Independent Investigation of the Catalyst Release from Martinez Refining Company on November 24-25, 2022

Report prepared by

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Table of Contents

I. Foreword 3

II. Executive Summary 4

III. Introduction 4

A. Objectives 4
B. Scope and Approach 4
C. Report Format 4

IV. Background 5

V. Description of the Incident 6

A. Prior to the Incident 6
B. Shut-down of the CCU 7
C. Establishing Catalyst Circulation 7
D. CCU Feed Reintroduction: November 24 Day Shift 8
E. Feed Reintroduction: November 24 Night Shift 9

VI. Facts 10

A. Sequence of Events 10
B. Causal Chain 11
C. Contributing Factors 15

VII. Root Causes, Contributing Causes, and Recommendations 16

VIII. Review of MRC's Investigation Report and Status of Action Plan 22

Appendix A: Scope of Work 27

Appendix B: Investigation Team Makeup 27

Appendix C: Discussion of Wet Gas Scrubbers vs. Electrostatic Precipitators Functionality During Process Startup Application in Fluid Catalytic Cracking Service 28

Appendix D: Glossary 29

Appendix E: Resolution of Oversight Committee Comments 33

I. Foreword

On the night of November 24-25, 2022, the Martinez Refining Company (MRC), which is part of the PBF Energy family of refineries, experienced an incident in which a large amount of catalyst from the Catalytic Cracking Unit (CCU) was released into the City of Martinez, California and surrounding areas. The Contra Costa [County] Health Hazards Materials Programs (CCHHMP) classified this incident as a Community Warning System (CWS) Level 2 or higher incident, which meets the definition of a Major Chemical Accident or Release (MCAR). This investigation was conducted as provided in the Contra Costa County Industrial Safety Ordinance (ISO).[1]

Scott Berger and Associates, LLC was chosen by the MRC Oversight Committee to perform this independent investigation. This report describes the investigation results, including root causes, contributing causes, and human factors. The investigation followed the methodology described in *Guidelines for Investigating Process Safety Incidents*[2]. In performing this investigation, the team relied on both eyewitness and expert testimony of MRC employees, along with documents and data provided by MRC, relevant technical references, and the investigators' experience in the field of process safety.

The investigators believe that the MRC employees interviewed gave true and accurate statements and honest opinions to the best of their abilities, and that employees felt free to provide their input without retribution.

The investigators have confidence that the root causes of the incident described in this report are accurate to the best of their knowledge and experience in engineering and process safety, and that the recommendations are appropriate.

[1] Contra Costa County. (2023). § 450-8.016. stationary source safety requirements., Chapter 450-8. risk management, division 450. hazardous materials and wastes, Title 4. health and safety, ordinance code, Contra Costa County. The State of California; Contra Costa County. http://www.contracostaco-ca.elaws.us/code/oc_title4_div450_ch450-8_sec450-8.016

[2] Center for Chemical Process Safety (CCPS), *Guidelines for Investigating Process Safety Incidents* (3rd ed.), AIChE/Wiley, (2019).

II. Executive Summary

Shortly after midnight on November 21, 2022, a safety system automatically shut down the MRC CCU due to the failure of control electronics of the Regenerator Air Blower. Repairs were made to the blower and the CCU was brought back online overnight on November 24-25. At about 20:30 on November 24, as the rate of uncracked hydrocarbon feed to the CCU was being returned to normal, the CCU catalyst regenerator vessel (Regenerator) overfilled with catalyst, resulting in a release of catalyst to the City of Martinez, California and surrounding areas. White catalyst powder was found covering horizontal surfaces on the ground and on resident's vehicles and trash cans, southwest, west, and northwest of the refinery. Based on the quantity released (> 20 tons) and the impact to the community, Contra Costa Health Hazardous Materials Programs (CCHHMP) staff identified this incident as a Community Warning System (CWS) Level 2 or higher incident.[3] As a result, it was considered a Major Chemical Accident or Release (MCAR). Based on analysis of samples collected and community complaints, Contra Costa Health Hazards Materials Programs (CCHHMP) staff identified that this incident as a Community Warning System (CWS) Level 2 or higher incident

None of the catalyst fell in the refinery. Refinery personnel were unaware of the release while it was occurring. and only learned of the incident when neighbors reported it the next morning. As catalyst was being released, refinery personnel continued to incrementally increase the rate of feed to the CCU. The release stopped at about 04:00 on November 25, and the start-up was completed at about 06:15. Approximately 24 tons of airborne catalyst powder were released to the community. No injuries or damage to the CCU were experienced with this event. The root causes of this incident and recommendations for addressing them are presented in this report.

III. Introduction

A. Objectives

On behalf of the MRC Oversight Committee, CCHHMP hired Scott Berger and Associates, LLC (see Appendix B) to perform an independent root cause analysis incident investigation. This report describes the findings of that investigation and offers recommendations for improving plant operations in the future.

B. Scope and Approach

The scope of this report includes the timeline of events, and causal factors leading up to the release of catalyst. Work was conducted both on-site at the MRC and offsite, and included review of documents and operational data, personnel interviews, and detailed analysis. The reporting of this incident by MRC to Bay Area authorities was specifically excluded from this investigation. Additional details are provided in Appendix A.

C. Report Format

This report describes the process of "cracking" hydrocarbon molecules as the CCU was intended to be operated, the timeline of events leading up to the incident, the root causes, the contributing causes. It identifies gaps in the facility's Process Safety management system along with human factors that contributed to the incident, and offers recommendations to correct these gaps, along

[3] See https://cwsalerts.com/about-cws/frequently-asked-questions/

with implementation priorities. This report also provides an evaluation of MRC's investigation report to CCHHMP. The appendices in this report summarize the scope of work, present the investigation team experience, and compare the use of wet gas scrubbers to electrostatic precipitators during process start-up of CCUs.

IV. Background

Figure 1 provides an overview of the Catalyst Cracking Unit (CCU) process, the primary focus of this incident. Connected processes mentioned in the figure include the CO Boilers (COBs), the Cracked Gas Plant (CGP), and the Flare Gas Recovery Unit.

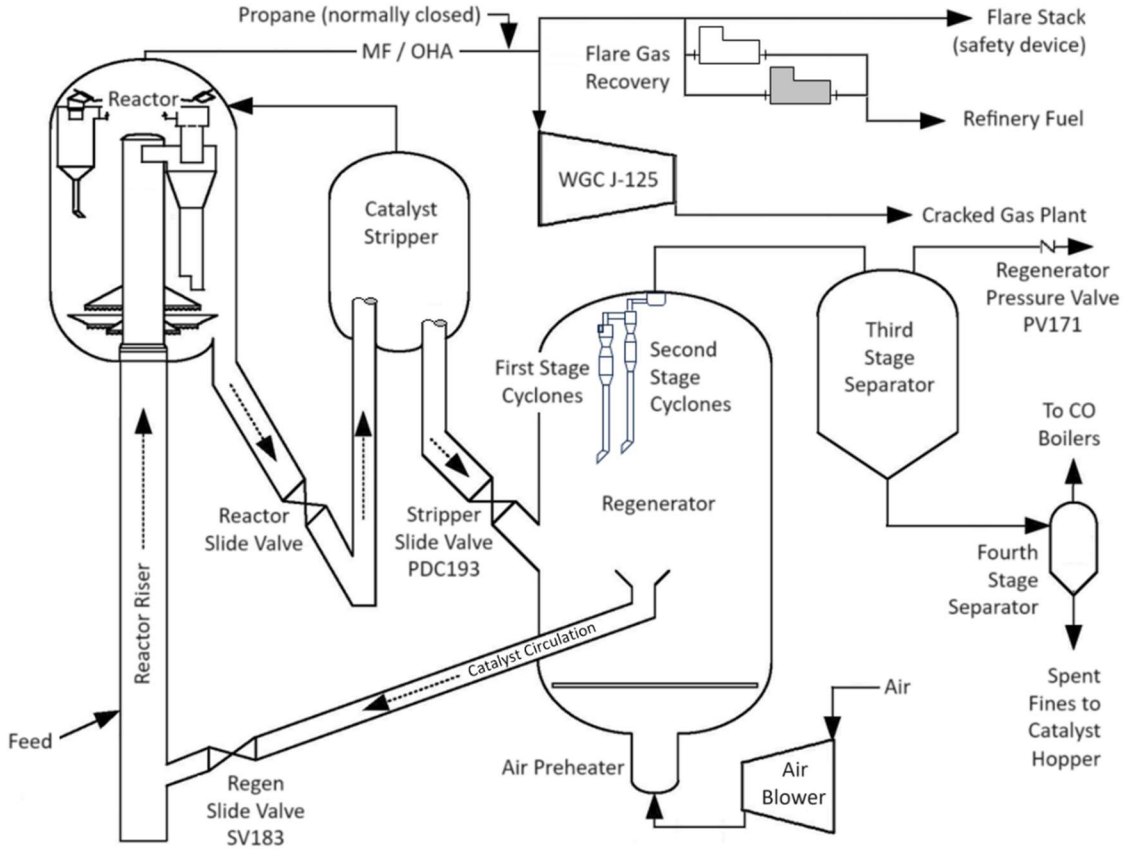

Figure 1: MRC's Catalytic Cracking Unit

Catalytic cracking was developed and commercialized circa 1940. This technology increases the yield of high-quality products by reducing, or "cracking," larger complex hydrocarbon (HC) molecules[4] into lighter products. Larger HC oils are heated and pumped into the Reactor Riser (RR) where they contact nearly 1300 °F powdered catalyst. In the RR, the larger HC molecules are cracked into smaller molecules such as gasoline, butane, or propane. This reaction also deposits carbon on the catalyst.

[4] See glossary entry for "Feed" for more details about hydrocarbon feed to the CCU.

At the top of the RR, cyclonic separators (cyclones) separate the now-spent catalyst from the HC vapor.

The cracked hydrocarbon vapor continues to the Main Fractionator (MF) where liquid products are separated, and the vapor further cooled before being collected in the Overhead Accumulator (OHA). Off-gas from the OHA flows to the Wet Gas Compressor (WGC) which compresses it for processing in the Cracked Gas Plant (CGP). The WGC also functions to regulate the OHA pressure. This in turn controls Reactor pressure and the pressure above the Stripper slide valve (Stripper SV or SSV).

The spent catalyst flows to the Catalyst Stripper, where steam is used to strip HC from the spent catalyst. The SSV maintains a level in the Catalyst Stripper, and then the catalyst flows through that valve, returning to the Regenerator.

The Air Blower provides combustion air to the Regenerator where carbon is burned off the catalyst. This also provides heat to maintain the desired temperature of catalyst flowing to the RR.

The catalyst in the Regenerator is fluidized by the upward flow of air and combustion gases. The catalyst is suspended in a dilute phase near the top of the Regenerator and in a dense phase below. The interface between dilute and dense phases constitutes the "catalyst level." The level indication is calculated from differential pressure (dP) between the bottom and top of the Regenerator.

Regenerator combustion gases (flue gas) entrain fine catalyst (fines). Most of these fines are removed as they pass through the First Stage Cyclones. The catalyst fines fall through the dip leg into the dense phase of the Regenerator. The small quantity of fines remaining in the flue gas continues to the Second Stage cyclones. These and the downstream, external, Third Stage Separator (TSS) and Fourth Stage Separator (FSS) work in a similar manner. Personnel periodically remove catalyst fines from the TSS and FSS for disposal.

If the Regenerator catalyst level is too low, the dip legs lose their seal, allowing catalyst from the dense phase to overload the TSS and FSS. Likewise, if the Regenerator catalyst level is too high, the dip legs become choked, also resulting in catalyst carry-over to the TSS, FSS, and beyond.

The Regenerator pressure is controlled by a pressure control valve, PV-171, routing flue gas to the COBs via the Flue Gas Expander Turbine. Flue gas from the FSS carries the small amount of remaining catalyst fines which are removed by the three (3) Electrostatic Precipitators (ESPs). Each ESP discharges its treated exhaust to atmosphere via an associated COB stack.

V. Description of the Incident

A. Prior to the Incident

In 2018, the then-owner of the facility, Shell Oil Products, conducted a process hazard analysis (PHA) of the CCU.[5] Shell's PHA identified a potential process upset scenario involving high-high differential pressure (dP) in the Fourth Stage Separator (FSS) leading to a possible catalyst release. However, they classified the scenario as a consequence severity two (2) according to Shell's five (5) level consequence evaluation scale. Based on Shell's risk decision policy, it was determined that no additional mitigating measures were required.

[5] See glossary entry PHA for more information.

In 2022, the current owner of the facility, PBF Energy, conducted a PHA of the Carbon Monoxide Boilers (COBs), a downstream process that receives flue gases from the FSS. That PHA identified a similar potential process upset scenario. Like Shell, MRC classified it as consequence severity two (2), with no additional mitigating measures needed.

As learned from the experience of this release, the consequences of these upset conditions should have been classified as a consequence severity three (3), based on the need to clean-up the released catalyst. If this had been recognized at the time of these PHAs, Shell's and MRC's risk management policies would have led them to implement additional measures to prevent this type of incident.

B. Shut-down of the CCU

At approximately 01:06 on November 21, 2022, an instrument failure within the CCU Air Blower (J-123) triggered a safety system that shut down the CCU and diverted CCU feed away from the Reactor Riser (RR). It also de-energized the Electrostatic Precipitators (ESPs)[6] and performed other safety functions.[7] Shortly after the ESPs were de-energized, the continuous opacity monitors on the COB stacks sounded an alarm indicating high opacity (a reading greater than 4 Ringelmann). It is important to note that while this represented an exceedance of the refinery's air permit condition, the high opacity condition is not the incident being investigated.

Following the CCU shutdown, the Wet Gas Compressor (WGC; J-125) continued to operate. As the quantity of wet gas grew smaller, the WGC total discharge flow control valve (5FC340; WGC spillback valve) automatically opened in an attempt to prevent compressor surge and potential damage to the WGC. Shortly thereafter, this valve was placed in Manual.

C. Establishing Catalyst Circulation

The Air Blower (the equipment that failed, causing the CCU to shut down) was repaired and restarted at around 10:40 on November 21. CCU feed can be reintroduced only after establishing stable catalyst circulation. Before starting catalyst circulation, the Regenerator bed must first be heated with hot air to about 1000 °F. However, the next step, igniting the gas-fired Air Preheater (F-65) was initially unsuccessful. As cooler air flowed through the Regenerator, the catalyst bed temperature continued to drop.

Meanwhile, the WGC operation was unstable, operating at or near surge conditions.[8] At around 11:30 on November 21, personnel opened valves to route propane from storage to the WGC via the Main Fractionator (MF) Overhead Accumulator (OHA). This stabilized WGC operation. Propane continued to flow, gradually reducing refinery propane inventory. Propane flow would not be stopped until much later.

[6] The final stage of cleaning CCU flue gases to remove remaining catalyst fines.

[7] See process diagram in Figure 1.

[8] Like all compressors, the Wet Gas Compressor is designed to handle gases with a set range of physical properties. Operating outside this range can damage the compressor, in some cases causing catastrophic failure. Surge is one such condition. It occurs when the molecular weight and density of the gas is too low. In the WGC, the gas being pumped can flow backwards around the turbine blades in an oscillating manner. In severe cases the oscillation can result in severe equipment damage and loss of process containment.

Troubleshooting and repair of the Air Preheater ignitor involved a Production Specialist who had expertise in CCU operation and systems, as well as a deep commitment to the success of the refinery. From the time this Specialist began working on the ignitor until after the incident, this individual followed a pattern of working 22–25 hours, resting at home for a few hours, and then returning to work another similarly long period. This individual served in a key decision-making role during this period.

The Air Preheater ignitor was repaired, and the pre-heater burner was ignited at about 09:00 November 22. Heating the Regenerator bed and establishing catalyst circulation continued until about noon on November 24.

D. CCU Feed Reintroduction: November 24 Day Shift

A step in the startup procedure prior to re-introducing feed to the Reactor Riser (RR) involved placing the Stripper Slide Valve (SSV) in Auto (although it did not explain why). Per the procedure, personnel put the SSV into automatic control mode (Auto) at 04:45 on November 24. Then at 06:29 on the day shift, personnel reverted the SSV to manual control mode (Manual)[9] to address a transient condition that occurred while establishing stable catalyst circulation. After the transient condition was resolved around 07:30, the SSV should have been returned to Auto, but this was not done. Nonetheless, feed reintroduction began shortly after noon on November 24 with the SSV in Manual. The SSV remained in Manual until well into the night shift.

Around the time that feed reintroduction began, the refinery inventory of propane had dropped to a level at which Refinery Logistics was required by refinery policy C(A)-20 to notify operating units of impending low propane inventory. Following this policy, Logistics and CCU personnel evaluated the rate of propane consumption compared to the minimum required inventory. Personnel considered that as feed increases, the CCU would start to make propane and heavier hydrocarbons and ultimately relieve the need for propane to the WGC. Therefore, they decided to continue drawing propane at the same rate. As feed was slowly increased, personnel manually cut back on propane to the OHA, and simultaneously worked the WGC spillback valve closed in Manual. The WGC spillback valve was placed in Auto at 23:10 on November 24. Monitoring and managing the propane inventory and flow to the OHA required additional operator attention.

With the initial reintroduction of feed, a pressure surge occurred. Because the WGC spillback valve was in Manual, it did not automatically respond to the increased pressure. The brief pressure rise automatically opened a pressure control valve from the OHA to the flare system. Normally, two compressors in the flare system would redirect the released gases to a location in the refinery where those gases could be recovered. However, one of the two compressors was down for maintenance, so a portion of those gases were briefly released to the flare. This was the second flaring event experienced by the day shift. The Cracked Gas Plant (CGP), the unit that receives cracked products from the CCU and shares a control console with the CCU, was also opened to flare earlier that day.

[9] When starting up a process unit, changing conditions can require personnel to temporarily take manual control (Manual) from time-to-time, because automatic controls (Auto) are tuned preferentially to operate under normal reaction conditions.

E. Feed Reintroduction: November 24 Night Shift

Normally, the feed reintroduction procedure would be conducted by two Console Operators, one focused on operating the Compressed Gas Plant (CGP) while the other focused on the CCU. However, on the night shift, the fatigued Production Specialist took charge of some of the CGP and CCU console operations. This changed the dynamics and situational awareness of operating the CCU console.

When the night shift personnel started their shift at 18:00 on November 24, they found the SSV still in Manual. This reinforced to them a preconception that this valve was sticky and balky. Among the personnel working that evening, there was a general belief that the SSV could be given a series of small manual input changes to valve position without a response, and then the valve would move suddenly, potentially more than desired. The SSV remained in Manual until 23:25.

Between 19:10 and 20:20 on November 24, the SSV remained at 37.0% open. During this period, the dP across the SSV increased from 2.9 to 5.9 psi, significantly increasing the rate of catalyst flowing from the Stripper to the Regenerator. As a result, by 20:07 the Regenerator Catalyst Bed level rose steadily from about 30 feet to above the critical high alarm level of 34 feet, where it remained until 20:57. The high catalyst level overwhelmed the first and second stage cyclones, sending a much higher than normal load of catalyst fines to the third stage separator (TSS) and fourth stage separator (FSS). The FSS high dP alarm sounded at a 20:32, and the high-high alarm sounded at 20:34, indicating that the FSS was too full with catalyst.

Other than for a ten-minute period after midnight around 02:45, the FSS remained at high-high dP until shortly after 04:00 on November 25. During this period, catalyst passed on to the CO Boilers (COBs), from there to the ESPs (that were de-energized[10]), and then out the stack.

It is clear that the rate of release of the catalyst was highest from about 20:32 until at least 20:56 when the Regenerator Catalyst Bed dropped below the critical high alarm level. It is not known at what time the First and Second Stage Cyclones returned to full function. A doorbell camera of a person living near the refinery captured catalyst falling from about 20:40 until about 23:30. Because the FSS remained in high-high dP alarm (and therefore was impaired) until shortly after 04:00 on November 25, the release of catalyst could be expected to have continued until then, albeit at a rate too low to have been detected by the camera. It is expected that the rate of catalyst emission returned to the high opacity condition that existed before the incident. As discussed above, the high opacity condition is not considered part of this incident.

The WGC spillback valve was placed in Auto at 23:10 on November 24 and the SSV was placed in Auto at 23:26. Full feed rate to the RR operation was reached at approximately 06:15 on November 25, and the ESPs were re-energized shortly afterward.

[10] The release rate was well in excess of the capacity of the ESPs. Had they been energized, the quantity of catalyst released would have been only somewhat less.

VI. Facts

A. Sequence of Events

Table 1 describes the timeline and sequence of events for the catalyst release incident as described in Section V. The key events, shown in **bold**, are discussed further below.

Table 1: Sequence of Events

Day	Time (Approx.)	Event
2018, 2022		**Related scenarios considered in PHAs. Conclusion: no action required**
November 21	01:06	Air Blower Vane Controller tripped; feed diversion; ESP tripped, shut down
	Morning	Air Blower Controller repairs began and blower restarted
	All day	Air Preheater (F-65) Ignitor problems
	11:01	WGC Spillback valve placed in Manual
November 22	09:00	Air Preheater burner ignited
November 24 Day Shift	01:20	Catalyst circulation established
	04:45	Stripper SV partially opened to start catalyst circulation
		Stripper Bed level controller (SSV) placed in Auto mode
	06:29	**Stripper SV placed in Manual mode**
	07:30	Condition requiring Stripper SV to be placed in Manual resolved, but Stripper SV not returned to Auto
	08:00	Delay, Debutanizer bottoms, Cracked Gas Plant (CGP) pressure
	12:15	Torch oil increased to raise catalyst bed temp to 1100 °F
		Gasoline column depressurizing valve was still open to flare (CGP)
	12:42	Opened one feed nozzle to RR about 25%
		MF OHA PC to flare (in Auto) opens 1-2 minutes with initial introduction of feed
		Approximately six incremental feed rate increases over 8-1/2 hours
	Soon after	**Decision that additional flaring was off-limits**
	12:50	Open remaining RR feed nozzles to 25%
	13:00	Apparent time of propane inventory alert
	Soon after	Decision to not increase rate at which propane was being drawn
November 24 Night Shift	20:00-20:30	**Regenerator bed high-high level**
	20:02	RR outlet temp dropped from 950 °F to 900 °F over five minutes; sour water to the riser cut from 24 to 9 GPM; presumed decrease in wet gas production
	20:03	**Apparent feed change event continuing until 20:08**
	20:12	FSS dP dropped (catalyst dumped)
	20:26	**FSS dP increased rapidly (20 minutes)**
	20:30	**Fourth Stage Separator (FSS) high-high dP, release began**
	23:00	WGC spillback flow control valve placed in Auto (already closed at this point)
		Place WGC J-125 Recycle Gas flow controller 5FC-364 valve CV-364 in Auto
	23:30	SSV placed in Auto; FSS level begins to drop
		Regenerator Air Blower rate adjusted
		FSS remained at high-high dP three hours, release continued
November 25	02:45 - 03:00	FSS apparently emptied twice
	03:00 - 04:00	**High-high FSS dP (again)**
	04:00 - 04:15	**FSS dP returned to normal, catalyst release apparently ended**
	06:15	CCU began operating stably at full rate; ESP re-energized

B. Causal Chain

The causal tree for this incident is shown below (Figure 2). The key links in the causal chain are described in this section.

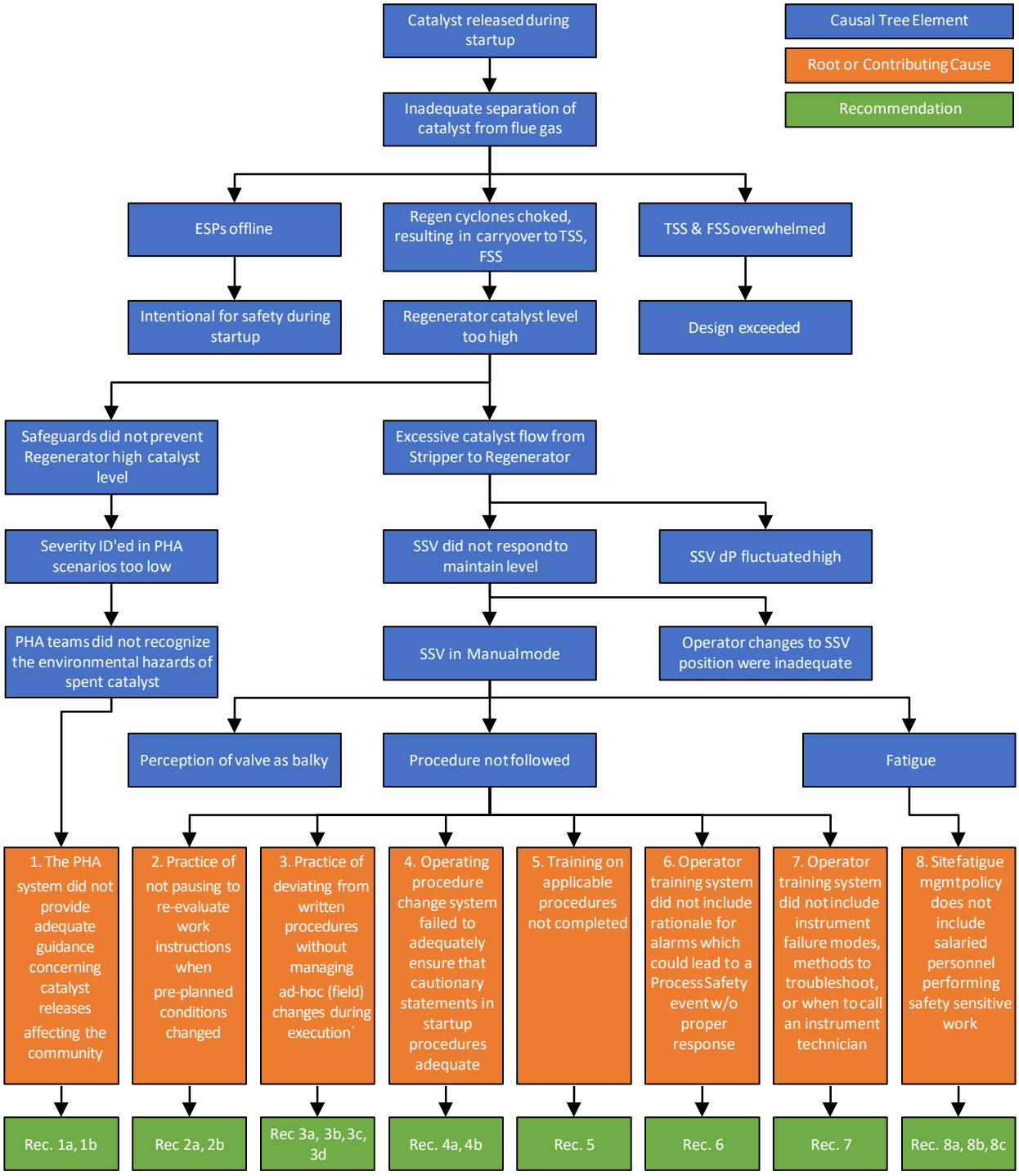

Figure 2: Causal tree of November 24-25, 2022, Catalyst Release Incident

Evaluation of PHA scenarios as "No Action Required": Long before this incident, two separate process hazards analyses (PHAs) had been conducted. Each considered causes that could lead to catalyst carryover: the Shell Oil Products CCU PHA in 2018, and the MRC/PBF CO Boilers PHA in 2022. Each PHA team identified scenarios with a potential for a severity two (2) environmental consequence (meaning, minor or no lasting environmental effect, a quantity of release requiring agency notification, or short duration remediation). After evaluating the 2022 catalyst release, CCHHMP determined that the event was a Community Warning System (CWS) Level 2 or higher MCAR due to the need to clean up the released catalyst. The Shell and MRC/PBF systems assign a consequence category of 3 if environmental cleanup is required.

Stripper SV not in Auto for feed re-introduction: Operating procedures call for the Stripper SV to be placed in Auto before introduction of feed. Additionally, an Engineer had earlier advised personnel not to put the feed in until the SSV was in Auto, not to introduce feed unless the valve could be run in Auto, and if it couldn't be managed then to call out an Instrument Tech. The valve was placed in Auto at 04:45 on November 24 while catalyst circulation was being established. However, at 06:29, together with a procedural step to adjust Regenerator and OHA pressures for correct dP's across the SV's, the Stripper SV was placed in Manual. Process data shows that the condition requiring the Stripper SV to be placed in Manual was resolved by 07:30, at which point it should have been placed back in Auto. However, the SSV remained in Manual until 23:25, well after the release began. Instead of operating in Auto per procedure, personnel manually adjusted the SSV position in response to process conditions.

According to the same Engineer, if the SSV had been in Auto mode according to the procedure, there may have been a brief period in which catalyst circulation stalled, but the regenerator level would not have gone high, and therefore the release would not have occurred.

Practice of accepting excessive deviation from procedures: In discussions with MRC's operating and professional personnel, it was learned that the refinery broadly expects Operators to address process problems by using their training to operate the process however they feel necessary to achieve operational objectives. By contrast, good operating practices would define clear expectations on how the process should be operated and what transient changes could be made in the field. Any changes beyond those limits should be evaluated and approved at the appropriate level. MRC personnel investigating this incident focused on personnel operating the SSV too slowly, rather than on the fact that they did not follow either the procedure or the verbal feedback about operating in Auto that were given prior to feed re-introduction.

Procedures exist to drive consistency in performance and to identify the safest way to operate. Therefore, if automatic controls are specified, it is because that is the safest way to operate. Automatic controls are not perfect, though. Sometimes personnel must take manual control. For example, if automatic controls are overreacting or reacting too slowly, manual control would be used to correct the situation. Once the situation is corrected, personnel need to restore automatic control as soon as possible. Or, if the problem with automatic control is more serious, personnel need to bring in an Instrument Technician or Engineer to troubleshoot and correct the problem. And if the procedure needs to be changed during execution, there is a process by which the proposed

"redlined" changes are analyzed and approved by the Process Engineer and possibly others. During this incident, none of these actions occurred.

It's worth noting that the reason for operating the SSV in Auto was not given in the feed reintroduction procedure (CCU-1110), nor in the CCU Unit Console Operator Task Training Workbook Rev. 1. Lacking a specific written basis regarding the rationale for needing the SSV in Auto prior to the introduction of feed, and with a "tribal belief" that the SSV was unreliable ("sticky and balky"), the valve was not returned to Auto prior to the introduction of feed to the RR. It is not known how personnel came to view the SSV as sticky and balky, even though instrument data indicate that it worked adequately. This view was broadly held.

The failure to ensure the SSV was in Auto before introducing feed is a deviation from procedures that had a direct causal link to the incident. Several other deviations from procedures (discussed in section VI.C) served as distractions to personnel and therefore contributed to the incident.

Inadequate training of personnel: MRC policy requires that prior to executing infrequently used procedures, personnel must receive "just-in-time training," as specified in a note in the CCU Console operator training workbook[11]. This training is needed to familiarize operators with the challenges they are likely to encounter while executing the procedures and how to respond if those challenges should arise.

Since the publication of version 1.2 of this report, MRC has stated that training on this procedure is included in the refresher training that is conducted every three years (i.e., not "just-in-time" as specified in the training manual). At the time of the catalyst release, the CCU Console was being operated by the Production Specialist and a Shift Supervisor. While the Specialist certainly had deep knowledge of all aspects of CCU operation, that individual did not routinely run the CCU and a corresponding refresher training record for that person was not provided to inform this investigation. The Shift Supervisor became qualified as a CCU console operator in 2018 but subsequently was promoted to Shift Team Leader. That individual's training records were quite extensive but did not document either Just-in Time training or CCU console operator refresher training in the past three years.

Excessive work hours for key personnel: For each refinery unit, MRC recognizes key personnel as Specialists due to their experience and deep knowledge. These individuals are highly respected by other refinery personnel and management. Specialists believed that they had to be "superheroes," coming to the rescue to resolve any difficulty that arose in their units.

[11] *"Just-In-Time" Training: Any procedure that is used infrequently (would not be expected to be used at least once a year) will be trained "just-in-time." Just-in-time training is usually associated with operating procedures that are used for special events like normal startups & normal shutdowns for scheduled turnarounds, temporary operations, non-routine tasks, non-routine maintenance events, project work, etc. Just-in-time training would only be required for those individuals that would be involved in the execution of the procedure. Any operator using a procedure that requires just-in-time training will be trained to a Skill Level (as described above) to assure the operator 1) understands their responsibilities with the procedure and 2) can safely execute the procedure as written prior to starting the procedure activities.*

When the initial Air Blower trip occurred, a CCU production specialist began working extremely long hours. Each day, the specialist worked 22–25 hours straight, went home for a short rest, then worked another 22–25 hours, repeating this pattern until the CCU reintroduction of feed process was complete. The specialist's excessive hours in performing the safety-sensitive work would have been against refinery fatigue policy G(A)-34[12], but it applied only to hourly personnel. Additionally, the policy focuses more on equalizing overtime than on fatigue management.

On the night shift of November 24, this individual decided to work the control board alongside the two personnel required to perform the feed reintroduction procedure. Including an additional person as a console operator blurred console responsibilities, contributing to the temporarily overlooked FSS high-high dP alarm. The Production Specialist operated the controls for the WGC, leaving the rest of the CCU to another individual. The Production Specialist directed this other Operator to avoid flaring and not ask for additional propane for the WGC. The Specialist also reinforced that the SSV should be kept in Manual and moved in small increments. Later, when the Operator realized that they had missed the FSS high-high dP alarm, the Specialist told them they hadn't missed it, when they clearly had.[13]

The excessive work hours of this individual between November 21 and 24 was not unique to this individual. In discussing this situation with a MRC representative, it was disclosed that after the catalyst release incident, refinery leadership intervened to prevent another refinery specialist from working excessive hours. As described by this representative, this second specialist was reported to have taken this intervention as a criticism.

There are several reasons why the Production Specialist may have deviated so far from operating procedure and didn't heed the Engineer's advice to keep the SSV in Auto and contact the instrument technician if it could not be run that way. Fatigue played a role in these decisions. That fatigue resulted from the specialist's perception of needing to personally be involved in resolving every difficulty. In addition to fatigue, the Production Specialist was faced with multiple distractions due to the concurrent operational changes. Meanwhile, although they were tasked with performing complex, non-routine start-up procedures, neither was a regular Console Operator. And finally, there are no records that the Specialist (or the other Console Operators) completed the required just-in-time training. It would be appropriate, in the face of these factors, to have paused reintroduction of

[12] The Refinery Scheduling and Hours of Service Limits Policy G(A)-34 (referred to here as the fatigue policy policy), places strict limits on working more than 14 hours consecutively and limits unavoidable workdays longer than 18 hours. The fatigue policy is informed by Recommended Practice (RP) 755, published by the American Petroleum Institute (API) to help companies avoid having workers whose abilities and judgements are compromised by fatigue. However, API RP 755 specifically prohibits greater than 18 consecutive work hours, while MRC's G(A)-34 does not.

[13] Note that when an alarm sounds, the console operator can silence the alarm. The alarm notification remains on the alarm screen until the alarm condition is corrected. The alarm will not sound again unless the condition is corrected and then re-occurs.

the feed. The implementation of the refinery stop-work authority policy (or other policy that would address such a situation)[14] did not consider difficulties in running the process in the way intended.

C. Contributing Factors

Distractions: Four deviations from procedures occurred that, although not strictly causes of the catalyst release, occupied personnel's attention, slowing or delaying the manual adjustments to SSV position needed to prevent the release.

- *Operating the WGC spillback valve in manual*: Evaluation has shown that the WGC should have been run in Auto mode, requiring less attention from personnel. The procedure called for the WGC to be run in Auto from the beginning of feed reintroduction. However, this didn't happen until approximately 23:00, 2.5 hours into the catalyst release. It appears that the decision to remain in Manual mode was influenced, at least in part, by the call from Refinery Logistics regarding low propane inventory. That call, in turn, was premature in view of the slow and decreasing consumption of propane by the WGC.
- *Decision that flaring was off-limits*: The flare system is a critical safety system for relieving excessive pressure excursions in the Reactor and MF systems. No Operator wants to rely solely on the activation of a critical safety system to prevent an incident. This is especially true when that critical safety system is a flare (a release of gas) that irks members of the local community. However, operating the controls with the specific aim of avoiding flaring is contrary to procedures and is an added distraction to personnel.
- *Sticky Regenerator Slide Valve*: While this valve rarely needed to be moved, it required periodic adjustment during start-up, and would sometimes stick, requiring operator attention.
- *Coordination with the CGP and MF start-up*: These units tied to the CCU were experiencing additional operational difficulties.

Engineering design: Two engineering designs common to other refinery's CCUs may have helped MRC avoid the incident:

- *Cascade control of the Reactor/Regenerator dP to the Regenerator Pressure Controller*: In MRC's CCU, operators manage this dP by changing the Regenerator pressure setpoint. In similar refineries, the Regenerator pressure control valve setpoint is determined in Cascade[15] from the Reactor/Regenerator dP indication, helping to more consistently control the SSV dP. In 2018, then-owner Shell had planned to implement this control system upgrade during the CCU turnaround, but ultimately decided not to do so.
- *Direct measurement and control of Reactor feed rate during feed reintroductio*n: MRC measures the feed rate to the reactor with a flow meter and controller located upstream of the point of feed diversion. As a result, as feed begins to be introduced, an unknown fraction of the measured flow rate goes to the Reactor, while the rest remains diverted. Without a measurement of flow rate

[14] Feedback received from MRC following report version 1.2 indicates that this scenario would have been covered by a different policy than their Stop Work Policy. Nonetheless, it would have been appropriate to stop/pause work at this time, and that policy, or implementation thereof, did not lead to that decision.

[15] Cascading is a control scheme in which the setpoint for an automatic control is derived from another process variable. As that process variable changes, the controller setpoint automatically adjusts.

during feed reintroduction, it is possible for a larger than intended increment of feed to be introduced. Indirect evidence indicates this may have happened in the 20:00–20:30 time frame, providing personnel with an added challenge in controlling dP and Regenerator level. This was not a causal factor for the catalyst release, however, because if the SSV had been in Auto, it would have responded adequately.

The Holiday: November 24, 2022, was Thanksgiving. While MRC personnel stated that holidays were like any other operating day, this was clearly not the case. Instead of console operators, a Shift Supervisor and a Production Specialist were operating the CCU. MRC personnel denied that personnel were reluctant to call an Instrument Technician or Process Engineer for support when the incident started because of the holiday, but such reluctance would be understandable.

VII. Root Causes, Contributing Causes, and Recommendations

This section summarizes the root causes and contributing causes of the incident and the supporting evidence for these classifications. It also puts forward recommendations regarding safer operations in the future and the priority for addressing these recommendations.

Root and contributing causes are identified in four categories, pertaining to the Process Safety management system (MS), to Engineering Design (ED), or to human factors (HF). Table 2 lists the root causes of the incident along with recommendations for MRC. Table 3 lists the contributing causes, also with recommendations for MRC. Additional recommendations for MRC and for CCHHMD follow the tables.

A priority is suggested for each recommendation, as follows:

- Short term (ST): A recommendation that should be addressed as soon as possible
- Routine (R): A short term recommendation that should be repeated regularly so that the refinery continues to follow the recommendation over time.
- Long range (LR): A recommendation in which work should be started in the short term but can be expected to take time to implement across the refinery
- Next Turnaround (NT): A recommendation which should be addressed as part of the next CCU unit turnaround.

Table 2: Root Causes and Recommendations for MRC

#	Type[16]	Root Cause	Evidence	Recommendations	Priority[17]
1	MS	The PHA system did not provide adequate guidance concerning how catalyst releases affect the community.	PHA scenarios evaluated in the 2018 CCU PHA and the 2022 COB PHA related to this incident were classified as consequence severity two (2), rather than consequence severity three (3); as a result, additional mitigation measures were not recommended.	a. Clarify scenario consequence assessment guidance in corporate risk assessment policy to provide more accurate guidance regarding environmental consequences of catalyst releases.	ST
				b. Review relevant refinery PHAs for similar scenarios where environmental consequences of PHA scenarios may be underestimated.	ST
2	MS	MRC's policies/programs did not lead workers to pause to re-evaluate work instructions when pre-planned conditions changed (lack of situational awareness, gap(s) in Stop Work or other appropriate policy/program did not address).	MRC proceeded with non-normal startup: • on a holiday • with technical personnel who are not normally console operators • some of whom didn't complete required just-in-time training • while operating multiple dynamic process conditions in manual control • with multiple operational challenges and while executing a complex, non-routine procedure • with highly fatigued key personnel • while addressing other distracting and challenging factors	a. Add consideration of situational factors to Pre-startup Safety Review/Prepare to Operate instructions in refinery start-up procedures.	ST, R
				b. Update stop-work policy/program or other appropriate policy/program and associated training to include evaluation of complex situations in non-routine work.	ST, R

[16] ED = Engineering Design, MS = Management System

[17] LR = Long range effort which should start soon but can be expected to continue, NT = Next Turnaround, R = Routine, ST = Short Term

Table 2 (Continued): Root Causes and Recommendations for MRC

#	Type[18]	Root Cause	Evidence	Recommendations	Priority[19]
3	MS	A practice existed of deviating from written procedures without managing ad-hoc changes (i.e., making "redline" field changes which include review and approvals).	• MRC's MCAR investigation focused on adequate control of SSV in Manual, instead of why SSV was operated in Manual when the procedure and training said it should be in Auto. • Procedure also was not followed for WGC control and feed reintroduction.	a. Review and revise the site procedure for managing operating procedure changes made during procedure execution (i.e., "field changes") as needed to ensure that the means for 'redlining' changes, ad-hoc review, approvals, and training for subsequent shifts are addressed.	ST
				b. Affected personnel are educated as needed for compliance.	
				c. That the system provides prompt review and revision of executed procedures to incorporate approved changes.	
				d. That the system includes metrics which provide management oversight of adherence to written procedures.	
4	MS	The operating procedure development and change system failed to adequately ensure that cautionary statements in the startup procedure were adequate.	The operating procedure to Startup from Unplanned Feed Outages (CCU-1110) did not address the rationale and importance of operating the SSV in Auto during feed introduction to prevent high regenerator catalyst level.	a. In the operating procedure development and change system, review criteria for the use of cautionary statements prior to critical procedural steps. Revise the procedure review checklist to confirm that cautionary statements are included when appropriate.	ST
				b. Update operating procedure CCU-1110 to include a caution statement explaining the rationale for ensuring that the SSV is in Auto mode when feed is introduced to the RR.	ST

[18] ED = Engineering Design, MS = Management System

[19] LR = Long range effort which should start soon but can be expected to continue, NT = Next Turnaround, R = Routine, ST = Short Term

Table 2 (Continued): Root Causes and Recommendations for MRC

#	Type[20]	Root Cause	Evidence	Recommendations	Priority[21]
5	MS	Gaps in training program: Either the training program did not ensure that just-in-time training was being completed as prescribed, or gaps in CCU console operator refresher training.	• There is no record to document completion of just-in-time training on an infrequently used procedure (CCU-1110) by personnel involved with performing the procedure. • There is no record of 3-year refresher training for individuals running the CCU on the 11/24 night shift	a. As appropriate, modify the training management system to ensure that "just-in-time" training for this and other relevant procedures is conducted (per the CCU Unit Console Operator Task Training Workbook and other refinery task training workbooks,) or to ensure that 3-year refresher training is provided to all personnel who will operate relevant processes. b. Correct or clarify the text referring to Just-in-Time training in the CCU Console Operator Training Manual, if appropriate.	ST

6	MS	The operator training system did not include rationale for process alarms which could lead to a process safety event without proper operator response.	• The CCU Console Operator Task Training Workbook did not address the following:
			  ○ The rationale and importance of maintaining the regenerator catalyst bed level below 30 feet
			  ○ The rationale and importance for the high-high dP alarm on the FSS, particularly when the ESPs are de-energized.
			• Personnel involved in starting up the CCU did not recognize the potential catalyst release as serious; thus, they were merely dealing with the symptom of high-high dP on FSS.
				Develop or update the criteria for operator training and conduct a review of materials to ensure that the basis for each alarm involved as a safeguard in process PHA scenarios is included in the training materials.	LR

[20] ED = Engineering Design, MS = Management System

[21] LR = Long range effort which should start soon but can be expected to continue, NT = Next Turnaround, R = Routine, ST = Short Term

Table 2 (Continued): Root Causes and Recommendations for MRC

#	Type[22]	Root Cause	Evidence	Recommendations	Priority[23]
7	MS	The operator training system did not include the information needed to understand how instruments fail, simple troubleshooting methods, and when to call an instrument technician.	Personnel involved in starting up the CCU incorrectly believed the SSV (and other instruments) to be sticky and balky yet did not call out an instrument technician to resolve the balky valve.	Standardize the approach for response to malfunctioning instrumentation and educate affected operations personnel. Address basic types of instruments, how they malfunction, simple troubleshooting methods, instrument criticality, when to ask for instrument technician assistance. Include a reference to the MRC program for bypassing a safety device.	ST
8	MS	The site policy for managing fatigue does not include salaried personnel performing safety sensitive work.	• The intent of the fatigue policy is to "distribute overtime as equally and as reasonably practical among eligible employees while remaining in compliance with company and legal requirements limiting hours of service." • The fatigue policy does not apply to non-hourly personnel, even for safety-sensitive work. • A non-hourly individual working the CCU console during startup worked significantly more than fatigue management requirements prescribed in the fatigue and scheduling policy. • The non-hourly individual's excessively long shifts continued unchallenged throughout the incident.	a. Modify the fatigue and scheduling policy to include both all hourly and all salaried personnel performing safety-sensitive activities.	ST
				b. Educate affected individuals who weren't previously covered by the policy.	ST
				c. Provide leadership oversight of fatigue policy, supported by relevant metrics.	ST

[22] ED = Engineering Design, MS = Management System

[23] LR = Long range effort which should start soon but can be expected to continue, NT = Next Turnaround, R = Routine, ST = Short Term

Table 3: Contributing Causes and Recommendations for MRC

#	Type[24]	Contributing Cause	Evidence	Recommendations	Priority[25]
1	ED	Personnel had difficulty managing the dP between the Reactor and the Regenerator during CCU startup.	This contributing cause is documented in operational data from startup performed in November 2022.	Consider upgrading the control scheme of Reactor/Regenerator dP to Cascade control of the Regenerator pressure setpoint.	NT
2	ED	Lack of flow indication of feed to the RR increased the difficulty of managing the WGC suction pressure / Reactor pressure / SSV dP.	This contributing cause is documented in operational data from startup performed in November 2022.	Consider adding a flow meter to inform operators of actual feed flow rate to the RR.	NT

[24] ED = Engineering Design, MS = Management System

[25] LR = Long range effort which should start soon but can be expected to continue, NT = Next Turnaround, R = Routine, ST = Short Term

Additional Recommendations to MRC

The system that MRC used to manage fatigue, Policy G(A)-34, did not specify how to monitor performance of a fatigued individual, or the means to ensure that performance was monitored. The exceedance form reviewed in this investigation merely indicated "Increased monitoring," and there was no means of indicating that this was done. The following changes to this policy are recommended:

- Update Attachment B, *Critical Exceedance Form* for fatigue management, to clearly identify the nature of the exceedance.
- Specify in the policy specific management actions to be used monitor the performance of the fatigued individual to prevent mishap.
- Require documentation that the required management actions were conducted.

VIII. Review of MRC's Investigation Report and Status of Action Plan

MRC delivered their investigation report to CCHHMP on February 3, 2023. In the report MRC, identified two root causes and one contributing factor, along with a Human Factors analysis, and presented eleven corrective actions. In this section the MRC report is reviewed, taking into account the information assembled through the independent investigation. MRC also included in their report an analysis of their incident reporting. MRC's reporting of this incident was outside the scope of this independent investigation and therefore is not discussed here.

In general, this investigation found that MRC's MCAR investigation did not identify root causes. That is, MRC did not identify the management system gaps or failures. While the corrective measures described by MRC were generally in the right areas, their failure to identify root causes resulted in proposed corrective measures that fell short of correcting the management system gaps.

MRC's Root Cause 1[26]: *As the Reactor pressure increased, the set point changes to Regenerator pressure control valve PV-171 were being made manually and did not effectively offset the increased Reactor pressure and the resulting flow of catalyst from the Reactor and Stripper into the Regenerator.*

Analysis: The result of this investigation shows that manual adjustment of control valve PV-171 may have been a contributing cause. If this valve's control system had been designed according to common industry practice and operated in the appropriate mode, it would have helped prevent the incident.

MRC's Root Cause 2: *As the Regenerator catalyst bed level increased, the changes to the position of the Stripper slide valve were being made manually and were insufficient to prevent the Regenerator catalyst bed level from continuing to increase.*

Analysis: This investigation found that the Stripper slide valve was supposed to have been placed in Automatic prior to the first reintroduction of feed. However, it remained in Manual in the time leading up to the incident and for several hours into it. If it had been operated in Automatic, the incident would not have occurred. Therefore, while it may have been possible for personnel to have made

[26] This and the other root causes, contributing causes, and human factors were excerpted from MRC's MCAR report.

more aggressive changes to the valve position to control Regenerator catalyst bed level, the root cause was the deviation from the procedure by not operating the valve in Auto.

MRC's Contributing factor: *During the re-introduction of feed to the CCU, the Wet Gas Compressor (WGC) was near surge conditions and required the injection of propane into the Main Fractionator (MF) Overhead Accumulator to increase the molecular weight of the gas and prevent flaring. The MF overhead pressure, which ultimately controls the Reactor pressure, could not be reduced to help balance Reactor and Regenerator pressures because of low propane inventory in the refinery.*

Analysis: The result of this investigation showed that the propane situation may have been somewhat of a distraction to operating personnel.

MRC's Human Factor Analysis: *This analysis [MRC's's MCAR Report] revealed two (2) instances in which MRC personnel did not comply with refinery policy and procedure during the incident. First, there was a deviation from the refinery's Work Schedule Expectations for Staff (Exempt and Non-Exempt) policy regarding an individual who exceeded his hours limitation. Second, some End of Shift Reports were not properly completed pursuant to the refinery's Roles and Responsibilities SOSO procedure.*

However, it was concluded that these deviations do not appear to have directly contributed to the root causes of the incident because the individual who exceeded his hours limitation was not directly involved in the pressure and catalyst bed regulations discussed above.

Analysis: This investigation determined that one worker was so far in excess of hours-of-service requirements that it was almost inevitable that bad decisions would be made. This worker did not have direct control over the SSV but sat next to and was a significant influence on the worker operating those controls. This individual was in a role that was not covered by the refinery fatigue policy G(A)-34. As such, this investigation found root causes in the refinery's Work Schedule Expectations for Staff policy.

The absence of end of shift reports was confirmed in this investigation. While it does not appear to have been a root cause, the lack of reports hindered the investigation and represents a lack of operational discipline that may carry into other activities.

MRC's Corrective Action No. 1: *Based on the learnings from this incident, develop a control strategy for automating the differential pressure control between the Regenerator and Reactor during startup and feed re-introduction.*

Analysis: The control strategy envisioned by MRC for this scenario would bring MRC's CCU up to date with common industry practice. If the update control strategy from this corrective action had previously been implemented, it would have helped prevent this incident.

Status of MRC's Action: As of July 31, 2023, MRC had developed the strategy, and plans to implement it during the 2025 turnaround. It was also learned that this modification was planned by Shell for the 2018 turnaround but was deferred for economic reasons.

MRC's Corrective Action No. 2: *Based on the learnings from this incident, CCU Operator alarm actions for Regenerator/Reactor differential pressure and Regenerator catalyst bed level will be updated to provide additional alarms and response guidance to MRC personnel in the event of such alarms.*

Analysis: This investigation recommends providing additional response guidance for alarms, especially the FSS high-high dP alarm.

Status of MRC's Action: As of July 31, 2023, MRC stated that the response guidance for these alarms had been added to the console.

MRC's Corrective Action No. 3: *Based on the learnings from this incident, develop additional operator training on steps to take to address high Reactor/Regenerator differential pressure as well as high or low Regenerator catalyst bed level.*

Analysis: As described in section VI.B., this investigation found that MRC had a practice of deviating from procedures. MRC's Corrective Action No. 3 supports that finding. While this finding is necessary, it is more important to reinforce through training the importance of following procedures, the need to return controls to Auto after correcting process deviations in Manual, and the need to evaluate and approve redline changes to procedures.

Status of MRC's Action: As of July 31, 2023, MRC stated that the training materials were developed. As of November 13, 2023, training was in progress.

MRC Corrective Action No. 4: *Based on the learnings from this incident, modify Operating Procedure CCU-1110 and other relevant procedures to provide additional instructions on when to put the Stripper slide valve into level control to regulate the flow of catalyst to the Regenerator.*

Analysis: The procedure as it existed on November 24, 2022, did specify when to put the SSV into level control. It was learned in this investigation that Corrective Action No. 4. was intended to mean that additional explanation of the rationale for placing the SSV in Auto level control should be provided in the procedure. This is consistent with Root Cause 4 of this investigation, which also recommends a broader evaluation of procedures across the refinery to review, and if necessary, define criteria for when cautionary statements are required.

Status of MRC's Action: As of July 31, 2023, MRC stated that warnings were added to procedure CCU-1110, with the added requirement that if the SSV cannot be put in Auto, approval of either of two (2) supervisors was required to run in Manual.

MRC Corrective Action No. 5: *Based on the learnings from this incident, evaluate options to increase the molecular weight of wet gas sent to the WGC during CCU startup and feed re-introduction.*

Analysis: This is a worthwhile option to consider for various operational reasons. However, this investigation concluded that propane limitation did not affect WGC operation during this incident, other than through being an added distraction.

Status of MRC's Action: As of July 31, 2023, MRC stated that the inventory requirements of procedure C(A)-20 had been updated. As of November 13, 2023, a strategy for using butane as an alternative to propane was in the engineering evaluation stage.

MRC Corrective Action No. 6: *Based on the learnings from this incident, reiterate to MRC personnel the expectations and requirements to comply with the refinery's Work Schedule Expectations for Staff (Exempt and Non-Exempt) policy.*

Analysis: This investigation concluded that the refinery fatigue policy addressed only hourly workers, even though some salaried workers do perform safety-sensitive work, such as occurred in this incident. Root Cause 8 of this investigation provides deeper recommendations, one of which is covered in MRC Corrective Action No. 8.

Status of MRC's Action: As of July 31, 2023, MRC stated that the policy was updated. As of November 13, 2023, training was being implemented.

MRC Corrective Action No. 7: *Based on the learnings from this incident, reiterate to MRC personnel the expectations and requirements to complete End of Shift Reports and audit to ensure compliance with the refinery's Roles and Responsibilities SOSO [sic: Start of shift operations] procedure.*

Analysis: This certainly should have been happening, and the missing day shift report made this investigation more challenging. While the missing report did not appear to have a direct or indirect impact on this incident, it reflects a potential issue that should be addressed, for example by management tracking the metrics related to End of Shift Reports.

Status of MRC's Action: As of July 31, 2023, MRC stated that this had been reiterated to personnel and that a new required learning module on this topic had been implemented.

MRC Corrective Action No. 8: *Based on the learnings from this incident, develop additional tools to increase the effectiveness of oversight of staff employee work schedules and fatigue management.*

Analysis: This corrective action goes hand-in-hand with MRC Correction No. 6 and this investigation's Root Cause 8. Having better tools is helpful, but the tools must be routinely used by refinery leadership to manage compliance with the fatigue management policy.

Status of MRC's Action: As of July 31, 2023, MRC stated that the reporting tool had been implemented.

MRC Corrective Action No. 9: *Based on the learnings from this incident, add an indication of the CCU FSS pressure differential to the Utilities Console with the appropriate alarm and response guidance to MRC personnel to better assess the potential for release.*

Analysis: This would help increase awareness of a potential catalyst release. Additionally, actions for CCU operations personnel to take when this alarm sounds on the CCU Console should be defined.

Status of MRC's Action: As of July 31, 2023, MRC stated that the indication had been added.

MRC Corrective Action No. 10: *Based on the learnings from this incident, update the MRC community monitoring procedures to include activation and MRC personnel response for defined opacity events.*

Analysis: This investigation concluded that the high-high dP condition in the fourth stage separator should be one trigger for community monitoring.

Status of MRC's Action: As of July 31, 2023, MRC stated that the procedure was updated. A copy of the updated procedure was provided to the investigators and verified on November 13, 2023.

MRC Corrective Action No. 11: *Based on the learnings from this incident, evaluate Operating Procedure CCU-1110 and other relevant procedures to determine if the ESPs can be safely activated in the CCU startup process.*

Analysis: Even if MRC's ESPs had been operating at the time of the incident, the quantity of catalyst released would not have been substantially reduced. Furthermore, because of the 2006 Shell-affiliated FCC Unit incident and the 2015 ExxonMobil Torrance incident, both of which involved HC flowing into an ESP during shutdown/startup and resulting in explosions, the refining industry has determined that it is important to deactivate ESPs during shutdown and startup procedures to preventing similar incidents.

Status of MRC's Action: As of July 31, 2023, MRC concluded that it was important to continue following industry guidance, which continues to recommend against this.

Appendix A: Scope of Work

The focus of this report is the events leading up to the release of catalyst (in the form of a white powder) into the City of Martinez sometime between 20:00 on November 24, 2022, and 04:00 on November 25, 2022. Within the refinery, the scope includes the CCU, the COB unit, and the bulk propane storage facility, as well as the oversight and support functions for these units located elsewhere in the refinery.

The scope of this investigation excluded reporting by MRC of the release of catalyst to the relevant agencies, as this is being handled via other channels.

The information and conclusions described in this report were obtained through:

- Review and analysis of documents and data provided by the refinery
- Interviews of employees directly running the CCU at that time
- Interviews of other refinery employees who oversaw or supported CCU operations
- Experience in Process Safety and refinery operations of the investigators

Most of the interviews were conducted on the MRC site, in the presence of the refinery attorney and outside counsel representing the individuals being interviewed. Nonetheless, the scope of this investigation focused on identifying causes related to Process Safety management systems and intentionally avoided assigning blame to any individual.

Appendix B: Investigation Team Makeup

The independent investigation team included Scott Berger, President of Scott Berger and Associates, LLC. Working with Tim Mullowney, Founder of Petrochor, LLC under subcontract. Their distribution of labor during the investigation is shown in table 4.

Table 4: Investigation Team Members and Roles

Role	Performed by
Team Leader	Scott Berger
FCC Process Operator	Tim Mullowney
FCC Technology Expert	Tim Mullowney
Process Engineer	Scott Berger
Process Safety Specialists	Both
Human Factors Specialists	Both
Mechanical Integrity Specialist	Tim Mullowney

Scott Berger, CCPSC has forty-five years of experience in process safety, environment, health, and safety (EHS) management, chemical engineering, chemical manufacturing, process engineering, and human factors. Since 2015 he has worked as a consultant in process safety with focus on process safety leadership, process safety management systems, training for basic process safety competency, incident investigation, and litigation support. During this period, he also co-authored three books on process safety for the Center for Chemical Process Safety (CCPS), *Driving Process Safety Improvement from Investigated Incidents, Process Safety Leadership from the Boardroom to the Frontline,* and *Essential Practices for Creating, Strengthening, and Sustaining Process Safety Culture.*

From 2001 to 2015 he served as Executive Director of CCPS. He is a CCPS-Certified process safety professional (CCPSC), a Fellow of the American Institute of Chemical Engineers, and a Fellow of the Center for Chemical Process Safety.

Tim Mullowney has more than thirty-five years of broad experience in oil and gas, production, refining, and process safety. Following twelve years operating a Fluidic Catalytic Cracking unit (console and field) and other processes, Tim worked in the Mechanical Integrity / Reliability group, and for three years was responsible for the site Incident Investigation program where he began leading major investigations. His final roles at Phillips 66 were in the corporate HSE group where he was Process Safety Director and Senior Process Safety Consultant, roles which included responsibility for the global refining incident investigation program.

He founded Petrochor, an independent process safety consulting firm, in 2017. His practice includes development of process safety management systems for refining companies, providing a variety of process safety competency trainings, risk assessments, and incident investigations.

Appendix C: Discussion of Wet Gas Scrubbers vs. Electrostatic Precipitators Functionality During Process Startup Application in Fluid Catalytic Cracking Service

Electrostatic precipitators (ESPs) have become a common tool for preventing the emission of any catalyst fines that have not already been removed and recovered by the cyclones and separators used to clean CCU Regenerator flue gas. In general, ESPs work well and are quite reliable. The primary challenge of operating any ESP is to prevent flammable vapors from flowing to them, because these vapors are a potential source of ignition. It is also important to keep flammable vapors out of the Regenerator; the measures that accomplish this also keep flammables out of the ESP.

The ExxonMobil Torrance ESP explosion in 2015 demonstrated how some abnormal, upset conditions can lead to hydrocarbon vapors reaching the ESP and causing an explosion. Learning from Torrance, companies across the industry now provide for automatic de-energizing of ESPs during upsets. Feed diversion, such as occurred at MRC on November 21, 2022, is one example of how this works. Refineries do not re-energize their ESPs until the CCU is back to full, stable operation.

An alternative to the use of ESPs for controlling catalyst emissions, is to install wet scrubbers. Like ESPs, wet scrubbers are designed to remove catalyst fines at the rate of pounds per hour. These have the advantage of not providing an ignition source, and therefore can be left running during times when ESPs cannot. A properly designed wet scrubber system would prevent the high opacity condition that occurs during times the ESP has to be de-energized. Wet scrubbers are used in a few refineries, but they have several potential drawbacks. They occupy a large footprint, so many refineries don't have space in which to locate them. They also can be large consumers of water, which is in limited supply in many areas.

More importantly, a wet scrubber designed to handle the same emission load as an ESP (pounds per hour) would be equally ineffective in addressing the overload conditions (many tons per hour) experienced in this incident. As noted earlier in this report, even if MRC's ESP had been in service during the catalyst release event on November 24-25, 2022, the release would have overwhelmed the ESP's capacity. Similarly, if MRC had been using a wet scrubber instead of an ESP during the November 24 incident, the wet scrubber would also have been overwhelmed, and the quantity of release would have been reduced only slightly.

Appendix D: Glossary

Term	Definition
AIChE	American Institute of Chemical Engineers.
API	American Petroleum Institute; a trade and standards organization supporting the petroleum industry.
Automatic (Auto)	A control mode where a component (e.g., a valve) is automatically adjusted to maintain a process parameter (e.g., a level) at a set value.
C(A)-20	A policy of MRC that controls minimum and maximum inventory levels of products, by-products, and intermediates.
Cascade	A control mode in which a controller set point is obtained based on some other process variable or condition.
Causal factors	A factor that contributed to the incident, and that, if eliminated, would have prevented the incident or reduced its severity or probability.
Causal Tree	A diagram used to determine root causes; in general, causes lower in the tree drive events higher in the tree, leading to the incident (top event).
Catalyst	For the CCU process, a proprietary material that facilitates the chemical reactions that "crack" large hydrocarbon molecules into smaller ones.
Catalyst Stripper	A section of the CCU Converter where hydrocarbon is removed from catalyst with steam.
CCHHMP	Contra Costa Health Hazards Materials Programs.
CCPS	Center for Chemical Process Safety; a global technical organization operated by AIChE that supports the petroleum, chemical, and related industries with guidance and training for managing Process Safety.
CCU	Catalytic Cracking Unit; a grouping of refinery equipment that converts (cracks) high molecular weight hydrocarbons into hydrocarbons with lower molecular weight.
CCU-1110	The procedure used by MRC to re-introduce feed to the CCU.
COB	CO Boiler; a boiler in which carbon monoxide in the Regenerator flue gas is oxidized to carbon dioxide, reducing the toxicity of CCU emissions and producing heat that is used to generate steam.
Console	A group of computer screens and keyboards used to control the process and monitor process conditions and alarms.
Contributing cause	A factor that contributed to the incident.
CWS	Community Warning System, an all-hazards community notification system of Contra Costa County, intended to alert residents about any potential health hazards and emergencies that may be occurring.

Term	Definition
Cyclone	A conical device that separates particles from air streams by a swirling action that pushes the particles to the wall and then down to the bottom of the cone, while cleaner air exits the top.
Day shift	Work hours starting 06:00 and ending 18:00.
dP	Differential pressure; the difference between the pressures as measured at two different points.
ESP	Electrostatic Precipitator; a pollution control device that uses static electricity to remove small particles from process exhausts.
Feed	Feed of uncracked hydrocarbon to the CCU. Various uncracked hydrocarbon streams may be fed, depending on production needs. These may include flashed distillates, light, heavy and extra heavy gas oils, and diesel hydrotreater products
Fines	Particles of catalyst that are much smaller than the average particle size.
Flare	A device in which emergency hydrocarbon releases from refinery processes are safely burned in a controlled fashion, generally at a high elevation and far away from occupied areas.
Flue Gas	Combustion gases from the Regenerator.
FSS	Fourth Stage Separator; the fourth stage in a series of devices that remove catalyst fines from the flue gases of the Regenerator.
G(A)-34	MRC's "Scheduling and Hours of Service Limits Policy." The policy by which MRC manages worker fatigue (fatigue policy).
GPM	Gallons per minute.
HC	Hydrocarbons; chemicals made up of carbon and hydrogen.
Hot standby	A phase of CCU operation where feed is diverted, either with or without catalyst circulation.
Human factors	The evaluation of how people interact with equipment, controls, and their work environment.
ISO	The Industrial Safety Ordinance of Contra Costa County.
Management system	Policies, procedures and standards that describe how specific functions are to be carried out, performance is verified, and performance is improved.
Manual	A control mode in which control devices (e.g., valves) respond only to operator input.
MCAR	Major Chemical Accident or Release, as defined by CCHHMP.
MF	Main Fractionator; the column that receives product from the Reactor.
MRC	Martinez Refining Company, a unit of PBF Energy.

Term	Definition
MW	Molecular weight.
NDA	Non-disclosure agreement; an agreement binding two parties to protect each other's confidential business information.
Night shift	Work hours starting 18:00 on one day and ending 06:00 the next day.
OHA	Overhead Accumulator; a tank which receives the two-phase overhead flow from the CCU Main Fractionator (MF). The pressure of the Reactor depends upon the pressure of the MF, which depends on the pressure of this tank.
Opacity	The degree to which visibility of a background (i.e., blue sky) is reduced by particulates, measured either in % or Ringelmann.
Operating procedures	Written, step-by-step instructions and information necessary to operate equipment, compiled in one document including operating instructions, process descriptions, operating limits, chemical hazards, and safety equipment requirements.
Operator	An individual who is trained and qualified to operate a process or some portion of a process.
PHA	Process Hazard Analysis; a study in which process hazards are identified and a wide range of deviation scenarios are analyzed to determine if the unit's safeguards are adequate.
Reactor	A vessel where the catalytic cracking reaction occurs and hot catalyst is disengaged from HC vapor.
Redlined changes	Field changes made during execution of a procedure that have been reviewed and approved by the appropriate personnel.
Regenerator	A vessel in the CCU system in which coke is burned off spent catalyst, reheating catalyst.
Ringelmann	A unit of opacity. 1 Ringelmann is approximately 20% opacity.
Root causes	Gaps in Process Safety management systems, including human factors.
RR	Reactor Riser; the section of the CCU Reactor where the cracking reaction takes place.
Slide valve	A valve that operates by sliding a paddle over an opening to control the flow of catalyst from one vessel to another.
SOSO	Start of shift operations; a procedure with formal reporting used at MRC to handover operations from one shift to the next.
Spillback valve	A valve which routes compressor discharge back to the suction to maintain minimum flow through the machine, preventing compressor surge.
Stripper	A vessel in the CCU system in which residual hydrocarbon is removed from catalyst with steam.

Term	Definition
SSV	Stripper slide valve; the valve which regulates the flow of catalyst from the Stripper to the Regenerator.
Surge	A condition that can exist in centrifugal compressors when they handle a gas lower in molecular weight than they were designed to handle. Surge occurs when the gas being pumped flows backwards around the turbine blades in an oscillating manner. In severe cases the oscillation can result in significant equipment damage and loss of process containment.
Top event	The release event being investigated.
TSS	Third Stage Separator; the third of four devices that removes catalyst from Regenerator flue gases.
Wet gas scrubber	A system where exhaust gases are contacted with water to remove particles and water-soluble gases.
WGC	Wet Gas Compressor; a multi-stage centrifugal compressor designed for condensable hydrocarbons which takes suction on the OHA and increases the pressure of the gaseous vapor allowing it to flow to the Cracked Gas Plant.

Appendix E: Resolution of Oversight Committee Comments

Comments from the Oversight Committee were provided via a Microsoft Excel® table, with spaces provided for the investigators' responses and actions. This table is presented starting on the following page.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
1	Kent Hull	Community Member of OC	My main concern is that the authors state that people should be commended for doing what is expected of them. When is that worthy of a commendation? I feel that establishes that cooperation and honesty are not expected/required and thus the process is flawed.	General Report Comment		In this paragraph, we are thanking the individuals for speaking openly. This intent can be accomplished with the second sentence of this paragraph only.	Deleted the first sentence of page 3, paragraph 3
2	Ben Therriault	Community Member of OC	What is the adherence to procedure and culture. The deviation from standard procedures, especially concerning the Stripper Slide Valve (SSV), appears to be a significant factor. The culture of 'objective-based' operation over strict procedural adherence could be a systemic issue that needs to be addressed.	General Report Comment	These comments were submitted in a single cell. They have been broken up for ease of responding	This comment restates key points of the report and does not appear to request any changes.	None needed
3	Ben Therriault	Community Member of OC	What can be done about training and fatigue management? The report highlights lapses in 'just-in-time' training and issues with fatigue management, particularly in key personnel. How can training be made more effective and adherence ensured? What steps can be taken to avoid overworking, which may lead to critical errors?	General Report Comment		These points were identified in the report as root causes with recommendations for MRC to address.	None needed
4	Ben Therriault	Community Member of OC	The report points out possible improvements in reactor-regenerator differential pressure management and feed flow measurement. How can these technical enhancements be implemented effectively to prevent future incidents? What can be done about communication and alarm management? There seems to be a gap in response to critical alarms and communication during the incident. What measures can be implemented to improve situational awareness and responsiveness during critical operations?	General Report Comment		These points were identified in the report as contributing causes with recommendations for MRC to address.	None needed

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
5	Ben Therriault	Community Member of OC	The report lists root causes and recommendations in categories like process safety management, workplace culture, engineering design, and human factors. How can MRC prioritize and implement these recommendations to mitigate risks in future operations?	General Report Comment	These comments were submitted in a single cell. They have been broken up for clarity in responding	Suggested prioritization was included with all recommendations in this report.	None needed
6	Ben Therriault	Community Member of OC	It's also important to compare the findings and recommendations of this independent report with those from MRC's internal investigation. Are there discrepancies or areas that MRC overlooked?	General Report Recommendations MRCs Recommendations		This is discussed in Section VIII of the report. What may not have been clear was that in general, MRC's MCAR investigation did not identify root causes, and their corrective measures fell short of correcting management system gaps.	Added text to the introductory paragraphs of Page 22, Section VIII explaining this.
7	Ken Axe	PBF	I spoke with both operations support engineers on December 14, and neither gave this instruction. See series of comments on topic 2 starting on page 12.	Page 6 (CCH will provide word document received from PBF as well for all of Ken Axe's comments)		This comment was recorded in Tim Mullowney's notes from a meeting with an engineer that occurred on 9/25/2023. Version 1.2 erred in stating that this engineer was an operations support engineer. In verbal comments at the oversight meeting on 2/1/24, a PBF representative also noted that "instructions" come from operating supervision, not engineers.	Changed "unit process engineer" to "an engineer" on page 8, section D, paragraph 1. Changed "instructed" to "advised" on page 8, section D, paragraph 1. Note that this comment was repeated in lines 11 and 14, applying to different parts of this report. The same changes were made in each location.
8	Ken Axe	PBF	Series of Xs and ? Over causal tree elements (all xs see word doc) and root/contributing causes numbers 1,2,3,5 (x) and 4,6,7 (?)	Page 11		Based on the independent investigation, these causal tree elements are appropriate and need to be retained.	None needed.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
9	Ken Axe	PBF	This is not a root cause, and did not present an opportunity to add IPL's and prevent occurrence of the November 2022 incident. The guide word HAZOP technique does not provide a PHA team with knowledge of consequences that are unknown to them. The 2018 and early 2022 PHA teams were not aware that a catalyst release could result in catalyst deposition in the community. Only after the November 2022 incident were MRC personnel aware of this phenomenon. MRC also learned (anecdotally) after November 2022 that there have been other occasions (four of them) in industry like the November 2022 incident at MRC, resulting in aggregation of catalyst particles and deposition at ground level. The 2023 CCU PHA does take this consequence into account, and does acknowledge the need for additional IPL's.	Page 12 in reference to PHA root caust		The definition of a root cause is "A failure or gap in the process safety management system." This comment acknowledges that the guidance in the management system documents used to guide the 2018 and 2022 PHAs had a gap in recognizing the consequences of this event scenario. It is a proper root cause.	None needed
10	Ken Axe	PBF	Neither operations support engineer (the one on days, or the one on nights) instructed anyone that the stripper slide valve must be in auto: I spoke with both of them on December 14 specifically about this claim, which did not appear in Draft 1.1 of this report. Only one of them spoke with Berger and Mullowney, and she didn't say this to them (Nam and I were present for all interviews).	Page 12 in reference to Stripper Slide Valve root cause		Same comment as line 7	See resolution of line 7 comment and page 12, paragraph 2.
11	Ken Axe	PBF	Operations did not "disregard" the procedure, and the engineer gave no such instruction. Operations placed the valve in Manual in order to control process parameters that it appeared to them were not being sufficiently controlled in automatic. Operators are trained and authorized to do this.	Page 12 in reference to Stripper Slide Valve root cause		The stripper slide valve was placed in manual at 06:29 on 11/24 to address a transient upset. Data trends suggest this transient was resolved by 07:30. At this point, it should have been placed back into automatic.	Added this clarification in 3 places, to emphasize how long the deviation from the procedure lasted. See page 8, Section 2, paragraph 1.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
12	Ken Axe	PBF	MRC does not consider operations to be "objective-based." Nobody at MRC indicated this. This was a label inferred erroneously by Berger and Mullowney, along with all of the presuppositions that come along with their understanding of this label. It is also false to portray this as a feature of MRC's culture.	Page 12 in reference to Culture of deviating from procedures		On three separate occasions, a senior, knowledgeable MRC employee told investigators that operators were trained and authorized (see line 12) as well as expected (see MRC MCAR report Root Cause 2) to use their training to take whatever means necessary to meet process objectives, and to do so without review or oversight. While the specific term "objective-based" was not used by this employee, the actions taken by operators on 11/24/22 demonstrated that they were following this approach. Furthermore, MRC's MCAR report root causes focused on how the operator manually controlled the stripper slide valve (and regenerator pressure control), and not on the long duration of time the procedure was deviated from without evaluation and approval. Note also that MRC's actions to address their self-identified corrective measures included adding review and oversight related to the stripper slide valve to the procedure CCU-1110, which is an acknowledgement by MRC that their oversight of field changes was inadequate.	Edited the text to remove the term "objective based", and added text explaining the good operating practice of defining action limits and properly managing field changes. See page 12, paragraph 4.
13	Ken Axe	PBF	Again, operations did not "disregard" the procedure, and the engineer gave no such instruction.	Page 12 in reference to Culture of deviating from procedures		Same comment as line 7.	See page 14, last paragraph

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
14	Ken Axe	PBF	We agree with this statement. We believe that this is the explanation for the stripper slide valve being in manual, NOT that there is a "culture of accepting deviation from procedures.:	Page 12 in reference to Culture of deviating from procedures		Nonetheless, after the transient condition that required the operator to take manual control of the stripper slide valve was resolved, it was left in manual instead of being returned to auto. Considering that the culture survey will follow this investigation, it is appropriate for "culture" to be replaced by "practice" in this report, and evaluation of culture deferred to the culture survey.	Replaced "culture" with "practice" in discussing this topic. See pages 12, 18, and 24. Changed Root Cause "Type" of "Culture" to "Management System" on pages 16-20.
15	Ken Axe	PBF	Per the training SME, training on the two Hot Standby procedures, CCU-3305 and -3310, as well as reintroduction of feed, CCU-1110, are not administered "just-in-time. CCU-3305 and -3310 are administered as "skill" level refresher training every three years, and CCU-1110 is administered as "awareness" level training every three years. Just-in-time training is applied to *predictably* infrequently used procedures, like those associated with turnarounds. Use of 3305, 3310, and 1110 can come up at any time, and are therefore refreshed every three years.	Page 13 in reference to inadequate training of personnel		The text about refresher training was excerpted from the MRC document indicated in the report. However, if training for feed reintroduction is instead covered in the 3-year refresher training, then the training record of the individual controlling the stripper slide valve shows no refresher training in the last 3 years. Training records we received did not show any training for the fatigued individual.	Expanded text to include both just-in-time and refresher training. Expanded recommendation to correct the gap, whether it was in just-in-time training or in refresher training. Moved text excerpt to a footnote at request of CCHHMP. See page 13, section "Inadequate training of personnel."

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
16	Ken Axe	PBF	Berger and Mullowney spoke with one operations specialist, who did not (and could not) provide a basis for what specialists believe. The operations specialist provided answers to leading questions about "superhero" performance, rather than applying the term to himself or others. It is a reach to infer that responsible, committed subject matter experts indicate a negative aspect of culture. The fatigue issue does not require "superhero culture" as a root cause, and in fact is not depicted that way on the causal tree.	Page 13 in reference to excessive work hours		It is true that we spoke only to one operations specialist. However, while discussing the issue of fatigue management, a PBF SME made a point of telling us that based on MRC's learning from the incident, refinery management had to intervene to prevent another specialist from working excessive hours. In this conversation, this SME used the "Superhero" designation.	Inserted text referencing a second case that a MRC representative described during the investigation. See page 14, paragraph 3.
17	Ken Axe	PBF	I don't recall this statement being made by the "operator," and it was not corroborated by the operations specialist.	Page 14		This came from interviewing the shift team leader who was filling in as operator. As recorded in our notes: STL: "How could I have missed that, [Op spec's name]? Do you remember if I got the alarm? "OS: "Of course you did. I didn't want to bother you. I told the outside operator to drop the cat fines out of the FSS." Since this did not result in a root cause, the original text is suitable.	None needed
18	Ken Axe	PBF	See comments associated with topic 2 on page 12.	Page 14		Repeat of Mr. Axe's comment in line 10.	See resolution of line 7 comment and page 12, paragraph 2.
19	Ken Axe	PBF	Is "almost certainly" a fact, or speculation?	Page 14		Fatigue played a role.	Deleted "almost certainly". See page 14 paragraph 4.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
20	Ken Axe	PBF	Stop work authority applies to situations that "could reasonably result in death or serious physical harm" or are associated with "a process safety hazard." There was not such a situation. MRC has other processes for intervening in other situations, but the operating team did not know that they were having a community impact while it was occurring. The other factors listed here would not necessarily require intervention.	Page 14		Mr. Axe appears to be citing the narrow language of the CalOSHA regulation related to Stop Work Authority. He notes that the refinery has other "processes" for intervening in such situations. In our investigation, we considered a broader definition of Stop Work Authority which would include this situation. Regardless, personnel did not pause work when they should have. If MRC covers this situation in a different policy, then the root cause and recommend would apply to that policy instead. Recognizing that MRC uses the term "Stop Work Authority" in the narrower sense, it is appropriate to clarify the wording of this root cause accordingly. Nonetheless, a release of 24 tons of catalyst fines containing various metal contaminants is a notable event. If it does not meet the definition of a process safety incident, it is at minimum a high potential near miss event.	Added footnote 14 explaining that if this situation is covered by another policy/program, a gap existed in that policy/program instead of in the Stop Work policy/program. See page 15 footnote. Added "or other appropriate policy/program" to recommendation 2b. See page 17.
21	Ken Axe	PBF	"Potentially." Again, fact, or speculation?	Page 14		It is clear from discussion with the console operator, that he was overwhelmed, and he was unaware that FSS HH dP meant a release was occurring.	Removed "potentially" and adjusted remaining text to read well. See page 16, section C, first paragraph.
22	Ken Axe, CCH noted the same comment	PBF	MRC's MCAR report	Page 22, correction of typo		Thank you.	Corrected typo. See page 23, paragraph 3.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
23	Ken Axe	PBF	ISA 18.2 defines alarm floods in terms of annunciation rates. Shelved alerts did not annunciate, but were included in the data, showing adjacent 10-minute totals of 13 and 12. ISA 18.2 also defines alarm floods as annunciation rates "likely to exceed the operator response capability." Total operator response capability is dependent on the number of responding operators. Typically, when rates are calculated, the number of annunciations is divided by the number of responding operators. MRC concludes that alarm flood did not occur.	Page 22 in relation to discussion of MRC action 2		MRC continues to reduce excessive alarms as per ISA 18.2 and this was not a root cause, so the statement was removed	Statement removed. See page 23, analysis of MRC Corrective Action No. 2.
24	Steven Devine	City of Martinez	replace current language to state "chosen by the ISO Oversight Committee" to give credit to that group. NH comment: suggest MRC Oversight Committee instead of ISO Oversight Committee	Page 3	Foreword	Thank you.	Changed to "chosen by the MRC Oversight Committee". See page 3 paragraph 2.
25	Steven Devine	City of Martinez	Consider … "and surrounding areas"	Page 4		Thank you.	Text added. See page 3 paragraph 1 and page 4 paragraph 1.
26	Steven Devine	City of Martinez	Of what? Catalyst or crude oil?	Page 4		The hydrocarbon feed to the CCU.	Added footnote clarifying that this is hydrocarbon feed to CCU. See page 5 footnote 4. Added a description of "feed" to the glossary. See page 29.
27	Steven Devine	City of Martinez	Seems odd to be commenting on the controversial wet gas scrubbers… when the report makes clear other areas in which the firm	Page 4		Evaluating this topic was specified in the scope of work given by the MRC oversight committee.	None needed.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
			is not commenting on… as it would be out of scope.				
28	Steven Devine	City of Martinez	Consider inserting … "theoretical"	Page 5		This report should have used the term "Scenario" instead of "Condition," which has the same meaning in this context as "Theoretical".	Changed "Condition" to "Scenario". See page 6, section V.A., paragraph 1.
29	Steven Devine	City of Martinez	Consider inserting … "theoretical"	Page 5		See line 28	See line 28.
30	Steven Devine	City of Martinez	Crude or Catalyst?	Page 5		See line 26	See line 26.
31	Steven Devine	City of Martinez	What does this mean in layperson terms.	Page 5		Agree that this should be explained.	Added a footnote that explains surge. See page 7 footnote 8.Added a definition of surge to the glossary. See page 31.
32	Steven Devine	City of Martinez	Consider: "Unit Process Engineer"	Page 6		Agree that it is appropriate to capitalize all role titles throughout the report.	Globally capitalized all role descriptions/titles.
33	Steven Devine	City of Martinez	Consider moving "Following this policy" to later in sentence	Page 6		After reviewing this recommendation, we concluded that the original phrasing works better.	No change.
34	Steven Devine	City of Martinez	Consider capitalizing "Production Specialist"	Page 7		See line 32	See line 32.
35	Tom Lang	Community Member	It is a pretty difficult read, and I am not sure that once it is published, a layman will be able to really understand what happened on Thanksgiving of last year. There is a lot of slang and much of the narrative is quite indirect, raising more questions than it answers. The tables and graphics are not instructive, and the table of priorities pretty much has everything as priority one.	General Report Comment		The PowerPoint presentation recommended by Mr. Lang in line 36 was developed, and should help address this comment as well. Based on this comment, we agree that the descriptions of the priorities should be explained better.	Added text clarifying the meanings of the priority designations. Replaced "Priority Implementation" with "Short Term". See bottom of page 16.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
36	Tom Lang	Community Member	I would recommend that when this is released to the public, there should be a PowerPoint with some critical bullets, starting with the general practices (departure from protocols, override of automated settings, superhero culture) and indicating how that led to the key specific technical failures resulting in the release. This should be in simple, easy to understand language.	General Comment		A PowerPoint presentation was developed and presented to the Oversight Committee on February 1, 2024.	PowerPoint presentation will be available through the CCHHMP Martinez Refining web page. The PowerPoint will be updated for the community meetings.
37	Tony Semenza	Community Member	1.There is still the question of why the FCC start-up was being done manually. I have always maintained that a big part of this problem was that the MRC was using non-FCC operators to help in the startup. This goes to the Culture of accepting deviation from procedures discussed on page 12.	Page 12		The report identifies the use of Manual mode counter to procedure, as a root cause and makes appropriate recommendations to correct this root cause.	None needed.
38	Tony Semenza	Community Member	2.Another issue is the superhero culture that seems to be accepted at MRC. I did not find anything addressing this in any of the tables pages 16 thru 20.	Pages 16-20		The superhero “culture” was not itself identified as a root cause. Indeed, strong support of the refinery mission and goals should be a positive. It becomes a problem only when it leads to unmanaged fatigue. The report found a root cause related to fatigue management	None needed.
39	Tony Semenza	Community Member	3.On page 21 MRC's Root Cause 1 analysis seems to say that valve pv 171 that the valves control system is not designed according to common industry practice. If true that’s a serious problem	Page 21		We reached the same conclusion as MRC that if this valve and its control scheme are upgraded, it will be easier to prevent this incident in the future.	None needed.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
40	Nick Plurkowski	PBF USW	Did the Regen Pressure control valve have previous issues of being stuck? Were maintenance records or reports of issues looked into?	General Report Comment		We did receive feedback regarding a number of supposedly "sticky" valves, but we did not find that the Regen pressure valve performance was a root cause of the incident.	None needed.
41	Nick Plurkowski	PBF USW	The mixed message about flaring – I'm not sure I understand the safety aspect of flaring as described, combined with the public outcry against flaring, or what options the Company really has to prevent or plan for flaring. I understand that assuming you cannot flare might lead to a more complicated startup procedure, but shouldn't the procedure be correct? Shouldn't flare minimization be the goal? I don't want operators to get instructions not to use a safety device, but I also don't want it to become a regular thing…	General Report Comment		Agreed. Flare minimization should be the goal, but the flare is an important safety device that should be used when needed.	None needed.
42	Nick Plurkowski	PBF USW	On P.10 in the table between 13:00 on Nov 24 and '20:00-20:30' there is a 'Soon after' line item that is not clear when reading through the details of that on p.6. Basically, p.6 makes it sound like the decision to continue using propane was made, but doesn't describe the conditional approach to the use of propane, due to curtailment.	Page 10		The decision was to continue drawing propane at the same rate, but not any faster, even if needed.	Edited this text to match wording on page 6. See page 10.
43	Nick Plurkowski/ CCH noted the same comment	PBF USW	The footnote on p.13 that continues to p.14 is confusing – could it just fit on one page?	Page 13		Thank you.	Footnote now fits completely on page 13.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
44	Nick Plurkowski	PBF USW	P.14, 1st sentence is misleading as the Staff employee did not complete the 'two personnel' required to perform the feed introduction. It should have been two qualified, hourly, operators.	Page 14		The procedure requires two qualified operators, but does not specify hourly. The relevant issue is training, whether just-in-time training or appropriate refresher training. Evidence of either type of training for the individuals focused on operating the CCU was not found in the investigation.	Training issue clarified in reply to line 15.
45	Nick Plurkowski	PBF USW	P.14, paragraph 2 – last two sentences: -Why isn't the DECISION to continue being challenged? -Stop Work Authority is a worker's last line of defense, we should be challenging the systems and decisions that allow risk to reach the last line of defense	Page 14		Challenging a worker decision, i.e. blaming the worker, is generally inappropriate in an incident investigation. If an operator did not pause or stop operation when appropriate, the root cause lies in how the stop/pause work policy was written, trained, implemented, and/or monitored.	See line 20.
46	Nick Plurkowski	PBF USW	P.15 'The Holiday' The tone of the 2nd sentence: "The console operators who normally would have worked the evening shift took time off, leaving a shift supervisor and a production specialist to operate the CCU. -While this is factually true, I believe the tone of this sentence can be misinterpreted as blame on the workers who took time off, missing the fact that they were approved to take time off and the decision to continue without them was made. Whose decision was it to use the Operations Specialist and Team Leader as board operators? This goes back to #5 above, as well as #6- there was a decision made to go forward	Page 15		We did not in any way intend to suggest workers who took earned time off were to blame.	Deleted reference to workers taking time off. See page 16, "The Holiday".

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
47	Nick Plurkowski	PBF USW	Table 2: Root Causes… p16 Could we include an example along the lines of "(ex. More operators)"	Page 16		There were sufficient people (maybe even too many people) available in the control room. The key issues were (a) training, (b) fatigue, (c) not following procedures, and (d) not pausing work when appropriate. It is conceivable that as part of addressing these issues, MRC could decide they need more operators, but it is not seen as a root cause.	None needed.
48	CCH Hazmat	CCH	"The reporting of this incident to Bay Area authorities was specifically excluded from this investigation…" Suggest adding by MRC before this	Page 4		Thank you.	Insertion made on pages 4, 22, and 26.
49	CCH Hazmat	CCH	"This report describes the process of "cracking" hydrocarbon as the CCU was intended to be operated…" Suggest adding molecules after hydrocarbon	Page 4		Thank you.	Insertion made on pages 4 and 5, with reference to new glossary item on page 29 describing hydrocarbon feed to the CCU.
50	CCH Hazmat	CCH	Suggest moving section V (background) before section IV (Description of Incident)	Overall report		Agreed.	Reordering of sections done.
51	CCH Hazmat	CCH	Suggest after the first sentence, a statement be added that clarifies what a PHA is or add a footnote to the definition.	Page 5		Thank you.	Added footnote reference to PHA glossary item
52	CCH Hazmat	CCH	"As the quantity of wet gas grew smaller, the WGC total discharge flow control valve (5FC340; spillback valve) automatically opened in an attempt to prevent compressor surge and potential damage to the WGC." Suggest that clarifying language be added to explain the consequences of a compressor surge and function of spill back valve	Page 5		Thank you.	Explained surge in a footnote related to this text and also in the Glossary. See page 7 footnote and page 31.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
53	CCH Hazmat	CCH	"light-off" Suggest this is clarified for the general public or a definition added to Appendix D.			Thank you.	Text was changed to "igniting the burner". See page 7, section C, paragraph 1.
54	CCH Hazmat	CCH	SSV when first used is not defined. Suggest changing to Stripper Slide Valve (SSV)	Page 6		Thank you.	Done. See page 8, section D, paragraph 1.
55	CCH Hazmat	CCH	Page 6: General comment for paragraphs 1,2, and 3. Clarify for general public where feed was reintroduced.	Page 6		Thank you.	Changed sentence on of this paragraph to "reintroducing feed to the Reactor Riser (RR)". See page 8, section D, paragraph 1.
56	CCH Hazmat	CCH	CCH acknowledges that acronyms are mostly defined on first use and again in Appendix D Glossary, however consider redefining some key terms like SSV, RR, HC and dp in report.	General Report		SSV noted (and corrected) per line 54. The other 3 terms were defined on first use. Verified that other terms were defined on first use.	See line 54.
57	CCH Hazmat	CCH	Figure 1: Catalytic Cracking Unit, suggest adding MRC before Catalytic	Page 8		Thank you.	Done. See page 5 Figure 1 caption.
58	CCH Hazmat	CCH	consistently refer to WGC spillback control valve as such (in current draft this is stated as WGC or WGC spillback.	Pages 6 and 7		Thank you.	Done. Multiple changes on pages 8, 9, 10, and 15.
59	CCH Hazmat	CCH	"The vapor continues to the Main Fractionator (MF) where liquid products are separated, and the vapor is further cooled before being collected in the Overhead Accumulator (OHA)." Suggest adding HC before vapor	Page 8		Thank you.	Done. See page 6 paragraph 1.
60	CCH Hazmat	CCH	Figure 1: Suggest labeling air compressor as air blower for report consistency	Page 8		Thank you.	Done. See page 5 figure 1.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
61	CCH Hazmat	CCH	"Table 1 describes the timeline and sequence of events for the catalyst release incident. As detailed above in section III.C." If Section Iv and V are switched as suggested above this reference needs to change to IV.	Page 10		Thank you.	Done.
62	CCH Hazmat	CCH	General Comment, to be consistent with the presentation from 2/1/24 and as stated on the presentation slides, replace the word culture with practice from root causes in Figure 2 and update corresponding report language to clarify as necessary (including in tables).	Pages 11 and 12, 16-20, 23-24		Thank you.	Done.
63	CCH Hazmat	CCH	Figure 2, define PS	Page 11		Thank you.	Relabeled figure replacing PS with Process Safety. See page 11, Figure 2.
64	CCH Hazmat	CCH	Clarify what is meant by "Objective based"	Page 12		Thank you.	Resolved in response to line 12.
65	CCH Hazmat	CCH	"MRC personnel denied that personnel were reluctant to call an instrument technician or process engineer for support when the incident started because of to the holiday, but such reluctance would be understandable". Suggest removing the "to" highlighted in red.	Page 15		Thank you.	Typo corrected. See page 16, "The holiday" paragraph.
66	CCH Hazmat	CCH	Suggest labeling tables 2-5 all as Table 2 and relabel Table 6 to Table 3.	Pages 16-20		Thank you.	Done; also changed "Table 7" to "Table 4."
67	CCH Hazmat	CCH	"Develop or update the criteria for operator training and conduct a review of materials to ensure that the bases for alarms involved as safeguards in process PHA scenarios are included in the training materials." Correct bases to basis.	Page 18		Original text was grammatically correct. Each alarm has a basis, so multiple alarms have multiple bases. However, we understand this can be confusing, so text clarified.	"ensure that the basis for each alarm involved…". See page 19, recommendation 6.

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68	CCH Hazmat	CCH	"Community Warning System of the Contra Costa Industrial Safety Ordinance". CCH suggest changing this to Community Warning System. The CWS is an all-hazards community notification system intended to alert residents about any potential health hazards and emergencies that may be occurring	Page 27	Appendix D	Thank you.	Corrected. See page 28.
69	CCH Hazmat	CCH	MCAR is defined as Major Chemical Accident or Release	Page 28	Appendix D	Thank you.	Corrected. See page 29.
70	CCH Hazmat	CCH	Define RQ when used on page 12	Page 12		Noted	Since this is the only usage, replaced RQ with "a quantity of release requiring agency notification". See page 12, paragraph 1.
71	CCH Hazmat	CCH	CCH suggest that the following sections be reviewed and language clarified in more general terms to help aid with readability for the general public: Paragraphs 3 page 7, Table 1, Paragraph 9 of page 8, Distractions and Engineering Design section on pages 14 and 15, and reactor definition in Appendix D	General Report		No suggested edits were provided with this comment. Note, there were only 3 paragraphs on page 8. Upon review of the indicated paragraphs, it appears they are acceptable as originally written.	Specific edit suggestions would be welcomed for the final version of the report.
72	CCH Hazmat	CCH	"An individual working the CCU console during startup worked significantly more than fatigue management requirements prescribed in the fatigue and scheduling policy." Suggest clarifying this individual was non-hourly.	Page 19	Table 5	Noted	Done. See page 20, third bullet under "Evidence".
73	CCH Hazmat	CCH	"The excessively long shifts continued unchallenged throughout the incident." Suggest clarifying this statement to state whose long shifts were unchallenged	Page 19	Table 5	Noted	Done. See page 20, fourth bullet under "Evidence".

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74			Suggest replacing 4 stage with multiple stage	Page 26	Appendix C	Expanding on the spirit of this comment, it wasn't necessary to specify the number of stages in this paragraph	Deleted "four (4) stages of ". See page 27, Appendix C, first paragraph.
The following comments were made by the Oversight Committee during the 2/1/24 presentation							
75	Tom Lang	Community Member	So the question that I have. It's really a general observation that leads to a few questions. And thinking of the stripper slide valve, which is a very important part of the process right? It just sort of boggles my mind that there isn't a big blinking red light that says: Hey, this is either open or closed and if either open or closed, whether I'm in automatic or manual, and if that is the case, and it is so important, why isn't that status interlocked with the settings on these feed valves that are feeding gas into the reactor?		These comments were submitted in a single cell. They have been broken up for clarity in responding These comments were submitted in a single cell. They have been broken up for clarity in responding	The operator console does show whether the valve is being controlled in manual or auto. We believe this concern was captured and addressed by the recommendation made both in this investigation and MRC's investigation about providing appropriate warning statements in the procedure.	None needed.
76	Tom Lang	Community Member	And the you know, the other thing that kind of surprised me is the idea of well, hey, you know, maybe we better have a differential pressure sensor between the reactor and the you know the other containment units.			As clarification, add to the Engineering Design part of Section VI.C. that Shell had intended to implement this change at the 2018 turnaround, but ultimately did not. Shell's motives for this deferral were not investigated.	Clarification added. See pages 15 (Engineering Design) and 23 (Status of MRC's Corrective Action No. 1.
77	Tom Lang	Community Member	And II just don't understand why that full plan would not be absolutely full of sensors with the appropriate interlocks.			The plant is indeed full of sensors and interlocks. The specific interlock issue is described in root cause 1 of this report. That is, in Shell's and MRC's PHAs, the potential consequence of the catalyst carry-over scenario was understated, and therefore the need for a specific additional safeguard designed to address this scenario was not identified.	None needed. See page 17, Table 2, Root Cause 1.

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78	Tom Lang	Community Member	Does this reflect a systematic under investment by Pbf in the plan? Because you would think that a you know, a plant with such a high potential environmental impact would have a design where there would be a fundamentally automated control system that human operators would have to consciously override, you know, in order to do things that sort of fell outside the normal range.		These comments were submitted in a single cell. They have been broken up for clarity in responding	Evaluating the financial aspects of this incident fell beyond the scope of the investigation.	None needed.
79	Tom Lang	Community Member	And so this lack of kind of an automated framework, and a modern system of sensors and interlocks makes me think that it leads to this idea that you know, as you pointed out in your report that the operation of the plant sort of relies on these sort of super workers, and there's a tendency of the staff to deviate from procedures. You know things like that? And does that represent kind of an underlying sort of lack of faith in the operational integrity of the plant. And so I guess what in the end, I'm wondering. You know, these recommendations are all about sort of procedures and processes on how to properly operate a manually controlled plan when in reality, you know, there's a fundamental problem that things that should be automatically sensed and controlled and interlocked aren't done that way. So I'm sorry if this has been more of a rant than a you know specific question. But that's my general impression.			This paragraph summarizes Mr. Lang's verbal comments noted above in lines 77-80.	None needed.

	Commenter Name	Organization	Comment	Page of Report	Section of Report	Scott Berger & Assoc. Response	Report Modifications Made
80	Ben Therriault	Community Member	Start off about the slide valve and then basically was the unit shut down? Was it open? Was it inspected for damage?Was there some type of erosion? Or, you know, other type of damage. When, how often did that happen?		These comments were submitted in a single cell. They have been broken up for clarity in responding	The stripper slide valve (SSV) can only be inspected when the entire CCU is down for maintenance. This last happened in 2018 and will happen again until 2025. It was not necessary to inspect the SSV for this investigation because operational data showed that it could have restricted the flow rate of catalyst sufficiently to have prevented the incident, if it had been operated in automatic.	None needed.
81	Ben Therriault	Community Member	Then just another issue I wanted raise was, you know, a lot of people understand that the air district found that the wet gas scrubber was feasible in its own air, quality, rule, analysis and decision. A lot of people in the community want to know. You know, we're pointing out the fact that replacing the Esps with a wet scrubbing would eliminate source of ignition. That is an explosion hazard. And this was one of the issues in the incident, you know. Does the report, you know, talk about whether it be inherently safer to have equipment solution? Or you know this company? Do any adequate, inherent safety analysis? And or did report, you know, talk about this this feasibility?			This report agrees that a wet gas scrubber could be safely operated under conditions where an ESP would have to be de-energized. This would have prevented the opacity condition that preceded the catalyst release. However, both ESPs and Wet Gas scrubbers are intended to remove relatively small quantities of catalyst per hour (i.e., pounds per hour), while the incident released catalyst at a rate of tons per hour, well above the capacity of either device. In conclusion, it is valid for the air district to consider wet gas scrubbers for routine conditions, however, the absence or presence of a wet gas scrubber was not a factor in the release of 24 tons of catalyst.	Clarification added that wet gas scrubbers can prevent the opacity condition that is typical when ESPs are de-energized. However, like ESPs they are designed to remove pounds per hour of catalyst fines, and would not be effective against the tons per hour being emitted during this incident. See page 27, Appendix C.

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82	Ben Therriault	Community Member	And you know the investigation. Investigation can't just be, you know, based on, you know, interviews and documents needs to be people who like took a look and actually looked at the slide valve in particular, and so need to know, like, has that actually occurred, that people actually looked at the equipment? Etc. and you know, on the process hazard analysis.			See line 80.	See line 80.
83	Ben Therriault	Community Member	The Pha of shell you know.It doesn't seem like Mrc, you know, really did a good job of identifying, you knowthe issues of of that unit. And you know, how is that? Gonna get addressed, you know. Will there be a safety analysis for that?			We understand that MRC repeated the PHA in 2023, and in that PHA they properly quantified the consequences of this scenario. However, we did not verify this as it was outside the scope of our investigation.	None needed.
84	Tony Semenza	Community Member	Yeah, just a couple of questions, Nick asked the question about flaring. I wanna make sure we follow up on that, because I'm not sure I understand whether or not the flaring would have prevented the incident if they flared again.		These comments were submitted in a single cell. They have been broken up for clarity in responding	Opening the valve to the flare system when the reactor pressure rose around 8:30 PM, might have helped prevent the release.	None needed.
85	Tony Semenza	Community Member	So you know the follow up on Nick's comment. also on the fourth stage separator. I guess the question is the alarms, were the alarms going off, were they silenced the how?			It is our understanding that the alarms were acknowledged, but the console operator did not remember having done so. Once an alarm has been acknowledged, it won't sound again unless the alarm condition clears and then reappears.	A clarifying footnote was added to the relevant text in section VI.B. See page 14, footnote 13.
86	Tony Semenza	Community Member	How often are the 4 State separator drained?			Under normal situations, the FSS is drained as needed, perhaps 1-2 times a day. Once the release began, the FSS was being drained almost continuously until near the end of the release.	None needed

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87	Tony Semenza	Community Member	And then I have a question to follow up on what Ken said and this goes to maybe you Nicole, and your team, what's the were you part of the interview process when the interviews were taking place? And if it wasn't said, how did it get into the report? You know, I mean, are you guys involved in the in the interviewing process so that there's a third party, or and then for Scott. Was there anybody who you wanted to interview that that wasn't available to you. And let's see, just those kind of questions. I'll look for answers from either Scott or you, Nicole, or your team, that's all. I had			We took notes of what the individuals said. A few changes were made based on Mr. Axe's comments.	Please see lines 7, 10, and 13.
	CCH notes that Ken Aex and Nick Plurkowski commented but they both indicated they were reading their written comments submitted and noted above						
88	CCH	CCH	Please clarify if the call from Refinery Logistics was following current MRC policies. Page 14 Distractions Bullet 1			Yes, the policies as current at the time.	None needed
89	CCH	CCH	Please clarify which industry standard is being referenced to determine maximum of 10 alarms per 10 minute period for two consecutive periods. Page 22 MRC Corrective Action #2.			ISA 18-2. However, please note that this investigation did not find alarm flooding as a root cause, and related text was removed.	See line 23.