Burnaby Refinery Internal Investigation Summary

August, 2024

Table of Contents

Introduction

In January 2024, Burnaby experienced a rapid change in temperature during a severe and prolonged cold weather snap. Temperatures remained well below freezing for several days, leading to previously unseen operational, instrumentation and equipment issues.

On January 21, 2024, the Burnaby refinery experienced an operational event involving the Fluid Catalytic Cracking (FCC) Unit, which required temporary shutdown. The team responded swiftly and effectively to ensure the safety of the community and the integrity of our operations.

We have since completed a comprehensive review of the matter, identifying key factors that contributed to the event as well as additional learnings related to our response to the event, including opportunities to enhance operating documentation, procedures and compliance. The investigation covered all aspects of the operational process, safety protocols, and response measures. We are sharing these findings to maintain transparency and reinforce our commitment to operational excellence.

It is crucial to highlight that despite the challenges, the Burnaby refinery team took all appropriate actions to safeguard the community and maintain safety standards. Our commitment to continuous improvement and safety remains paramount as we move forward.

Process

The investigation at the refinery was initiated on January 23, 2024. An investigation team was assembled which included a wide range of technical experts, including Process Safety Management Supervisors, Process Safety Risk Engineers, Process Engineers, Operations, Equipment Specialists, Technology Specialists, and Worker Health and Safety representatives. Collectively, these experts undertook a thorough and objective examination of the event.

The investigation employed the *TapRooT* methodology, a systematic approach to root cause analysis. The team conducted extensive interviews with area operators, shift supervisors, process engineers, maintenance technicians, and emergency responders through the Winter and Spring of 2024. These interviews were crucial for gathering firsthand accounts and insights into the sequence of events. Additionally, the investigation included a detailed timeline analysis, causal factor identification, and examination of the refinery's operating procedures and winterization activities.

The primary objective of the investigation was to identify the root causes and contributing factors to the January 21 event. The findings and recommended corrective actions were documented comprehensively to prevent recurrence and further improve the refinery's safety and operational protocols.

Timeline

November – December 2023

The refinery conducted its usual winter preparations to ensure that equipment susceptible to freezing was properly winterized, heat traced, and/or insulated.

January 11, 2024

In response to a natural gas curtailment notice from Fortis BC, the refinery began reducing its use of interruptible natural gas, switching to its own fuel gas and running two boilers on diesel. Later that day, Burnaby experienced a severe temperature drop, falling below freezing. As a result of the cold snap, the refinery faced several operational challenges that required additional maintenance and support.

January 12, 2024

On January 12, temperatures dropped to -13°C, causing signal losses, including the diesel flow meter for Boiler 5. This led to the Waste Heat Boiler tripping at 4 a.m. and Boiler 5 at 1:30 p.m., preventing pressure maintenance. As a result, pressure in the main steam headers (400 psi and 140 psi) fell, halting the steam turbine-driven fans. The CO Boiler and No. 4 Boiler shut down around 2 p.m., causing a total steam loss.

At 2:20 p.m., with steam pressure dropping, an emergency shutdown of the Fluid Catalytic Cracking (FCC) Unit was initiated for safety. Torch oil was introduced to the lower regenerator to maintain heat using Vacuum Gas Oil (VGO). By 10 p.m., steam pressure began to recover, stabilizing by midnight. However, catalyst circulation to the reactor wasn't fully completed, leaving some petroleum coke and unstripped hydrocarbons on the catalyst until start-up was attempted.

January 13 – 19, 2024

On the morning of January 13, management decided to keep the FCC and the rest of the refinery idle until weather conditions improved. An initial restart date of January 15 was set but was postponed as assessments of frozen assets continued and cold weather persisted.

Between January 13 and 19, several leaks caused by freeze-thaw conditions were identified and either isolated or repaired. While the refinery was idle:

- The FCC reactor was isolated from the fractionator.
- The upper and lower regenerator temperatures stayed hot (around 1,000°F) due to torch oil injection.
- Catalyst was circulated between the upper and lower regenerators.

During an inspection in the week of February 11, excess oil was unexpectedly found in the FCC. A review revealed that VGO, supplying the torch oil, had leaked through the FCC Feed Emergency Shutdown Valve into the FCC riser and reactor. It was initially believed that the feed system was properly isolated. Further inspection found that some valves were passing.

From January 15 to 19, the regenerators' temperature and density remained stable, and emissions were kept within permitted levels. On January 19, steps were taken to bring the refinery back online.

January 20, 2024

On January 20, the FCC unit startup process began as per procedure. The reaction mix valve was reopened, and catalyst circulation from the reactor and stripper to the lower regenerator was attempted. Although successful at 8:30 a.m., the catalyst soon solidified in the stripper and standpipe, a condition known as "set-up."

To clear the blockage, Operations attempted rodding and steaming above the spent catalyst slide valve. By 3:50 p.m., after several attempts, a section of catalyst and condensate was unexpectedly released into the lower regenerator during valve adjustments. Excess VGO and condensate also entered, causing temperatures to drop rapidly from 1,000°F to 290°F. Torch oil was shut off due to low temperatures, and the FCC stack opacity spiked for 10 minutes, remaining elevated for an hour. The temperature stabilized around 300°F, evaporating the condensate and drying the released catalyst.

Maintenance was called to light the regenerator air heater, but oil was unexpectedly found in the heater during igniter installation, halting work on the heater and the FCC startup. Plans were made to drain the heater during the night shift.

By 6:30 p.m., opacity began rising again and continued overnight. Troubleshooting linked this to steam from evaporating condensate and drying catalyst. A 10:00 p.m. meeting addressed the issue, and with no resolution in sight, the FCC unit was scheduled for shutdown at 6:00 a.m. the next day. The reversal of the startup process began after the 6:45 a.m. shift meeting.

January 21, 2024

At 6:30 a.m., temperatures rose in the lower regenerator, signaling increased combustion as condensate evaporated and dried the catalyst. This was triggered by unexpected VGO accumulation in the reactor and stripper from January 12 to 20, marking the event’s start.

To shut down the FCC and isolate the fractionator, pressure had to drop from 12 psig to 4 psig. This began at 7:00 a.m., increasing air velocity in the regenerator by 40% and accelerating combustion. Excess oxygen in the stack dropped from 11% to 3% by 7:04 a.m.

At 7:20 a.m., Shift Supervisors received a report of a strong odour from Area 1. While investigating, they heard a loud pop at 7:26 a.m. and saw the stack plume change from white-grey to green-black.

A radio call cleared all non-essential personnel from the site. By 7:32 a.m., excess oxygen in the stack dropped to 0%, indicating partial combustion in the regenerator. The upper regenerator temperature spiked, showing combustion had spread. The main air blower was turned off, but the fluffing air compressor remained operational.

Operators successfully isolated the reactor from the fractionator. At 8:02 a.m., unburned hydrocarbons reached the stack and intermittently ignited until 8:16 a.m.

At 8:03 a.m., the fluffing air compressor was turned off, and the Incident Command System was activated. The Burnaby Fire Department was notified at 8:10 a.m. By 9:00 a.m., perimeter monitoring was established, and Burnaby Fire and RCMP controlled access. Public advisories were issued around 11:00 a.m.

Key Finding 1: Incomplete Closure of FCC Feed Valves Allowed FCC Feed Flow

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Findings

The investigation revealed the FCC Emergency Shutdown Valve was the correct design specification and met industry standards. However, FCC feed flow passed through the FCC shutdown valve and the manual block valves. The following findings were identified:

- FCC feed flow passing the block valves may have been caused by improper closing, valve leakage, or foulant in the system.
- There is an opportunity to enhance the identification and mitigation of abnormal weather and operating conditions prior to future FCC Unit start-ups.

Continuous Improvements

Several improvement actions are being implemented:

- We have replaced and tested the manual block valves and have added a validation step to the shutdown procedure to ensure complete isolation of the FCC feed system.
- We are developing an 'Abnormal Situation Action Plan' to further guide decision-making, including clear sign-off protocols during start-up, with additional training provided to all relevant personnel.

Key Finding 2: The severity and length of the January cold snap created previously unseen instrumentation issues

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Findings

In January 2024, Burnaby experienced a rapid change in temperature during a severe and prolonged cold weather snap. Temperatures remained well below freezing for several days, leading to previously unseen operational, instrumentation and equipment issues. The following findings were identified:

- Some of the key instruments were adversely impacted by extreme weather.
- While impacted instruments did not have a history of being susceptible to freezing, the Waste Heat Boiler master steam flow controller, Ultra-Low Sulfur Diesel flow meter, DHT Feed flow transmitter, and Boiler Feed Water Pressure transmitter experienced freezes in their sensing lines.

Continuous Improvements

Several improvement actions are being implemented:

- Key instrumentation, including the Waste Heat Boiler master steam flow controller, the Ultra-Low Sulfur Diesel flow meter, the DHT Feed flow transmitter, and the Boiler Feed Water Pressure transmitter, will have enhanced freeze protection, including heat tracing and insulation before the next winter.
- In addition to engaging third-party expertise, we have a dedicated team, including operations, maintenance, and technical representatives, working on reviewing and updating the refinery's winterization strategy, processes, and procedures.

Key Finding 3: Improved Incident Response Guide and broader stakeholder consideration would have improved communications

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Findings

The investigation highlighted the need for improvements to the Incident Response Guide, which will enable improved communication with the Burnaby community and enhanced coordination with external stakeholders and agencies. The following findings were identified:

- Sections of the Incident Response Guide (IRG) can be improved to enable accurate classification of operational activities, ensure the appropriate escalation of operational events, and enable timely stakeholder engagement.
- Operational events must be viewed with a broader stakeholder lens, including regulatory and reporting obligations and actual and potential community impacts.

Continuous Improvements

Several improvement actions are being implemented:

- We are simplifying the IRG, particularly initial classification and notification, and assessing operational events through both a regulatory and community impact lens to enable a swift and comprehensive stakeholder response.
- Establishing trusted communication channels. Following the event, we established new communication channels and leveraged existing ones, including social media, mail drops, and community information sessions. These provide established platforms for greater community engagement.
- We are working with key external stakeholders to establish clear communication protocols and accountabilities. Additionally, we have engaged third-party expertise.