SafeZone* Services Identifies and Prevents Refinery Salting Episodes

Challenge

A North American refinery experienced severe restriction in their crude unit overhead system during an operating campaign to maximize middle distillate production. The unplanned shut down, lost production, and maintenance expense impact was estimated at $30MM. Equipment inspection and deposit analysis revealed that the increased pressure drop resulted from salt fouling and related corrosion.

Although the refinery was processing a crude diet that consisted of sources known to contain triazine-based H_2S scavengers, the refinery had operated in a "maximum distillate" mode previously on a similar crude slate with no apparent negative impact. Crude oils treated with H_2S scavengers are prone to salting in the crude tower overhead due to tramp amine contamination due to the scavenger chemistries commonly used. Additionally, there were no clear conclusions as to which operating variables drove the salt-based corrosion failure, despite traditional salt-point calculations being performed weekly.

A GE team, composed of on-site engineers and remote experts, was assembled to determine the root cause and recommend corrective actions.

Solution

Overhead system corrosion, salting, and fouling control is a complex interaction of ionic chemistry, kinetics, equipment configuration, and operating conditions. Since GE was already intimately familiar with this crude unit, the system configuration and operating parameters were already mapped out. The GE team gathered historical and current operating data, local readings, available laboratory data, and accumulator water testing results of the chemistry and amine speciation. Using this data, they built a customized and calibrated model of the crude unit using SafeZone technology and services to identify root causes and drive to potential solutions.

SafeZone works with and builds on GE's long-standing LoSALT* program and our combined approach to controlling overhead corrosion. It is a service that focuses on maintaining the reliability and integrity of the crude unit overhead system while optimizing operating variables for improved economic outcomes. The program uses time-series measurements and stochastic analytics to quantify system salt and water dew points, detect periods when salting has occurred, and conditions where salting is likely to occur again. It identifies root causes, advises on operating and design adjustments to move out of salting conditions to a "safe zone", and predicts the performance for future operating states based on recommended operating tactics.

The team utilized GE SafeZone to determine system dynamics and output by quantifying system variability within several operating windows, coupled with boundary value analysis. The results of the analysis rapidly uncovered more effective operating conditions believed to offer the best economic performance.

Analysis revealed that, prior to the crude column overhead fouling, the overhead reflux rate was reduced as compared to previous maximum distillate campaigns. This, in turn, pushed column operation into a salting regime, which lead to salt fouling of the overhead system and subsequent increase in pressure drop across the overhead heat exchange system. Discussions with the refinery revealed that the reflux rate was lowered primarily to save energy downstream of the crude unit. The study clearly showed how the operating moves to save energy led to the unintended consequence of overhead failure. Note that this tower does not have a top pump-around or overhead system water wash, so reflux rate can have marked impact on system salting potential.

Figure 1 shows a comparison between the 2014 and 2015 distillate maximization campaigns. The chart plots reflux rate over time. The data points are color-coded with one output from the SafeZone analytic called "Salt Probability Index" (SPI). SPI indicates the probability that salt will form in the overhead system given the system parameters at the given time. The index shown as red, yellow, or green; red indicates a high salting probability, green is a low salting probability, and yellow a cautionary boundary layer between green and red. As indicated by the numerous red data points during the 2015 campaign, the changes from 2014 to 2015 markedly increased the salting probability, demonstrating that the SafeZone services can accurately detect periods of salting and measure the impact that changes to operations or chemistry can have on salting potential.

Further, **Figure 2** shows a comparison of the pressure drop in the atmospheric tower overhead system (blue line) compared to a moving average of the SPI (red line).

As can be seen, there is good agreement between this measurement and the calculated SPI. This indicates that consistently controlling SPI to a sufficiently low value will help prevent a pressure drop increase due to salt fouling.

Results

The study shows that changes to operating points can have a significant effect on salting potential. Additionally, changes to practices that take into consideration the salting impact as an additional factor to maintain operation in the "safe zone" but still produce desired product yields are possible and practical. As a result of the report-out of the study, the plant has modified their operating practices and maintain operations in the safe zone with regard to salting.

It is also shown that conducting regular SafeZone analyses are valuable to help maintain the balance between production and reliability are practical and easy to implement by using GE's SafeZone services.

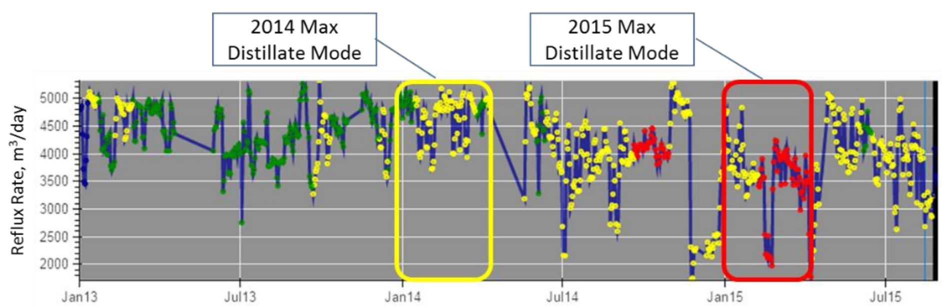

Figure 1: Reflux rate and salt probability index (SPI)

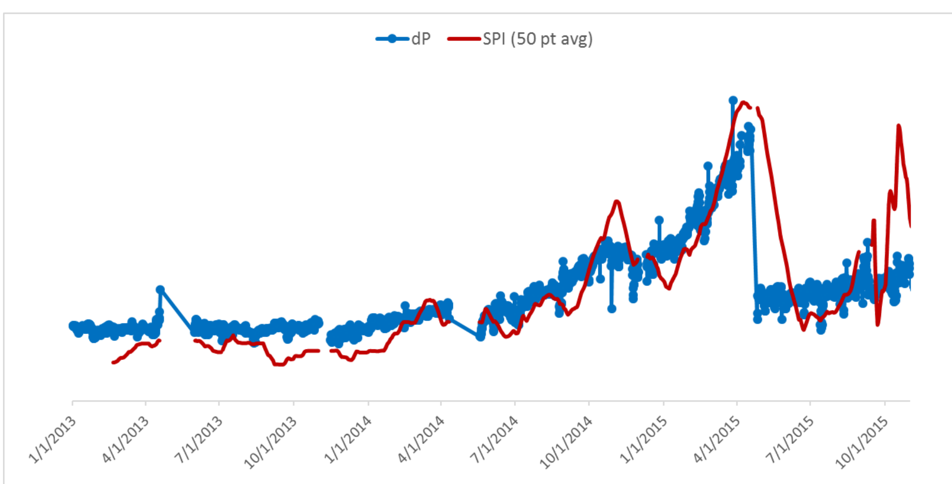

Figure 2: Overhead pressure drop and SPI