MPC Los Angeles Refinery Carson North Area Fire Investigation

Location:	Marathon Los Angeles Refinery, Carson Operations (LAR-C)
Date of Incident:	February 25, 2020
Time of Incident:	22:49 Pacific Standard Time
Investigation Began:	February 26, 2020 15:00
Date of Report:	July 23, 2020
Name of Incident:	LAR-C North Area Fire Incident
Investigation Method:	TapRoot™ Root Cause Analysis

Summary of the Incident

On February 25 at 22:49, a flash fire and ensuing process fire occurred due to ignition of light hydrocarbon material released from the Light Ends Depropanizer (LED) Unit located in the LAR-C North Area. Multiple process units were shut down and the surrounding process area was immediately isolated. Emergency response was initiated, with the unit fully isolated and fire extinguished on February 27 at 08:37.

This incident was classified as an API Process Safety Tier 1 event due to the repair costs exceeding the API RP 754 Tier 1 threshold dollar amount.

This event was deemed a "major incident" pursuant to 8 CCR 5189.1 and 19 CCR 2735.1.

The Investigation Team focused on identifying the release point, identifying the cause of the initial release, and developing action items to address the root cause of the incident.

Immediate Corrective Actions and Interim Measures Implemented

Upstream units were shut down and feed to the LED Unit was isolated. The Refinery Emergency Response Team (ERT) arrived on scene and began offensive maneuvers. The Los Angeles County Fire Department (LAcoFD) was staged but did not aid the Refinery ERT. The fire was extinguished on February 27 at 08:37.

The LED Unit was shut down, isolated, and decontaminated. The unit is currently down.

Meteorological Conditions

Wind speed:	4.9 mph
Wind direction:	East
Temperature:	70°F
Humidity:	20%
Pressure:	30.64 in Hg
Precipitation:	0 in

Materials Released

A mixture of light hydrocarbon material was released from the LED Unit.

Injuries and Environmental Impacts

All personnel were accounted for and no physical injuries were sustained. There were no off-site injuries. No impacts to the environment were detected.

Community Impacts

Air monitoring was conducted. No community shelter-in-place or evacuation were required for the incident.

The sheriff's department closed Wilmington Avenue on the west and 223rd on the north of the Refinery. All lanes of Interstate 405 at Wilmington Avenue were closed by the California Highway Patrol for about an hour.

Emergency Response

The Refinery ERT arrived on scene and provided offensive maneuvers to extinguish the fire. LAcoFD was staged outside the refinery, but mutual aid was not required.

Agency Notification

Notifications were made to South Coast Area Quality Management District (SCAQMD), Los Angeles County Sanitation District (LACSD), California Office of Emergency Services (Cal OES), and National Response Center (NRC).

Cal/OSHA, LAcoFD, and SCAQMD opened incident investigation inspections for the LED Unit fire. The investigation team collaborated with Cal/OSHA on evidence collection, laboratory selection and testing methodology.

Incident Investigation Team

The investigation was started February 26 at 15:00 with the collection of Distributed Control System (DCS) data and review of operating data. Preservation of the process unit was completed immediately following the conclusion of the emergency response activities. Collection of physical evidence was done consistent with Cal/OSHA guidance.

The investigation team was assembled, and a kick-off meeting was held at February 27 07:00. The investigation team was led by a trained root cause incident investigator with over 40 years of industry experience. The team consisted of corporate and local process safety professionals, a rotating equipment subject matter expert, materials and corrosion subject matter experts, a Certified Fire and Explosion Investigator, and a USW process safety representative.

Background on the Light Ends Depropanizer (LED) Unit

The LED Unit takes a mix of light hydrocarbon feed stream from the Hydrocracker Debutanizer Overhead Accumulator, No. 1 Reformer Stabilizer Accumulator and No. 2 Reformer Stabilizer Reflux Drum, which are combined in a single feed stream upstream of the Comingler Cooler. The cooled feed then enters the Flash Drum prior to entering the LED Depropanizer. The LED Depropanizer is a distillation tower that separates propane and lighter hydrocarbons from isobutane and heavier hydrocarbons. The overhead

streams, which are lighter products, are either sent to the Hydrocracker Hydrogen plant, the fuel gas system or the FCC Gas Plant. The LED bottoms stream is processed further then sent to storage.

Event Description

On the February 25 night shift, the LED Unit was operating under normal conditions. At approximately 22:50, a light hydrocarbon leak occurred in the LED Unit. The LED Unit board operator received five alarms in ten seconds, including Area LEL Detector alarm on the LED Unit and neighboring unit. 17 seconds after the Area LEL detectors, a flash fire occurred when light hydrocarbons ignited.

Operations immediately began the unit shutdown and the Refinery ERT was dispatched. The Refinery ERT arrived on scene and began offensive maneuvers.

Upstream units were shut down and feed to the unit was isolated within 20 minutes. Failed lines in the unit continued to feed the fire. These lines were systematically identified and isolated. All but the fuel gas line was isolated by February 26 at 06:08. The fuel gas line was interconnected throughout the north area of the refinery and scaffolding was built to access valves to fully isolate. One of the valves required re-work to complete the isolation plan, which delayed full isolation. The fire was extinguished on February 27 at 08:37.

Timeline

A timeline of the events was established using recorded DCS data that stores values of process variables and status of alarms, as well as witness statements and interviews.

Time on 2/25/2020	Description
19:30	Normal operation per operator interviews. Operator completed last round at 19:30.
22:48	DCS data indicates normal operation.
Approximately 22:48	Equipment failure that resulted in a release of light hydrocarbon material from the LED Unit. Release rate could not be determined because of the damage the equipment sustained.
22:48:45.9	DCS Alarm: LED Tower Reflux Low Flow Alarm
22:48:46.1	DCS Alarm: LED Overhead Accumulator Low Pressure Alarm
22:48:48.8	DCS Alarm: LPG Area LEL Detectors Alarm
22:48:53.3	DCS Alarm: LED Tower High Differential Pressure Alarm
22:48:55.0	DCS Pressure Indicator: LED Contactor Pressure begins to decrease
22:48:56.7	DCS Alarm: LED Contactor Low Pressure Alarm
22:49:00	PI Process Book historized database captured at one-minute snapshots showed LED Reflux rate at 0, LED Feed Rate decreasing, and LED Accumulator and Contactor pressure decreasing.
22:49:06	Security Footage: Vapor cloud ignition
22:49:12	Console Operator acknowledges alarms on DCS
23:00	Emergency Responders arrive on scene and assume offensive maneuvers
23:10	Console Operator sends signal to close feed valve
12/26/2020 06:08	LED Unit isolated. Leaking fuel gas valve continues to feed the fire.
2/27/2020 08:37	Fuel gas isolation complete and fire extinguished

Post Incident Data Review

The investigation team conducted a post-incident unit walkdown to identify damaged piping or equipment for metallurgical testing. Multiple release locations were identified during this walkdown and a full visual inspection of the Depropanizer piping was conducted to ensure all release locations were identified.

Metallurgical analysis of damaged equipment and piping determined the most probable initiating release was from the Overhead Condenser, RPV-3175. The metallurgical analysis identified a pre-existing crack in the condenser shell head, and by inherent design a stagnant region exists in the area of the head. Corrosives could concentrate and contribute to additional corrosion.

The team reviewed the following studies as part of the investigation: the 2015 Process Hazard Analysis (PHA) and the 2016 RBMI Corrosion Study. The 2020 LED PHA, Hierarchy of Hazard Control (HCA) and Safeguard Protection Analysis (SPA) were being conducted at the time of the incident. These draft reports also were reviewed by the team; no applicable findings were identified. A Damage Mechanism Review (DMR) was conducted in April 2020 as part of the ongoing LED PHA effort and was conducted with participation of Subject Matter Experts (SMEs) from the incident investigation team.

The 2016 RBMI Corrosion Study noted that RPV-3175 was susceptible to Wet H_2S Damage. The LED feed streams contain both H_2S and chlorides with a potential for water carryover to the LED.

The original code of construction that was applied to RPV-3175 was the 1959 ASME BPVC, which required the shell to undergo stress relief heat treatment after fabrication. However, the engineering spec did not include this requirement and no data exists to indicate this treatment was performed. Because the engineering spec did not require stress relief, the condenser shell was not stress relieved after the 1971 weld overlay repair to the shell head.

The site's prior inspection manuals required inspection of this vessel and the preferred but not only inspection technique for this service was by wet fluorescent magnetic particle testing (WFMT) on 10 to 20% of the vessel in random areas to detect internal surface breaking cracks. Although the weld repair was inspected visually, there is no evidence to indicate this weld overlay was inspected for potential cracking in the previous WFMT inspections performed in 2005, 2009 and 2015.

Based on the information discovered during the investigation and described above, the investigation team concluded that the fuel source of the LED fire was a release of light hydrocarbon material from the Depropanizer Overhead Condenser, RPV-3175. The design of the exchanger created an area of stagnation in the condenser head that likely had adequate concentration of corrosive material that contributed to stress corrosion cracking of the weld overlay repair.

A release from a crack in the condenser head would have cooled the condenser head from vapor expansion. The cooling of the shell head could have negatively affected the material properties causing the crack to propagate and catastrophically fail.

Root Causes and Corrective Actions

The causal analysis for this incident yielded the following root causes and corrective actions:

Causal Factor	Root Cause	Corrective Action	Hierarchy of Controls Analysis
CF_1 – 1961 Design Spec did not specify stress relief on the shell head of RPV-3175, nor was it conducted after the 1971 repair.	Equipment Difficulty; Design; Spec Needs Improvement (NI)	1. Ensure that WFMT inspection has been performed on all non-post weld heat treated pressure boundary repairs for LED unit pressure equipment in wet H2S service. Any documented repairs without WFMT inspection shall be addressed prior to return to service. 2. Ensure replacement exchanger conforms with the appropriate code of construction.	Procedural Procedural
CF_2 – WFMT inspection occurred on full penetrations weld seams but not on the 1971 weld overlay repair.	Equipment Difficulty; Preventative/Predictive Maintenance (PM); PM NI; PM for Equipment NI	3. Implement appropriate inspection practices to mitigate Wet H_2S Cracking at LED Unit.	Procedural
CF_3 – Unit had history of corrosion occurrences that were addressed but source of chloride corrosion was not mitigated. Project to address feed chloride corrosion was initiated but not yet implemented.	Management System; Corrective Action; Correction Action Not Yet Implemented	4. Install chloride guard bed on feed from reformer units to remove chlorides.	2nd Order