

Black Powder Results in NGLF Interruptions

Yahya T. Al-Janabi, Noktan Alyami, Matteo Leoni,
Anaam Al-ShaikhAli, Eid F. Al-Helal, Taib B. Abang
Saudi Arabian Oil Company,
Dhahran 31311, Saudi Arabia

ABSTRACT

De-ethanizer reboilers in a Natural Gas Liquid Fractionation (NGLF) plant fouled repetitively. Samples of deposited sludge were collected and analyzed. Results of the sludge samples analyses reveal a chemical composition typical of black powder: Magnetite (Fe_3O_4), Goethite ($\gamma\text{-FeOOH}$) and trace amounts of Quartz (SiO_2). By process of elimination, pipeline loops were the suspected source of these solids. The results show that Fe_3O_4 is the main component which normally originates in these cases from a process of dissolved oxygen corrosion due to the presence of very small amounts of oxygen and water in the pipeline. The presence of oxygen and water in the pipeline could be due to the exposure of the pipeline to the atmosphere during pipeline construction or other major repairs. Silicon dioxide (SiO_2) is a natural compound of silicon and oxygen found mostly in sand which again could enter into the pipeline during construction or major repairs. For comparison and possible new insights, results of previous studies conducted internally were also reviewed. Based on identified types of corrosion and chemical reactions products, a reversed sequence of events was reconstructed. The main corrosion mechanisms proposed are oxygen corrosion, under-deposit corrosion, and microbiologically-influenced corrosion (MIC), as well as erosion of mill scale by sand particles. The laboratory analyses were conducted using X-Ray Diffraction (XRD), Wavelength Dispersive X-Ray Fluorescence (WDXRF) spectrometry, Thermogravimetric Analysis (TGA), and Environmental Scanning Electron Microscopy integrated with Energy Dispersive X-Ray Spectroscopy (ESEM/EDS).

Key words: black powder, natural gas liquid fractionation (NGLF), pipeline corrosion

INTRODUCTION

Black powder in the gas industry is a chronic issue and this paper will provide more data which will enrich the existing body of literature and possibly advance our understanding to prevent or manage black powder formation and associated adverse effects.

The main objective of this study was to investigate excessive cleaning of reboilers due to fouling by solid contaminants at a Natural Gas Liquids Fractionation (NGLF) plant. Since 2019, there have been an unprecedented increase in the frequency of reboilers cleaning. The aim of this study was to identify potential root-causes and propose appropriate measures to avoid recurrence.

Table 1
Summary of Pipeline Loops

Pipeline	Length (km)	Diameter (in.)	Year Built	Commissioning Date
Loop-1	206	30	2014	June-2019
Loop-2	308	30	2014	March-2016
Loop-3	72	30	2014	Feb-2018
Loop-4	155	32	2018	Oct/Nov-2019
Loop-5	430	32	2018	Oct/Nov-2019

From July 2019, the NGLF plant experienced severe fouling at the de-ethanizer reboilers, as shown in Figure 3. These deposits resulted in reducing the performance of the reboilers, which led to cleaning the reboilers 31 times over a period of 11 months extending from July 2019 until June 2020. A fouled reboiler due to deposits on the reboiler tube bundle, will significantly impact the reboiler performance by reducing the overall heat transfer coefficient and increasing the amount of steam required to meet the desired process temperature. In addition, the presence of solid contaminants resulted in significant impairments to ethane product specifications.

There were three potential sources of these contaminants and these are:

1. Gas Plants
2. Crude Processing Facilities
3. Pipeline Loops

By studying the operational data of gas plants and crude processing facilities, it was concluded that both were not the source of these solid contaminants. Pipeline loops were the remaining potential source of these contaminants. Spikes of moisture level were observed in the moisture data of the NGLF feed over time, Figure 4. The NGLF had experienced high moisture contents exceeding 70 ppmv following commissioning activities of loop-1 in June 2019, and loops-4&5 in October/November 2019. The moisture upper limit is set at 30 ppmv. This observation further indicated that pipelines could be the source of these contaminants.



Figure 3: Solid deposits at reboilers of the NGLF De-ethanizer unit.

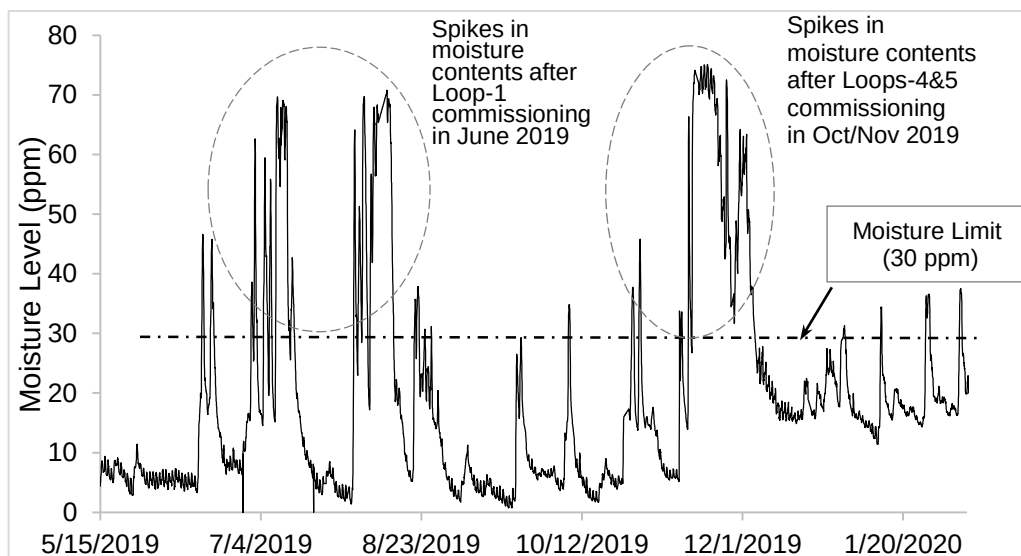


Figure 4: Moisture level over time in NGLF C₂+NGL feed.

EXPERIMENTAL PROCEDURE

In order to determine the composition and source of solid contaminants, two samples were collected for analysis: 1) from the De-ethanizer reboilers shown in Figure 3, and 2) from the feed working bullet, Figure 5. The first sample was black in color and amorphous in nature. The second sample was collected since cleaning the reboilers 31 times did not improve the situation and the performance of the reboilers continued to decline. Following inspection of the feed working bullets, one bullet was found to be full of sludge, Figure 5, where 1700 drums of sludge were collected. The collected sludge was equivalent to 350 m³.



Figure 5: Picture of sludge sample found in NGLF feed working bullet that was collected in June 2020.