ERG

MEMORANDUM

TO: Shaun Burke, USEPA/OECA/OCE/AED
Scott Patefield, USEPA/Region 8

FROM: Dan Roper, Marissa Maier, ERG

DATE: May 12, 2023

SUBJECT: **OCE-4 Technical Direction 20 – Suncor Refinery Consent Decree Reportable Incident Analysis**

1. INTRODUCTION

Under OCE-4 Technical Direction 20, EPA directed ERG to analyze the frequency of reported upsets, malfunctions, and excess emissions at the Suncor Commerce City Refinery (Suncor) compared to other refineries under consent decrees. For this analysis, ERG relied upon publicly available information, including Root Cause Failure Analyses (RCFA) required as part of Suncor's and other refineries' consent decrees with EPA. Section 2 of this memorandum summarizes the frequency of consent decree reportable incidents: acid gas flaring incidents, tail gas incidents, and hydrocarbon flaring incidents. Section 3 summarizes the root causes of acid gas flaring incidents and tail gas incidents at Suncor and discusses best practices at other refineries.[1]

Suncor has three Claus sulfur recovery units (SRU). Plant 1, the former Conoco refinery, has two SRUs (#1 and #2) with more than 95% of the refinery's sulfur recovery capacity. Plant 1 has the majority of the refinery's hydrotreating capacity that generates acid gases. The #1 and #2 SRUs share a Tail Gas Unit (TGU) and tail gas incinerator. The TGU includes a reducing gas generator (RGG) for conversion of sulfur species to H_2S followed by amine absorption for recycling of acid gas to the Claus process. Plant 2, the former Valero refinery, has one SRU (#3) with a tail gas incinerator but no tail gas treatment unit.

2. REFINERY INCIDENT COMPARISON

Compared to eleven other refineries from around the United States during 2016 to 2020, Suncor had the greatest number of tail gas incidents and second greatest number of acid gas flaring incidents. For hydrocarbon flaring incidents, Suncor was in the middle of the comparison group at the seventh greatest number of incidents out of the twelve refineries.

[1] "TD20_Suncor RCA Review_2022-05-07.xlsx" provides a more detailed description and categorization of the acid/tail gas incidents based on information provided in the Root Cause Failure Analyses (RCFA) required as part of Suncor's consent decree.

2.1 Refinery Incident Comparison Data Set

For this analysis, ERG compared Suncor to eleven other refineries under consent decrees. Only refineries that submitted consent decree semiannual reports during 2016 to 2020 were considered. Of those refineries that submitted reports, ERG selected several refineries located in EPA Region 8 as well as refineries from other EPA regions. ERG attempted to include refineries of a similar crude capacity to Suncor, but this was not possible for all regions. Table 1 below identifies the refineries selected and their crude capacities in barrels per calendar day (bpcd).

Table 1. Refineries Compared

Refinery	Region	Consent Decree	Total Operable Capacity (bpcd)[1]
Chevron El Segundo	9	Chevron	269,000
Chevron Pascagoula	4	Chevron	356,440
Chevron Salt Lake	8	Chevron	54,720
ExxonMobil Billings	8	ExxonMobil	61,500
ExxonMobil Joliet	5	ExxonMobil	238,600
HollyFrontier El Dorado	7	Frontier	162,000
HollyFrontier Woods Cross	8	Holly	39,330
Monroe Trainer	3	ConocoPhillips	190,000
PBF Energy Torrance	9	ExxonMobil	160,000
Phillips 66 Borger	6	ConocoPhillips	146,000
Phillips 66 Ferndale	10	ConocoPhillips	105,000
Suncor Commerce City	8	Conoco, Valero	103,000

1. Capacities as of January 1, 2021, per U.S. Energy Information Administration.

Except for Suncor, the refineries submitted semiannual reports for January–June and July–December for each year. Suncor submitted reports for these periods under the Conoco consent decree, but under the Valero consent decree it submitted reports for October–March and April–September. For this analysis, ERG counted the reports covering October 2015–March 2016 and April 2016–September 2016 as the 2016 reports and similarly for the remaining years.

2.2 Incident Frequency

The tables below present the number of acid gas flaring incidents, tail gas incidents, and hydrocarbon flaring incidents reported for 2016–2020.

Table 2. Acid Gas Flaring Incident Frequency

	Number of Acid Gas Flaring Incidents					
Refinery	2016	2017	2018	2019	2020	5-Year Total
Chevron El Segundo	0	0	0	1	0	1
Chevron Pascagoula	0	0	0	1	0	1
Chevron Salt Lake	0	0	1	1	0	2
ExxonMobil Billings	0	0	0	1	0	1
ExxonMobil Joliet	0	0	0	1	1	2
HollyFrontier El Dorado	5	1	1	7	1	15
HollyFrontier Woods Cross	2	1	0	0	0	3

Table 2. Acid Gas Flaring Incident Frequency

	Number of Acid Gas Flaring Incidents					
Refinery	**2016**	**2017**	**2018**	**2019**	**2020**	**5-Year Total**
Monroe Trainer	0	0	0	0	0	0
PBF Energy Torrance	2	0	0	0	0	2
Phillips 66 Borger	0	2	1	0	1	4
Phillips 66 Ferndale	0	0	1	1	0	2
Suncor Commerce City	3	1	2	3	1	10

Table 3. Tail Gas Incident Frequency

	Number of Tail Gas Incidents					
Refinery	**2016**	**2017**	**2018**	**2019**	**2020**	**5-Year Total**
Chevron El Segundo	0	0	0	0	0	0
Chevron Pascagoula	0	0	1	0	0	1
Chevron Salt Lake	0	2	0	4	1	7
ExxonMobil Billings	0	0	0	0	0	0
ExxonMobil Joliet	0	2	3	1	2	8
HollyFrontier El Dorado	2	3	2	3	0	10
HollyFrontier Woods Cross	0	0	0	0	0	0
Monroe Trainer	1	1	0	0	0	2
PBF Energy Torrance	1	0	0	0	0	1
Phillips 66 Borger	3	6	2	2	0	13
Phillips 66 Ferndale	0	0	0	0	1	1
Suncor Commerce City	4	3	4	4	5	20

Table 4. Hydrocarbon Flaring Incident Frequency

	Number of Hydrocarbon Flaring Incidents					
Refinery	**2016**	**2017**	**2018**	**2019**	**2020**	**5-Year Total**
Chevron El Segundo	3	0	4	1	1	9
Chevron Pascagoula	5	8	7	7	5	32
Chevron Salt Lake	2	1	2	4	5	14
ExxonMobil Billings	3	4	7	8	7	29
ExxonMobil Joliet	6	6	6	6	6	30
HollyFrontier El Dorado	14	19	25	23	5	86
HollyFrontier Woods Cross	7	2	2	1	0	12
Monroe Trainer	0	0	0	0	1	1
PBF Energy Torrance	13	7	2	4	2	28
Phillips 66 Borger	6	2	6	7	2	23
Phillips 66 Ferndale	1	0	2	1	0	4
Suncor Commerce City	0	0	9	4	4	17

3. ACID GAS AND TAIL GAS ROOT CAUSE REVIEW

The Conoco and Valero consent decrees require acid gas flaring incidents and tail gas incidents to be investigated and reported. Under the Conoco consent decree, Suncor reported both acid gas flaring incidents and tail gas incidents. Under the Valero consent decree, Suncor reported only acid gas flaring incidents because the Plant 2 #3 SRU does not have a tail gas treatment unit.

ERG reviewed the incidents that occurred in 2016 to 2020 and sorted the root causes into broad categories to identify frequent types of causes. Individual incidents may have more than one category assigned.

Table 5. Acid Gas and Tail Gas Incident Root Cause Summary

Root Cause Category	Incident Type		
	Acid Gas	Tail Gas	Total
Electrical – External	2	4	6
Equipment Failure	8	10	18
Electrical – Internal	3	3	6
Level Control	5	4	9
Startup / Shutdown	2	5	7
Hydrocarbon Carryover / Foaming	6	4	10
Contractor Involved	1	2	3

Note that each incident report was counted as a single occurrence regardless of incident length. All incidents classified as "level control" were also classified as "equipment failure". Most (i.e., 7/9) "level control" incidents were also categorized as "HC Carryover/Foaming." Based on the information provided in Suncor's RCFAs, the most common cause of acid and tail gas flaring incidents was equipment failure, followed by hydrocarbon carryover/foaming.

Suncor contracted a third-party consultant, Kearney, to conduct a separate root cause investigation of Suncor's Fluidized Catalytic Cracking Unit (FCCU) and SRUs as part of Suncor's settlement agreement with the Colorado Department of Public Health & Environment (CDPHE).[2] Suncor published the Kearney report on its website. The report concluded that only 17% of the SRU and FCCU incidents between July 2017 and June 2019 were driven by technical and/or equipment failure.[3] The Kearney report more often identified underlying issues related to procedures, interfaces (e.g., communication, delineation of responsibility), and escalation (e.g.,

[2] Kearney. 2021. Suncor Commerce City Refinery – Third-Party Route Cause Investigation. April 12. Available at: https://sustainability-prd-cdn.suncor.com/-/media/project/suncor/files/about-us/commerce-city/kearney-report/kearney-final-third-party-root-cause-investigation.pdf?modified=20210902045705

[3] There were several differences in the incidents that Kearney and ERG included in their respective analyses. Kearney included all incidents involving both the SRUs and FCCU, while ERG focused on the SRUs. Additionally, Kearney considered near misses and incidents that did not result in air emissions exceedances, while ERG reviewed RCFA's of AG and TG flaring incidents required as part of Suncor's CD with EPA. Additionally, in some instances, Suncor appears to have generated two separate RCFA's for a single initiating event that resulted in both AG and TG flaring. In total, approximately 43 of the incidents that Kearney reviewed were related to Suncor's SRUs. This may be compared to the 53 AG and TG flaring incidents that ERG reviewed.

proper allocation of resources to prevent issues from being more severe).[4] While this could be due to differences in the incidents that Kearney and ERG included in their respective analyses, it could also indicate that Suncor's RCFAs under the consent decrees are not identifying the underlying root cause of SRU-related equipment failures.

3.1 Equipment Failure

Equipment failure was the most frequent root cause category that Suncor identified in its acid gas flaring and tail gas RCFA reports. Electrical systems and level control systems (e.g., controllers, transmitters) were the two types of equipment most frequently involved in acid gas flaring and tail gas incidents.

Several of the electrical equipment failures occurred in the refinery's substations resulting in multiple process unit or plant-wide impacts. Suncor did not provide any information on the age and/or condition of its substations as part of its consent decree response materials; however, aging substations are a common issue at other refineries. For example, the Marathon (former Tesoro) Los Angeles refinery's substation replacement was the subject of a paper at the IEEE 2016 Petroleum and Chemical Industry Technical Conference, "Implementing a substation replacement program in an operating refinery (The 10-year plan)."[5] This paper discusses the implementation of a 10-year plan to replace aging process unit substations and details how a team that is "knowledgeable with process unit operating, reliability maintenance, and process unit optimizing can design a substation that is maintainable, reliable, and through the life of the substation maximize profits through on-line availability of electrical power for the process unit."[6]

ERG did not identify repeated failures of individual equipment, but the frequent failures in level control systems generally suggest that the preventive maintenance, inspection, and testing of the level control systems upstream of the SRUs may require enhancement. Additionally, industry-wide, "HC carryover/foaming" is often associated with loss of level control in the amine treatment units upstream of SRUs. Of the nine acid gas flaring and tail gas incidents with root causes related to the level controller, seven also involved HC carryover/foaming.

3.1.1 Equipment Failure Prevention Requirements

Section 112(r) of the Clean Air Action (Risk Management Plan) addresses accidental release presentation. The Risk Management Plan rule includes 112(r)(1) General Duty Clause requirement to design and maintain a safe facility and Mechanical Integrity requirements related to equipment inspection, testing, and correction of deficiencies (40 CFR 68.73(d) and (e)).

Additionally, the American Petroleum Institute (API) publishes standards/recommended practices that are applicable to petroleum refineries. These standards include:

[4] Kearney 2021, p. 10

[5] https://ieeexplore.ieee.org/document/7589208

[6] https://ieeexplore.ieee.org/document/7589208

- API Standard 565 – Thermal Reactors for Sulfur Recovery Units in General Refinery Services.

- API 570 – Piping Inspection Code: In-service Inspection, Rating, Repair, and Alteration of Piping Systems

- API Recommended Practice 574 – Inspection Practices for Piping System Components

- API Recommended Practice 580 – Risk-Based Inspection.

API 565 is a relatively new standard (published on May 31, 2022), which "provides recognized industry requirements and guidance for the design, specification, fundamental operation, instrumentation, control, safeguarding, and maintenance of sulfur recovery unit (SRU) thermal reactors used in general refinery services." The other API standards/recommended practices provide guidance on the inspection and repair of piping and other system components.

3.1.2 Assessment of Suncor's Equipment Maintenance Program

A 2020 112(r) inspection focused on Suncor's FCCU did not identify any findings related to Mechanical Integrity or adherence to recognized and generally accepted good engineering practices (RAGAGEP), including API standards/recommended practices. In contrast, the Kearney report indicated that Suncor's maintenance spending was at industry standard levels,[7] but noted several weaknesses related to maintenance, including:

- Regarding inaccurate risk estimates, "[t]he site experienced loss of primary containment incidents that resulted in prolonged leakage of substances (e.g., lube oil) that were addressed with temporary fixes and later escalated to higher-volume releases." [8]

- "The refinery struggles with using available resources to execute top priorities. Due to the complexity and breadth of planned initiatives, the refinery is not always able to execute all activities that are strategic and important." [9]

- "[I]t was not clear that the maintenance strategy was consistently focusing on the right activities. That is, although deferred activities had a limited impact on the level of risk at the site, there was no assurance that activities that were not deferred would contribute significantly to lowering operational risk." [10]

- "An analysis of budget variances at the site during this timeframe showed that maintenance practices focused on corrective activities due to resource constraints, while deferring preventive items after conducting a risk assessment. A variance analysis of the maintenance budget showed that from 2017 to 2019, the actual cost spent on emergency

[7] Kearney 2021, p. 8

[8] Kearney 2021, p. 15

[9] Kearney 2021, p. 15

[10] Kearney 2021, p. 20

corrective actions was twice the originally planned budget, while the amount spent on preventative maintenance was 10 percent less than the originally planned budget." [11]

As noted above, the Kearney report concluded that incidents were most frequently due to underlying issues related to procedures, interfaces (e.g., communication, delineation of responsibility/accountability), and escalation (proper resources use to prevent issues from becoming more severe), rather than equipment failures. This suggests that Suncor's acid gas flaring and tail gas RCFA investigations may not be identifying the underlying root cause of SRU-related equipment failures.

3.2 Electrical Supply Failures and Upgrades

3.2.1 Internal Failures

Several of Suncor's acid gas flaring and tail gas root cause investigations pointed to internal issues with the refinery's power supply. These issues included an electrical upset caused by an undetected breach in cable insulation or loose connections, unexpected electrical trips, and a power interruption at the West/Sandown feed of the refinery's primary power supply substation, due to a partial loss of insulating gas in the switcher (system not wired to alert Suncor or Xcel). The Kearney Report did not address internal electrical supply issues other than passing references to unexpected power outages or blips.

3.2.2 External Failures

In addition to incidents related to internal electrical system failures, the Suncor RCFA indicated that there were several acid gas flaring and tail gas incidents were caused by third-party power supply interruptions. The most recently available RCFA (dated March 13, 2019) indicated that, "At its next regularly-scheduled meeting with Xcel Energy, Suncor will discuss with Xcel potential options (if any) to address weather related electric power interruptions at the refinery in the future." Suncor has not provided a follow-up report for this incident and it is unclear what further actions Suncor and/or Xcel took to address power interruptions. Other refineries in EPA Region 8 have addressed electrical supply issues in the past, including weather-related electrical supply interruptions. Note that the Kearney Report did not address electrical supply issues other than passing references to unexpected power outages or blips.

3.2.3 Internal and External Electrical Upgrades at Other Refineries

The Sinclair Wyoming refinery reported several flaring incidents related to a power loss during cold weather in December 2009. Sinclair reported that it coordinated with its utility company, Rocky Mountain Power, to provide redundancy to prevent future outages. The refinery installed a ring bus in 2010 that allowed it to receive power from two different power plants through two different 230 KV lines. The ring bus was designed so that a fault on either line would not interrupt power to the refinery.

The Marathon (former Tesoro) refineries in Mandan, North Dakota, and Salt Lake City, Utah also made electrical upgrades to address external power outages. The Mandan refinery

[11] Kearney 2021, p. 21

projects included a new, second supply line from the utility as well as a new substation.[12] The Salt Lake City projects included a new Rocky Mountain Power substation and transmission lines as well as a new Marathon substation.[13]

[12] https://www.powereng.com/library/delivering-highly-reliable-power-for-a-refinery/

[13] https://www.powereng.com/library/salt-lake-city-refinery-reliability-upgrade