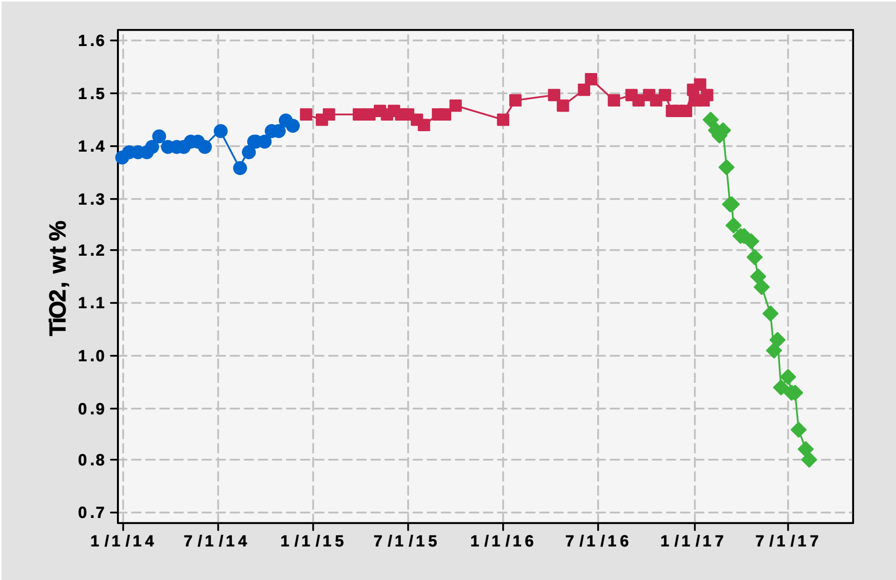
- **Fe, wt%**

Iron is a contaminant in feed and is in the clay of the fresh manufactured catalyst. Organic-based Fe contamination can lead to pore closure, which can impact bottoms cracking. The presence of Na and CaO can act as fluxing agents aggravating the effect of Fe.



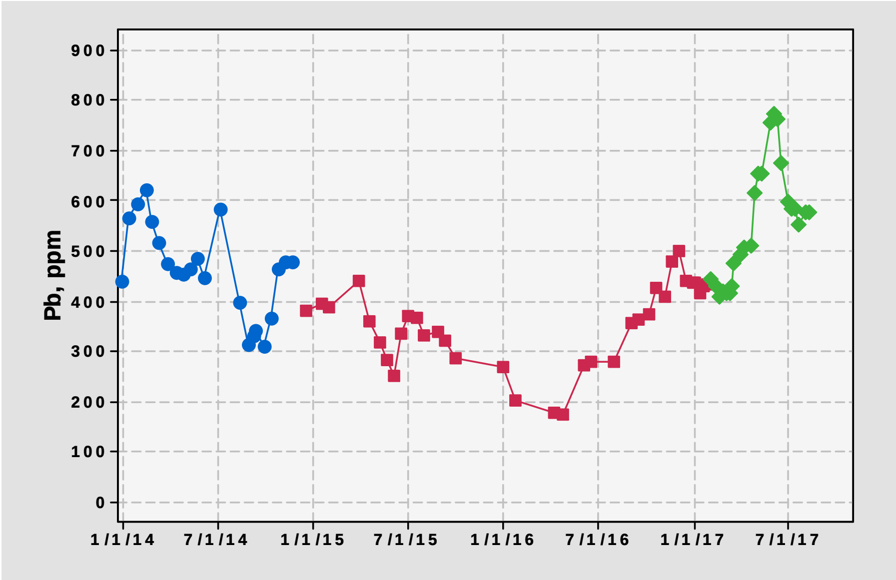
- **TiO$_2$, wt%**

  Titanium is used when tracking the turnover rate to a new catalyst. Titanium is in the clay used in catalyst manufacture and is catalytically inert.



- **Pb, ppm**

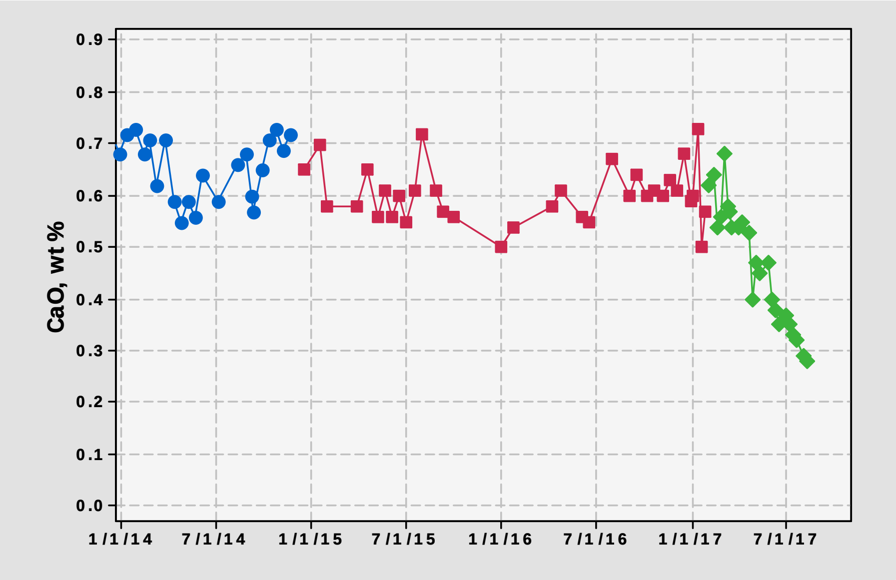
  Lead (Pb, ppm) is present in some FCC feeds. Lead is typically sourced from slop streams in the FCC feed. Lead can deactivate the platinum in CO Promoter.



GRACE

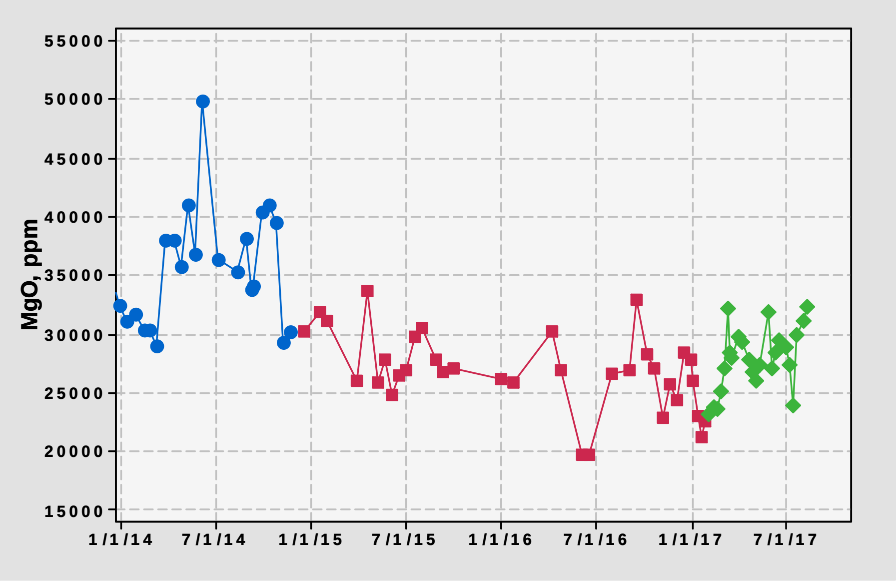
- **CaO, wt%**

  Calcium acts to deactivate FCC catalyst. Calcium is found in FCC feeds and refinery slop streams which are fed to the FCC unit.



- **MgO, ppm**

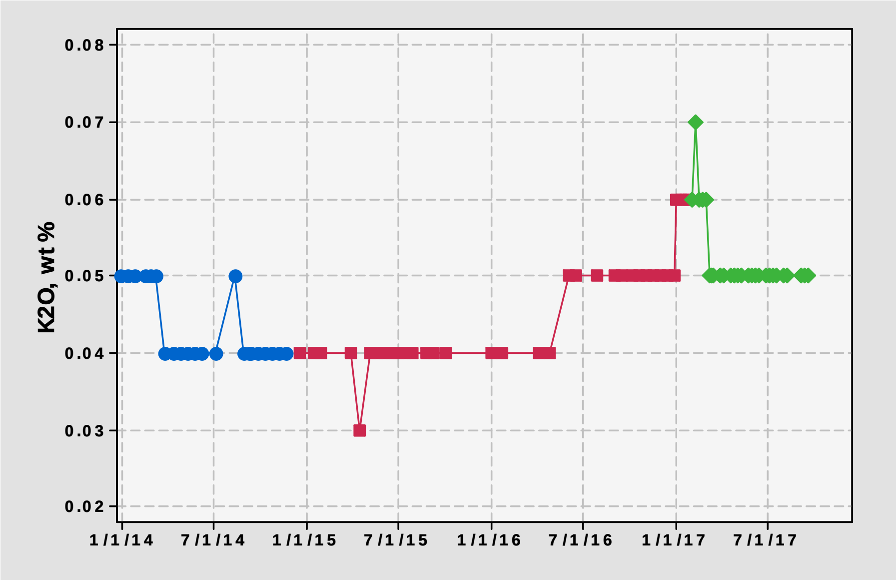
  Most Magnesium is present as a result of Flue Gas SOx Reduction Additives. Some MgO is found in FCC feeds.



GRACE

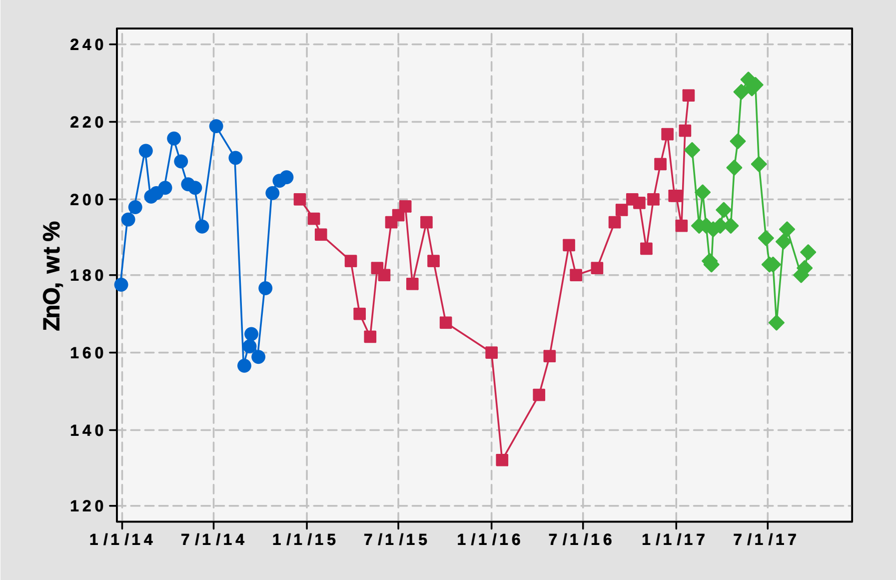
- **K2O, wt%**

  Potassium acts to deactivate FCC catalyst in a similar fashion as Sodium. Potassium can be found in some FCC feeds. If an HF Alky is in use, K2O can be seen on equilibrium catalyst if acid soluble oils are directed to the FCC. Deactivation by this mechanism can be severe.



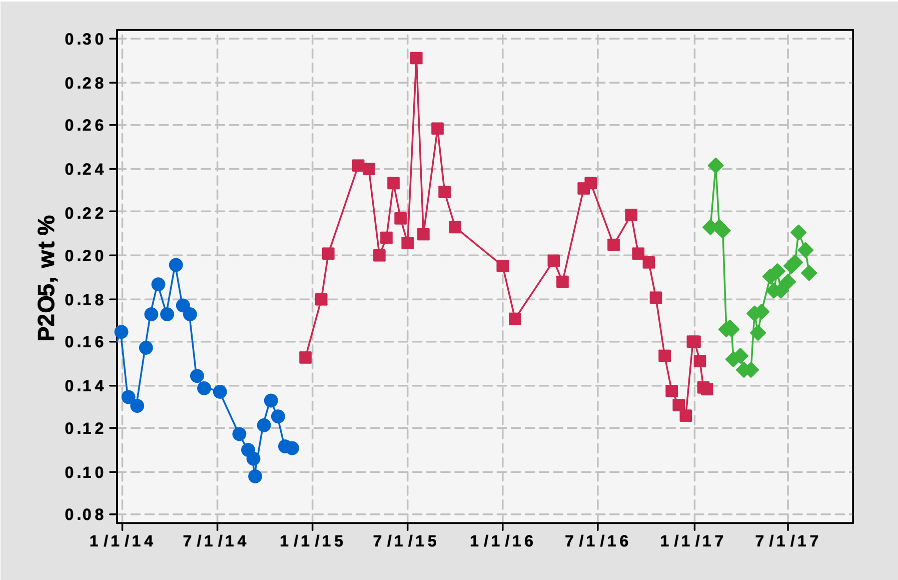
- **ZnO, pm**

  ZnO is present in some FCC feeds; often a result of lube slop streams. It is also an ingrediant in some FCC additives.



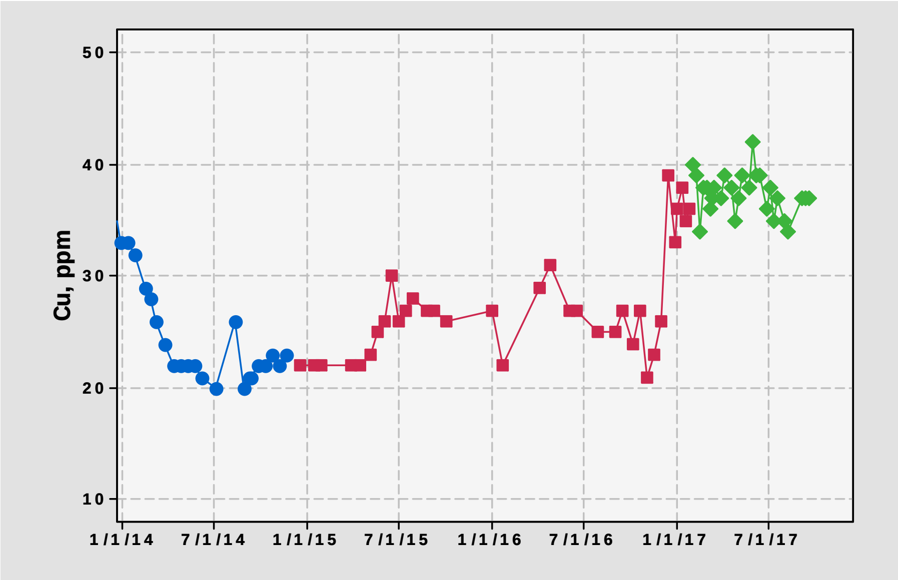
- **P2O5, wt%**

  Most Phosphorous is present as a result of the addition of Lt. Olefin additives to the FCC. Some FCC catalyst is stabilized using P2O5.



- **Cu, ppm**

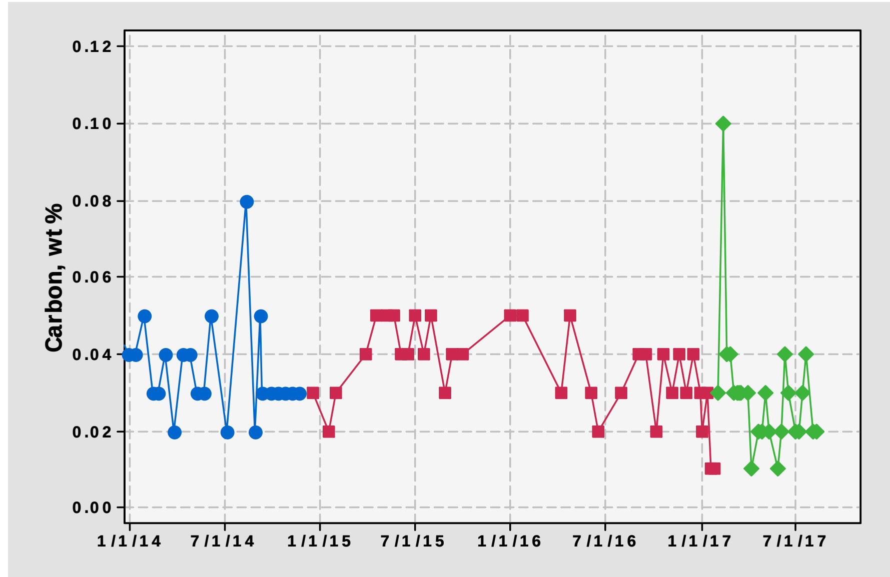
  Copper acts similarly to nickel in causing dehydrogenation reactions in the FCC unit. Copper can be found in FCC feed. Copper is also an ingredient in some FCC additives.



GRACE

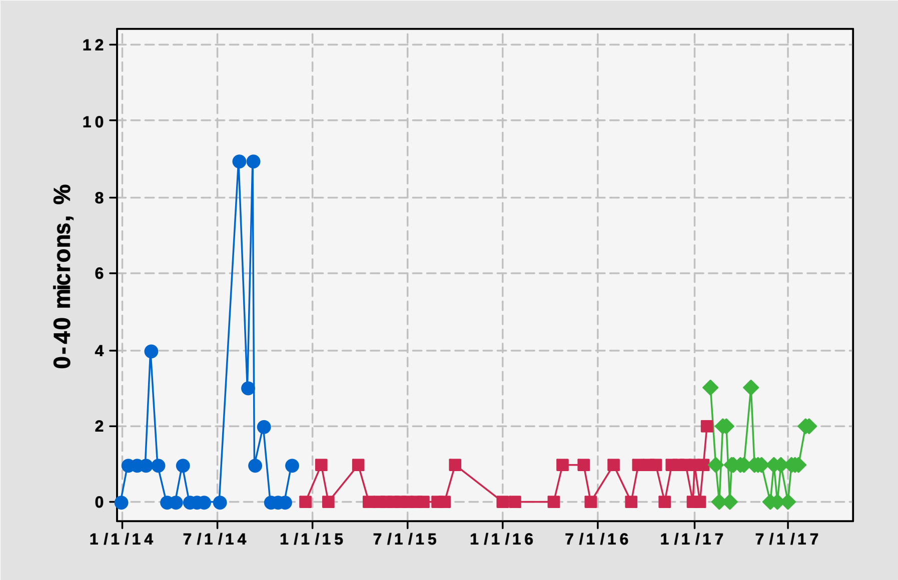
- **Carbon**

Carbon on equilibrium catalyst is measured to help determine the efficiency of the regeneration. Full combustion units typically operate below 0.10 wt% carbon. Partial burn units can operate higher. MAT activity is measured on a carbon free basis. Carbon on regenerated catalyst blocks active sites and reduces the effective activity of the catalyst in the FCC unit.



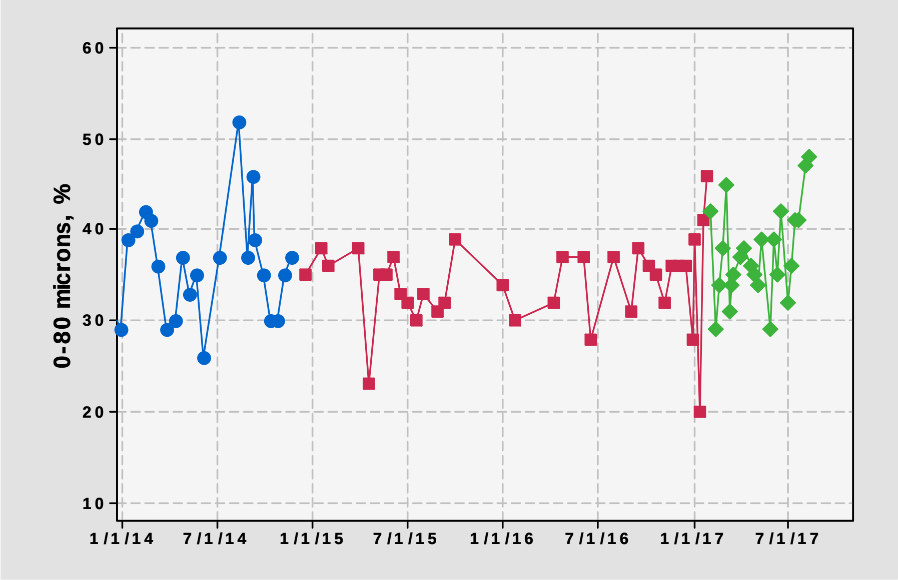
- **Particle Size 0-40 μm**

  The 0-40 μ content aids in circulation of the catalyst. The 0-40 content is also used to gauge cyclone efficiency and to identify attrition sources.



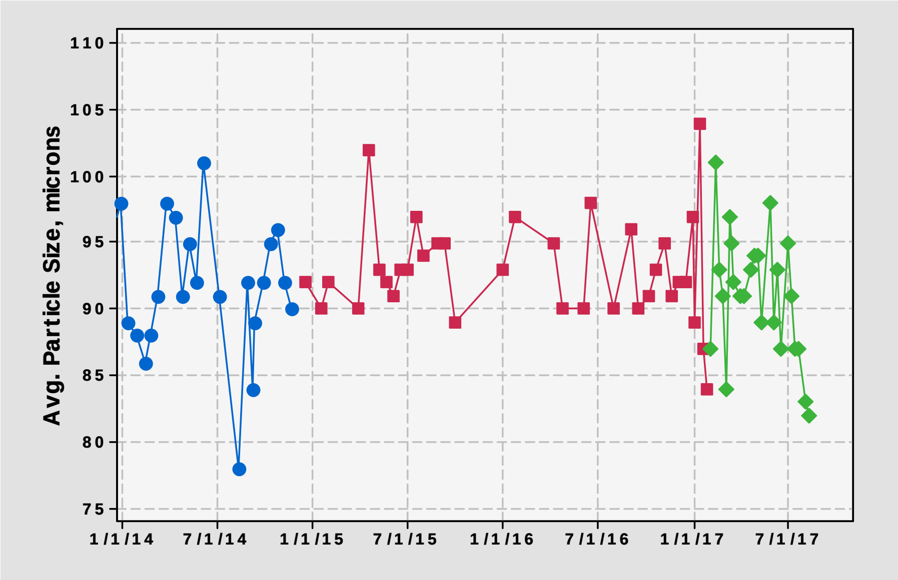
- **Particle Size 0-80 μm**

  The 0-80 μ content is an indicator of the flow characteristics of the equilibrium catalyst inventory and cyclone efficiency.



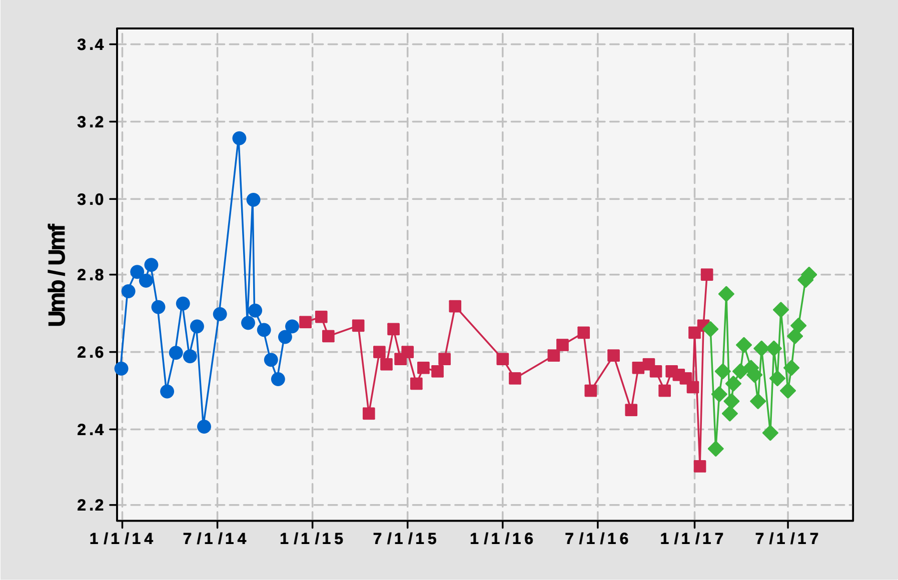
- **Average Particle Size (APS), µm**

  The average particle size (APS) is an important indicator of the flow characteristics of the equilibrium catalyst inventory. APS is affected by the fresh APS distribution, catalyst attrition, and cyclone efficiency



- **UMB/UMF**

  The U_{mb}/U_{mf} is a fluidization factor used to estimate the fluidization capabilities of an equilibrium catalyst. The value of a "good" U_{mb}/U_{mf} is unit dependent. However, higher Umb/Umf represents an inventory with better flow characteristics.



Factors Affecting ECAT Quality

- **Fresh Catalyst Properties**
  - **Equilibrium catalysts are directly affected by fresh catalyst properties. For example, a unit using a high activity zeolite catalyst would have a high equilibrium activity, all other factors remaining equal.**
- **Unit Deactivation**
  - **Regenerator operation affects equilibrium catalyst activity. Thermal and hydrothermal deactivation can occur from torch oil, spray water or steam being introduced in the regenerator. Regenerator design can also have an impact on catalyst activity and deactivation rates.**
- **Average Age**
  - **Deactivation also depends upon the residence time of the equilibrium catalyst in the unit. This is influenced by the daily fresh catalyst addition rate. The higher the addition rate, the lower the average age of the catalyst.**
- **Feedstock Quality**
  - **Contaminant metals in the feedstock such as nickel, vanadium and copper are harmful to equilibrium catalyst performance, as well as alkali/alkaline metals (calcium, magnesium, potassium and sodium). An increase in coke and gas yield is expected at higher nickel, copper or vanadium levels. Sodium and vanadium destroy zeolite and reduce the activity of the catalyst**

A loss in unit conversion can be monitored by changes in catalyst properties

Usual Causes:

- **Increased regenerator severity**
- **Increased metals: sodium & vanadium (also alkali or alkaline metals), Torch oil addition (thermal deactivation, high velocity attrition)**
- **Excessive steam in regenerator (hydrothermal deactivation)**

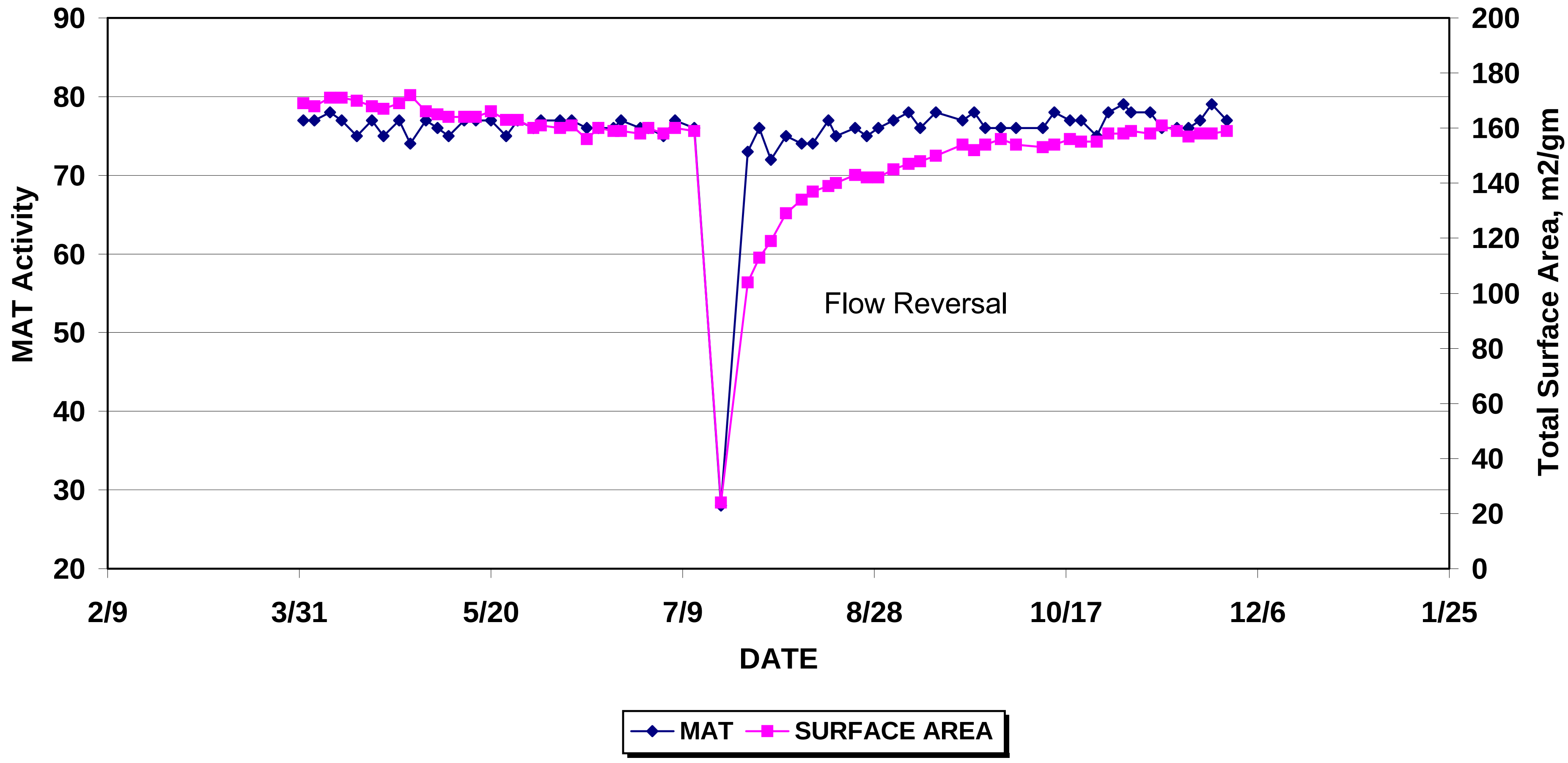
Symptoms of Deactivation

- **THERMAL DEACTIVATION**
  - **ECAT MAT drops**
  - **Lower surface area**
  - **Lower pore volume**
  - **ABD increases**

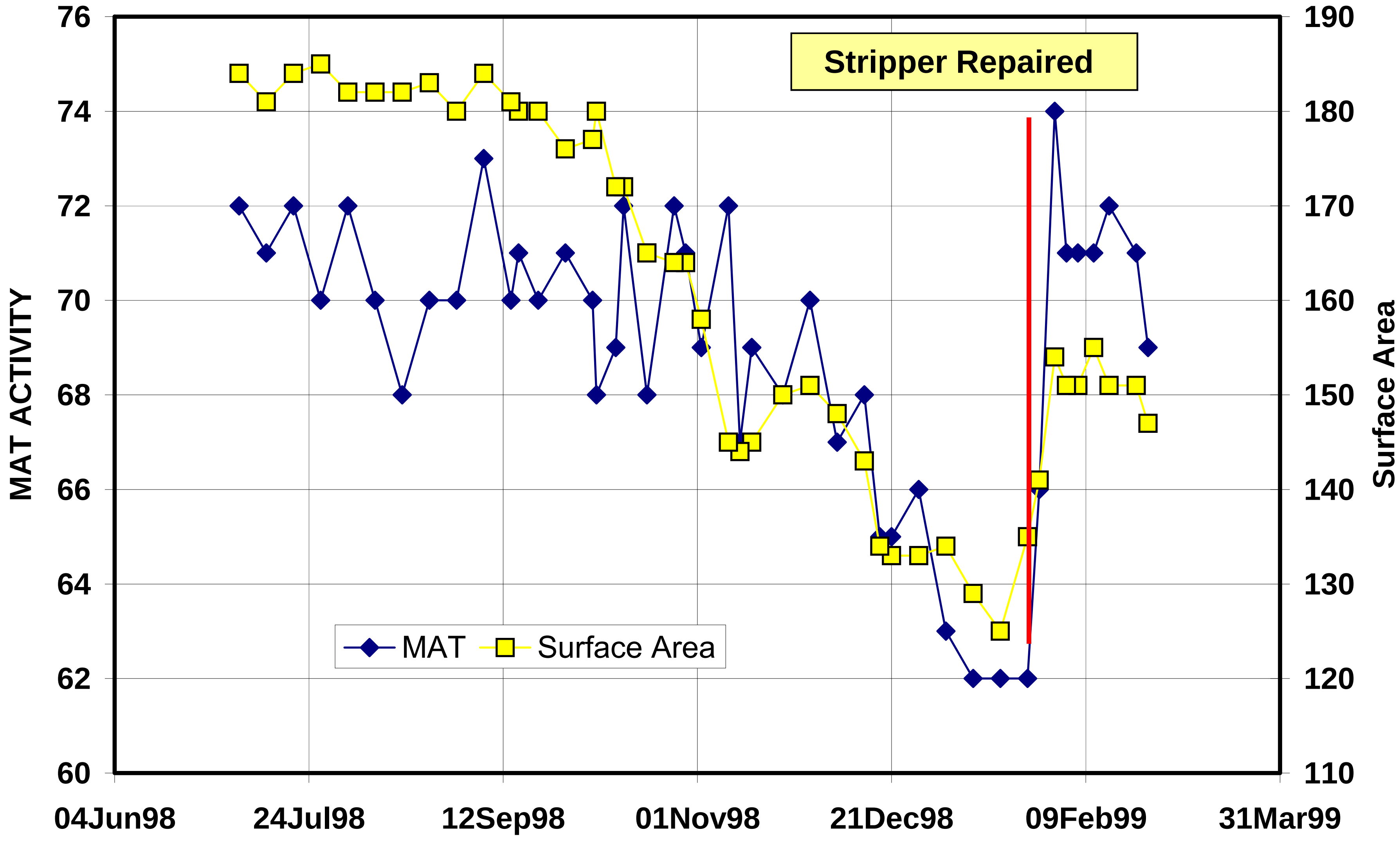
- **HYDROTHERMAL DEACTIVATION**
  - **ECAT MAT drops**
  - **Lower surface area**
  - **Pore volume relatively constant**
  - **ABD relatively constant**

Example of Thermal Deactivation

GRACE



Example of Hydrothermal Deactivation



- **Particle Size Distribution of ECAT and Fines**

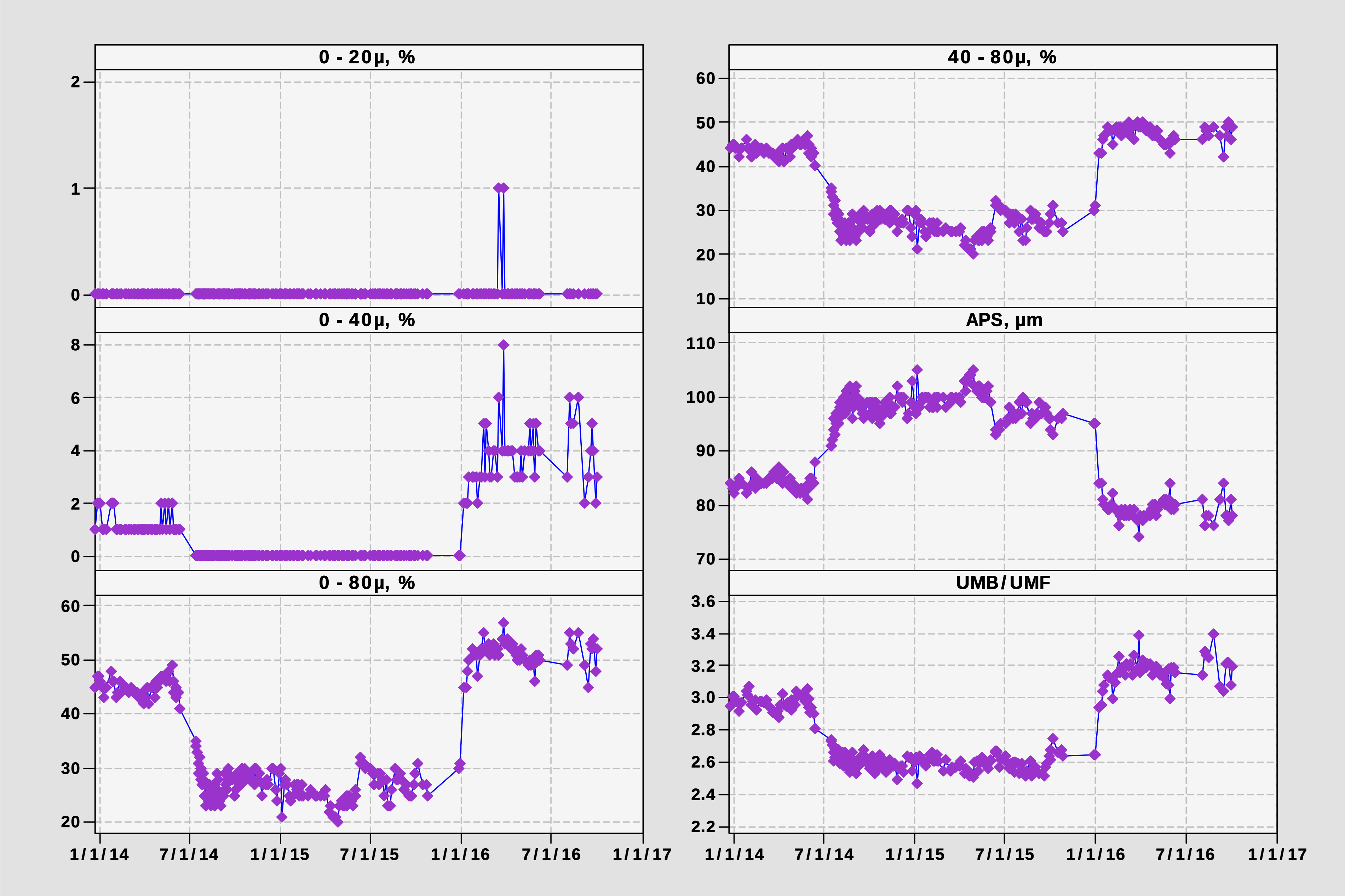
  - **In general, a higher 0 to 40 micron fraction in ECAT exhibits better flow characteristics.**

  - **ECAT PSD is affected by fresh catalyst PSD, cyclone efficiency and catalyst attrition resistance.**

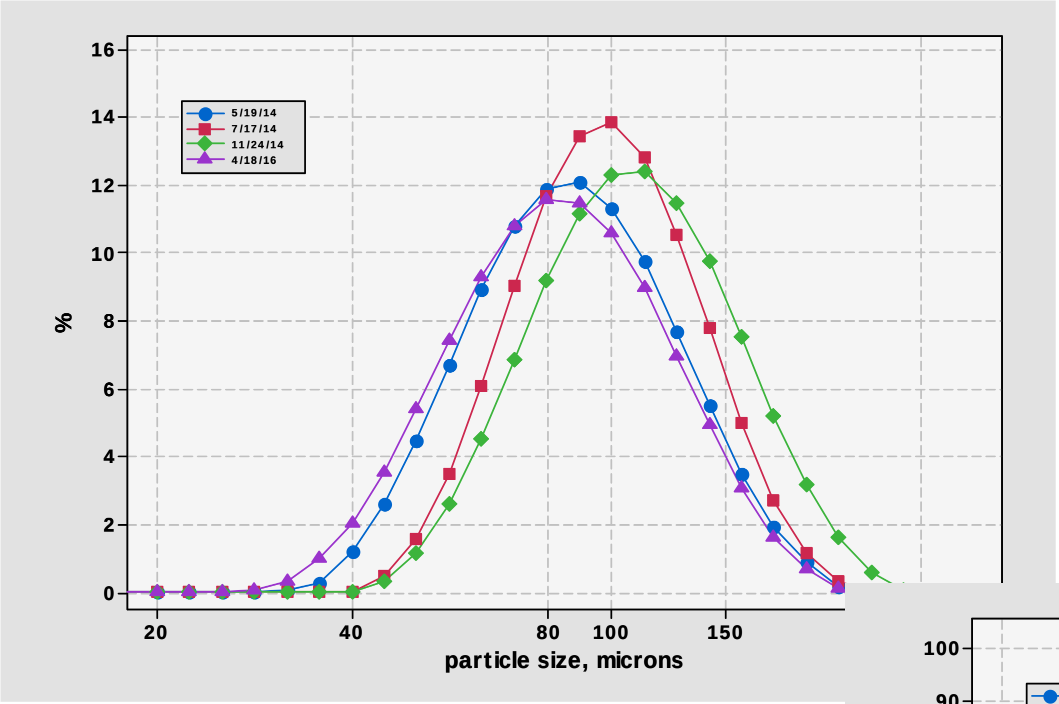
  - **Gradual changes in 0-40 and APS are indicative of degrading cyclone performance or heavier cyclone loading.**

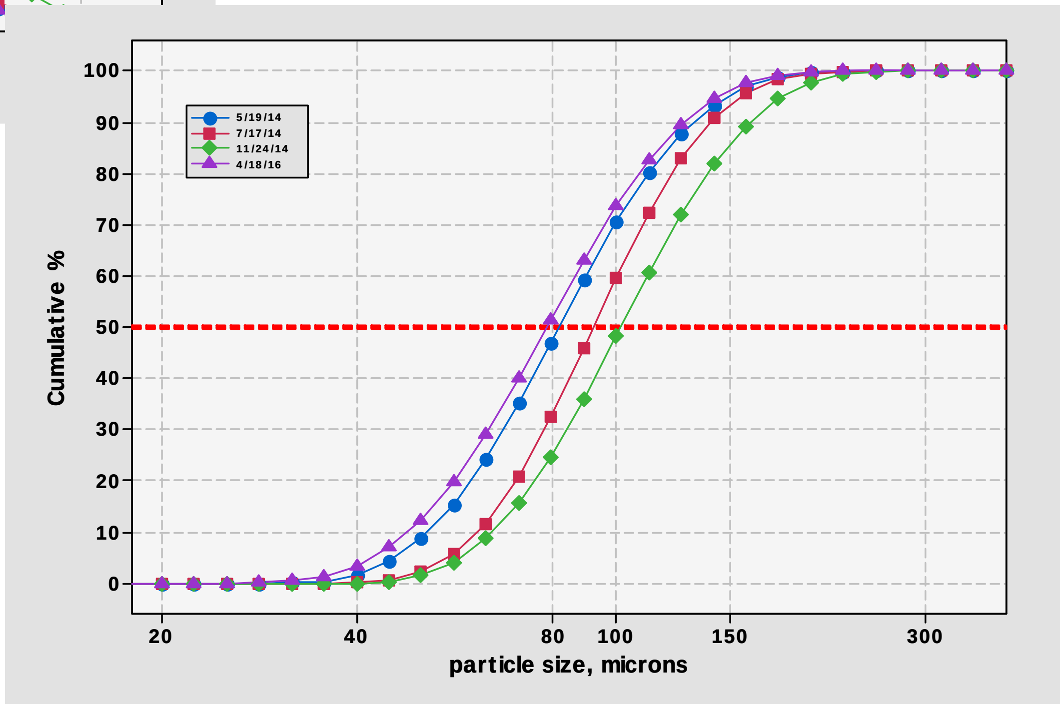
  - **PSD of the ESP or Third Stg. Separator Fines important for troubleshooting the unit.**

Example of Cyclone Problems – ECAT PSD

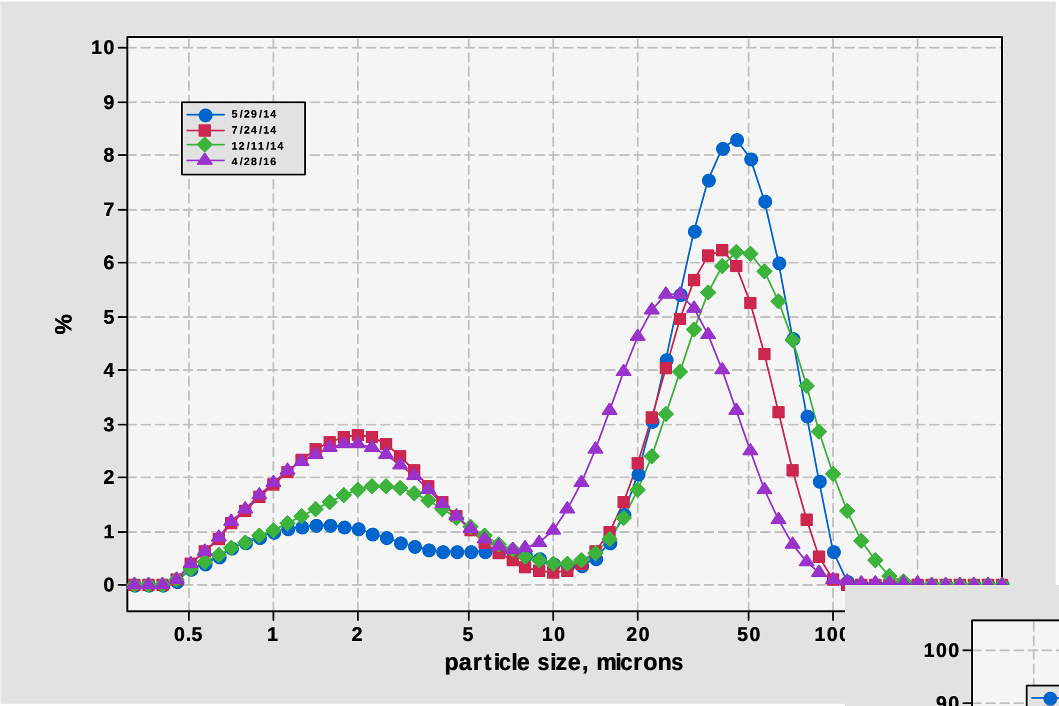


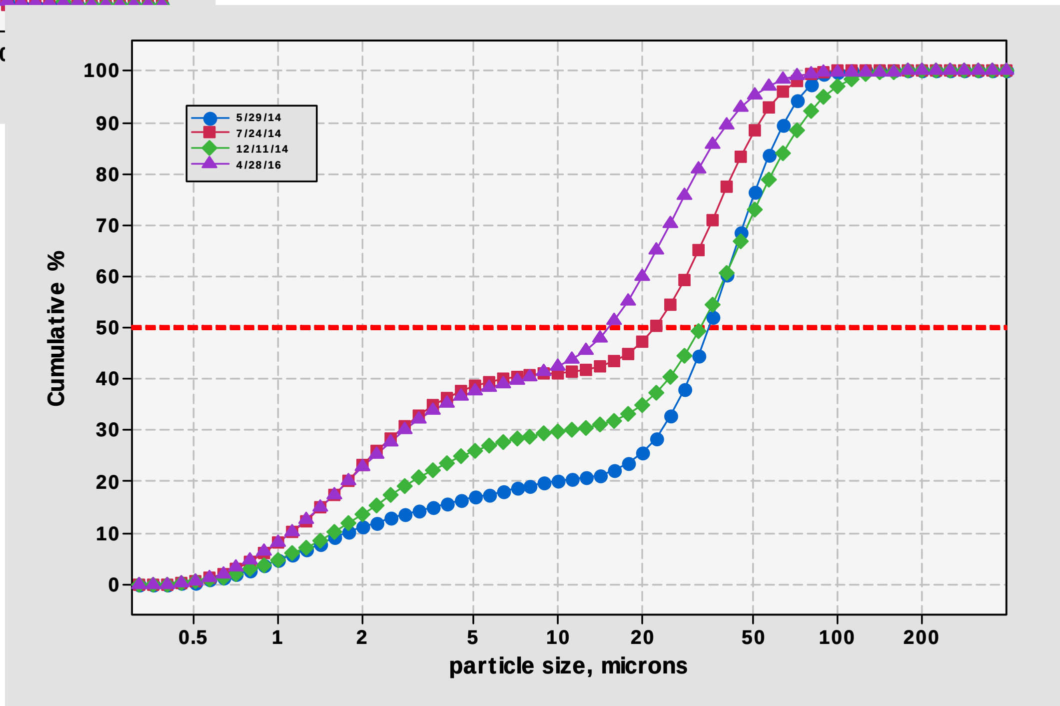
Example of Cyclone Problems – ECAT PSDs





Example of Cyclone Problems – FINES PSDs





GRACE

Talent | Technology | Trust